PSM
Microbiology

Research Article 2021 | Volume 6 | Issue 4 | 95-107

Open Access

Article Information

Received: September 26, 2021

Accepted: November 5, 2021

Online first: November 12, 2021

Published: November 22, 2021

Keywords

Staphylococcus aureus,
Pseudomonas aeruginosa,
Burn infections,
Lavandula,
Plectranthus,
Thyme volatile oils.

Authors' Contribution

EHLA and MAA conceived and designed the study; EHLA performed and analysed microbiology part; MAA done chemical part. EHLA and MAA wrote, revised and gave final approval for publication of the paper.

How to cite

Alhamzi, E.H.L., Al.Maqtari, M.A., 2021. Effect of Some Volatile Oils on *Staphylococcus aureus* and *Pseudomonas aeruginosa* Isolates from Burn Patients. PSM Microbiol., 6(4): 95-107.

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Effect of Some Volatile Oils on *Staphylococcus aureus* and *Pseudomonas aeruginosa* Isolates from Burn Patients

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Abstract:

Burn wound infection is a major complication in burn patients after the initial period of shock. Microbial infection of burn wounds causes more than 70% mortality in burn patients. This study was conducted from March 2019 to May 2019 at Teiba Center for Burns Surgery in Al-Jumhory Hospital located in Sana'a city, Yemen. A total of 40 swab specimens of burn wounds were collected. Specimens were inoculated on Blood agar media and MacConkey Agar media and were incubated aerobically for 24 hours at 37 °C. Specimens of third-degree burns were inoculated on Blood Agar media and incubated anaerobically for 75 hours at 37°C. Bacterial colonies were identified by biochemical and diagnostic tests. Screening of volatile oils (*Lavandula pubescens*, *Plectranthus barbatus,* and *Thymus laevigatus*) for antibacterial activities was done by the disk diffusion method. Our results showed that 25 (63%) of patients were males and 15 (37%) were females. The second-degree burns were the most common 18 (45%), followed by third-degree burns 13 (32%), 25 (62%) were flame, 7 (18%) were scalds, 8 (20%) cases were chemical burns. Out of 28 positive cultures, *Staphylococcus aureus* was the most common organism isolated 20 (71%), followed by *Pseudomonas aeruginosa* 8 (29%). Lavandula oils and Plectranthus oils showed inhibition against the growth of *S. aureus* and *P. aeruginosa* at 20µl.

INTRODUCTION

Burn wounds are major problem of public health globally, burn infection in Low Middle - income countries (LMIC) leads to high mortality rates of over 95% (Amissah *et al.,* 2017). The burn injury of skin layers provides a rich external environment of necrotic tissue that supplies bacteria with a rich medium of nutrient elements that cause pus (Jasem *et al*., 2018). Burns are caused by flame, chemical acids or alkalis, electric high voltage (>1000 mV) and low voltage (< 200 mV), and by scalding. Scald burns represent the most frequent group in the world (Garcia-Espinoza *et al*., 2017).

Pseudomonas aeruginosa is the most common bacteria which causes fierce infection in burnt wound patients (Nath *et al.,* 2017). Burn wounds of patients may lead to life-threatening infections. *P. aeruginosa* in burn wound patients plays a prominent role in life-threatening nosocomial pathogen serious infections (Humaid, 2018; Ranjbar *et al.,* 2011). Strains of *P. aeruginosa* in the internal nosocomial environments cause several diseases, predominantly pneumonia urinary tract infections, bacteremia, meningitis, and skin infections. In burn wound patients, *P. aeruginosa* cause mortality and morbidity. In addition, *P. aeruginosa* causes 4%-60% nosocomial infections in different regions of the earth (Nath *et al.,* 2017).

Staphylococcus aureus is an opportunistic bacteria that causes skin infections as well as invasive infection in burn wound patients (Al-Khawlany *et al.,* 2021). Methicillin resistant *S. aureus* (MRSA) in a South African intensive care burn unit was the third most common bacteria identified in blood media (Amissah *et al.,* 2017). Burn wound victims in hospitals of developing countries are at high risk of nosocomial infections caused by *S. aureus* (Amissah *et al*., 2017; Iqbal and Ashraf, 2021).

Many commonly used antibiotics have no effect on the growth of *P. aeruginosa* isolates. Studies carried out in Iran showed that burn wound infection caused by multi-drug-resistant (MDR), *P. aeruginosa* is a nosocomial infection among hospitals of Iranian (Ranjbar *et al*., 2011).

The transmission of bacteria to the burn injury surfaces of patients occurs by fomites, personnel hygiene of the hands, and to some extent by hydrotherapy. The most common bacteria isolated from burn injury are *P. aeruginosa, S. aureus, S. pyogenes,* and various Enterobacteriaceae bacteria (Alebachew *et al*., 2012).

Volatile oils are aromatic compounds and liquids distilled from different plant parts. Different studies have shown that volatile oils possess antimicrobial and antioxidant activities, with their chemical constituents being responsible for these properties (Al.Maqtari and Alhamzi, 2021). The environmental conditions and several other factors directly influence the relative production of volatile oils (Semeniuc *et al*., 2018). *Lavandula* includes about 39 species and it belongs to Lamiaceae family. Lavender oil is known for its antimicrobial activities (Bayrak *et al*., 2017).

The medicinal potential of plant is due to the presence of active constituents, having different pharmacological effects such as antiseptic agents, analgesic, digestive healing, diuretics, expectorants, tranquilizers, emollients, anti-watery diarrheal, among others (Ashraf *et al.,* 2020; Iqbal and Ashraf, 2018, 2019; Shahzad *et al.,* 2017). The use of herbal medicine acknowledging its effectiveness has been documented in various studies (Ullah *et al.,* 2018; Verissimo *et al*., 2014; Zaynab *et al.,* 2018).

Thymus genus comprises of aromatic herbal medicinal plants (Hadipanah and Khorami, 2016) because of their pharmacological and biological characteristic. Flowering and leaves parts of *Thymus* sp. are used in traditional medicine. *Thymus* volatile oils are widely used in the flavoring of food, cosmetics, perfume, pharmaceutical industry, also for the preservation of different food products against the growth of bacteria and fungi (Ahmadi *et al*., 2015). Thyme volatile oils were found to be active against growth of pathogenic gram-

negative and gram-positive bacteria except for *P. aeruginosa* (Al-Bayati, 2008).

The current study aimed to isolate and identify *P. aeruginosa* and *S. aureus* from wounds infections of burn patients in Teiba Center for Burns Surgery in Al-Jumhory Hospital located in Sana'a city, Yemen.

MATERIALS AND METHODS

Ethical approval

The protocol of this work was approved by the Medical Ethics Committee of the Sana'a University. Before starting data and specimens' collection, the aims and methods of study were clarified to participated patients and an agreement was made.

Data Collection

A total of 40 persons fulfilling the inclusion criteria were recruited for the study.

Collection of burn wound samples

40 suppuration swabs specimens were obtained from 40 burn patients at Teiba Center for Burns Surgery in Al-Jumhory Hospital located in Sana'a city. The age of the studied burn wound patients was at least 60 years old.

Identification of specimens

Suppuration swabs were cultured on MacConkey Agar and Blood agar media and incubated aerobically at 37 °C for 24 hours. Swabs of third degree burn wounds were cultured on Blood media and incubated anaerobically at 37 °C for 75 hours (Alghalibi, 2011; Brenner *et al.,* 2005). Bacterial colonies were identified by colony morphology, hemolytic characteristics, lactose fermentation, Gram stain, and biochemical tests (Brenner *et al.,* 2005; Iqbal *et al.,* 2015; Saleem *et al.,* 2018).

Collection of plant samples

Three plant samples (aerial parts) were collected from Ibb (*Lavandula pubescens*), Taiz (*Plectranthus barbatus*) and Sana'a (*Thymus laevigatus*) Republic of Yemen. They were identified by botanists at the Department of Biology, Faculty of Sciences, Sana'a University.

Extraction of volatile oils

One hundred gram of each plant leaves were subjected to hydrodistillation for approximately three hours using a Clevenger type apparatus (Sharififar *et al.,* 2008).

Determination of the constituents of volatile oils using Gas Chromatography-Mass Spectrometry (GC-MS)

This part of our study was carried out in Department of Chemistry, The University of Alabama in Huntsville, USA. The composition of each volatile oil was described as follows:

Chemical analysis

Volatile oils were analyzed by Gas chromatographic-mass spectral (GC-MS) using an Agilent 6890 GC with Agilent 5973 mass selective detector [MSD, operated in the EI mode (electron energy = 70 eV), scan range = 45-400 amu, and scan rate = 3.99 scans/sec], and an Agilent ChemStation data system. The GC column was an HP-5ms fused silica capillary with a (5% phenyl)-polymethyl siloxane stationary phase, film thickness of 0.25 µm, a length of 30 m, and an internal diameter of 0.25 mm. The carrier gas was helium with a column head pressure of 48.7 kPa and a flow rate of 1.0 mL/min. Inlet temperature was 200°C and interface temperature was 280°C. The GC oven temperature program was used as follows: 40°C initial temperature, hold for 10 min; increased at 3°C/min to 200°C; increased 2°/min to 220°C. A 1%, w/v, solution of the sample in CH_2Cl_2 was prepared and 1µL was injected using a splitless injection technique. Identification of the oil components was based on their retention indices determined by reference to a homologous series of n-alkanes, and by comparison of their mass spectral fragmentation patterns with those reported in the literature (Adams, 2007) and stored on the MS library [NIST database (G1036A, revision D.01.00) /ChemStation data system (G1701CA, version

C.00.01.080]. The percentages of each component are reported as raw percentages based on total ion current without standardization.

Antibacterial activity for some of volatile oils

The antibacterial activities of three different types of volatile oils (*L. pubescens*, *P. barbatus* and *T. laevigatus*) were done by the disk diffusion method (Iqbal *et al.,* 2016), which used as check and to select between efficient essential oils. It was performed using 18 h cultivation at 37°C in 10 ml of Mueller Hinton media. The bacterial cultures were adjusted to 10^6 CFU/ml with sterile saline solution. One hundred microliters of the bacterial suspensions were spread over the petri-dishes containing Mueller-Hinton media using a sterile swabs in order to get a uniform microbial growth on both test and control petri-dishes. Essential oils were done at 20 µl. Three paper disks (diameter of disk papers was 5mm) were made in the media. Oils were introduced into each of the disks in labeled petri dish using a sterile micropipette.

Gentamicin (10µg/ mg) was used as positive control (El-Malti *et al.,* 2007). The plates were then incubated at 37°C for 24h, after which zones of inhibition were measured and recorded. The zones of inhibition were taken to be the diameter of the zone visibly showing the absence of growth including the 5 mm well. If there were no inhibition the value of 0 mm were assigned to the test samples (Magwa *et al.*, 2006; Saleem *et al.,* 2020).

The percentage of inhibition was calculated as followed:

$$\text{Inhibition (\%)} = \frac{\text{Growth diameterof the sample} - \text{Control growth diameter}}{\text{Control growth diameter}} \times 100$$

The zone of inhibition of the tested microorganisms by the essential oils extracts were measured using HiAntibiotic Zone Scale - ™C reader model PW297 (India) (Shittu *et al.,* 2007).

RESULTS

This investigation was carried out using 40 pus cells specimens obtained from burn injury patients at Teiba Center for Burns Surgery in Al-Jumhory Hospital located in Sana'a city. Out of the total 40 pus cells swabs, 28 (70 %) yielded positive inoculation with burn infections, while the rest swabs gave negative cultures. Be present of pus cells specimens based on inoculation results is shown in (Table 1).

Table 1. Be present of pus cells specimens based on inoculation results.

Positive culture		**Negative culture**		**Total**	
No	%	No	%	No	%
28	70	12	30	40	100

The abundance of the burn wound patients based on the genera and inoculation results is shown in Table (2). Out of the total patients, 25 (62.5 %) were male, 17 (60.7 %) had positive burn wound infection while out of 15 (37.5%) were female, 11 (39.3 %) had positive burn infections.

Table 2. The abundance of the burn wound patients based on the genera and inoculation results.

Gender	**Positive culture**		**Negative culture**		**Total**	
	No	%	No	%	No	%
Male	63	25	32	8	68	17
Female	37	15	33	4	73	11
Total	100	40	30	12	70	28

Table (3) shows incidence of *S. aureus* 20 (71.43 %) and *P. aeruginosa* 8 (28.6%) isolated from 28 burn infection patients.

Table 3. Ratio of S. aureus and P. aeruginosa bacteria isolated from 28 burn cases.

Isolated Microorganisms	**No. of cases**	**%**
S. aureus	20	71
P. aeruginosa	8	29
Total	28	100

The incidence of the burn wound patients in relation to their location and inocubation results is shown in Table (4). It was found that out of 40 burn infection patients, 25 (63%) living in rural region, while 8 (15.8%) were living in urban region. Out of 28 burn patients who lived in rural regions, 20 (80 %) had positive burn infection while out of 8 patients living in urban regions, 8 (53%) had positive burn infections.

Table 4. Incidence of the burn wound patients in relation to their location and inoculation results.

Location of living	Positive culture		Negative culture		Total	
	No	%	No	%	No	%
Rural	20	80	5	20	25	63
Urban	8	53	7	47	15	37
Total	28	70	12	30	40	100

Table (5) shows that out of 40 burn wound patients in our study, 9 (.23.2%) had first-degrees burns, which 2 (22%) of them had positive burn infection, 18 (45%) had second-degrees burns (Figure 1), which 14 (78%) of them had positive burns infections, 13 (32%) had third-degrees burns (Figure 2), 12 (92%) had positive burn wound infections.

Table 5. Distribution of the burn wound patients based on the degree of burn wound inoculation results.

Degree of burn	Positive culture		Negative culture		Total	
	No	%	No	%	No	%
First-Degree	2	22	7	78	9	23
Second-Degree	14	78	4	33.3	18	45
Third-Degree	12	92	1	8	13	32
Total	28	70	12	30	40	100

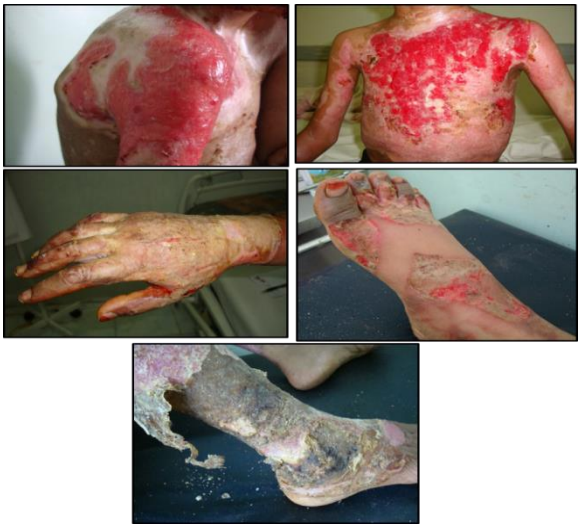


Fig. 1. Burn patients with Second- Degree.

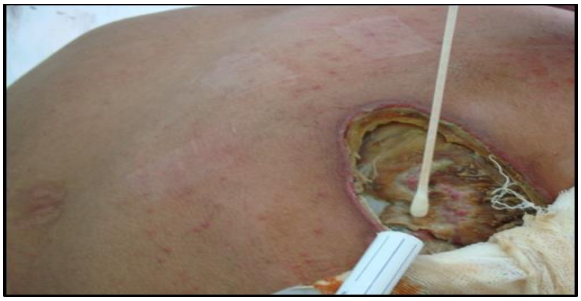


Fig. 2. Burn patients with Third- Degree.

Table (6) showed that out of 40 burn patients included in this study, 25 (62%) were caused by flame, 15 (60%) had positive burn infection, 7 (18%) were caused by scalds, 5 (71%) had positive infections, 8 (20%) were caused by chemical, 8 (100) had positive infections.

Table 6. Incidence of the burn wound patients based on the causes of burn wounds and inoculation results.

Cause of burn	Positive culture		Negative culture		Total	
	No	%	No	%	No	%
Flame	15	60	10	40	25	62
Scalds	5	71	2	29	7	18
Chemical	8	100	0	0	8	20
Total	28	78.3	12	21.7	40	100

Physical properties of volatile oils extracted from some plants species grown in Yemen.

The volatile oils used in the present study were obtained by hydrodistillation from three plant samples using Clevenger–type apparatus. The physical characteristic and yield of volatile oils are appeared in (Table 7). Our study showed that the yield of volatile oils was obtained from *L. pubescens* (1.0 l ml / 100g), *P. barbatus* (1.1 l ml / 100g) and *T. laevigatus* (0.80 ml /100g). pH of volatile oils extracted were *L. pubescens* (4.10), *P. barbatus* (7.40), and *T. laevigatus* (4.50).

Table 7. The physical characteristic and yield of volatile oils extracted from different plants grown in Yemen.

Plant (volatile oil)	Weight (gram)	Consistency	Refractive index	Density (g\cm3)	pH	Yield			
						ml	%	gram	%
L. pubescens	100	Thin	1.4944	0.97	4.10	1.01	1.01%	0.97	0.97 %
P. barbatus	100	Medium	1.4869	1.06	7.40	1.10	1.10%	1.10	1.10 %
T. laevigatus	100	Medium	1.4930	0.84	4.50	0.80	0.80%	0.67	0.67%

Antimicrobial activity of volatile oils

The study results showed that the *P. barbatus* volatile oil produced complete inhibition against growth of *S. aureus* and it produced inhibition zone against growth of *P. aeruginosa* at 20µl (38 mm and 10 mm) respectively (Plate 1).

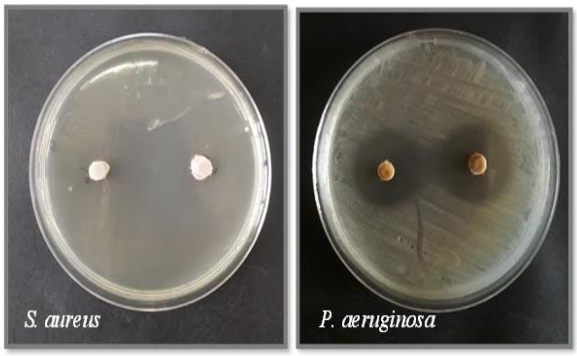


Plate 1. The antimicrobial activity *P. barbatus* volatile oils against *S. aureus* and *P. aeruginosa* at 20µl.

The *L. pubescens* volatile oil produced inhibition zone against growth of *P. aeruginosa* and *S. aureus* at 20µl (22 mm and 11 mm) respectively (Plate 2).

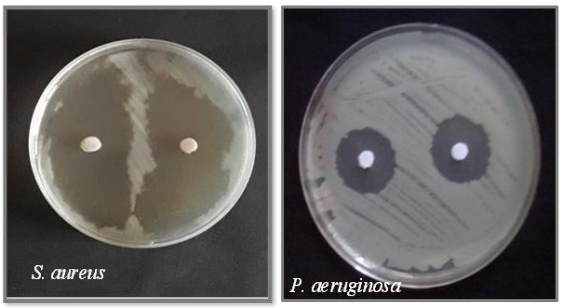


Plate 2. The antimicrobial activity of *L. pubescens* volatile oil against *S. aureus* and *P. aeruginosa* at 20µl

The study showed that the *T. laevegatus* volatile oil produced inhibition zone against *S. aureus* and *P. aeruginosa* at 20µl (9 mm and 4 mm) respectively (Plate 3).

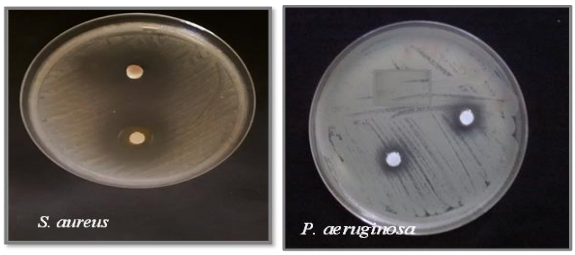


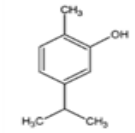
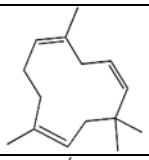
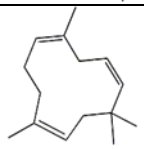
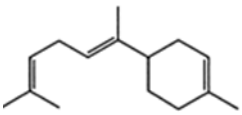
Plate 3. The antimicrobial activity of *T. laevegatus* volatile oil against *S. aureus* and *P. aeruginosa* at 20µl

Extraction of volatile oils

The main chemical constituents in *L. pubescens* (Ibb) volatile oil

Data in the Table (8) showed that four constituents were present in the volatile oil obtained from *L. pubescens* (Ibb). These constituents were Carvacrol (70.0%), Caryophyllene oxide (5.48%), Caryophyllene (3.74%) and α-Bisabolene (2.52%).

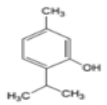
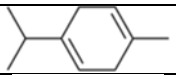
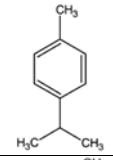
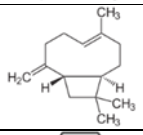
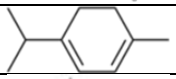
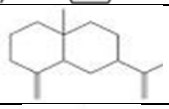
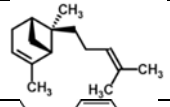
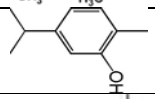
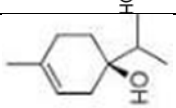
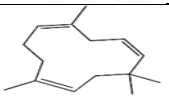
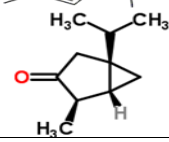
Table 8. The main chemical constituents of L. pubescens (Ibb) volatile oil.

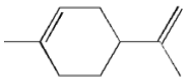
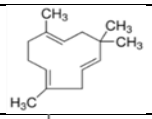
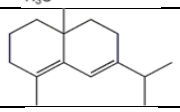
Constituents	%	Chemical structure
Carvacrol	70.00	
Caryophyllene oxide	5.48	
Caryophyllene	3.74	
Alph-Bisabolene	2.52	

The chemical constituents in *P. barbatus* volatile oil

Data in Table (9) showed that *P. barbatus* oil consists of fourty one constituents. The major constituents were thymol (48.7%), γ- Terpinen (20.0%), *p*-Cymene (9.2%) and (*E*)-Caryophyllene (6.4%). The minor constituents were α-Terpinene (2.8%), β-Selinene (2.1%), Myrcene (1.4%), Carvacrol (1.1%), α-*trans*-Bergamotene (1.1%), Terpinen-4-ol (1.0%), Caryophyllene oxide (0.9 %), α-Thujene (0.8%), Limonene (0.6%), α-Humulene (0.5 %), δ-Selinene (0.4 %), α-Pinene (0.3%), α-Phellandrene (0.3 %), δ-Cadinene (0.3%), *cis*-Sabinene hydrate (0.2%), Terpinolene (0.2%), Linalool (0.2%), β-Pinene (0.1 %), (E)-β-Ocimene (0.1%), cis-p-Menth-2-en-1-ol (0.1%), Borneol, α-Terpineol (0.1%), Thymol acetate, α-Copaene (0.1%), γ-Muurolene (0.1%), Germacrene D (0.1%), α-Muurolene (0.1%), γ-Cadinen (0.1%), τ-Cadinol (0.1%), 1,8-Cineole (tr), Sabinene (tr), trans-Sabinene hydrate (tr), Humulene epoxide II (tr), (Z)-β-Ocimene, p-Cymen-8-ol (tr), Camphene (tr) and δ-3-Carene (tr).

Table 9. The chemical constituents of P. barbatus volatile oil.

Constituents	%	Chemical structure
Thymol	48.7	
γ-Terpinene	20.0	
p-Cymene	9.3	
(E)-Caryophyllene	6.4	
α-Terpinene	2.8	
β-Selinene	2.1	
Myrcene	1.4	
α-*trans*-Bergamotene	1.1	
Carvacrol	1.1	
Terpinen-4-ol	1.0	
Caryophyllene oxide	0.9	
α-Thujene	0.8	

Limonene	0.6	
α-Humulene	0.5	
δ-Selinene	0.4	
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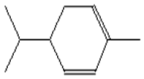
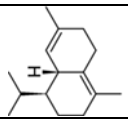
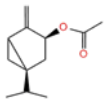
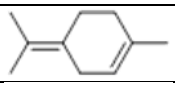
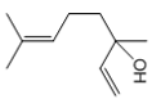
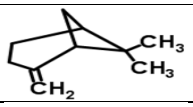
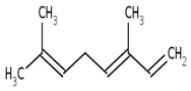
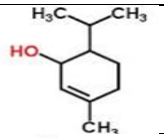
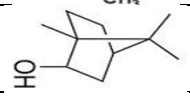
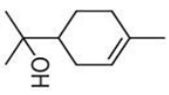
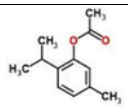
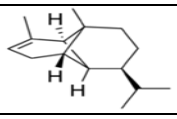
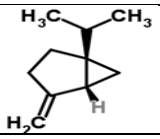
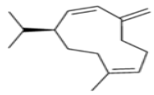
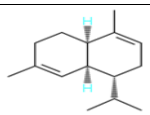
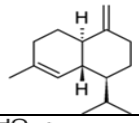
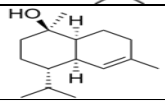
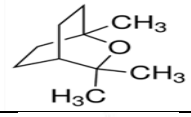
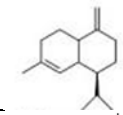
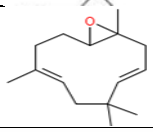
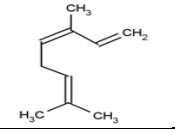
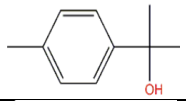
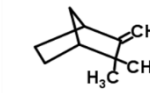
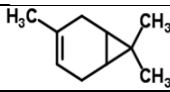
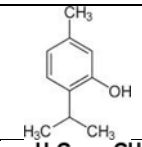
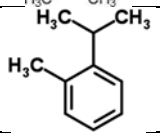
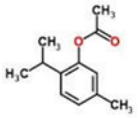
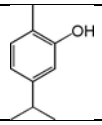
α-Phellandrene	0.3	
δ-Cadinene	0.3	
cis-Sabinene hydrate	0.2	
Terpinolene	0.2	
Linalool	0.2	
β-Pinene	0.1	
(*E*)-β-Ocimene	0.1	
cis-*p*-Menth-2-en-1-ol	0.1	
Borneol	0.1	
α-Terpineol	0.1	
Thymol acetate	0.1	
α-Copaene	0.1	

γ-Muurolene	0.1	
Germacrene D	0.1	
α-Muurolene	0.1	
γ-Cadinen	0.1	
τ-Cadinol	0.1	
1,8-Cineole	tr	
Sabinene	tr	
Humulene epoxide II	tr	
(*Z*)-β-Ocimene	tr	
p-Cymen-8-ol	tr	
Camphene	tr	
δ-3-Carene	tr	
Total Identified	100.0	

The main chemical constituents in *T. laevegatus* volatile oil

The major constituents obtained from *T. laevegatus* volatile oil were Thymol (52.46%), o-Cymene (8.97%), Thymol acetate (8.83%) and Cavacrol (4.96%) (Table 10).

Table 10. The main chemical constituents of Thymus laevegatus volatile oil.

Constituents	%	Chemical structure
Thymol	52.46	
o-Cymene	8.97	
Thymol acetate	8.83	
Cavacrol	4.96	

DISCUSSION

Our study showed that 28 (70%) of the burn patients examined had positive burn infection and 12 (30 %) of the burn patients examined had negative burn infection. This result is in agreement with Alghalibi et al. (2011) who found that 45 (64.29%) of burn patients examined had positive burn infection and 25 (35.71%) examined had negative burn infection.

In the present study burn wounds infections in males were in 25 burn wound patient (63%); 17 (68%) had positive infections while in females it was in 15 cases (37%); 11 (73%) had positive infections. This study is similar to the results reported by Alghalibi et al. (2011) and Zampar et al. (2017) showed that burns injuries infections in males cases120 (59.1%) were more than burns injuries infections in females cases 83 (40.9%). This may be due to males are exposed more to burns injuries and wear loose fitting clothes which easily catch fire. Also mostly food restaurant workers for cooking are males.

Our data found that the most isolated bacteria among burn wound patients with burn wound infection was *S. aureus* 20 (71%) followed by *P. aeruginosa* 8 (29%). This result similar to study (Norbury *et al*., 2016) showed that the most common bacteria isolated from burn wound infection patients were *P. aeruginosa* followed by *S.aureus.*

The current study found that 25 (63%) of the burn infection patients came from rural regions, 20 (80%) had positive infections while 15 (37%) came from urban regions, 8 (53%) had positive infections. In a similar study by (Alghalibi *et al*., 2011) who found that most of the victims 122 (61%) came from rural area and rest 78 (39%) were from urban area.

Our study showed that second-degree burns were the most common type in burn infection patients 18 (45%), 14 (78%) had positive infections, 13 (32%) burn infection patients had third-degree burns, 12 (92%) had positive infections and 9 (23%) had first-degree burns, 9 (23%) had positive infections. Similarly (Zampar *et al.,* 2017) found that the highest be present of burn wound infection showed in burn wound patients who had second degrees burns (64%).

Our results showed that flame burns wound were the most common type in burn infection patients 25 (62%), followed by chemical burns wound 8 (20%). These results are in similar to Zampar et al. (2017), who showed flame burns wound were the most common types in burn wound patients.

The major constituent of *L. pubescens* was carvacrol (70. %). These results differ to Serban et al. (2011) who showed the main chemical constituents of *lavandula* oil were β-Linalool (32.39%) and linalyl acetate (31.03%).

The major constituent of *P. barbatus* oil was Thymol (48.7%), our data disagree with Rodrigues et al. (2013) who observed that the major components of *P. barbatus* oil was eugenol (25.1%). The major compound of *Thymus laevegatus* essential oil was Thymol (52.46%)

Lavender aviation oil showed inhibitory activities against growth of *P. aeruginosa* and *S. aureus*. These results are similar to Benbelaid *et al*., 2012 who showed that oil has antibacterial activities against growth of *P. aeruginosa* and *S.*

aureus. Similar study by Serban et al. (2011) reported that *L. pubescens* oils had antibacterial activities against growth of *S. aureus*. These results differ to Pasoua *et al.,* (2005) who showed that lavander oil did not show any antibacterial activities against *P. aeruginosa* while they found similar results with thymus oil.

The high antibacterial activities of essential oil were caused by the high percentage of Carvacrol (70.0%). The present study has shown that the *P. barbatus* volatile oil have highly antibacterial activities. The high antibacterial activities of essential oil were caused by the high percentage of thymol (48%, 7%). In this investigation *T. lavigatus* volatile oil showed high antibacterial activity against *S. aureus*. These study results are similar to other findings determined by Imelouane et al. (2009) and Dorman and Deans (2000).

CONCLUSION

Our study findings showed that most of male patients have burn wound. The most common of burn wounds were infected by *S. aureus*, it is the major hospital bacteria in burns. Among the volatile oils, *P. barbatus* volatile oils had high antibacterial activates.

ACKNOWLEDGMENT

The authors are grateful to Professor William Zetzer, Department of Chemistry, The University of Alabama in Huntsville, USA and the nurse at Teiba Center for Burns Surgery in Al-Jumhory Hospital located in Sana'a city.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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