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Occurrence and Frequency of Outdoor and Indoor Airborne Fungi of Suez General Hospital, Suez, Egypt

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ABSTRACT

This study aimed to determine the occurrence and frequency of fungi in the outdoor and indoor (reception and intensive care) air of Suez General Hospital as well as to investigate the antifungal activity of some volatile oils against isolated toxigenic species. Samples were collected through passive sedimentation using settle plate method. Sabouraud dextrose agar (SDA) plates were exposed to air and incubated at 28°C for 7 days. 39 species represents 13 fungal genera were isolated from the outdoor and indoor air and the most common genera were *Aspergillus, Penicillium, Cladosporium, Alternaria,* and *Rhizopus*. The total colony forming units of airborne fungi of the outdoor, reception, and intensive care unit (ICU) were 2063.25, 1395.15, and 884.25 CFU/m^3, respectively. *Aspergillus flavus* recorded the highest occurrence with the highest frequency in the outdoor and indoor air and produced aflatoxins B^1 and B^2. Cinnamon essential oil showed high antifungal activity against the isolated toxigenic fungi and its fumigation inhibited the germination of spores of these fungi.

keywords: Bioaerosols, Contamination, Mycotoxins, Fumigation, Antifungal, Cinnamon.

INTRODUCTION

The progressive increase of fungal infections in hospitals and the high rates of morbidity and mortality with which they are associated in the last years encourage the researchers worldwide to study and identify the bioaerosols. Monitoring of bioaerosols in hospitals can give information for epidemiological examination of nosocomial infectious diseases, control of airborne fungi and as a quality control indicator (Li and Hou 2003; Cent-eno and Machado, 2004; Fernstrom and Goldblatt, 2013). Several studies have been conducted on the fungal contamination in outdoor and indoor environ-ments of the hospitals because most outbreaks of nosocomial fungal diseases have been attributed to airborne fungi from sources outside of the hospital (Dacarro *et al.,* 2003; Vonberg and Gastmeier, 2006; Goudarzi *et al*., 2017; Rostami *et al.,* 2017).

It has been reported that several fungi from different environmental sources may disperse over great distances by air currents and may be inhaled, ingested, or come in direct contact with individuals who have no contact with the infectious source. In indoor environments, the main source for microbes is usually the outdoor air (Su *et al.,* 2001; Shelton *et al.,* 2002). In the indoor air, microbes come and go, which is a natural phenomenon. Ventilation and cleaning are the usual removal processes of microbes in indoor environments. However, microbes may also grow indoors on building materials and structures. In such a situation, they may be responsible for different harmful effects causing negative aesthetic effects such as dirty appearance and unpleasant odors (Portnoy *et al.,* 2005). Although indoor environment may help in the occurrence and distribution of indoor fungi by growing them on building materials, flower pots, foodstuffs, house dust and pet bedding materials (Araujo and Cabral, 2010). The fungal genera *Aspergillus, Penicillium, Cladosporium* and *Alternaria* are the most dominant fungi in the atmosphere of hospitals and are potential human pathogens (Rainer *et al.,* 2000).

Undoubtedly, the main concern about microbial growth in indoor environments is related to the strong link to the adverse health effects in the occupants (Douwes and Pearce, 2003; Li and Yang, 2004). The importance of airborne fungi has been increased not only due to the health hazards caused by the spores themselves but also for their secondary metabolites. The airborne fungi may secrete numerous toxic secondary metabolites which can be harbored by the spores and causes toxicity when entering the host body (Araujo and Cabral, 2010). In addition, several volatile organic compounds and oils may be secreted by these fungi and their fumigation affects human health. Therefore, it is necessary to characterize and identify the contaminated microbes in the indoor environments of hospitals and to study their temporal fluctuation to achieve a more accurate exposure assessment of patients. So, the present investigation aimed to identify the common outdoor and indoor fungi of the Suez General Hospital.

MATERIALS AND METHODS

Sampling sites

The air sampling was carried out in triplicates during six visits at Suez General Hospital, Suez Governorate, and Egypt. Sampling was carried out in three different sectors; two different indoor sites (hospital reception and intensive care unit) and an outdoor site (hospital garden).

Air sampling and isolation of fungi

Air sampling from the different sectors at the hospital was performed at mid-day (hospital working time) using the settle plate method according to Hoekstra *et al.* (2004). Sabouraud dextrose agar (SDA) medium supplemented with chloroamphenicol (50 µg/ml) and rose

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bengal (10 µg/ml) (in order to minimize the appearance of bacteria) was used for catching and isolation of airborne fungi from the target hospital. The plates were exposed for 15 minutes in each exposure, positioned 170 cm height (roughly human respiration height) and then sealed and incubated at 28°C for 7 days. The appeared fungi were expressed as colony forming units per cubic meter of air (CFU/m^3) and estimated according to the equation, CFU/m^3 = a·10000/p·t·0.2 (Stryjakowska-Sekulska *et al.*, 2007). Where: a = the number of colonies on the Petri plate, p = the surface area of the Petri plate, 0.2 = constant and t = the time (duration) of Petri plate exposure.

Identification of the isolated fungi

All the isolated filamentous fungi were identified to the genus, species and varieties level based on the macroscopic features of their colonies and the microscopic morphological characteristics of their spores and hyphae according to Moubasher (1993) for fungi in general, Raper and Fennell (1965) for *Aspergillus* spp., Booth (1977) for *Fusarium* spp., Domsch et al. (1980) for fungi in general, Ellis (1976) for Dematiaceous hyphomycetes, Pitt (1985) for *Penicillium* spp.

Mycotoxins detection by the selected fungal isolates

Mycotoxin productions by the highly occurrence isolated fungi were detected to determine the percent of toxigenic fungi among the recovered isolates. Glucose-Czapek's broth medium supplemented with 0.2 % yeast extract and 1% peptone was used for mycotoxins detection by the selected fungal isolates (the highest frequency and occurrence). Each isolate was inoculated in 50 ml medium and incubated at 28±1°C for 10 days. The content of each flask was homogenized and sonicated with 100 ml chloroform, filtered and dried over anhydrous sodium sulfate. The chloroform layer was evaporated under vacuum and spotted on thin layer chromatography (TLC) plates G60 F254 for the qualitative analysis of mycotoxins. The plates were developed in TLC jars 5x22x22 cm in diameter (Zeiss, Jena, Germany) saturated with chloroform: methanol (97: 3, v/v). The developed plates were visualized under short wave length (254 nm) and long wave length (354 nm) ultraviolet irradiation (UV IS, Desage, Heidelberg, Germany). Mycotoxins were detected and identified in comparison with appropriate reference standards.

Antifungal activity of essential volatile oils against some fungi

Ten essential volatile oils including Mint (*Mentha sativa*), Basil (*Ocimum basilicum),* Jasmine *(Jasminum officinale*), (Rose damascene) (*Thymus* vulgaris), Jojoba (*Simmondsia chinensis*), Lavender *(Lavandula latifolia*), Thyme (*Thymus vulgaris*), Clove (*Syzygium aromaticum*), Cinnamon (*Cinnamomum verum*) and Rosemary (*Rosmarinus officinalis*), extracted previously with the same authors, were tested as antifungal for the selected toxigenic fungal isolates. The antifungal activity of chosen essential oils was evaluated against the tested fungi using the agar well diffusion method. Petri dishes with a diameter of 9 cm were inoculated by 500 µl of fungal spores (10^6) suspension and poured by Saboraud dextrose agar (SDA) medium. Agar wells (6 mm in diameter) were prepared using a cork-borer and inoculated by 100 µl of natural essential oil. After incubation for 3 days at 28°C, all plates were examined for formation of inhibition zones around the wells and the diameters of inhibition zones were measured in millimeters.

For determination of the minimal inhibitory concentration (MICs) of the tested volatile oils on the tested fungi, different concentrations (10, 20, 30, 50, 70 and 100 % v/v) of the oils were prepared using ethyl alcohol. 100 µl of each concentration was inoculated into the agar well of the seeded fungal inoculated plate. The plates were then incubated at 28ºC for 3 days. MICs were then recorded as the lowest concentration of the tested oil which inhibited fungal growth.

Effect of fumigation of the active volatile oils on spore germination of the tested fungi

In order to determine the antifungal activity of tested essential oils fumigation on the growth of the tested fungi, fungal spores of each tested fungus were inoculated onto the SDA plates in which 1ml of each oil was injected on the inside surface of the inverted lid. After incubation at 28°C for 4 days, the fungus colony diameter was examined in comparison with the control (Brito *et al.*, 2007).

RESULTS

Outdoor and indoor fungi of air of Suez General Hospital

Isolation of airborne fungi contaminated the outdoor and indoor atmosphere of Suez General Hospital was conducted and the results presented in table (1). It is obvious that 39 species and two varieties belonging to 13 fungal genera were recovered and identified. View on the diversity of generic level revealed that the genus *Aspergillus* showed the greatest spectrum by being represented by 11 species and two varieties followed by *Penicillium* which represented by 11 species. The third fungal genera in order were *Alternaria*, *Cladosporium* and *Rhizopus* represented by three species each. According to the species frequency *Aspergillus flavus* was the highest and recorded in the six visits (100 %). On the other hand, according to the colony forming units the genus *Aspergillus* was the highest in outdoor, reception and intensive care unit (ICU) with 707.4, 569.85, and 432.3 cfu/m^3, respectively, followed by *Penicillium* with 393, 216.15, and 196.5 cfu/m^3, respectively (Fig. 1).

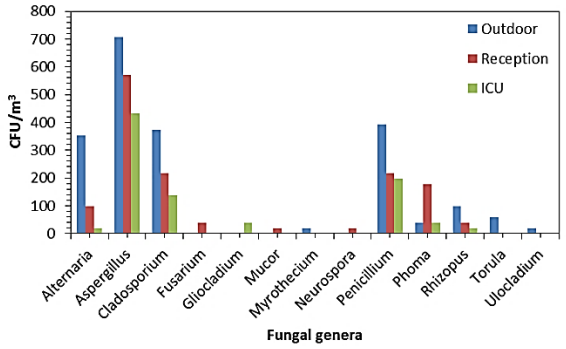

Figure (1): The total colony forming units (cfu/m^3) of the isolated fungal genera.

The fungal species *Alternaria phragmospora, Aspergillus carbonarius, Aspergillus flavus, Aspergillus niger, Cladosporium herbarum, Penicillium brevicompactum, Penicillium duclauxii, Penicillium expansum* and *Phoma herbarum* were the most common occurrence fungi and recovered from the air of outdoor, reception and ICU of the studied hospital. Comparison between the total colony forming units of the isolated fungi from air of out-door, reception and ICU cleared that the outdoor is more than the indoor sites and the total colony forming units of fungi in intensive care unit are less than of the reception. Also the data shown in figure (2) revealed that the lowest number of fungal genera and species was recovered from the air of intensive care unit whereas the highest number of fungal species was observed in the out-door.

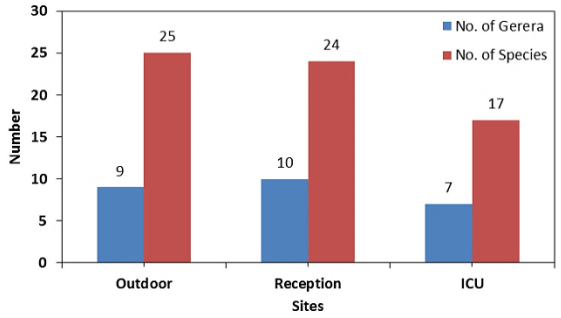

Figure (2): Number of fungal genera and species isolated from the outdoor and indoor air of Suez General Hospital.

It is clear that the survival airborne fungal genera in the intensive care unit were *Alternaria, Aspergillus, Cladosporium, Gliocladium, Penicillium, Phoma and Rhizopus. Penicillium* was the highest broad spectrum and presented by six species followed by *Aspergillus* by five species whereas the other remaining genera were represented by one species. All the isolated fungal species from the air of intensive care unit were in low occurrence and frequency except *A. flavus* which recorded in high concurrence (235.8 cfu/m^3) and high frequency (83.33 %) and followed by *Cladosporium herbarum* as moderate occurrence (137.55 cfu/m^3).

Mycotoxin production potential of some isolated fungi in the present investigation

A total of 57 isolates representing 33 species of the fungal genera *Aspergillus* (11 species), *Penicillium* (11 species), *Cladosporium* (3 species), *Alternaria* (3 species), *Phoma* (one species), *Fusarium* (one species), and *Rhizopus* (3 species), were examined for their potentiality to produce mycotoxins. The results showed that all the tested isolates of the four fungal genera *Cladosporium, Cochlibolus, Phoma* and *Rhizopus* could not produce any mycotoxin. On the other hand, the three tested isolates of each of *Aspergillus flavus, Penicillium chrysogenum, P. purpurogenum, P. steckii, Alternaria alternata*, and *Fusarium oxysporum* were able to produce mycotoxins and produced aflatoxin B^1 and G^1, sterigmatocystin, rubratoxin, alternariol, and diacetoxyscirpenol, respectively (Table 2). The remaining tested isolates of the other species of *Aspergillus* and *Penicillium* were unable to produce the examined mycotoxins.

Antifungal activity of some essential volatile oils against the isolated toxigenic fungi

The inhibition effect of ten essential volatile oils on some isolated toxigenic fungi was recorded in table (3). Among the tested essential volatile oils, jasmine, jojoba, lavender, thyme and rosemary showed no antifungal activity against any tested fungal isolate, while the essential oil of cinnamon was showed high significant antifungal activity against all the tested molds. The antifungal activity of the rose essential oil comes next to cinnamon and showed high significant antifungal activity against *Alternaria alternata, Aspergillus flavus, Penicillium chrysogenum, Penicillium purpurogenum* and *Penicillium* and *steckii*, whereas, it showed moderate antifungal activity against *Aspergillus niger*, and *Fusarium oxysporum*. Clove essential oil showed high antifungal activity against *Alternaria alternata* and showed moderate antifungal activity against *Fusarium oxysporum, Penicillium purpurogenum and Penicillium steckii* and recorded low antifungal activity against *Aspergillus flavus*, and *Penicillium chrysogenum.* Based on these observed results, the present study was extended to investigate the minimum inhibitory concentrations of the three active oils, cinnamon, rose and clove on the growth of the tested fungi.

Table (1): Total number of colony forming units (cfu/m^3) and frequencies percent (out of 6 visits) of airborne fungi of the outdoor, reception and intensive care unit of Suez General Hospital.

Genera and Species		Outdoor		Reception		Intensive Care Unit	
		CFU/M^3	Frequency %	CFU/M^3	Frequency %	CFU/M^3	Frequency %
Alternaria	*A. alternata*	98.25	50.00	39.3	33.33	0	0.00
	A. chlamydospora	216.15	33.33	0	0.00	0	0.00
	A. phragmospora	39.3	16.67	58.95	33.33	19.65	16.67
	A. carbonarius	137.55	50.00	78.6	50.00	78.6	33.33
	A. flavipes	19.65	16.67	0	0.00	19.65	16.67
	A. flavus var. columinaris	58.95	33.33	117.9	50.00	0	0.00
	A. flavus var. flavus	334.05	100.00	176.85	83.33	235.8	83.33
	A. japonicus	0	0.00	19.65	16.67	0	0.00
Aspergillus	*A. niger*	58.95	50.00	98.25	66.67	39.3	16.67
	A. oryzae	19.65	16.67	0	0.00	39.3	16.67
	A. parasiticus	0	0.00	0	0.00	19.65	16.67
	A. restricus	0	0.00	19.65	16.67	0	0.00
	A. sydowii	0	0.00	19.65	16.67	0	0.00
	A. ustus	58.95	16.67	0	0.00	0	0.00
	A. versicolor	19.65	16.67	39.3	16.67	0	0.00
	C. australiensis	19.65	16.67	0	0.00	0	0.00
Cladosporium	*C. cladosporides*	58.95	16.67	78.6	33.33	0	0.00
	C. herbarum	294.75	66.67	137.55	33.33	137.55	33.33
Fusarium	*F. oxysporum*	0	0.00	39.3	16.67	0	0.00
Gliocladium	*G. roseurm*	0	0.00	0	0.00	39.3	16.67
Mucor	*M. circinelloides*	0	0.00	19.65	16.67	0	0.00
Myrothecium	*M. verrucaria*	19.65	16.67	0	0.00	0	0.00
Neurospora	*N. cristae*	0	0.00	19.65	16.67	0	0.00
Penicillium	*P. brevicompactum*	117.9	33.33	39.3	33.33	19.65	16.67
	P. canescens	0	0.00	39.3	16.67	0	0.00
	P. chrysogenum	98.25	66.67	0	0.00	39.3	33.33
	P. duclauxii	58.95	16.67	19.65	16.67	39.3	16.67
	P. expansum	39.3	16.67	39.3	16.67	19.65	16.67
	P. funiculosum	0	0.00	39.3	16.67	58.95	33.33
	P. griseofulvum	0	0.00	0	0.00	19.65	16.67
	P. janthinellum	39.3	33.33	0	0.00	0	0.00
	P. puberulum	0	0.00	19.65	16.67	0	0.00
	P. purpurogenum	39.3	33.33	0	0.00	0	0.00
	P. steckii	0	0.00	19.65	16.67	0	0.00
Phoma	*P. herbarum*	39.3	16.67	176.85	50.00	39.3	16.67
	R. arrhizus	39.3	33.33	19.65	16.67	0	0.00
Rhizopus	*R. oryzae*	58.95	33.33	19.65	16.67	0	0.00
	R. stolonifer	0	0.00	0	0.00	19.65	16.67
Torula	*T. graminis*	58.95	33.33	0	0.00	0	0.00
Ulocladium	*U. atrum*	19.65	16.67	0	0.00	0	0.00
Total		**2063.25**		**1395.15**		**884.25**	

Table (2): *Mycotoxins* production by some isolated toxigenic fungi from the outdoor and indoor air of Suez General. Hospital

Fungal Species	Aflatoxin B1	Aflatoxin G1	Diacetoxyscirpenol	Sterigmatocystin	Trichodermin	Alternariol	Rubratoxin
Alternaria alternata	-	-	-	-	-	+	-
Aspergillus flavus	+	+	-	-	-	-	-
Fusarium oxysporum	-	-	+	-	-	-	-
Penicillium chrysogenum	-	-	-	+	-	-	-
P. purpurogenum	-	-	-	-	-	-	+
P. steckii	-	-	-	-	-	-	-

The minimum inhibitory concentrations (MIC) of the three active tested volatile oils against the selected fungi were determined by the agar well diffusion method and recorded in table (3). The MIC of cinnamon oil was 10 µl/ml medium against *Aspergillus flavus* and *Penicillium* steekii and was 5 µl/ml medium against *Alternaria alternata, Fusarium oxysporum*, *Penicillium chrysogenum,* and *Penicillium purpurogenum*. The MIC of rose oil was recorded as 100 µl/ml against *Aspergillus flavus* and *Penicillium purpurogenum*, 10 µl/ml for *Penicillium steckii* and 5 µl/ml for *Alternaria alternata, Fusarium oxysporum*, and *Penicillium chrysogenum.*

Table (3): Antifungal activity determined by inhibition zone (IZ) and Minimum inhibition concentration (MIC) of the selected three active volatile oils against the selected toxigenic fungi.

Fungal species	Rose oil		Clove oil		Cinnamon oil	
	IZ (mm)	MIC (µl/m)	IZ (mm)	MIC (µl/ml)	IZ (mm)	MIC (µl/ml)
Penicillium chrysogenum	31±0.2	5	14.5±0.3	5	35.5±0.5	5
Fusarium oxysporum	17±0.1	5	17.5±0.1	5	40±0.1	5
Aspergillus flavus	25.5±0.1	100	12±0.2	100	33±0.2	10
Alternaria alternata	25.5±0.1	5	31±0.2	5	36.5±0.1	5
Penicillium steckii	31 ±0.1	10	23±0.5	100	34.5±0.2	10
Penicillium purpurogenum	35±0.2	100	24.5±0.3	10	39±0.2	5

Effect of fumigation of the selected three active volatile oils on growth of the tested fungi.

The fumigation of both cinnamon and rose oils inhibited spores germination of all tested fungi. However, volatilization of clove oil suppressed the growth of *Penicillium chrysogenum* and inhibited spores germination of the remaining test fungi. It was obtained from the recorded data that the volatilization vapor of clove essential oil had fungi static activity whereas its direct application showed fungicidal activity (Table 4).

Table (4): Effect of fumigation of the selected antifungal oils on the growth of the isolated toxigenic fungi.

Fungal species	Fungal growth			
	Cont.	Rose	Clove	Cinnamon
Penicillium chrysogenum	+++	-	+	-
Fusarium oxysporum	+++	-	-	-
Aspergillus flavus	+++	-	-	-
Alternaria alternata	+++	-	-	-
Penicillium steckii	+++	-	-	-
Penicillium purpurogenum	+++	-	-	-

(+++): good growth, (+): low growth, (-) no growth.

DISCUSSION

The current study investigated the presence of mycobiota in indoor and outdoor air of the common hospital located in Suez, Egypt. The environments of the tested hospital were contaminated with different fungi from 13 genera. Several studies were conducted on the presence and diversity of fungi in outdoor and indoor air of hospitals in different countries of the world (Faure *et al.*, 2002; Augustowska and Dutkiewicz, 2006; Sautour *et al.*, 2009; Panagopoulou *et al.*, 2002; Kuleta *et al.*, 2009; Shams-Ghahfarokhi *et al*., 2014). In the present study, the fungal genera *Aspergillus, Penicillium* and *Cladosprium* recorded the highest frequency among the total isolated fungi followed by *Alternaria* and *Phoma* that is consistent with other studies (Gorny and Dutkiewicz, 2002; Perdelli *et al.*, 2006; Tormo-Molina *et al.*, 2012; Goudarzi *et al.*, 2017).

The predominance of these fungal genera may be due to their ability to produce numerous small and light spores that generally borne and scattered by the air, whereas *Alternaria*, *Phoma* and some other fungal genera produce fewer, larger and heavier spores which tend to have faster settling (Vonberg and Gastmeier, 2006). Among *the Aspergillus* species reported in the current study, *A. carbonarius* and *A. flavus* were isolated from the two hospitals with a frequency higher than those of other species. This is in accordance with the reports of other researchers on predominance of these species in hospital environments (Pakshir *et al.*, 2007; Sautour *et al.*, 2009; Omoigberale *et al.*, 2014; Paul *et al.*, 2015; Rostami *et al*., 2017).

The results of the present study show various levels of contamination in all the hospital different sites, even though some areas are equipped with air conditioning systems. Such contamination may be caused by a range of factors, such as, ineffective infection control programs, noncompliance with procedural norms, another reason is due to inefficient operation or inadequate maintenance of the air conditioning system, which can allows unfiltered outside air to enter patient rooms and the crowdedness of patients in reception areas. Another important reason is the using of multi-bed rooms in the intensive care units.

Different fungal genera and species in indoor and outdoor atmosphere especially *Penicillium* and *Aspergillus*

species were known as mycotoxin-producers (Nielsen, 2003). When fungi common in the atmospheres and house dust were cultivated in building materials, several mycotoxins were produced in vitro (Nielsen, 2003; Nieminen *et al*., 2002). However, the production of mycotoxins by indoor fungi growing in building materials is much lower (can be absent) than the production in culture medium, probably due to the much lower concentration of nutrients in the former conditions (Nielsen, 2003). Ren *et al.* (1999) even reported that no mycotoxin production from several *Aspergillus* strains (isolated from indoor air) growing on building materials (although most of the strains did produce mycotoxins when grown in culture media). *A. flavus* is occasionally isolated from building materials, and since this species produces the most potent naturally-occurring carcinogen, aflatoxin B^1 (Davis *et al*., 1966; Frisvad and Thrane, 2002). *A. ochraceus* is occasional isolated in a similar study from building materials, and produces a variety of mycotoxins including *ochratoxin A, penicillic* acid, *xanthomegnin*, viomellein, and vioxanthin (Frisvad and Thrane, 2002).

The tested isolates of *Alternaria alternata* produced alternariol, however the tested isolates of *A. chlamydospora* and *A. phragmospora* could not produce any mycotoxin. The *Alternaria* species predominates in buildings (Andersen *et al*., 2002; Nielsen *et al.,* 1999). On laboratory media, *Alternaria* species group produce *alternariols*, *tentoxin*, *tenuazonic* acids, *altertoxin* I, and a number of unknown metabolites (Andersen *et al*., 2002). The results also showed that the tested isolate of each of *Fusarium lateritium* and *F. poae* could not produce mycotoxin, whereas, the tested isolate of *F. oxysporum* produce diacetoxyscirpenol. Sautour *et al*. (2009) isolated the airborne fungi from outdoor air and indoor two haematological units in a France hospital and recorded *Fusarium* with low frequency in all cases.

Recently, different studies were conducted to use the essential oils extracted from different plants as a potential way to control fungal contamination (Burt, 2004; Soliman and Badea, 2002; Tajkarimi *et al.*, 2010). The antifungal activity of ten volatile oils (Mint, Basil, Rosemary, Jasmine, Jojoba, Lavender, Thyme, Rose, Clove and Cinnamon) against the isolated toxigenic fungi varied not only from one essential oil to another but also among fungal species. Jasmine, Jojoba, Lavender, Thyme and Rosemary essential volatile oils showed no antifungal activity against any tested fungal isolate. The present study showed that the essential oil of cinnamon was the most active antifungal against the tested fungi and showed high antifungal activity against all the tested molds. In our study we also found that the essential oil extracted from Cinnamon zeylanicum demonstrated strong antifungal activity on both the species of *Aspergillus*. The antimycotic activity of cinnamon bark due to the presence of cinnamaldehyde is well known (Viollon and Chaumont, 1994). Similarly, in vitro antimicrobial activity of *Cinnamon zelyanicum* (bark) against human pathogenic fungi and commensally bacteria was studied by Chaumont (2003) and Matan *et al*. (2006).

The antifungal activity of the rose essential oil comes next to cinnamon and showed high antifungal activity against the tested fungi. In a similar study, Shohayeb *et al*. (2014) tested the antifungal activity against some species of *Aspergillus* and *Penicillium* and reported that the rose oil exerted antifungal activity against the tested fungi. Sukatta *et al*. (2008) previously reported that the mixing of clove oil and cinnamon oil at appropriate ratios result in an improvement of the efficacy against the postharvest decay fungi of grapes *Aspergillus niger* and *Alternaria alternata.* The recorded data indicated that fumigation of the rose, clove and cinnamon oils inhibited the germination and growth of the tested toxigenic fungi and this mean that the using of these oils in mixing with the detergents and other disinfectants in hospitals decrease or inhibit the air pollution by fungi in hospitals, moreover, it will give a good odor without any side effects on the patients.

CONCLUSION

The present investigation was conducted to identify the outdoor and indoor airborne fungi Suez General Hospital in Suez Governorate, Egypt as well as to control the isolated fungi. The study revealed that a total of 13 fungal genera were isolated from the outdoor and indoor air of the two hospitals. *Aspergillus, Penicillium, Cladosporium, Alternaria* and *Phoma* were the most common genera and collected from all the studied sites of Suez General Hospital. Some isolated fungi had the ability to produce mycotoxins for example the isolated *Aspergillus flavus* produced *aflatoxin* B. Antifungal activity of some essential oils against the toxigenic fungi was studied and the obtained results revealed that rose, clove and cinnamon oils were active against these fungi and the fumigation of these oils inhibited the spores germination of these fungi. The present study recommends the mixing of these volatile oils with the used disinfectants in the hospitals which will give a safe enjoyable odor by its fumigation and control the fungal contamination.

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تواجد وكثافة الفطريات المحمولة في الهواء الخارجى والداخلى لمستشفى السويس العام، السويس، مصر

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الملخص العربي

هدفت هذه الدراسة إلى تحديد تواجد وكثافة الفطريات في الهواء الطلق والداخلي (الاستقبال والرعاية المركزة) في مستشفى السويس العام وكذلك للكشف عن النشاط المضاد لبعض الزيوت الطيارة ضد الأنواع الفطرية المعزولة والمفرزة للسموم. تم جمع العينات من خلال الترسيب المباشر باستخدام طريقة ترسيب الاطباق. تم تعريض اطباق الوسط الغذائى السابورود دكستروز أجار (SDA) للهواء وحضنت عند ٢٨ درجة مئوية لمدة ٧ أيام. تم عزل عدد ٣٩ نوعا فطريا تمثل ١٣ جنس من الهواء الخارجي والداخلي وكان الأكثر شيوعا هى أجناس الاسبيرجيلس، بنيسيليوم، كلاذوسبوريوم، التيرناريا وريزوبوس. كما بلغ مجموع الوحدات لتكوين المستعمرات من الفطريات المحمولة جواً في الهواء الطلق ووحدة الاستقبال ووحدة العناية المركزة كالاتي:٢٠٦٣.٢٥ و ١٣٩٥.١٥ و ٨٨٤.٢٥ خلية / م ٣ على التوالي. وسجل النوع الفطرى أسبيرجيلس فلافس أعلى معدل مع أعلى كثافة في الهواء الخارجى والداخلي وكان له القدرة على انتاج الأفلاتوكسينات B1 و B2. وأظهر زيت القرفة نشاطًا عاليًا ضد الفطريات المعزولة المفرزة للسموم الفطرية، وكما أدى تبخير الزيت إلى تثبيط إنبات جراثيم هذه الفطريات.