INTERNATIONAL BACCALAUREATE BIOLOGY EXTENDED ESSAY

Research On Antıbacterıal Actıvıty Of *Rosmarinus Officinalis, Curcuma Longa, Hypercium Perforatum, Eucalyptus Globulus, And Melaleuca Alternifolia* Of Medıcınal Plants On *Staphylococcus Aureus*

Research Questıon: Do Rosmarinus Officinalis, Curcuma Longa, Hypercium Perforatum, Eucalyptus Globulus, And Melaleuca Alternifolia Medıcal Plants Have An Antıbactarıal Affect On Staphylococcus Aureus?

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INTRODUCTION

I have always been interested in alternative medicine. I started to think whether it can be more effective than conventional medicine or provide benefits in a healthier way. I started to do research and read scientific literature and the more I read the more I realized that it is an effective method.

Alternative Medicine: In the most general definition, alternative medicine includes medical practices which are estimated to treat but cannot be proven for that with scientific methods. Plants that are used as active ingredients in medicines are mainly used in this method. Active ingredients in plants are mostly extracted by distilling. Medicines in which compounds from plants are used are produced with medicinal plants or with compounds of these plants extracted in laboratories.

The immune system fights against diseases and weakens due to several reasons such as poor eating habits, stress, viral infections, genetic diseases (e.g.: diabetes), anxiety, distress, severe infections, severe depressions. People with weak immune system cannot be protected against pathogens and their health is adversely affected. Alternative medicine therapies intend to support and reinforce the immune system to help people fight off diseases. There are many other substances/compounds in plants used in alternative medicine other than those used as active ingredients in medicines i.e. there can be a wide range of compounds in a plant including active ingredients and other compounds. Since pharmacological and pharmaceutical effects of these compounds are not well known, most physicians do not trust in alternative medicine products. Additionally, due to adverse effects caused by medicines, which can lead to health problems and due to pharmaceutical therapies that are inconvenient and last long, there is an increasing trend for using alternative medicine methods. Alternative medicine, together with natural foods boosts the immune system however it should be used under medical supervision and the dosage is very important.

According to the World Healthcare Organisation data; 20,000 plants are used in medicine. Turkey has many medicinal plants thanks to its geographical location.

Some of the important medicinal plants that can be found in Turkey:

* Linden Tea (*Tilia cordata*)
* Laurel (*Laurus nobilis*)
* Rosemary (*Rosmarinus officinalis*)
* Eucalyptus *(Eucalyptus globulus*)
* Spearmint (*Mentha piperita*)
* Thyme (*Thymus vulgaris*)
* Turmeric (*Curcuma longa*)
* St John's Wort (Hypericum perforatum)

The group of compounds containing a benzene ring to which one or more hydroxyl groups are attached are called phenolic compounds or polyphenols. All compounds that contain at least one aromatic ring and a large amount of hydroxyl substituents in this ring are called phenolic compounds.

Based on what I have learned from the scientific literature I have read, I asked this question: is it possible to have healthier and more affordable products when compounds of medicinal plants are used in oral care products we use every day such as toothpaste and mouth wash? And I decided to conduct an experiment to find answers to this question. I started to do research on medicinal plants and I specifically chose those that have antibacterial and antiviral properties. Based on this research, I decided to use St John's Wort, rosemary and eucalyptus.

Oral flora has a rich diversity of microorganisms. This rich flora is boosted with food residue on teeth, aerobic and anaerobic parts of oral cavity, heat and decreased pH levels, which makes it hard to fight off diseases. Additionally, ineffective brushing, not brushing everywhere in the mouth which results in lack of effect of antibacterial properties of the toothpaste in all parts of the mouth are factors that have a negative effect on oral health. Therefore, chemical substances used in toothpastes, although they are individually successful, may be insufficient to protect oral flora since they stay in the mouth and have contact with teeth for a limited time. That's why I wanted to use oral care products in the experiment I planned to do.

I wanted to use turmeric (*Curcuma longa*) (picture 1) because it is a very popular plant thanks to its antibacterial and antiviral properties. When I did a research on this plant, I found out that it has been used for a very long time in medicine. Turmeric is native to Southeast Asia and it is cultivated in some regions in the world. In-vitro and in-vivo studies have found that curcumin, which is the active ingredient of turmeric is known for its antibacterial and antiviral properties.[1] [2] [3] Curcumin is known to have therapeutic effects on diabetic wounds, rheumatic pains and liver diseases. It has also beneficial effects on cuts, burns and bruises. Additionally curcumin has also been shown to help wounds heal faster and prevent infection. However, since it has a high level of volatile oil content, it should be used in diluted form.

[1] Negi, P. S., Jayaprakasha, G. K., Jagan Mohan Rao, L., & Sakariah, K. K. (1999). Antibacterial activity of turmeric oil: a byproduct from curcumin manufacture. Journal of agricultural and food chemistry, 47(10), 4297-4300.

[2] Jayaprakasha, G. K., Rao, L. J. M., & Sakariah, K. K. (2005). Chemistry and biological activities of C. longa. Trends in Food Science & Technology, 16(12), 533-548.

[3] Jurenka, J. S. (2009). Anti-inflammatory properties of curcumin, a major constituent of Curcuma longa: a review of preclinical and clinical research. Alternative medicine review, 14(2).

Turmeric is generally considered safe in clinical studies however dosage is important and it is not recommended to be used concomitantly with some medicines for chronic diseases. Although it has no known toxicity, some people can be allergic to it. [4]

Picture 1: Turmeric *(Curcuma longa)*

The second plant I wanted to use was rosemary (*Rosmarinus officinalis*) (picture 2). It has become increasingly popular in our country because of both its use in the kitchen and in medicine. Rosemary is scientifically an important aromatic and medicinal plant. Studies in the literature have shown that rosemary has positive effects on the immune system.

Rosemary is known to have antioxidant and antimicrobial properties and even have anticarcinogenic effects.[5] [6] Rosemary essential oil and compounds can differ depending on the regions harvest season and part of the plant used. Rosemary is one of the plants that are rich in phenolic compounds and therefore there are ongoing studies to use it in foods together with other medicinal plants that are rich in phenolic compounds (e.g.: thyme, sage etc.) . Main active ingredients of rosemary extract are carnasol and carnosic acid.[7] The most powerful of these active ingredients is carnosic acid.

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[4] Labban, L. (2014). Medicinal and pharmacological properties of Turmeric (Curcuma longa): A review. Int J Pharm Biomed Sci, 5(1), 17-23.

[5] Oluwatuyi, M., Kaatz, G. W., & Gibbons, S. (2004). Antibacterial and resistance modifying activity of Rosmarinus officinalis. Phytochemistry, 65(24), 3249-3254.

[6] Malayoğlu, H. B. (2010). Biberiyenin (Rosmarinus officinalis L.) antioksidan etkisi. Hayvansal Üretim, 51(2).

[7] Ayanoğlu, F., Başkaya, Ş., & Bahadırlı, N. P. (2016). Biberiye (Rosmarinus officinalis L.) bitkisinin uçucu yağ oranı, uçucu yağ bileşenleri ve antioksidan içeriğinde morfogenetik ve ontogenetik varyabilite. Mustafa Kemal Üniversitesi Ziraat Fakültesi Dergisi, 21(1).

It is known to be used for digestive system disorders and rheumatism however its dosage, just like with any other medicinal plant is very important. It can lead to adverse reactions when used concomitantly with some medicines.[8]

Picture 2: Rosemary *(Rosmarinus officinalis)*

Another medicinal plant I wanted to use in my experiment is St John's Wort (Hypericum perforatum) (picture 3)[9] which is used by people to help wounds heal.[10] This plant is used widely in the world as a household remedy. The main ingredient of this plant extract is the red coloured hypericin. This ingredient makes it possible to be used pharmacologically. St John's Wort extract shows several pharmacological effects. I specifically investigated its antibacterial properties in my study.

[8] Begum, A., Sandhya, S., Vinod, K. R., Reddy, S., & Banji, D. (2013). An in-depth review on the medicinal flora Rosmarinus officinalis (Lamiaceae). Acta scientiarum polonorum Technologia alimentaria, 12(1), 61-74.

[9] Çırak, C., & Kurt, D. (2014). Önemli tıbbi bitkiler olarak hypericum türleri ve kullanım alanları. Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 24(1), 38-52.

[10] Ernst, E. (Ed.). (2003). Hypericum: the genus Hypericum. CRC Press.

There are studies which show that its properties help to prevent hepatitis, intestinal tumours, infections caused by many viruses and growth of HIV virus.[11] [12]

Additionally St John's Wort is known to heal wounds and reduce inflammation. Above ground parts of the plant show good results when used to treat wounds, bacterial infections and headache. Antibacterial properties of St John's Wort are the result of two active ingredients: hyperforin and hypericin.[13] Additionally studies have shown that it is highly effective against gram positive bacteria. That is why I believe it is a good choice for my study.

Picture 3: St. John's Wort *(Hypercium perforetum)*

The other medicinal plant I chose was Eucalyptus which we hear more often recently with the start of the pandemic due to its antibacterial properties. Eucalyptus (picture 4) has strong antiviral and antibacterial properties.[14] Its pharmacologically active ingredient is eucalyptol. Eucalyptus has been used in a wide range of areas and for a wide range of illnesses.

[11] Barnes, J., Anderson, L. A., & Phillipson, J. D. (2001). St John's wort (Hypericum perforatum L.): a review of its chemistry, pharmacology and clinical properties. Journal of pharmacy and pharmacology, 53(5), 583-600.

[12] Shrivastava, M., & Dwivedi, L. (2015). Therapeutic potential of Hypericum perforatum: a review. Int. J. Pharm. Sci. Res, 6(12), 4982-4988.

[13] Saddiqe, Z., Naeem, I., & Maimoona, A. (2010). A review of the antibacterial activity of Hypericum perforatum L. Journal of ethnopharmacology, 131(3), 511-521.

[14] Mulyaningsih, S., Sporer, F., Reichling, J., & Wink, M. (2011). Antibacterial activity of essential oils from Eucalyptus and of selected components against multidrug-resistant bacterial pathogens. Pharmaceutical biology, 49(9), 893-899.

It is known especially to help in the treatment of respiratory diseases, asthma, bronchitis and even common cold. It is proven to have an alleviating effect on muscle and joint pains.[15] Its smell is known to affect the nervous system and provide relief.[16]

In addition to the above mentioned effects, its antimicrobial properties are known to help alleviate headaches, reduce local bleedings, reduce fever and work against malaria, wounds and inflammation. Additionally, eucalyptus leaves are used for therapeutic purposes. Of course dosage and method of application should be controlled. The main reason why I chose eucalyptus is that it is used effectively for oral diseases and periodontal diseases.[17] [18]

Picture 4: Eucalyptus *(Eucalyptus globulus.)*

The last medicinal plant I chose is the tea tree (*Melaleuca alternifolia*) (picture 5). The main reason why I chose this plant is that it is already used in many oral care products.[19] [20]

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[15] Vecchio, M. G., Loganes, C., & Minto, C. (2016). Beneficial and healthy properties of Eucalyptus plants: A great potential use. The Open Agriculture Journal, 10(1).

[16] Kurt, N. C., & Çankaya, İ. İ. T. (2021). Aromatherapy Applications And Essential Oils. Mersin Üniversitesi Tıp Fakültesi Lokman Hekim Tıp Tarihi ve Folklorik Tıp Dergisi.

[17] Tanaka, M., Toe, M., Nagata, H., Ojima, M., Kuboniwa, M., Shimizu, K., ... & Shizukuishi, S. (2010). Effect of eucalyptus-extract chewing gum on oral malodor: a double-masked, randomized trial. Journal of periodontology, 81(11), 1564-1571.

[18] Ragul, P., Dhanraj, M., & Jain, A. R. (2018). Efficacy of eucalyptus oil over chlorhexidine mouthwash in dental practice. Drug invention today, 10(5), 638-641.

[19] Soukoulis, S., & Hirsch, R. (2004). The effects of a tea tree oil-containing gel on plaque and chronic gingivitis. Australian dental journal, 49(2), 78-83.

[20] Kamath, N. P., Tandon, S., Nayak, R., Naidu, S., Anand, P. S., & Kamath, Y. S. (2020). The effect of aloe vera and tea tree oil mouthwashes on the oral health of school children. European Archives of Paediatric Dentistry, 21(1), 61-66.

Then I started to make some research about this plant. I found that it is endemic to Australia and grown on river banks and it is an oil which is produced by steaming tea tree leaves. Tea tree is believed to have antibacterial properties and additionally tea tree oil is used to treat acne, lice and bug bites.[21] Studies investigating tea tree oil have shown that when tea tree oil is added in shampoos, it is effective in treating dandruff if used for a certain a period of time. Therefore it is not only used in oral care products but also in many skin care products. Tea tree oil is mostly used in skin disorders caused by bacteria.[22] As with all medicinal plants, the dosage, application method and amount of tea tree oil is important. Generally it is a safe plant to use however studies have shown that it should not be ingested since ingestion can cause a toxic effect. In addition to that, people suffering from eczema are also recommended not to use it.

Picture 5: Tea tree *(Melaleuca alternifolia)*

Staphylococcus aureus is a type of bacteria of the Staphylococcaceae family. It is a gram positive bacteria and there are approximately 20 types. It is a commensal bacteria which is found in the skin flora however can cause diseases in certain host and environmental conditions. The reason why I chose this bacteria is the fact that it can naturally be found in the nasal and oral areas.[23]

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[21] Carson, C. F., Hammer, K. A., & Riley, T. V. (2006). Melaleuca alternifolia (tea tree) oil: a review of antimicrobial and other medicinal properties. Clinical microbiology reviews, 19(1), 50-62.

[22] Pazyar, N., Yaghoobi, R., Bagherani, N., & Kazerouni, A. (2013). A review of applications of tea tree oil in dermatology. International journal of dermatology, 52(7), 784-790.

[23] Stewart, G. C. (2005). Staphylococcus aureus. Foodborne pathogens: microbiology and molecular biology, 273-284.

Staphylococcus aureus is not considered a member of normal oral microbiota. There is limited information on the incidence of *S.aereus* in the oral cavity of health children.[24] It is also found in infected wounds and acne. Based on the information I gathered in my research, I wanted to use it to see whether it has any effect on the wounds found inside the oral cavity.

RESEARCH QUESTION

Do *Rosmarinus officinalis, Curcuma longa, Hypercium perforatum, Eucalyptus globulus, and Melaleuca alternifolia* medical plants have an antibactarıal affect on *Staphylococcus aureus*?

HYPOTHESIS

Each of the plants selected show different antibacterial properties. Effects of the plants used can vary. In this study, the effect of active ingredients on the growth of bacteria selected when essential oils of these plants are included in a variety of oral care products will be evaluated.

Do *Rosmarinus officinalis, Curcuma longa, Hypercium perforatum, Eucalyptus globulus, and Melaleuca alternifolia* medical plants have an antibactarıal affect on *Staphylococcus aureus*?

(H_0 Hypothesis):

Essential oils of medicinal plants have no effect on *Staphylococcus aureus* which can be found in the oral flora.

(H_1 Hypothesis):

Essential oils obtained from medicinal lice have a significant effect on Staphylococcus aureus, which can develop in the oral flora.

[24] Güven, Y., Topcuoğlu, N., Üstün, N., Aksakal, D., Doymaz, M. Z., Aktoren, O., & Külekçi, G. (2019). Pedodonti kliniği hastalarının ağız boşluğunda Staphylococcus aureus ve metisiline dirençli Staphylococcus aureus (MRSA) varlığı. 7tepe Klinik Dergisi, 15(3), 334-338.

VARIABLES

Independent Variables : Turmeric **(***Curcuma longa),* Tea tree *(Melaleuca alternifolia),* St. John's Worth *(Hypericum perforatum),* Eucalyptus *(Eucalyptus globulus.),* Rosemary *(Rosmarinus officinalis*).

Dependent variable **:** Diameter of inhibition zones

Controlled variable **:** Use of Gentamycin on bacteria (*Staphylococcus aureus*) as an antibiotic instead of essential oils

LIST OF MATERIALS

Materials	Quantity	Unit
Rosemary essential oil *(Rosmarinus officinalis)*	1	10ml
Turmeric essential oli *(Curcuma longa)*	1	10ml
St. John's Wort essential oil *(Hypercium perforatum)*	1	10ml
Eucalyptus essential oil *(Eucalyptus globulus)*	1	10ml
Tea tree essential oil *(Melaleuca alternifolia)*	1	10ml
Staphylococcus aureus ATCC 29213		
Mueller-Hinton Agar		
Mueller-Hinton Broth		
Distilled water		1000ml
Precision scale	1	
Water bath	1	
Petri dishes	35	
Burette	5	
Incubator		
Bunsen burner		
Micropipette		
Micropipette tips		
Autoclave		
Refrigerator		
Magnetic stirrer		
Pliers		
Beads		
Swap		
Laboratory coat		
Pen		
Ruler		
Data sheet		
Waste bottle		

METHOD DEVELOPMENT AND PLANNING

MATERIAL AND METHOD

Microorganisms: The types of bacteria used in my study were chosen from the "American Type Culture Collection (ATCC)" quality control strains which are recommended by the "Clinical and Laboratory Standards Institute (CLSI)" and known for their high sensitivity. Accordingly, *Staphylococcus aureus* ATCC 29213, a Gram (+) bacteria was used in my study.

EXPERIMENT SUMMARY

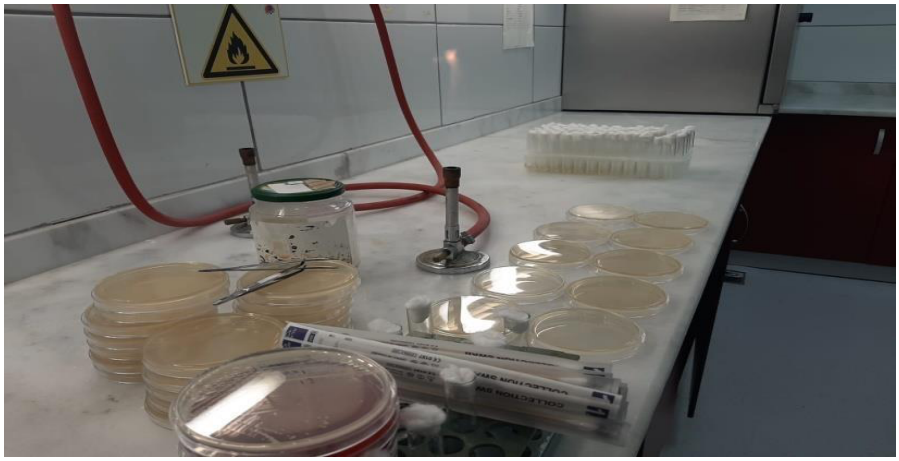
1. Commercially available essential oils of 5 medical plants were used on *Staphylococcus aureus* to understand their antibacterial activity.
2. With gas chromatography of the commercially available essential oils, phenolic compounds were determined. (Apendix)
3. Bacteria were cultured in the media using swaps in the solution that contain standard amount bacteria to determine the antibacterial activity.
4. Wells were bored using sterile beads in the media for the agar well diffusion method to evaluate antibacterial activity.
5. Essential oils were given numbers and then added in these wells and tested on the bacteria *Staphylococcus aureus*.
6. Media which also contain plant essential oils were kept at room temperature for 1 hour and then incubated at 37 C for 24 hours.
7. Gentamycin (antibiotic) was used as a positive control group.
8. The diameters of effects of essential oils post-incubation were measured.

Media: Mueller-Hinton Broth and Mueller-Hinton Agar broth were used.

METHOD

1. Preparation of the bacterial culture media

Bacterial culture media was prepared using commercially available MHA (Mueller Hinton Agar) and MHB (Mueller Hinton Broth). Powder media was weighed on a precision scale and dissolved in distilled water according to the ratios given in the package insert. Agar medium was placed in a boiling water bath and stirred occasionally until it was dissolved completely. Broth medium was dissolved using a magnetic stirrer. Media were sterilized at 1 atmospheric pressure at 121°C for 15 minutes. To prevent misting and moisture caused by the hot poured media, they were kept at 30°C. Sterilized media were poured on to the Petri dish with a thickness of 4mm (picture 6). Media were used to have subcultures of bacteria strains and grow bacteria. Culture media were kept in the fridge until used.

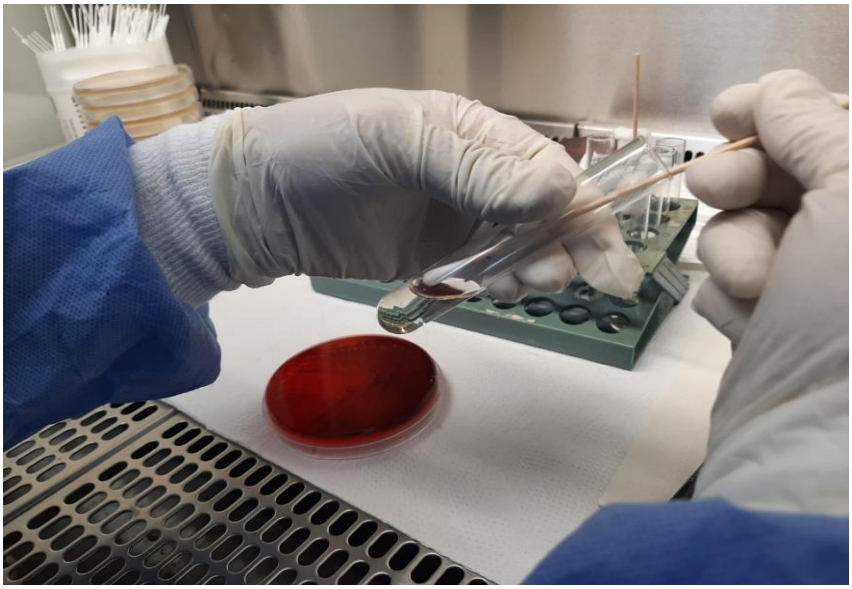


Picture 6: Preparation of the bacterial culture media

2. Preparation of the bacteria suspension

In my study, standard strains kept in glycerol stocks at -20° were used (selected from the "American Type Culture Collection (ATCC)" quality control strains which are recommended by the "Clinical and Laboratory Standards Institute (CLSI)" and known for their high sensitivity). Then they were taken out to thaw at +4°C and after being thawed MHB (Mueller Hinton Broth) broth was used to reactivate. Mueller Hinton Agar (MHA) was used for agar well diffusion method.

Then bacteria suspension was prepared in 3ml Mueller Hinton Broth to have all bacteria in 0.5 McFarland (1x 108 cell/ml) standard density (picture 7).



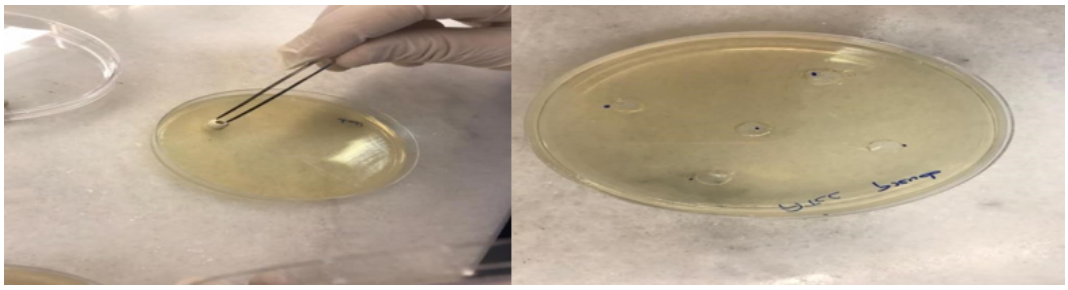
Picture 7: Preparation of the bacteria suspension

Staphylococcus aureus ATTC 29213 suspension was homogeneously cultured in Mueller Hinton Agar (MHA) using swaps. (picture 8).

Picture 8: suspension was homogeneously cultured in Mueller Hinton Agar

After the culture, media were kept to dry at room temperature for 5-10 minutes. Agar beads were used to punch holes in the inoculation agar and to create wells for the Agar Well Diffusion Method and the beads were sterilized by immersing in alcohol and then exposed to fire. Sterilized beads were held with pliers, five wells were created with sterile beads with 4 mm diameter, which were at the same distance to each other and to Petri dish walls

in the media (picture 9). Each well was assigned a number from 1 to 5 and essential oils used were also given numbers. (Since there was a medium with a standard 4 mm thickness in the disk diffusion test, the well diameter which creates inhibition zones that comply with the disk diffusion result with this media thickness was calculated to be 8 mm. 4 mm agar thickness and 9 mm well diameter is required for standard measurement)



Picture 9: Sterilized beads were held with pliers, five wells were created with sterile beads

Essential oils to be tested in wells were in numerical order;

1. turmeric in wells,
2. tea Tree in wells,
3. St. John's Wort in wells,
4. eucalyptus in wells,
5. Rosemary in wells

20µl from each suspension (picture 10).

After being kept at room temperature approximately for 1hour media were incubated at 37°C for 24 hours.

At the end of the incubation, antimicrobial activity diameters (inhibition zone) of the essential oils were measured.

Picture 10: 20µl from each suspension

RESULTS AND ANALYSIS

At the end of the incubation period, if the substance used was effective, inhibition zones where there was no apparent growth were formed around the wells.

Raw data table (table 1), Processed Data Table (table 2) and Anova (Table 3) These tables were made for analysis of variance at more than one value.

The inhibition values measured as a result of the experiment are shown in the table. (table 1)

Raw Data Table

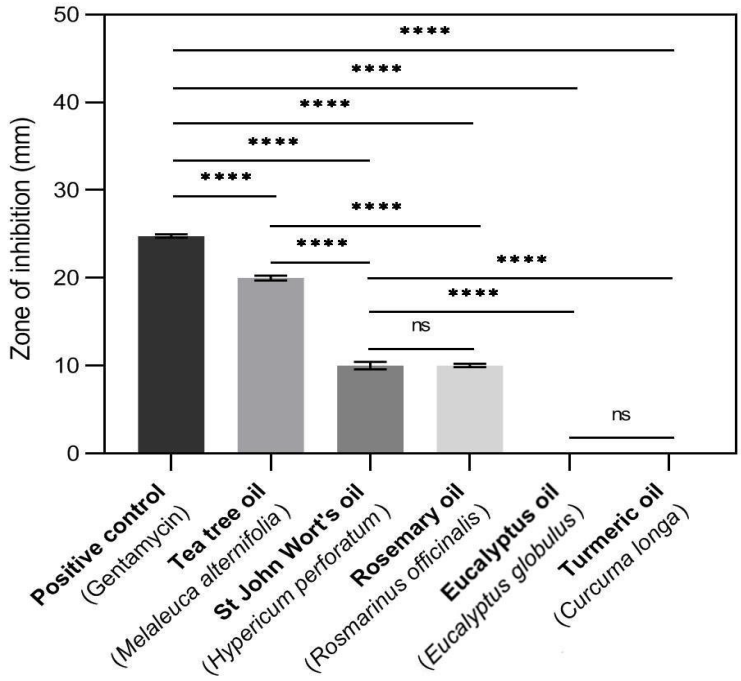
Well No	Trails	The diemeter of inbision zone (mm) ± 0,01
Positive control	1	24,78
	2	24,55
	3	24,85
	4	25,05
	5	24,07
1. Turmeric (*Curcuma longa*)	1	0,00
	2	0,00
	3	0,00
	4	0,00
	5	0 ,00
2. Tea Tree *(Melaleuca alternifolia)*	1	20,00
	2	20,04
	3	19,70
	4	20,01
	5	19,85
3. St. John's Wort *(Hypercium perforatum)*	1	10,00
	2	10,25
	3	10,6
	4	9,55
	5	9,70
4. Eucalyptus *(Eucalyptus globulus)*	1	0,00
	2	0,00
	3	0,00
	4	0,00
	5	0,00
5. Rosemary *(Rosmarinus officinalis)*	1	10,00
	2	10,30
	3	9,92
	4	9,80
	5	10,10

Table 1: Raw data of the inhabition zone of Turmeric oil, St. John's Wort oil, Eucalyptus oil, tea tree oil and rosemary oil of inhibition zones

Processed Data Table

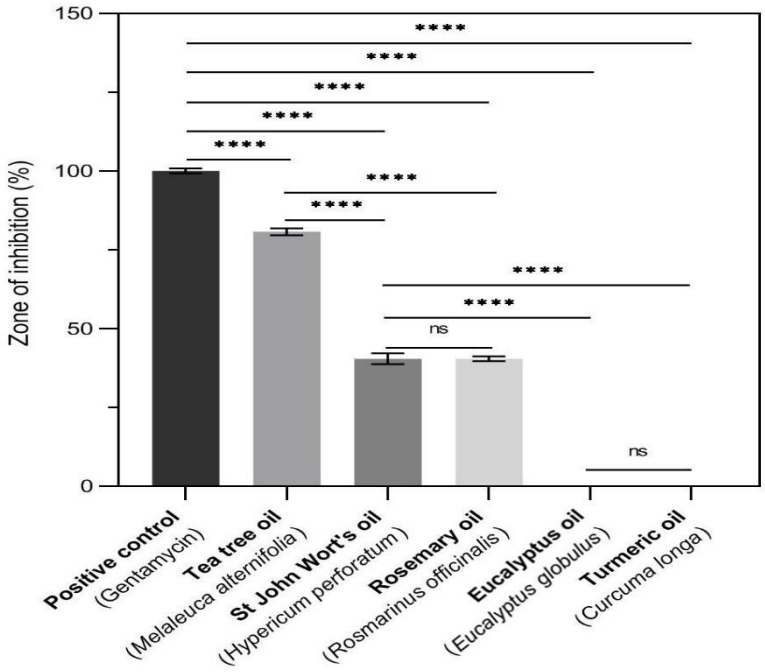
Well No	Average diameter of inhibition zone	Standart deviation	Standart error
Positive control (Gentamycin)	24.79	0.19	0.08
1. Turmeric (*Curcuma longa*)	0,00	0,00	0,00
2. Tea Tree *(Melaleuca alternifolia)*	20.01	0.27	0.12
3. St. John's Wort *(Hypercium perforatum)*	10.02	0.42	0.19
4. Eucalyptus *(Eucalyptus globulus)*	0,00	0,00	0,00
5. Rosemary *(Rosmarinus officinalis)*	10.02	0.19	0.08

Table 2: The average diameter of the inhibition zone, standart deviation and standart error in turmeric oil, tea tree oil, St. John's Wort oil, eucalyptus oil and rosemary oils



Graph 1: Average Inhibition zone graph of the groups in the study.(Error bars represent standart deviation)

*(n:5, ****p<0,0001, ns p>0,05)*



Graph 2: Inhibition zone graph of the groups in the study (%)

ANOVA						
Sourse of variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	2574.613027	5	514.9226053	9689.317042	7.87032E-39	2.620654148
Within Groups	1.27544	24	0.053143333			
Total	**2575.888467**	**29**				

Table 3: ANOVA

Anova was used because measurement was analysis of ariance based on more than one variable. (Table 3)

REPEAT #1

For *Staphylococcus aureus* ATTC 29213; inhibition zone with a 20 mm zone diameter in the well no 2 (tea tree) and inhibition zone with a 10 mm zone diameter in the well no 3 (St. John's Wort) and 5 (Rosemary) were measured. Other essential oils did not show any effect on the growth of *Staphylococcus aureus.*

REPEAT #2

For *Staphylococcus aureus* ATTC 29213; inhibition zone with a 20.4 mm zone diameter in the well no 2 (Tea tree) and inhibition zone with a 10.25 mm zone diameter in the well no 3 (St. John's Wort) and inhibition zone with a 10.3 mm zone diameter in well no 5 (Rosemary) were measured. Other essential oils did not show any effect on the growth of *Staphylococcus aureus.*

REPEAT #3

For *Staphylococcus aureus* ATTC 29213; inhibition zone with a 19.7 mm zone diameter in the well no 2 (Tea tree) and inhibition zone with a 10.6 mm zone diameter in the well no 3 (St. John's Wort) and inhibition zone with a 9.92 mm zone diameter in well no 5 (Rosemary) were measured. Other essential oils did not show any effect on the growth of *Staphylococcus aureus.*

REPEAT #4

For *Staphylococcus aureus* ATTC 29213; inhibition zone with a 20.1 mm zone diameter in the well no 2 (Tea tree) and inhibition zone with a 9.55 mm zone diameter in the well no 3 (St.

John’s Wort) and inhibition zone with a 9.8 mm zone diameter in well no 5 (Rosemary) were measured. Other essential oils did not show any effect on the growth of *Staphylococcus aureus.*

REPEAT #5

For *Staphylococcus aureus* ATTC 29213; inhibition zone with a 19.85 mm zone diameter in the well no 2 (Tea tree) and inhibition zone with a 9.7 mm zone diameter in the well no 3 (St. John’s Wort) and inhibition zone with a 10.1 mm zone diameter in well no 5 (Rosemary) were measured. Other essential oils did not show any effect on the growth of *Staphylococcus aureus.*

Control Group

Positive control group Gentamycin (antibiotic) was used on *Staphylococcus aureus* ATTC 29213. Diameters of inhibition zones after repeated 5 tests were 24.78 mm, 24.55 mm, 24.85mm, 25.05 mm and 24.7 mm respectively.

Diameters of the inhibition zones measured in my study are shown in Table 1. No inhibition zone was formed in the turmeric oil and eucalyptus oil groups. Data was evaluated and the following mean values were found: Gentamycin 24.786 mm; Tee tree 20.01 mm, St John's Wort 10.02 mm, Rosemary 10.024 mm. According to the data obtained, the biggest inhibition zone was observed with Gentamycin used as the positive control group. A significant difference was found between the inhibition zones observed with essential oils and the inhibition zones of the control group, however among the groups, the biggest inhibition zone was in the tea tree group and the smallest inhibition zone was in the St. John's Wort group (Graph 1).

Using the inhibition zone data of each group, percentage values for antibacterial activity of each group on *staphylococcus aereus* were calculated (Graph 2). When results were reviewed, gentamycin used as the positive control group was found to be 100% effective. When group values were reviewed, tea tree had an antibacterial activity of 80.73%, St John's Wort had 40.42 %, and rosemary had 40.44% antibacterial activity. The best antibacterial activity was found in tea tree based on the inhibition percentages.

CONCLUSION

Based on the results of the experiments medicinal plants that have an effect on *Staphylococcus aureus are Hypericum perforatum* (St John's Wont), *Eucalyptus globulus* (Eucalyptus), *Melaleuca alternifolia* (tea tree) and *Rosmarinus officinalis* (rosemary). The effects of other essential oils were insignificant. As observed in other studies, phenolic compounds from these 3 medicinal plants have an effect on *Staphylococcus aureus.*

Based on the findings of this experiment, these medicinal plants can be used to develop the intended oral care products (toothpaste and mouth wash). Products developed with these medicinal products have an effect on *Staphylococcus aureus* which can be found in the oral flora. Thus using products that are developed with these medicinal plants can prevent potential infections. At the same time, oral care products that contain these plants will be more natural which can make the products popular. Thus it can be possible to produce products from more natural ingredients that both cost less and attract people's attention more. With the increasing interest in natural/organic products in the market, these products can be met with a higher demand than other products.

In the experiment performed on s.aureus bacteria, it was observed that essential oils taken from medicinal plants had antibacterial effects. H_0 hypothesis was rejected.

Tea tree essential oil, which was found to be effective in the evaluations, has a significant effect, as it was found in the Linda L Halcon's *Staphylococcus aureus* and wounds: A review St. John's Wort oil, another essential oil, is again Goran S Nikolić's Antimicrobial activity of imanin from St. John's wort from two localities against *Staphylococcus aureus* has a significant antimicrobial effect.

As seen in the Chemical composition and antimicrobial activity of the essential oil of Rosemary study by Yang Jiang et al., its antimicrobial effect gave significant values. In the study, essential oils of turmeric and eucalyptus plants did not have a significant effect on *S. aureus.* In the experiement there is the H_1 hypothesis for a signiicant effect of tea tree, S. John's Wort and rosemary essentail oils on *S.aureus.*

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T.C.
MERSİN ÜNİVERSİTESİ REKTÖRLÜĞÜ
Tıp Fakültesi Dekanlığı

Temel Tıp Bilimleri Bölüm Başkanlığı
Tıbbi Mikrobiyoloji Anabilim Dalı Başkanlığı

[redacted] has done his IB diploma programme extended essay experiment in Mersin University Hospital Microbiology Laboratory by himself with the supervision of our staff.

Prof. Dr. Gönül ASLAN
Mersin Üniversitesi Hastanesi
Tıbbi Mikrobiyoloji
Anabilim Dalı Başkanı

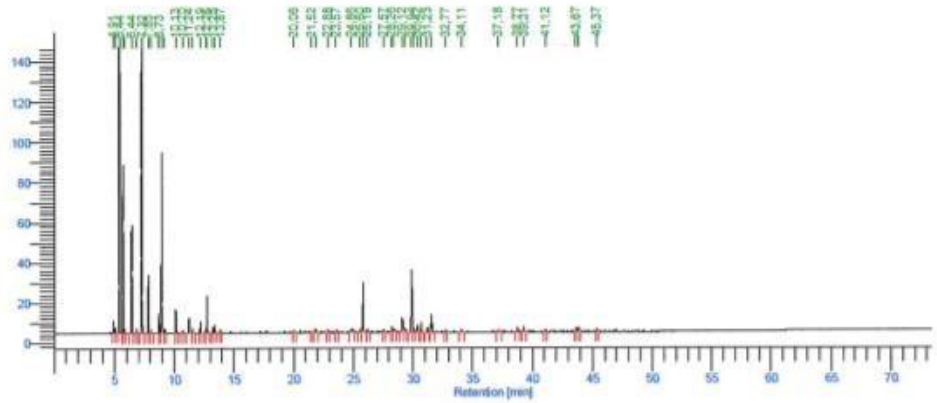
Prof. Dr. Gönül ASLAN
Chief of Microbiology Laboratory

APPENDIX: Gas Chromatography Results of Commercially Available Medicinal Plant Extracts From the Company Florame

Hypericum perforatum

Florame

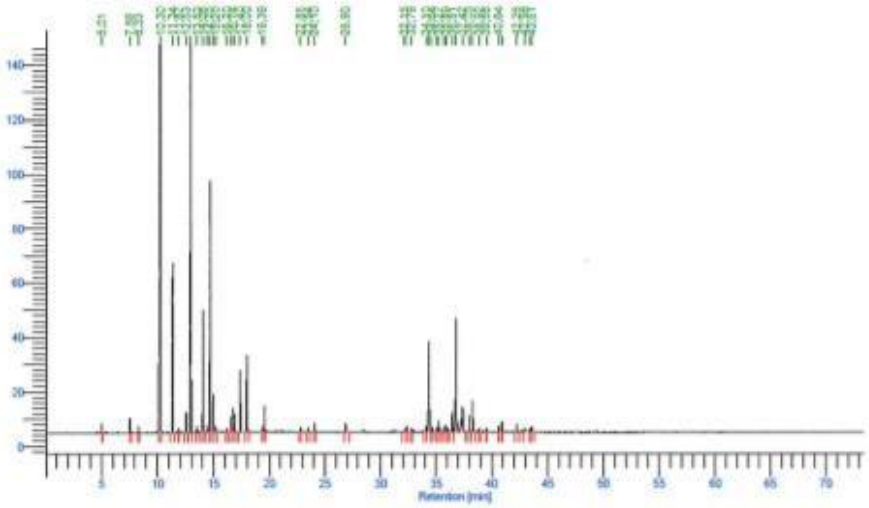
Annexe n°1 : résultats d'analyse sur colonne polaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
1		4,911	9577,27	0,21
2		5,074	5465,85	0,12
3	METHYL-2-OCTANE	5,442	2301104,06	49,37
4	NONANE	5,717	149125,15	3,20
5		5,818	5536,35	0,12
6	3-METHYLNONANE	6,441	120300,92	2,58
7	TRICYCLENE	6,860	4791,84	0,10
8	A-PINENE	7,325	930436,04	19,96
9	2-METHYLDECANE	7,850	70865,42	1,52
10		8,068	4966,50	0,11
11		8,734	23751,12	0,51
12	B-PINENE	8,979	291900,48	6,26
13		9,196	6726,59	0,14
14	MYRCENE	10,134	33484,61	0,72
15	A-TERPINENE	10,697	3803,30	0,08
16	LIMONENE	11,241	23055,11	0,49
17	B-PHELLANDRENE	11,551	6728,58	0,14
18	CINEOLE	12,191	16604,36	0,36
19		12,646	8833,34	0,19
20	G-TERPINENE	12,762	58914,83	1,26
21		13,249	8835,72	0,19
22	P-CYMENE	13,408	13461,96	0,29
23	TERPINOLENE	13,866	6245,96	0,13
24		20,056	4628,09	0,10
26	A-COPAENE	21,863	6528,07	0,14
27	CAMPHRE	22,879	3613,52	0,08
28	LINALOL	23,570	3565,20	0,08
29		24,864	12261,74	0,26
30		25,604	8464,11	0,18
31	B-CARYOPHYLLENE	25,844	119145,37	2,56
32		26,193	6119,27	0,13
33		27,573	4087,58	0,09
34		28,260	9962,68	0,21
35		28,424	8786,01	0,19
36	D CADINENE	29,116	41267,94	0,89
37		29,370	6547,77	0,14
38	D GERMACRENE	29,939	154374,41	3,31
39		30,079	7117,80	0,15
40		30,421	25144,37	0,54
41		30,724	19564,55	0,42
42		31,235	7968,52	0,17
43	BICYCLOGERMACRENE	31,548	52290,65	1,12
44		32,769	4134,88	0,09
45		34,107	4840,67	0,10
46		37,183	4044,42	0,09
47		38,771	7248,28	0,16
48		39,307	9941,46	0,21
49		41,122	4060,92	0,09
50		43,669	7722,62	0,17
51		43,879	7395,78	0,16
52		45,370	5553,66	0,12
		1085,900	4660885,69	100,00

Florame

Annexe n°2 : résultats d'analyse sur colonne apolaire

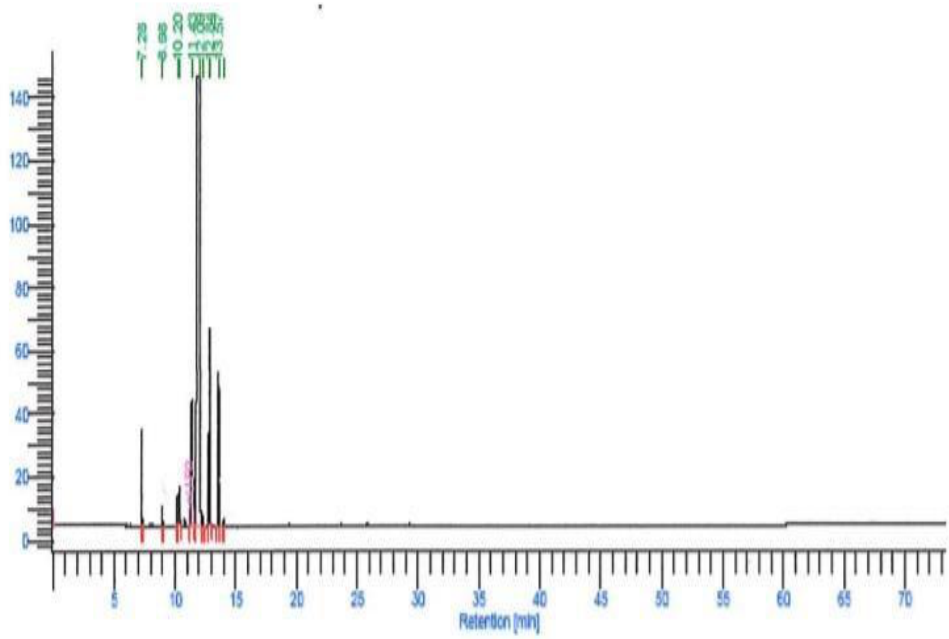


Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
1		5,010	6161,57	0,12
2		7,568	10605,02	0,21
3		8,330	5069,70	0,10
4	METHYL-2-OCTANE	10,296	2434464,81	48,23
5	NONANE	11,344	163840,82	3,24
6		11,567	3274,84	0,06
7	A-THUYENE	12,533	21309,35	0,42
8	A-PINENE	12,968	973851,71	19,29
9	CAMPHENE	13,527	7172,48	0,14
10	3-METHYLNONANE	14,056	132958,88	2,63
11		14,428	7587,77	0,15
12	B-PINENE	14,698	320940,23	6,36
13	MYRCENE	14,931	38693,35	0,77
14		15,198	5773,67	0,11
15	A-TERPINENE	16,198	4326,36	0,09
16	P-CYMENE	16,539	16596,90	0,33
17	LIMONENE+B-PHEL+CINEOLE	16,737	33435,50	0,66
18	CIS-B-OCIMENE	16,903	19808,56	0,39
19	TRANS-B-OCIMENE	17,399	67057,72	1,33
20	2-METHYLDECANE	17,997	90243,72	1,79
21	TERPINOLENE	19,386	8167,12	0,16
22	LINALOL	19,577	27619,94	0,55
23	BORNEOL	22,647	5181,76	0,10
24	TERPINEN-4-OL	23,538	5571,17	0,11
25	A-TERPINEOL	24,102	10843,41	0,21
26		26,901	11858,04	0,23
27		32,150	3701,26	0,07
28	A-COPAENE	32,342	8051,09	0,16
29		32,788	3513,93	0,07
30		34,099	8888,91	0,18
31	B-CARYOPHYLLENE	34,338	132467,05	2,62
32	E-B-FARNESENE	34,640	8174,51	0,16
33	AROMADENDRENE	35,099	6478,75	0,13
34		35,266	14091,31	0,28
35	A-HUMULENE	35,697	8178,04	0,16
36		35,892	8113,41	0,16
37		36,022	6445,74	0,13
38	B-CUBEBENE	36,510	30867,04	0,61
39	D GERMACRENE	36,834	186574,15	3,70
40	BICYCLOGERMACRENE	37,417	60518,83	1,20
41		38,032	20823,23	0,41
42	D-CADINENE	38,313	44395,91	0,88
43		38,916	4919,76	0,10
44		39,549	4258,07	0,08
45		40,043	7537,93	0,15
46		40,928	12695,04	0,25
47		42,258	10370,19	0,21
48		42,981	11411,80	0,23
49		43,426	5256,40	0,10
50		43,609	7198,80	0,14
		1302,617	5047207,07	100,00

Eucalyptus globulus

Florame

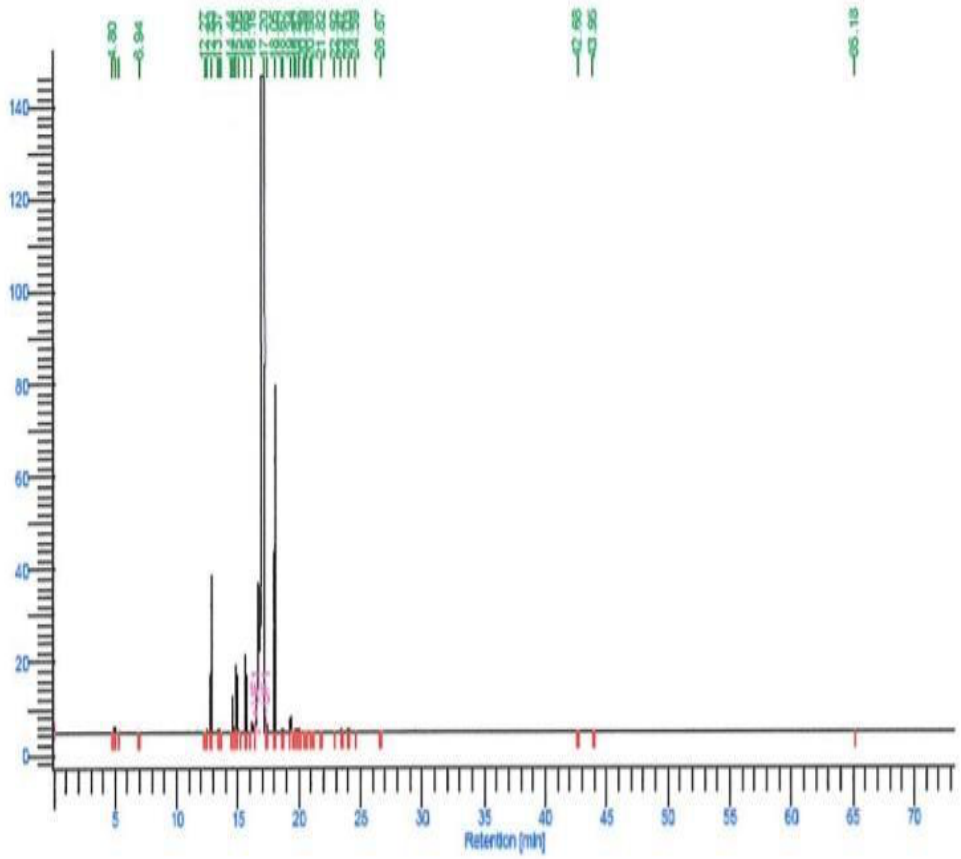
Annexe n°1 : résultats d'analyse sur colonne polaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
1	ALPHA PINENE	7.280	83981.79	1.49
2	BETA PINENE	8.991	20587.90	0.37
3	a phellandrene	10.204	41001.98	0.73
4		10.395	51983.97	0.93
5	LIMONENE + BETA PHELLANDRENE	11.435	409156.21	7.28
6	CINEOLE	12.094	4586302.20	81.64
7		12.336	9512.97	0.17
8	GAMMA TERPINENE	12.842	237885.47	4.23
9	PARA CYMENE	13.570	169053.91	3.01
10		13.997	8474.43	0.15
		113.113	5617840.84	100.00

Florame

Annexe n°2 : résultats d'analyse sur colonne apolaire

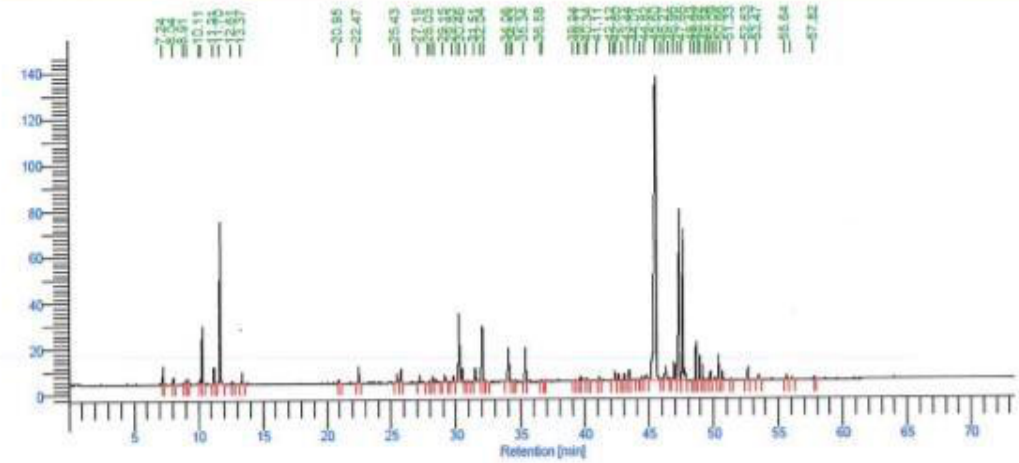


Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
7	ALPHA PINENE	12.826	94718.08	1.54
12	BETA PINENE	14.591	23495.10	0.38
14	MYRCENE	14.874	47384.94	0.77
16	ALPHA PHELLANDRENE	15.648	65205.96	1.06
17	ALPHA TERPINENE	16.183	12731.28	0.21
18	B-PHEL+LIMO+1.8CINEOLE	17.200	5627898.61	91.38
19		17.370	3744.96	0.06
20	GAMMA TERPINENE	18.050	271159.58	4.40
23		19.339	12477.31	0.20
		146.060	6159810.92	100.00

Curcuma longa

Florame

Annexe n°1 : résultats d'analyse sur colonne polaire

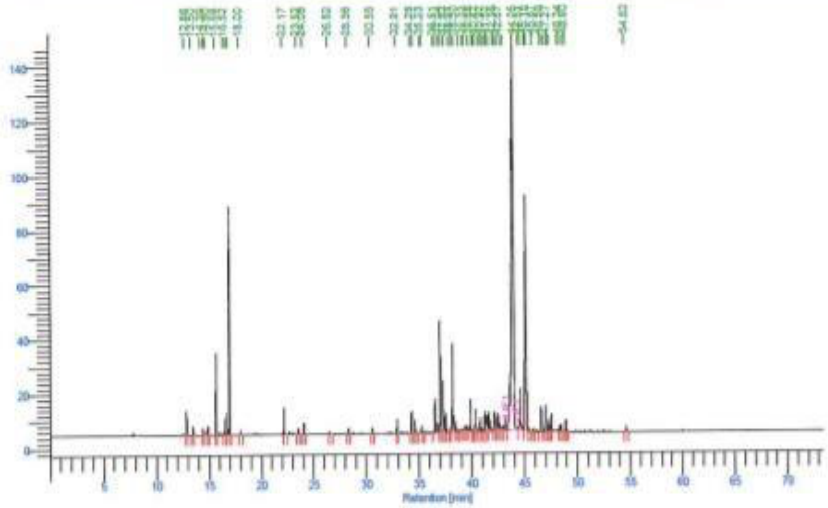


Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
1	A-PINENE	7.243	24292.61	0.60
2		8.044	8745.22	0.22
3		8.911	4099.48	0.10
4	B-PINENE	9.167	6029.11	0.15
5	MYRCENE	10.106	7734.82	0.19
6	A-PHELLANDRENE	10.290	81993.21	2.02
7	LIMONENE	11.213	24205.78	0.60
8	B-PHELLANDRENE	11.698	286171.66	7.06
9	G-TERPINENE	12.612	4539.73	0.11
10	P-CYMENE	13.374	16390.82	0.40
11		20.949	5280.53	0.13
12	CAMPHRE	22.472	29247.86	0.72

Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
13		25.433	17637.11	0.44
14	B-CARYOPHYLLENE	25.756	30818.71	0.76
15		27.188	13534.48	0.33
16		28.033	4924.80	0.12
17		28.213	9586.80	0.24
18	A-CARYOPHYLLENE	28.462	8096.79	0.20
19	A-TERPINEOL	29.153	16087.15	0.40
20		29.827	10580.68	0.26
21	ZINGIBERENE	30.278	147919.22	3.65
22	BICYCLOGERMACRENE	30.463	29836.30	0.73
23		30.918	2930.70	0.07
24		31.506	32470.54	0.80
25	GERMACRENE B	32.041	141047.07	3.48
26		32.306	3627.84	0.09
27	B-SESQUIPHELLANDRENE	34.059	70860.80	1.75
28		34.294	3017.97	0.07
29		34.527	4349.50	0.11
30		35.345	60703.03	1.50
31		36.585	4056.23	0.10
32		39.236	4340.78	0.11
33		39.587	6677.78	0.16
34		39.714	12841.30	0.32
35		40.112	4675.44	0.12
36		40.336	3016.00	0.07
37		41.113	7578.27	0.19
38		42.116	2998.25	0.07
39		42.378	13017.59	0.32
40		42.601	17128.04	0.42
41		43.066	15297.55	0.38
42		43.445	21319.86	0.53
43		44.007	4078.67	0.10
44		44.457	8683.87	0.21
45		44.824	18571.09	0.46
46	A-TURMERONE+CURCUMENOL	45.596	1501143.83	37.05
47		45.974	7941.33	0.20
48		46.287	45912.89	1.13
49		46.641	10219.08	0.25
50		46.963	48188.50	1.19
51	B-TURMERONE	47.371	504433.94	12.45
52	AR-TUMERONE	47.656	383645.78	9.47
53		48.427	3931.16	0.10
54		48.652	68833.17	1.70
55		48.918	48676.03	1.20
56		49.156	27215.53	0.67
57		49.541	3926.41	0.10
58		49.783	17316.82	0.43
59		50.093	5492.07	0.14
60		50.365	45419.70	1.12
61		50.664	14086.41	0.35
62		51.327	3737.75	0.09
63		52.629	25641.78	0.63
64		53.468	12112.92	0.30
65		56.639	11902.73	0.29
66		56.070	6372.11	0.16
67		57.821	4905.12	0.12
68		2416.454	4051894.10	100.00

Florame

Annexe n°2 : résultats d'analyse sur colonne apolaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
1	A-PINENE	12.858	25417.72	0.56
2	CAMPHENE	13.500	9983.73	0.22
3	SABINENE	14.394	6718.57	0.15
4	B-PINENE	14.628	5107.84	0.11
5	MYRCENE	14.901	8816.56	0.19
6	A-PHELLANDRENE	15.682	90073.94	1.99
7	P-CYMENE	16.524	18368.46	0.41
8	LIMONENE+B-PHELLANDRENE	16.724	30149.01	0.67
9	CINEOLE	16.966	307152.28	6.79
10	G-TERPINENE	18.003	4690.20	0.10
11	CAMPHRE	22.174	32729.70	0.72
12	TERPINEN-4-OL	23.516	7131.78	0.16
13	A-TERPINEOL	24.082	12375.19	0.27
14	CARVONE	26.515	3366.05	0.07
15	THYMOL	28.358	6576.12	0.15
16	D-ELEMENE	30.548	6058.38	0.13
17	B-ELEMENE	32.908	16891.21	0.37
18	B-CARYOPHYLLENE	34.282	28329.83	0.63
19	A-FARNESENE	34.613	15771.13	0.35
20		35.232	13829.81	0.31
21		35.416	3654.00	0.08
22	AR-CURCUMENE	36.508	46875.12	1.04
23	D GERMACRENE	36.755	14609.27	0.32
24	ZINGIBERENE	37.041	160206.59	3.54
25	B-SESQUIPHELLANDRENE	37.303	80835.83	1.79
26		37.528	25298.57	0.56
27		38.014	6670.11	0.15
28	GERMACRENE B	38.212	143187.66	3.17
29		38.499	12757.05	0.28
30		38.930	4120.67	0.09
31		39.332	8984.65	0.20
32		39.536	10442.03	0.23
33		39.881	51615.66	1.14
34		40.239	8466.11	0.19
35		40.345	30242.33	0.67
36		40.472	5304.87	0.12
37		40.779	18598.48	0.41
38		40.974	9456.47	0.21
39		41.235	35429.15	0.78
40		41.338	35357.89	0.78
41		41.518	31815.26	0.70
42		41.652	26571.17	0.59
43		41.853	9814.81	0.22
44		42.160	46449.78	1.03
45		42.299	25354.59	0.56
46		42.492	39507.32	0.87
47		42.673	16475.27	0.36
48		42.924	17277.27	0.38
49		43.112	25042.90	0.55
50	A+Ar-TURMERONE+CURCUMENOL	44.051	2035503.59	45.02
51		44.606	65619.11	1.45
52		44.768	13157.85	0.29
53	B-TURMERONE	45.148	568716.40	12.58
54		45.238	57244.24	1.27
55		45.356	7994.90	0.18
56		45.872	5739.65	0.13
57		46.590	33216.07	0.73
58		46.836	4499.00	0.10
59		47.020	34532.10	0.76
60		47.265	16596.73	0.37
61		47.394	8028.05	0.18
62		47.532	21208.10	0.47
63		48.337	10662.70	0.24
64		48.489	10104.96	0.22
65		48.681	3360.18	0.07
66		48.903	14760.06	0.33
67		49.038	2910.98	0.06
68		54.619	7704.70	0.17
		2501.175	4521517.74	100.00

Rosmarinus officinalis

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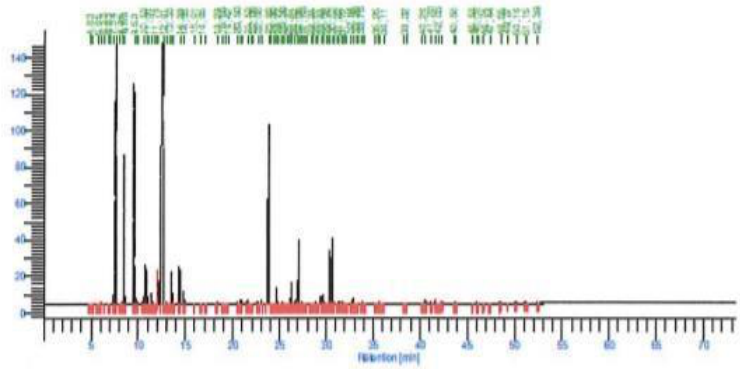
Annexe n°1 : résultats d'analyse sur colonne polaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
10		7,335	11041,49	0,22
11	alpha pinène + alpha thuyene	7,625	665452,74	13,25
13	ALPHA FENCHENE	8,319	3155,04	0,06
14	CAMPHENE	8,525	216550,40	4,31
15	B-PINENE	9,531	405694,69	8,08
16		9,760	7266,30	0,14
19		10,531	9644,02	0,19
20	Myrcene	10,812	62030,44	1,23
21	A-PHELLANDRENE	10,996	12534,80	0,25
23	A-TERPINENE	11,436	20499,80	0,41
26	LIMONENE	12,092	15092,42	0,30
27	1,8 cinéole + limonene	12,615	2336502,24	46,51
29		13,038	2776,05	0,06
32	G-TERPINENE	13,554	51149,69	1,02
33		13,627	2651,03	0,05
35	P-CYMENE	14,382	58157,68	1,16
36	TERPINOLENE	14,950	18034,56	0,36
46		20,861	5496,43	0,11
47		21,534	4766,34	0,09
51		22,078	2510,30	0,05
52	ALPHA COPAENE	23,052	9245,89	0,16
53	CAMPHRE	23,803	550267,86	10,95
57	LINALOL	24,666	27147,02	0,54
68	ACETATE DE BORNYLE	26,249	39826,26	0,79
71	TERPINEN -4 OL	26,991	31808,03	0,63
72	B-CARYOPHYLLENE	27,092	152868,12	3,04
84		29,443	15274,73	0,30
85	alpha caryophylène	29,705	17406,45	0,35
88	A-TERPINEOL	30,406	103574,71	2,06
89	BORNEOL	30,619	138129,64	2,75
95		31,720	3927,51	0,08

Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
99	verbénone	32,854	9549,62	0,19
100		32,953	3929,98	0,08
113		40,576	4863,95	0,10
115		41,656	6026,58	0,12
		705,799	5020942,70	100,00

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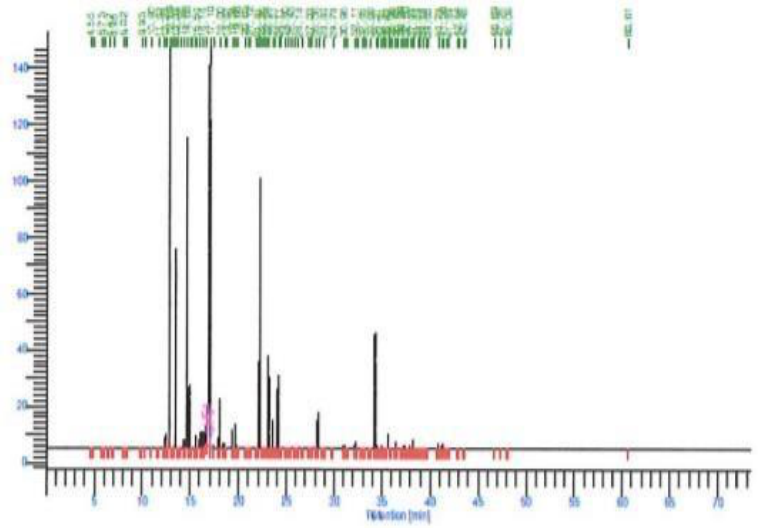
Annexe n°2 : résultats d'analyse sur colonne apolaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
20		12,416	10752,76	0,21
21	A-THUYENE	12,478	15933,92	0,31
22	ALPHA PINENE	12,888	633004,25	12,49
25	ALPHA FENCHENE	13,388	2917,15	0,06
26	CAMPHENE	13,496	215487,55	4,25
29	SABINENE	14,377	13050,78	0,26
30	B-PINENE	14,649	402452,94	7,94
31	MYRCENE	14,884	63331,11	1,25
34	ALPHA PHELLANDRENE	15,642	14561,45	0,29
35		15,919	10098,51	0,20
36	A-TERPINENE	16,161	20859,41	0,41
37	P-CYMENE	16,572	50375,06	0,99
38	1,8 CINEOLE + LIMONENE	17,097	2404038,97	47,43
39		17,350	3086,66	0,06
40	G-TERPINENE	17,996	51951,34	1,02
41		18,430	4776,94	0,09
43	TERPINOLENE	19,339	20150,65	0,40

Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
45	LINALOL	19,691	27705,03	0,55
46		19,856	2600,62	0,05
54	CAMPHRE	22,267	550655,06	10,86
60	BORNEOL	23,115	152030,56	3,00
61	TERPINEN 4 OL	23,514	30916,61	0,61
63	A-TERPINEOL	24,112	98218,41	1,94
76	ACETATE DE BORNYLE	28,321	41085,50	0,81
83		32,111	2529,42	0,05
84		32,302	8020,35	0,16
91	TRANS B CARYOPHYLLENE	34,311	157332,20	3,10
92		34,604	2986,92	0,06
94		35,063	2676,13	0,05
97	A CARYOPHYLLENE	35,667	17724,16	0,35
101		36,446	7056,09	0,14
106		37,201	2859,62	0,06
109		37,503	2866,43	0,06
110		37,991	3890,11	0,08
112		38,268	9727,03	0,19
120		40,902	4890,92	0,10
122		41,362	6283,90	0,12
		897,789	5068784,42	100,00

Melaleuca alternifolia

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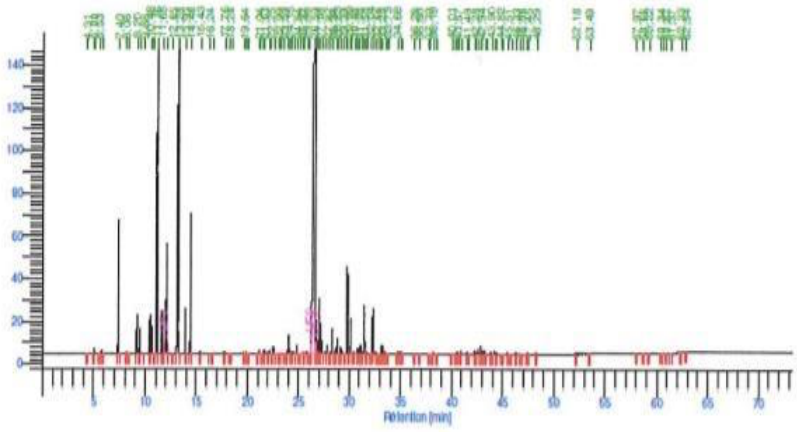
Annexe n°1 : résultats d'analyse sur colonne polaire



Pics ordre	Molécules Noms	Retention [min]	Aires [UV*sec]	Aires [%]
3		5,064	3553,99	0,06
7	ALPHA THUYENE+ALPHA PINENE	7,399	222642,16	3,63
11	BETA PINENE	9,199	47584,15	0,77
12	SABINENE	9,466	31548,30	0,51
14	MYRCENE	10,477	56412,13	0,92
15	ALPHA PHELLANDRENE	10,656	38966,25	0,63
17	ALPHA TERPINENE	11,162	688694,50	11,22
18	LIMONENE	11,652	56300,79	0,92
19	1,8 cineole + beta phellandren	12,072	233886,60	3,81
21	GAMMA TERPINENE	13,283	1340386,40	21,83
22	PARA CYMENE	13,932	61041,76	0,99
23	TERPINOLENE	14,459	252154,92	4,11
35		21,183	5008,26	0,08
37		21,631	5164,32	0,08
39		22,251	5600,40	0,09
40	ALPHA COPAENE	22,557	11088,74	0,18
45		23,909	2648,13	0,04
46	ALPHA GURGUJENE	24,046	28886,20	0,47
47		24,145	4554,65	0,07
49		24,534	3420,75	0,06
50	LINALOL	24,839	13516,52	0,22
56	TERPINENE-4-OL	26,597	2254051,88	36,71
57	TRANS BETA CARYOPHYLLENE	26,797	38628,98	0,63
58		26,917	22192,27	0,36
59	AROMADENDRENE	27,085	88529,46	1,44
60		27,294	20008,89	0,33
61		27,543	2788,41	0,05
62		27,617	12428,15	0,20

Pics ordre	Molécules Noms	Retention [min]	Aires [UV*sec]	Aires [%]
64	ALLOAROMADENDRENE	28,342	40418,80	0,66
65		28,661	3691,16	0,06
66		28,828	24969,11	0,41
67		29,167	9579,04	0,16
68		29,385	3463,26	0,06
70	ALPHA TERPINEOL	29,836	148670,62	2,42
71		29,985	7501,69	0,12
72		30,032	8762,09	0,14
73	LEDENE	30,163	67131,64	1,09
76		30,835	8376,20	0,14
77		30,998	7525,08	0,12
78		31,138	14603,06	0,24
80	BICYCLOGERMACRENE	31,503	89268,17	1,45
81		31,566	2606,30	0,04
84	DELTA CADINENE	32,334	88492,38	1,44
88		33,201	12253,29	0,20
93		34,896	3133,60	0,05
107		40,933	3645,60	0,06
110		42,276	4952,25	0,08
111		42,413	3810,12	0,06
112		42,641	7139,25	0,12
113	GLOBULOL	42,935	14008,97	0,23
114	VIRIDIFLOROL	43,213	6004,48	0,10
116		43,901	2768,56	0,05
117		44,187	5053,11	0,08
		1391,326	6140005,98	100,00

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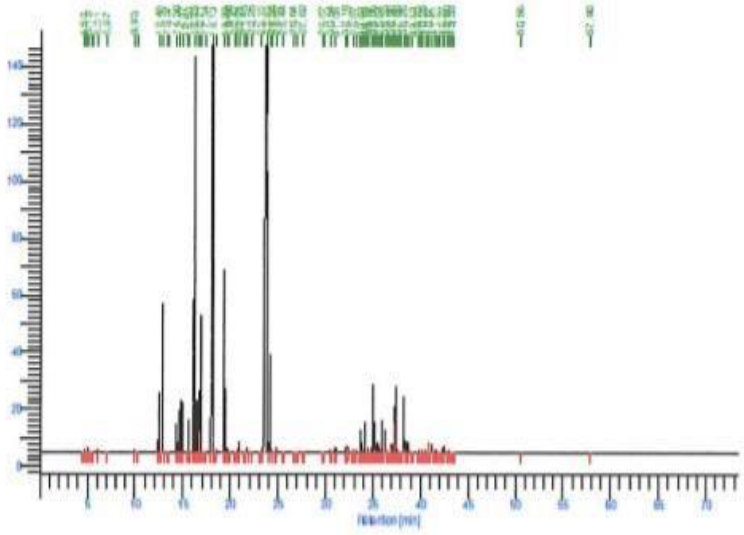
Annexe n°2 : résultats d'analyse sur colonne apolaire



Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
5		5,124	3024,01	0,05
13	ALPHA THUYENE	12,479	56725,65	1,01
14	ALPHA PINENE	12,939	146072,76	2,59
17	SABINENE	14,362	27992,36	0,50
18	BETA PINENE	14,596	42582,48	0,76
19	MYRCENE	14,875	50560,09	0,90
21	ALPHA PHELLANDRENE	15,641	35313,46	0,63
22	ALPHA TERPINENE	16,233	637233,49	11,32
23	PARA CYMENE	16,505	55133,00	0,98
24	LIMONENE	16,705	50766,03	0,90
25	BETA PHELLANDRENE	16,783	64915,50	1,15
26	1,8 CINEOLE	16,922	148291,24	2,63
29	GAMMA TERPINENE	18,132	1240667,75	22,04
30	TERPINOLENE	19,388	232696,66	4,13

Pics ordre	Molécules Noms	Rétention [min]	Aires [uV*sec]	Aires [%]
31		19,674	3960,39	0,07
35	LINALOL	20,907	11732,72	0,21
38		21,746	8422,27	0,15
41	TERPINEN 4 OL	23,811	2083235,19	37,01
42	ALPHA TERPINEOL	24,174	131376,10	2,33
43	ALPHA COPAENE	24,348	2551,28	0,05
44		24,824	4422,97	0,08
53		31,049	4312,13	0,08
54		32,155	4237,91	0,08
55		32,286	6656,83	0,12
56		32,345	2549,28	0,05
57		32,872	2847,47	0,05
58		33,223	2826,81	0,05
60	ALPHA GURJUNENE	33,790	25689,93	0,46
64	TRANS BETA CARYOPHYLLENE	34,254	35229,78	0,63
66		34,569	4478,37	0,08
68		34,903	4918,90	0,09
69	AROMADENDRENE	35,075	89927,12	1,60
70		35,190	9660,05	0,17
72		35,449	10817,70	0,19
73		35,643	8790,24	0,16
75	ALLOAROMADENDRENE	35,971	36385,27	0,65
76		36,330	26258,96	0,47
80		36,983	5097,61	0,09
81		37,053	14034,76	0,25
82	LEDENE	37,308	73677,69	1,31
83	BICYCLOGERMACRENE	37,397	82777,70	1,47
84		37,656	2607,58	0,05
87	DELTA CADINENE	38,275	69233,96	1,23
88		38,415	14393,74	0,26
90		38,673	11511,76	0,20
93		39,892	4599,97	0,08
95		40,246	2697,24	0,05
99	GLOBULOL	40,869	11713,27	0,21
100	VIRIDIFLOROL	41,199	9739,92	0,17
105		42,273	4260,14	0,08
106		42,421	6141,99	0,11
109		42,955	3519,46	0,06
		1506,787	5629269,89	100,00