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Preparation and Characteristics of Eco-Friendly Essential Oils and its Utilization for Finishing Cotton Fabrics

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Abstract: ***The present research concerns preparation and extraction of ecofriendly essential oils from natural sources and utilization for finishing bleached cotton fabrics. Lavender, thyme, and clove essential oils are extracted from natural sources and used in treatment of cotton fabrics, in order to give it a good smell and antibacterial characteristics, i.e. medical textile. The recent academic research shows that, aroma-enhanced textiles are being developed in the areas of sustainability environmental consciousness, health and well-being, and enhanced brand awareness. We developed medical textiles using the essential oils (lavender, thyme, and clove) with β-cyclodextrin inclusion compounds. B-cyclodextrin molecules are capable of forming inclusion compounds with essential oils that fit into the cone-shaped hydrophobic cavity. The fragrance inclusion compounds are fixed onto cotton by dry with a low temperature and then thermo fixed method. The essential oils were studied to prove its structure using various techniques such as IR spectra, GC-MS, the scanning electron microscopy (SEM) ….etc. Moreover, the antibacterial activity of treated cotton fabrics with, lavender, thyme, and clove against, Staphylococcus aureus and Escherichia coli was evaluated. The results show that the treated cotton fabrics with essential oils have antibacterial properties.***

Keywords: Extraction, eco-friendly, essential oils, medical textiles, preparation

1. Introduction

Essential oils (EOs) are present in various aromatic plants generally grown in tropical and subtropical countries. They are obtained from various parts of the aromatic plants, including leaves, flowers, fruits, seeds, buds, rhizomes, roots, and barks. Several techniques have been used to obtain essential oils from the plant. They are hydro distillation, solvent extraction, cold pressing, and supercritical fluid extraction [1-3].

Among these techniques, essential oils are most commonly obtained by a steam distillation method developed in the middle Ages in the Middle East. There is a record that Hippocrates, an ancient Greek physician, referred to aromatic plants as the 'father of medicine'. Aromatic plants, which contain essential oil, have been used since ancient times for various purposes including medical treatments, food preservatives, and flavoring food. The term 'essential oil' was used for the first time in the sixteenth century by Paracelsus von Hohenheim, who named the effective component of a drug, in his book, 'Quinta essential' [4]. In ancient Egypt, essential oils obtained from aromatic plants were used for disease prevention and treatment. Later, the Greeks and Romans inherited Egyptian practices of using essential oils in aromatherapy and expanded them to improve their life quality. For example, they used baths infused with the oils of jasmine, lavender, or ylang-ylang to stimulate mental relaxation.

Nowadays, approximately 3000 essential oils are known, about 300 of which are commercially available. The major constituents of essential oils are terpenes/ terpenoids and aromatic and aliphatic compounds, which are characterized as low-molecular-weight aroma chemicals [5-8]. Generally, essential oils are comprised of two or three major components in relatively high concentrations (20–95%) and other components present in trace levels. Components with relatively high concentrations in essential oils are d-limonene (over 80%) in Citrus peel oils, carvacrol (30%) and thymol (27%) in Origanum compactum oil, α-/β-thujone (57%) and camphor (24%) in Artemisia herba-alba oil, 1,8-cineole (50%) in Cinnamomum camphora oil, α-phellandrene (36%) and limonene (31%) in Anethum graveolens leaf oil, carvone (58%) and d-limonene (37%) in Anethum graveolens seed oil, and menthol (59%) and menthone (19%) in Mentha piperita oil. Generally, these major components of essential oils determine their biological properties, details of which are described in two comprehensive reviews on the biological activities of essential oils [9,10]. In the modern era, essential oils and some of their components have been used in various products such as cosmetics, household cleaning products and air fresheners, hygiene products, agriculture, and food, as well as in medicinal uses. Essential oils are also used in aromatherapy and other Para-medicinal practices [11-13]. Since organic chemistry developed to provide synthetic medicines in the middle of the twentieth century, the use of essential oils for medicinal treatment diminished compared with their use in cosmetics and foods. However, the demand for safe and natural alternative medicines has risen as a consequence of consumers' concern about the toxicity of

synthetic chemicals [14, 15]. Therefore, essential oils have recently begun to receive much attention as possible sources of safe and natural alternative medicines once again because they have been known to possess various medicinal activities, including antioxidant [16,17], anti-inflammatory [18,19], antimicrobial [20,21], antiviral [22,23], and anti-carcinogenic [24]. Consequently, studies on essential oils to evaluate the pharmacological properties in order to find possible alternative medicines have become active in recent years.

Thyme (Thymus sp.) and clove (*Syzygium aromaticum*) EOs are of much attention due to their high content and wide spectrum of phenolic compounds, antimicrobial and antioxidant properties, and potential for use in meat and meat products

Durable and re-generable antibacterial fabrics were prepared by using an innovative chemical technology employing a precursor biocidal agent, dimethyloldimethylhydantoin (DMDMH), in a chemical finishing process. The method resulted in significant add-on rates of hydration groups on cellulose and established a durable antimicrobial functionality, once the grafted heterocyclic compounds were chlorinated by diluted chlorine bleaching. Both cotton fabrics and polyester/cotton fabrics exposed to treatment baths containing from 2 to 10% of DMDMH acquired a powerful inactivating capacity against a wide range of food-borne and water-borne infectious disease agents. The biocidal functions are re-generable by regular laundry exposure to chlorine bleach and can withstand over 50 standard machine washes without appreciable deterioration. In addition to their powerful antimicrobial efficacy, the fabrics exhibited improved wrinkle resistance and maintained appropriate mechanical properties, making them ideal for medical and hygienic textile applications [25].

The present work was carried out with the following objectives, preparation and extraction of eco-friendly essential oils of lavender, thyme, and clove from natural sources and it is utilize for treatment of cotton fabrics, in order to give it good smell and against microbes and bacteria (medical textiles.)

2. Experimental

2.1. Materials

2.1.1. Cotton fabric

Mill scoured fabric and bleached cotton fabric160g/m^2, (kindly supplied by Miser Co., El-Mahalla Elcobra) was treated with a solution of 5g/l sodium carbonate and 2g/l nonionic detergent (Host pal C.V. from Clariant) at 95°Cfor 1/2 hour, thoroughly rinsed and air dried at room temperature.

2.1.2. Chemicals

β-Cyclodextrin hydrate 99% was provided by Merck, Germany (m.w. = 1135 g/mole),citric acid anhydrous was provided by Merck, Germany (m.w. = 192.12 g/mole), absolute ethyl alcohol ≥ 99.8%, hexadecane, egyptol, were of laboratory grade chemicals were used.

2.2. Methods

2.2.1. Essential oils extraction

Thyme, clove and lavender essential oils were isolated by hydro-distillation. Samples of dried flowering plants and buds were hydro distilled for 4 h in a Clevenger – type apparatus. The distillate (900 mL) was extracted with 100 mL of dichloromethane using a liquid–liquid continuous extractor for 6 h. The resulting extract was dried over anhydrous sodium sulfate, and the solvent was removed by a rotary flash evaporator. The distillation was stopped when the volume of extract was reduced to approximately 1 mL. Then the solvent was further removed under a purified nitrogen stream until the volume was reduced to 0.5 mL (1.04 g) of volatile extract and kept in dark in freezer until the essential oils analyzed by gas- liquid chromatography and mass spectrometry (GC-MS). The experiment was replicated three times.

The Essential oils used in study

Essential oils	Scientific name	Part of plant	Extraction method
Lavender	*Lavandula angustifolia*	Flowering plants	Steam distillation
Thyme	*Thymus vulgaris*	Flowers and leafs	Steam distillation
Clove	*Eugenia caryophyllata*	Buds of clove	Steam distillation

2.2.2. Preparation of Microencapsulation of Essential oils

The lavender, thyme, and clove essential oils with β-Cyclodextrin hydrate and citric acid in equal ratio were fashioned by mixture solution encompassing absolute alcohol and distilled water with ratio (1:3) hexadecane as stabilizer and egyptol as emulsifier. The solution was emulsified with a high-speed mixer at a speed of about 10,000 r.p.m. at a temperature of 40°C for 20 minutes. The emulsified system was transferred into a flask for cooling.

2.2.3. Fabrics Finishing Process

Different essential oils of lavender, thyme, and clove were used for treatment of woven cotton fabrics, by exhaustion method. The fabrics were kept absorbed in the solution containing the essential oils, (Liquor Ratio – 1: 15) for 20minutes at 40ºC in water bath. After finishing, the fabrics were removed, and dried at 100ºC in the oven for 4 minutes and then cured at 130 ºC for 3minutes.

2.3. Measurements and Analysis

2.3.1. Gas chromatography- Mass Spectrometry (GC–MS) Analysis

For Identification of volatile compounds, about 2 µl of each pure essential oil was used. GC analysis was performed by using Hewlett-Packard model 5890 (Hewlett- Packard, PerkinElmer Co., USA) equipped with a flame ionization detector. A fused silica capillary column DB-5 (Zebron Co., USA) (60 m × 0.32 mm, internal diameter) was used. The oven temperature was maintained initially at 50°C for 5 min, and then programmed from 50 to 250°C at a rate of 4°C/min. Helium was used as the carrier gas, at a flow rate of 1.1 ml/min. The injector and detector temperatures were 220 and 250°C, respectively. The retention indices (Kovats index) of the separated volatile components were calculated

using hydrocarbons (C_7–C_{21}; Sigma Aldrich Co.) as references [26]. The analysis was carried out by using a coupled GC Hewlett-Packard model 5890/MS Hewlett-Packard MS 5970 (Hewlett-Packard). The ionization voltage was 70 eV, and the mass range *m/z* was 39–400 a.m.u. The isolated peaks were identified by matching with data from the library of mass spectra (National Institute of Standard and Technology), and compared with those of authentic compounds and published data. The quantitative determination was carried out on the basis of peak area integration. Identification of the GC components was also confirmed with the help of National Institute of Standard and Technology mass spectra library data, as well as on comparison of their retention indices with those of authentic compounds [26].

2.3.2. Infra-red analysis

The infra-red of the essential oils Lavender, Thyme, and Clove before and after treatment and finishing the fabrics were measured using Infra-red spectrometer, Perkin Elmer, system 2000 FT-IR (Fourier transform IR spectrometer).

2.3.3. Scanning Electron Microscope (SEM)

Finishing fabrics of cotton with lavender, thyme, and clove essential oils particles are mounted on aluminum stubs, and sputter coated with gold in a 150 Å sputter (Coated Edwards), and examined by Jeol (JXA-840A) Electron Probe Microanalysis (Japan),magnification range 35 - 10,000, accelerating voltage 19 kV. In order to confirm the presence of fragrance particles.

2.3.4. Antibacterial activity testing

Antimicrobial activity of the tested essential oils against Gram-positive bacteria (*Staphylococcus aureus*, SA) and Gram-negative bacteria (*Escherichia coli*, EC) was tested according to AATCC Test Method 100-1999.

2.3.5. Free radical scavenging activity (DPPH Assay)

The free radical scavenging activity of the three tested essential oils was measured in terms of hydrogen donating or radical scavenging ability using the stable DPPH radical method [27]. The DPPH solution (0.1mM) in ethanol was prepared and 1.0mg/ml of this solution was added to 3.0 ml of extract solution (or standard) in solvent at different concentrations (10-50 µg/ml). Thirty minutes later, the absorbance was measured at 517 nm. Lower absorbance of the reaction mixture showed higher free radical scavenging activity. The capability to scavenge the DPPH radical was calculated using the following equation.

% inhibition = control – test/control × 100

Where 'control' was the absorbance of the control reaction and 'test' was the absorbance in presence of essential oil. The mean values were calculated from six experiments. The positive controls were those using the standard solution TBHQ.

2.3.6. Washing

Some cured samples were laundered for 30 min at a temperature of 40 °C according to the ISO 105-C01:1989 (E) standard [28] using a soap solution (5 g/l of soap) with a pH of 7 and a liquor-to-fabric ratio of 50:1. For the evaluation of fragrance, some samples were washed 5 times. After washing, they were air dried.

3. Results and Discussions

3.1. GC-MS Analysis of EOs

The chemical compositions of EOs from thyme, clove and lavender were determined by comparing the relative retention times and the mass spectra of oil components with mass spectra from data library. The EOs were characterized by one or two dominant components that are listed according to their retention time and percentage contribution (Table 1). The GC-MS analyses resulted in the identification of 16 components of thyme EO (Table 1). The major components of thyme EO determined by GC-MS were thymol (37.13%) followed by p- cymene (20.46%), terinyl acetate (15.58%), carvacrol (10.07%), and bisabolene (5.91%). The others comprise thujene, caryophyllene and geraniol (Table 1). There is a great variability and diversity of chemical composition of Thymus species due to many factors. Some thymus oils are characterized by the increased percentages of thymol, carvacrol, borneol, linalool or α-terpineol. Our findings also showed a good relation with the studies associated with EOs of Turkish origin Thymus species and Tunisian [29].

Clove EO consists of eugenol (85.6 %), heptyl acetate (9.27 %), linalool (1.81%), eugenyl acetate (0.8 %) and also caryophyllene oxide (0.97 %) (Table 2). Eugenol seems to have the highest proportion of tested clove EO as it was observed from our results. The variation in EO composition may be caused by ecological and geographical distribution and also climatic and soil variation condition.

The major components of lavender EO determined by GC-MS were linalool (29.40%) followed by cineole (23.45%), dihydro carveol (15.90%), thujanol (8.46%), thuj-3-en-10-al (4.34%), and camphor (2.41%)(Table 3). The chemical composition of examined lavender leaves and flowers was differentiated and dependent upon the plant organ and stage of its development [30].

Table 1: The Main Chemical composition of Thyme essential oil analyzed by GC/Ms

No	*Compound*	*%*
1	Thujene	1.3
2	p-cymene	20.46
3	Caren-7ol	0.07
4	Thymole	37.13
5	Methyl thymol ether	1.06
6	α-agarofuran	1.02
7	Spathulenol	1.08
8	Carvacrol	10.07
9	Terpinyl acetate	15.58
10	Caryophyllene oxide	1.08
13	Caryophyllene	2.11
14	Geraniol	0.5
15	Cadinene	2.68
16	Bisabolene	5.91

Table 2: The Main Chemical composition of clove essential oils analyzed by GC/Ms

No	*Compound*	*%*
1	heptanone	0.02
2	a- pinene	0.02
3	p- cymene	0.02
4	Limonene	0.05
5	Heptyl acetate	9.27
6	Linalool	1.81
7	Methyl salicylate	0.04
8	p- allyl phenol	0.21
9	Eugenyl acetate	0.8
10	Eugenol	85.6
11	caryophyllene	0.49
12	Caryophyllene oxide	0.97

Table 3: The main chemical composition of Lavendar essential oil analyzed by GCMS

No	*Compound*	*%*
1	Tricyclene	2.42
2	Artemisia triene	0.035
3	α-pinene	3.35
4	β-pinene	1.2
5	Cineole	23.45
6	Ocimene	1.26
7	4-Thujanol	8.46
8	Linalol	29.40
9	Isophorone	0.05
10	Isophorone (4-Keto)	5.43
11	Camphor	2.41
12	Terpinoel (cisDihydro)	0.56
13	Thuj-3-en-10-al	4.34
14	DihydroCarveol (ISO)	15.90
15	Pulegol (trans)	1.71

3.2 Transforms infrared (FTIR) spectra

Figures 1-3 show the Fourier transforms infrared (FTIR) spectra analysis for Lavender, Thyme and Clove respectively. The absorption bands at 3445.21, 3438.46, and 3446.17 cm^{-1} (Shown in Figures 1-3) indicates (-OH) group for Lavender, Thyme and Clove respectively, where clearly showed more broadening area of (-OH) group in case of clove (As shown in Fig.3). From where it may be assumed that found the (-OH) group and another methoxy group (-O-CH_3) in clove molecule, C-H stretching region (3200-2800 cm^{-1}) C-H stretches from aromatic and vinyl hydrocarbons occur at 3100-3000 cm^{-1}. C-H stretches for methylene groups occur near 2925 (asymmetric) and 2850 (symmetric) cm^{-1}, with the corresponding C-H stretches for methyl groups near 2962 and 2872 cm^{-1}. The hydrocarbon stretches for unsaturated carbon groups occur at higher wavenumbers, and the C-H stretches for saturated carbon groups occur at lower wave numbers [31], Figure 1, shown the C-H stretching vibration at 3087.48, 2968.87, and 2924.52 cm^{-1} in case of lavender, but in Figure 2, the C-H stretching vibration at 2961.16, 2925.48 and 2871.49 in case of thyme, as shown in Figure 3, the C-H stretching vibration at 3070.12, 2965.02 and 2843.52 in case of clove, this is may be due to thyme and clove have in it is structure aromatic ring but lavender has vinyl hydrocarbons. The C = C stretching vibration at 1643,1632, and 1638 cm^{-1}, while the C-O bands at 1 245, 1 235, and 1234 cm^{-1} for Lavender, Thyme and Clove respectively.

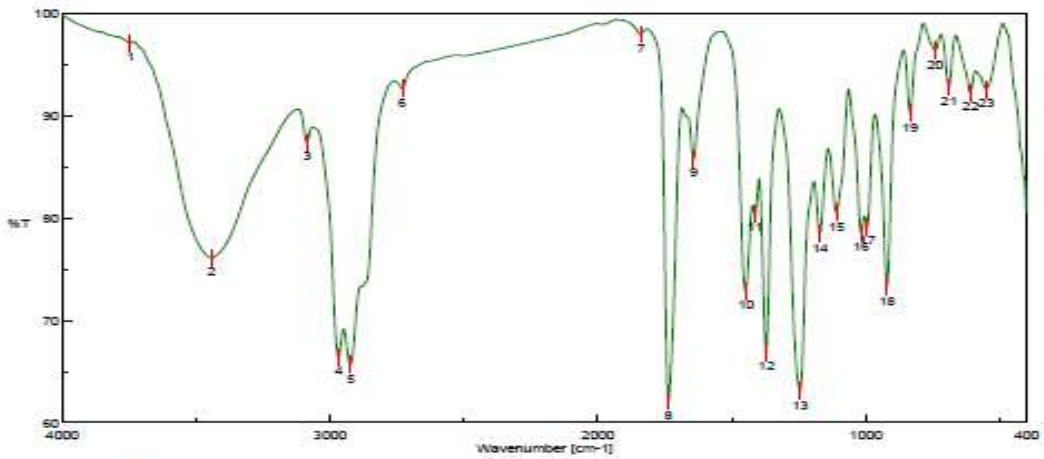

Figure 1: IR spectra of synthetized and extracted Lavender

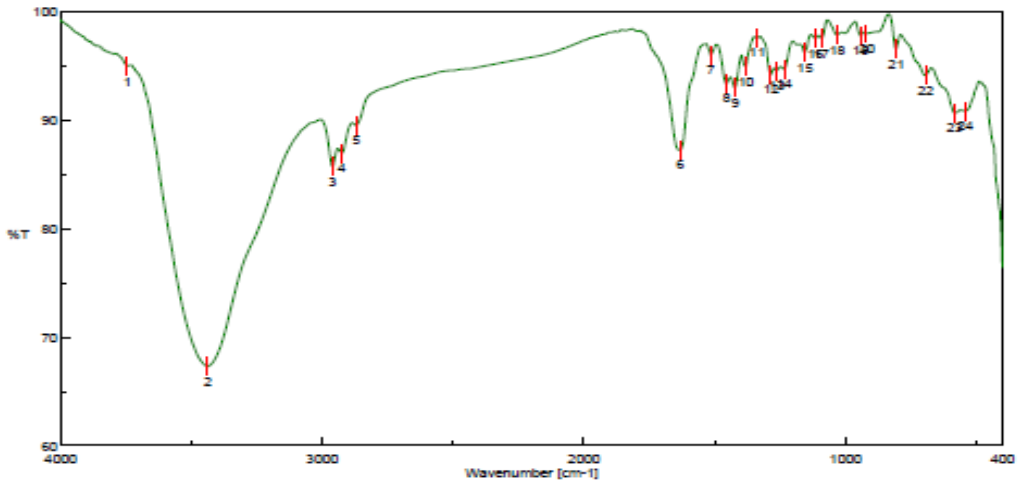

Figure 2: IR spectra of synthetized and extracted Thyme

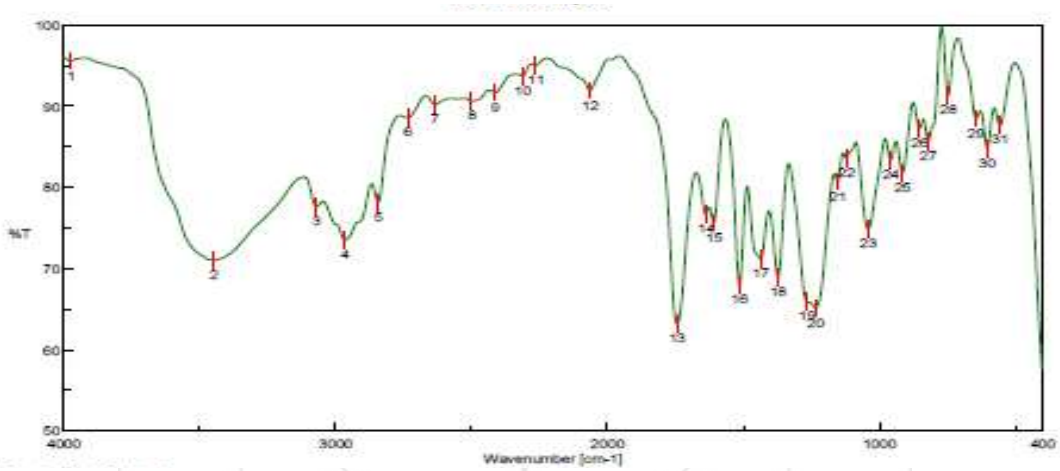

Figure 3: IR spectra of synthetized and extracted Clove

Figures 4-6 show the Fourier transforms infrared (FTIR) spectra analysis for bleached cotton fabric (cellulose fiber) which had been treated and finished with beta-cyclodextrin 10%, Citric acid-10%, 1% hexadecane and synthetic fragrance chemicals (Lavender, Thyme and Clove 5%) respectively. The absorption bands at 3409.53, 3408.57, and 3417.24 cm^{-1} shown in Figures 4, 5 and 6, indicates (-OH) groups in combined fragrance chemicals and finished bleached cotton fabric. From where it may be assumed that (-OH) group of cellulose is bonding with the (-OH) group of beta cyclodextrin. A carbonyl in a ketone usually occurs at 1720-1690 cm-^{1}, while a carbonyl band in an ester usually occurs at 1750-1730 cm-^{1} , the adjacent C-O stretching vibrations found in esters and aldehydes occur between 1400 and 1000 cm^{-1} [31], For finishing cellulosic fabrics a new absorption bands appeared at 1730.8, 1730.8, and 1728.87 cm^{-1}, this is appeared due to C=O stretching vibration, upon using Lavender, Thyme and Clove respectively, and the adjacent C-O stretching vibrations and absorption bands from 1400 cm^{-1} to 1000 cm^{-1}, synthetic fragrance chemical, cellulosic fiber and citric acid. Which was accord with the theory of cotton fabric (i.e. cellulose) treated by beta cyclodextrin and citric acid. Ester bond (-COO-) was generated between hydroxyl group of beta cyclodextrin and cotton fabric reacted with citric acid which was used as crosslinking agent. The (C=O) and the C-H stretching vibration 2926.45, 2924.52and 2914.88 cm^{-1} were improved slightly due to the improvement of macromolecular chain. The new strong absorption peaks at 1033.96, 1033.96 & 1031.73 for finished cellulosic with Lavender, Thyme and Clove respectively, as shown in Figures 4-6 improved that, beta cyclodextrin was fixed on cotton fabric with the aid of citric acid which crosslinking among the carboxyl group of acids, the hydroxyl group of cellulose and beta cyclodextrin occurred due to the esterification reaction. So it was speculated cotton fabric was cross linked successfully. Although, Lavender, Thyme and Clove fragrance oils were microencapsulated primarily before making any reaction with cellulosic.

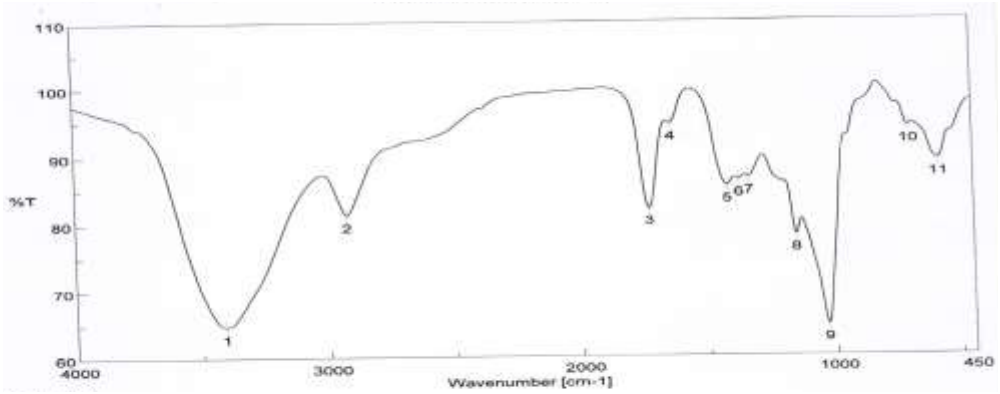

Figure 4: IR spectra of cotton fabrics after treatment with extracted Lavender

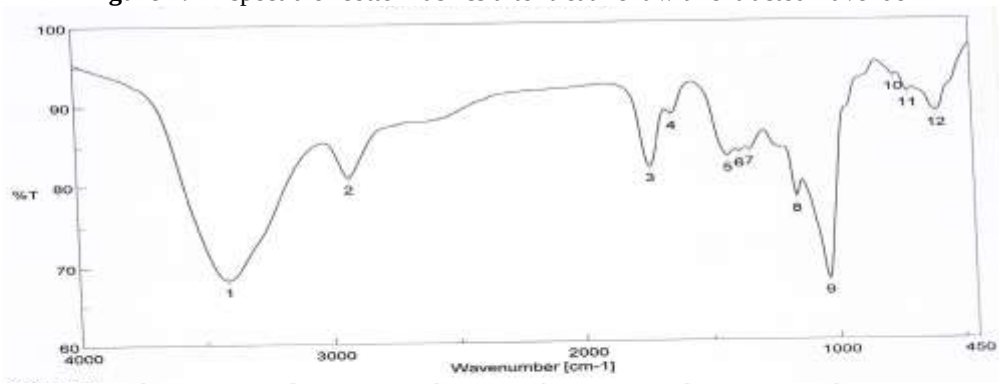

Figure 5: IR spectra of cotton fabrics after treatment with extracted Thyme

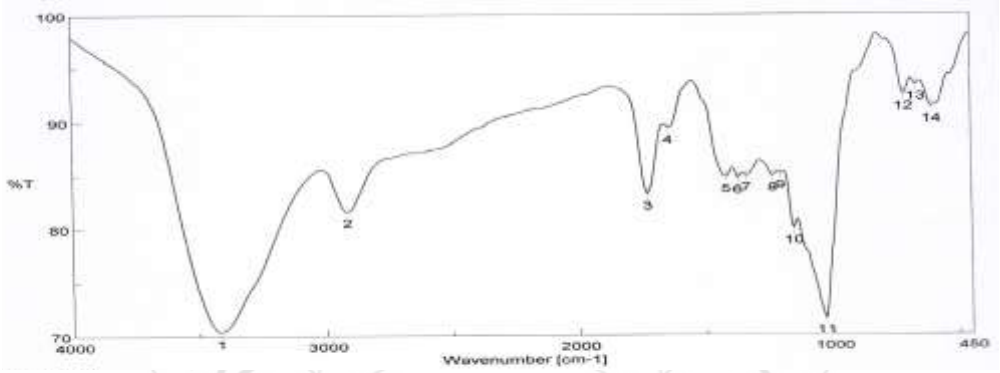

Figure6: IR spectra of cotton fabrics after treatment with extracted Clove

3.3. Antioxidant activity

Antioxidant activity is one of the most intensively studied subjects in essential oil research because oxidation damages various biological substances and subsequently causes many diseases, including cancer[31,32], liver disease [33], Alzheimer's disease [34]. Many diseases have been treated with antioxidants to prevent oxidative damage [35]. Recently, many researchers have been investigating the antioxidant activity of different essential oils in order to search for safe natural antioxidants. Consequently, various studies have shown that essential oils are ideal natural sources of antioxidants.

DPPH (·) assay is a trustworthy method to determine the antioxidant power of biological substrates. The DPPH(·) radical scavenging activity is generally quantified in terms of inhibition percentage of the pre-formed free radical by antioxidants, and the EC(50) (concentration required to achieve a 50% antioxidant effect) is a typically employed factor to state the antioxidant capacity and to evaluate the activity of different compounds [36,37]. The antioxidant properties of the microencapsulated essential oils of lavender, thyme and clove for its utilization for finishing cotton fabrics were evaluated for its plausible free radical mechanisms by the DPPH free radical scavenging assay. The results showed that clove essential oil was superior antioxidant in the DPPH scavenging activity (IC50 value 0.504±0.04µg/ml), followed by thyme (IC50 value 34.016±0.06µg/ml) and lavender (IC50 value 250.059±0.02µg/ml) essential oils, respectively, when compared to the standards TBHQ (IC50 value 5.25±1.45µg/ml)(Figure 7).

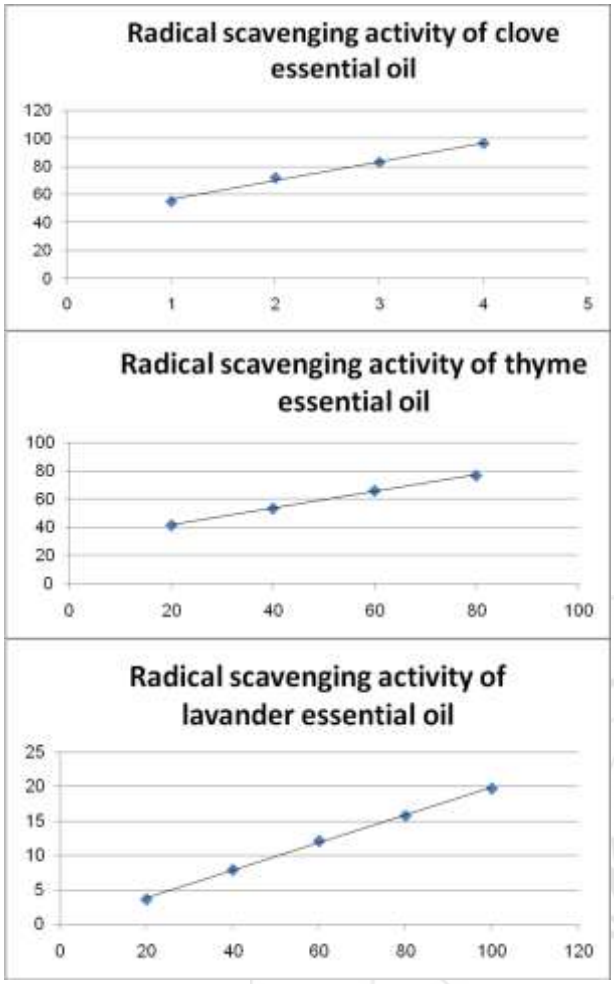

Figure 7: Radical scavenging activity of microencapsulated clove, thyme and lavender essential oils

Free radical scavenging assays using synthetic radicals like DPPH (1,1-diphenyl-2-picrylhydrazyl), $ABTS^{\cdot+}$ (2,2'-azinobis-3-ethylbenzothiozoline - 6-sulphonic acid), or biological radicals such as superoxide radical anions offer an easy and rapid way to screen herbal drugs, food and beverages for *in vitro* antioxidant activity. Antioxidants, such as phenolic compounds, can play a protective role to inactivate harmful reactive oxygen species. The antioxidant activity of phenolic compounds presents in the tested EOs represented as eugenol (clove), thymol and carvacrol (thyme) and camphor in lavender essential oils (Tables 1-3) is mainly attributed to their redox properties, which allow them to act as reducing agents, hydrogen donor and quenchers of singlet oxygen.

3.4. Scanning electron microscope (SEM)

Lavender, thyme and clove essential oils pre-treatment, cotton fabrics. The SEM images of cotton fabric treated with lavender, thyme and clove are shown in Fig. 8-10 respectively. From the results represent in figures we noticed that, the surface of the treated cotton fabrics is uniformly and covered by the particles of the finishing agent which containing the essential oil of the lavender, thyme and clove with cyclodextrin , citric acid and alcohol.

Comparing between the three figures we noticed that, in case of treated cotton with lavender essential oil (Fig. 8), the surface of cotton is more homogeneity but in case of using thyme and clove essential oils the surface of cotton is covered by a big particles of the finishing fragrance used and this is may be due to reaction happened between the fragrance and citric acid or cyclodextrin and give some precipitate.

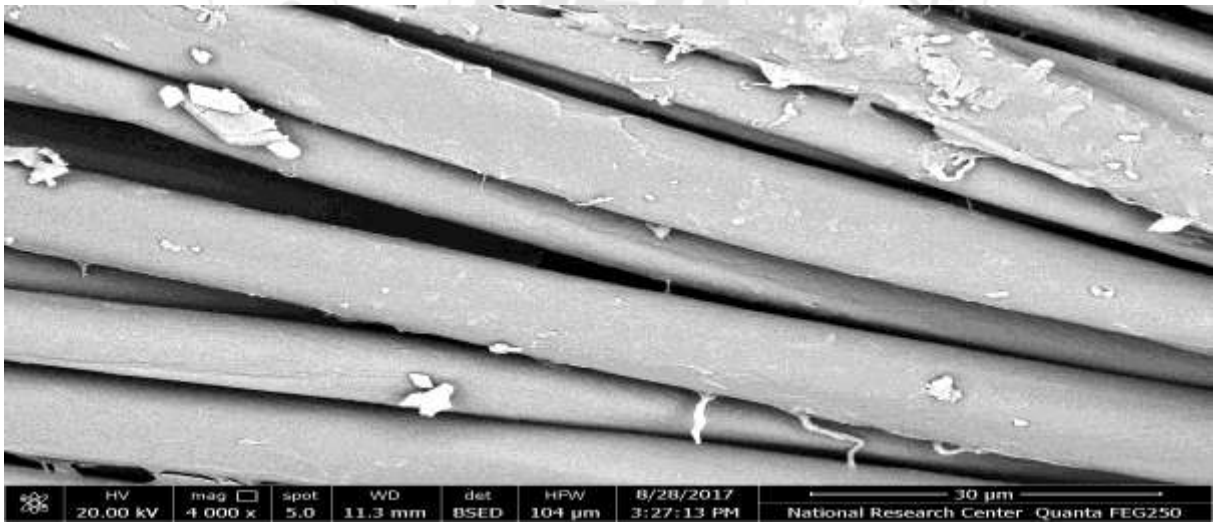

Figure 8: SEM images of treated cotton fabrics with lavender essential oil.

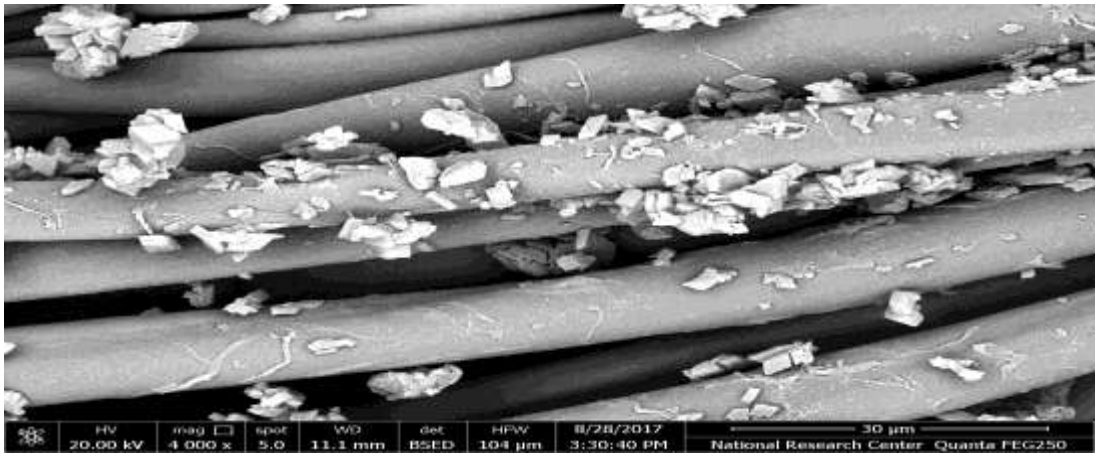

Figure 9: SEM images of treated cotton fabrics with thyme essential oil.

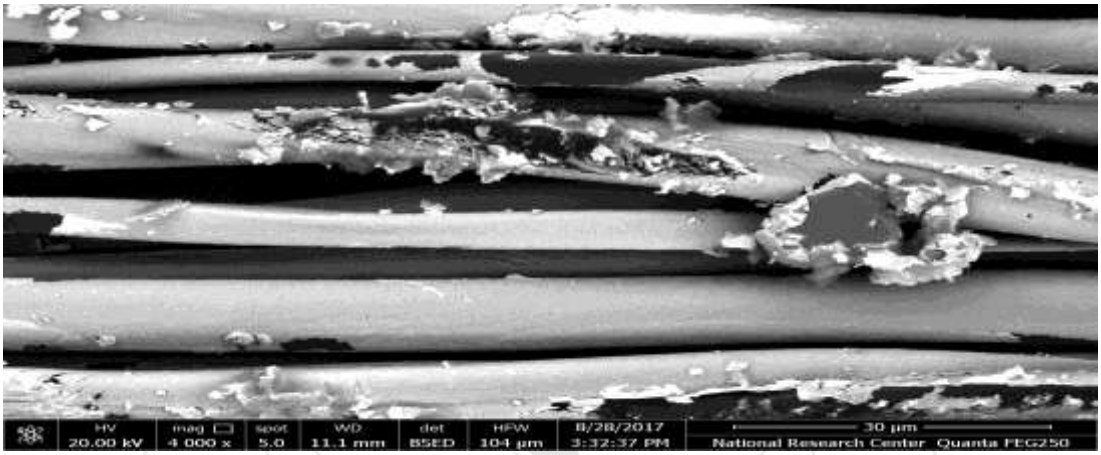

Figure 10: SEM images of treated cotton fabrics with clove essential oil

3.5. Antibacterial activity

Many studies showed that essential oils had antibacterial properties against a wide range of bacterial strains, such as *Listeria monocytogenes*, *Listeria innocua*, *Salmonella typhimurium*, *Escherichia coli*, *Shigella dysenteria*, *Bacillus cereus*, *Staphylococcus aureus*, and *S. typhimurium* [38]. Another report indicated that thirty out of sixty essential oils exhibited strong inhibitory activity against *Helicobacter pylori*, which is associated with severe gastritis and an increased incidence of peptic ulcers [39]. Generally, essential oils in decreasing order of antimicrobial activities are reportedly: oregano > clove > coriander > cinnamon > thyme > mint > rosemary > mustard > cilantro/sage [40, 41].

The antibacterial activity was evaluated by measuring the clear zone inhibition around the test sample after 24 h incubation. The effect of using essential oils of lavender, thyme, and clove for finishing cotton fabrics, then dried at 100ºC in the oven for 4 minutes and cured at 130 ºC for 3minutes on antimicrobial properties of treated cotton fabric is shown in Table 4. It was found that all tested samples have antibacterial activity but none of them has any antifungal activity on the tested microorganisms. The differences observed in the diameter of zone of inhibition between the cotton fabrics treated with lavender, thyme, and clove may be due to the difference in the susceptibility of bacteria to the samples. Treated cotton fabrics with thyme and clove had the highest antibacterial activity, this is may be as a result of the clove and thyme essential oils exhibited considerable antioxidant effect. Also it was obviously clear that the tested samples are effective against *Staphylococcus aureus* (G^+) growth higher than *Escherichia coli* (G^-). This may be ascribed to the thick layer around the cell wall of *E. coli* which resists the penetration of antibacterial active material to their cell walls to interfere in its metabolic pathway. The novelty of this work was arisen from its ability to fit the requirements of economic feasibility of medical textile, achieve the goal of fabrics has at smell good and has antibacterial.

Table 4: Effect of lavender, thyme, and clove essential oils on antimicrobial properties of finishing cotton fabrics, dried at 100ºC in the oven for 4 minutes and cured at 130 ºC for 3minutes.

Sample	Inhibition zone diameter (mm / 1cm Sample)			
	Escherichia coli (G^-)	*Staphylococcus aureus* (G^+)	*Aspergillus flavus* (Fungus)	*Candida albicans* (Fungus)
Treated cotton fabrics with lavender.	21	23	0.0	0.0
Treated cotton fabrics with thyme.	23	26	0.0	0.0
Treated cotton fabrics with clove.	18	20	0.0	0.0

3.6. Fragrance evaluation (fastness of fragrance to washing)

The fragrance on the treated fabric before and after a selected number of washing cycles was evaluated using a panel of five judges (Table 5). The judges used their fingernails to scratch on the fabric to break some of the capsules and smell the swatch. Then they wrote down for the presence of a very strong, strong, medium or weak fragrance or a 'No' for the absence of any fragrance. No judge performed testing for more than 15 min.

As shown in Table 5, before washing, a very strong fragrance was present on all samples (regardless of the type of essential oil used) after passing 20 days and after 50 days a strong fragrance was found ,but either after 60 days or after five washing a medium fragrance was obtained. Even after 5 washing, fragrance was judged to be present on all samples. There was a slight decrease in scent after five washes due to causing a reduction in the fragrance concentration on the fabric. The fragrance was much stronger on samples with a higher quantity of capsules, irrespective of the number of washing cycles.

Table 5: Number of judges evaluating the intensity of the fragrance

Sample	Before washing						After five washes
	10 days	20 days	30 days	40 days	50 days	60 days	
Treated cotton fabrics with lavender.	+++++	+++++	++++	++++	++++	+++	+++
Treated cotton fabrics with thyme.	+++++	+++++	++++	++++	++++	+++	+++
Treated cotton fabrics with clove.	+++++	+++++	++++	++++	++++	+++	+++

+++++ express very strong, ++++ express strong, +++ express medium

4. Conclusions

Lavender, thyme, and clove essential oils are extracted from natural sources and used in treatment of cotton fabrics, in order to give it a good smell and antibacterial properties i.e. medical textile.

B-cyclodextrin molecules are capable of forming inclusion compounds with essential oils that fit into the cone-shaped hydrophobic cavity.

Microcapsules with essential oil of lavender, thyme and clove can be successfully applied to cotton fabrics by exhaustion method.

Treated cotton fabrics with essential oils, lavender, thyme and clove had antibacterial activity against, Staphylococcus aureus and Escherichia coli, i.e. medical textile.

After 50 days a strong fragrance was found, but either after 60 days or after five washing a medium fragrance was obtained.

The novelty of this work was arisen from its ability to fit the requirements of economic feasibility of medical textile, achieve the goal of fabrics has at smell good and has antibacterial.

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References

[1] M. Billot and F.V. Wells, Perfumery Technology. John Wiley & Sons Inc., New York (1975).
[2] S.S., Handa, S.P.S. Khanuja, G. Longo, and D.D. Rakesh, eds. 2008. Extraction Technologies for Medicinal and Aromatic Plants, International Centre for Science and High Technology, Trieste (2008).
[3] J.E. Simon, Essential oils and culinary herbs. In: Advances in New Crops. Edits., J. Janick and J.E. Simon, pp. 472–83, Timber Press, Portland, OR (1990).
[4] E. Guenther, the Essential Oil. Volume IV. D. Van Nostrand, New York (1950).
[5] E. González-Burgos, M.E. Garretero and M.P. Gónmez-Serranillos, Sideritis spp.: Uses, chemical composition and pharmacological activities – A review. J. Ethnopharmacol., 135, 209–225 (2011).
[6] T.J. Betts, Chemical characterization of the different types of volatile oil constituents by various solute retention ratios with the use of conventional and novel commercial gas chromatographic stationary phases. J. Chromatogr. A, 936, 33–46 (2001).
[7] S. Arctander, Perfume and Flavor Chemicals. Published by the author. Montclair, NJ (1969).
[8] E. Pichersky, J.P. Noel and N. Dudareva, Biosynthesis of plant volatiles: Nature's diversity and ingenuity. Science, 311, 808–811 (2006).
[9] S.A. Burt, Antibacterial Activity of Essential Oils: Potential Applications in Food. Ph.D. thesis, Utrecht University (2007).
[10] F. Bakkali, S. Averbeck, D. Averbeck and D. Idaomar, Biological effects of essential oils. A review. Food Chem. Toxicol., 46, 446–475 (2008).
[11] J. Silva, W. Abebe, S.M. Sousa, V.G. Duarte, M.I.L. Machado and F.J.A. Matos, Analgesic and anti-inflammatory effects of essential oils of Eucalyptus. J. Ethnopharmacol., 89, 277–283 (2003).
[12] V. Hajhashemi, A. Ghannadi and B. Sharif, Anti-inflammatory and analgesic properties of the leaf extracts and essential oil of Lavandulaangustifolia Mill. J. Ethnopharmacol., 89, 67–71 (2003).
[13] N.S. Perry, C. Bollen, E.K. Perry and C. Ballard, Salvia for dementia therapy: Review of pharmacological activity and pilot tolerability clinical trial. Pharmacol.Biochem.Behav, 75, 651–659 (2003).
[14] S. Gaysinsky and J. Weiss, Aromatic and spice plants: Uses in food safety. Stewart Post Harvest Rev, 4, 1–9 (2007).

[15] D.L. Zink, The impact of consumer demands and trends on food processing. Emerg. Infect. Diseases, 3, 467–469 (1997).
[16] H.J.D. Dorman, P. Surai and S.G. Deans, In vitro antioxidant activity of a number of plant essential oils and phytoconstituents. J. Essent. Oil Res., 12, 241–248 (2000).
[17] K.G. Lee and T. Shibamoto, Determination of antioxidant potential of volatile extracts isolated from various herbs and spices. J. Agric. Food Chem., 50, 4947–4952 (2002).
[18] B. Vazquez, G. Avila, D. Segura and B. Escalante, Antiinflammatory activity of extracts from aloe vera gel. J. Ethnopharmacol., 55, 69–75 (1996).
[19] K.K. Park, K.S. Chun, J.M. Lee, S.S. Lee and Y.J. Surh, Inhibitory effects of [6]-gingerol, a major pungent principle of ginger, on phorbol ester-induced inflammation, epidermal ornithine decarboxylase activity and skin tumor promotion in ICR mice. Cancer Lett., 129, 139–144 (1998).
[20] M. Elgayyar, F.A. Draughon, D.A. Golden and J.R. Mount, Antimicrobial activity of essential oils from plants against selected pathogenic and saprophytic microorganisms. J. Food Prot., 64, 1019–1024 (2001).
[21] E.D. Lima, O.F. Gompertz, M.D. Paulo and A.M. Giesbrecht, In vitro antifungal activity of essential oils against clinical isolates of dermatophytes. Revista de Microbiologia, 23, 235–238 (1992).
[22] P. Schnitzler, K. Schon and J. Reichling, Antiviral activity of Australian tea tree oil and eucalyptus oil against Herpes simplex virus in cell culture. Pharmazie, 56, 343–347 (2001).
[23] P. Schnitzler, C. Koch and J. Reichling, Susceptibility of drug-resistant clinical Herpes simplex virus type 1 strain to essential oils of ginger, thyme, hyssop, and sandalwood. Antimicrob. Agents Chemother., 51, 1859–1862(2007).
[24] K. Aruna and V.M. Sivaramakrishnan, Anticarcinogenic effects of the essential oils from cumin, poppy and basil. Phytother. Res, 10, 577–580 (1996).
[25] Gang Sun , Xiangjing Xu , Julie R. Bickett , and Jeffrey F. Williams, Durable and Regenerable Antibacterial Finishing of Fabrics with a New Hydantoin Derivative, *Ind. Eng. Chem. Res.*, *40* (4), pp 1016–1021(2001)
[26] Adams R P. "Identification of essential oil components by gas chromatography/mass spectrometry". Carol Stream, IL, USA: Allured Publishing; (1995).
[27] M.S. Blois. Antioxidant determinations by the use of a stable free radical. Nature 1958; 29, 1199- 1200.
[28] ISO 105-C01:1989 (E) Color fastness to washing: Test 1 (Geneva: ISO, 1989).
[29] H. Baydar, , O. Sagˇ Dic, , G. Özkan, and T. Karadogˇ An, 2004. Antibacterial activity and composition of essential oils from Origanum, Thymbra and Satureja species with commercial importance in Turkey. Food Control 15, 169–172.
[30] R. Nurzyńska-Wierdak, G. Zawiślak. Chemical composition and antioxidant activity of lavender (*Lavandula angustifolia* Mill.) above ground parts. Acta Sci. Pol. Hortorum Cultus, 15(5) 2016, 225-241
[31] Michele R. Derrick, Dusan Stulik, and James M. Landry" Infrared Spectroscopy in Conservation Science″ The Getty Conservation Institute, Los Angeles, United States of America, *edition 10th* , 1999
[32] B. Halliwell and J. Gutteridge, The antioxidants of human extracellular fluids. Arch. Biochem. Biophys.280, 1–8 (1990).
[33] T. Paz-Elizur, Z. Sevilya, Y. Leitner-Dagan, D. Elinger, L.C. Roisman and Z. Livneh, DNA repair of oxidative DNA damage in human carcinogenesis: Potential application for cancer risk assessment and prevention. Cancer Lett, 266, 60–72 (2008).
[34] V.R. Preedy, M.E. Reilly, D. Mantle and T.J. Peters, Oxidative damage in liver disease. J. Intern. Fed. Clin. Chem., 10, 16–20 (1998).
[35] P. Moreira, M.A. Smith, X. Zhu, K. Honda, H.-G. Lee, G. Aliev and G. Perry, Since oxidative damage is a key phenomenon in Alzheimer's disease, treatment with antioxidants seems to be a promising approach for slowing disease progression. Oxidative damage and Alzheimer's disease: Are antioxidant therapies useful? News Persp, Drag (2005).
[36] J.-K. Moon and T. Shibamoto, Antioxidant assays for plant and food components. J. Agric. Food Chem., 57, 1655–1666 (2009).
[37] Z. Chen , R. Bertin , G. Froldi. EC50 estimation of antioxidant activity in DPPH· assay using several statistical programs. Food Chem. 2013, 138 (1):414-20).
[38] A. Wei and T. Shibamoto, Antioxidant/lipoxygenase inhibitory activities and chemical compositions of selected essential oils. J. Agric. Food Chem., 58, 7218–7225 (2010).
[39] V. Hulin, A. Mathot and P. Mafart, Les propriétés antimicrobiennes des huiles essentielles et composés d'arômes.Sci. Aliments, 18, 563–582 (1998).
[40] D. Kelly, The physiology and metabolism of the human gastric pathogen (Helicobacter pylori). Adv. Microb. Physiol., 40, 137–189 (1998).
[41] S. Burt, Essential oils: Their antibacterial properties and potential applications in foods – A review. Int. J. Food Microbiol., 94, 223–253 (2004).