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Indoor Airborne Microfungi in Different Sections of a Poultry Processing Plant in Sakarya City, Turkey

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Abstract: This study was performed in order to determine indoor airborne fungal concentrations in a poultry processing plant operating in Sakarya City–Turkey. Air samples were taken from April to September 2010 using a microbial air sampler from 6 different sections-animal reception, shocking and slaughter, harslet cleaning, dry cooling and ozonization, meat fragmentation and packing rooms - of the plant. The isolated microfungal specimens were identified and found to belong to 12 genera and 47 species. The identified microfungus measurement and relative percentages are as follows: *Penicillium* 87 CFU/m^3 at 25.51 %, *Aspergillus* 69 colony forming unit-CFU/m^3 at 20.23 %, *Cladosporium* 59 CFU/m^3 at 17.3 %, *Scopulariopsis* 28 CFU/m^3 at 8.21 %, *Alternaria* 25 CFU/m^3 at 7.33 %. Above five microfungi orders make up 78.59 % of the total microfungi flora found in our study.

Key Words: Poultry Processing Plant, Indoor Air, Food Hygiene, Airborne Fungi

Türkiye Sakarya İlindeki Bir Kümes Hayvanı Kesim Tesisinin Farklı Bölümlerindeki İç Ortam Havasındaki Mikrofunguslar

Öz:Bu çalışma Sakarya – Türkiye deki bir Kümes Hayvanı Kesim Tesisinin iç ortam havasındaki fungal konsantrasyonun tespit edilmesi için yapılmıştır. Araştırma materyali, kümes hayvanı kesim tesisinden seçilen; canlı hayvan alınımının yapıldığı yer, şoklama ve kesim odası, sakatat temizleme odası, kuru soğutma ve ozonlama odası, et parçalama odası, paketleme odası olmak üzere toplam 6 farklı alandan hava örnekleyici kullanılarak Nisan 2010 – Eylül 2010 tarihleri arasında toplanmıştır. İzole edilen mikrofungal örnekler tanımlanmış ve 12 cinse ait 47 tür tespit edilmiştir. Teşhis edilen mikrofungus cinsleri için genel dağılımda ilk sırayı 87 CFU/m^3 ve % 25,51*Penicillium*cinsi almış olup bunu 69 CFU/m^3 ve % 20,23 ile *Aspergillus* ikinci,59 CFU/m^3 ve % 17,3 ile *Cladosporium* üçüncü, 28 CFU/m^3 ve % 8,21 ile *Scopulariopsis* dördüncü, 25 CFU/m^3 ve % 7,33 ile *Alternaria* beşinci sırayı izlemiştir. Sıralamada ilk beş sırada yer alan bu mikrofunguslar toplam koloni sayısının % 78,59'unu oluşturmuştur.

Anahtar Kelimeler: Kümes Hayvanı Kesim Tesisi, İç Ortam Havası, Besin Hijyeni, Hava ile Taşınan Funguslar

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Introduction

The microbial quality of air is very important to ensure the safety and quality of food industrial processes (Altunalmaz et al. 2012). Airborne microorganisms are rarely free in the atmosphere and they generally reside on carriers of varying volumes and masses (Atik 1993). Dusts, one of these carriers are big particles of mineral nature with 10-200 µm diameters. Vegetable fibres, animal tissue wastes, feathers, pollens and skin epithelial particles are among potential dust resources. Dust particles can promote spore formation, viability and reproduction of organisms fixed on. In calm weather conditions, dust particles settle down vertically on solid surfaces at different speeds depending on their sizes. When the weather conditions become windy and in environments where air circulations are notable, such particles are transported in both vertical and horizontal directions (Onoglu & Gungor 2007).

The microbial load of air is influenced by the microflora of food items depending on the exposure time with them. In food processing plantations, aerosol formation, which is responsible for microorganism release, occurs in relation to some factors such as spray washing and cooling, use of high pressure sprayers for cleaning, washing of floor drainers and channels, use of mixers and motors and operation of other equipments (Temiz, 2001).

Microbial type and amount are important indicators of quality and hygiene in food industry. Food items of humans and animals are vulnerable for fungal invasion. Foods can undergo spoilage caused by various fungal agents during the time they reach consumers. Microbial growth taking place in food and food stores during storage can also lead to big amounts of spoilage (Ozkaya & Comert 2008).

Microbial contents of indoor air of different parts of a food processing plantation greatly differ from each other. The microbial concentrations in departments where hygiene control is provided are generally low but when raw food particles collected from sites where animals also live are transported to such relatively clean departments, microbial load of these departments increase inevitably. Microbial content of any place can be decreased by establishing an air current from clear areas to places with high contamination. Undesired contaminations that may occur in production and office departments can be prevented by using positive air pressure because if this is done, then, when doors are opened indoor air moves outside preventing outdoor air to come in. Also, microbial contamination can be minimized by filtering the air flows directed to production and office departments.

Workers in food processing activities are another source of aerosols. In addition, movements of any kind of equipments and humans cause turbulence air currents which in turn increase the microbial load of indoor air. In contrast to this, workers exposed to some non-infectious microorganisms and their components by inhalation may cause inflammation of the respiratory system.

Foods of animal origin can also constitute a source for chemical and biological contamination. Animal foods are contaminated by microorganisms by means of contact with animal skins, hair and feathers. Ingestion of contaminated animal foods increases types and numbers of microflora of digestive systems of animals. Microorganisms are also to carcase during slaughter. Tissues of healthy animals are free of microorganisms but surfaces of meats prepared for human consumption are generally contaminated by a number of bacteria, yeasts and fungi. The amount of contamination depends on the type of processing and storage duration and conditions (Ayhan 2000).

The outer surfaces of newly cut chickens, turkeys, geese and ducks posses not only the natural flora of these animals but also the microbial contamination taka place during slaughter, plucking and cutting processes (Ray, 2004).

Many food items undergo different treatments until they reach to consumers and the possibility of contamination in each of these treatment steps increases. Hygiene should be provided in each step of meat processing and the treated meats should be kept under suitable storage conditions. Chilling food items decreases their microbial loads but whatever the chilling temperature is, it is almost impossible to get rid of all microorganisms from such foods (Erol 2007).

The investigation of microbioflora of places where above treatment steps are performed will allow identification of microorganisms in these environments and determination of their concentration levels. Knowledge and monitoring of types and numbers of microorganisms in an environment will play important role in planning which measures might be taken.

Materials and Methods

The study material was obtained from six different departments – animal reception (AR), shocking and slaughter (SS), harslet cleaning (HC), dry cooling and ozonization (OR), meat fragmentation (FR) and packing rooms (PR) - of a poultry farm. Indoor air samples were taken bimonthly during a six months period.

A "Microbial Air Sampler" (MILLIPORE © Microbial Air Sampler) was used for airborne microfungal sampling and isolated microfungi were incubated at 25^{0}C for 7 days on plates containing Rose Bengal Peptone Dextrose Agar. For each sampling, 8 plates were used 6 of which were for different departments and 2 for sanitized and unsanitized meats, making the total sampling plate number 96. The numbers of microfungal colonies isolated during the whole study are given in Table 1. The microbial air sampler was preferred due to its practical usage and transportation ease. The most important feature of the sampler is that it allows adjusting the amount of air volume sampled at a time, thus giving a definite value for the microbial concentration present in the air volume sampled. The sampler aspirates a definite volume of air *per* time at a certain rate and allows the particles in the aspirated air sample to settle on the growth media used inside the sampler. The amount of air sampled for each sampling is 100 L (Onoglu & Gungor 2007). For each sampling performed, temperature and relative humidity values of the sampling departments were also recorded.

Isolation

For isolation of airborne microfungi in the selected departments of the poultry farm, Rose-Bengal Streptomycin Agar plates were placed in 90 mm cassettes of the sampler and the sampler was operated until a 100 L of air was aspirated. Samplings were performed in morning hours, from 8 to 11 a.m., at 1.30 m above ground level in the centre of the sampling departments. Microfungi sampled were incubated for 7 days in total darkness at 25^{0}C. At the end of the incubation, microfungal colonies were counted and their numbers were expressed as CFU (Colony Forming Unit)/m^3. Isolated microfungi were transferred to PDA slants and left at 25^{0}C for 10 days before placing at 4^{0}C to be used as stock cultures. All counted colonies were investigated macro- and microscopically for species identifications.

Identification

Microfungal specimes of the Dematiaceous Hyphomycetes group were inoculated to PDA and MEA media and incubated at 25^{0}C for 10-14 days. Isolated *Aspergillus* specimens were inoculated to CZ, CYA, CY$_{20}$S and MEA media and incubated at 25^{0}C for 7 days. For identifications of *Penicillium* species CYA, G$_{25}$N ve MEA media were used. For each species, 3 CYA, 1 G$_{25}$N and 1 MEA plates were used (Pitt, 1979 and 2000). The inoculations on CYA media were incubated at 5^{0}C, 25^{0}C and 37^{0}C whereas those on G$_{25}$N and MEA media were incubated at 25^{0}C for 7 days.

At the end of the incubations, each colony was investigated macroscopically for colony size (in mm), shape, upper and lower surface colors and presence of exudation and pigmentation. Colonies were also investigated microscopically for colony texture and types of conidial heads. The light microscopy investigations allowed determining morphological parameters such as conidiophore lengths, widths, phyalid lengths, conidial shapes and size. "The Genus *Penicillium* and Its Teleomorphic States *Eupenicillium* and *Talaromyces"* (Pitt 1979), "A Laboratory Guide To Common *Penicillium* Species" (Pitt 2000) were used for identification of *Penicillum* species, "The Genus *Aspergillus*" (Raper & Fennell 1965), "Identification of common *Aspergillus* species" (Klich 2002) and "Introduction to Food and Airborne Fungi" (Samson et al., 2010) were used for identification of *Aspergillus* species, "The Genus *Fusarium*" (Booth 1971), *Fusarium* species- An Illustrated Manual for Identification" (Nelson et al., 1983), "The *Fusarium* Laboratory Manual" (Leslie and Summerell, 2006), and "The Genus *Fusarium* a Pictorial Atlas" (Gerlach & Nierenberg 1982), were used for identification of *Fusarium* species. "Dematiaceous Hyphomycetes" (Ellis 1971), "*Alternaria* an Identification Manual" (Simmons 2007) and "The Genus *Cladosporium* and Similar Dematiaceous Hyphomycetes" (Crous et al. 2007) were used for identifications of *Alternaria* and *Cladosporium* species. On the other hand, "Illustrated Genera of Imperfect Fungi" (Barnett & Hunter 1999) was consulted for classification of the isolated microfungi at genus level.

Results

The colonial counts of the 72 plates used during the whole study showed that a total of 341 microfungi colonies were isolated from 7200 L air sampled (47.36 CFU/m^3). The distributions of the isolated colonies according to sampling months and stations were given in Table 1.

Table 1. The colonial counts of isolated microfungi according to sampling months and stations in terms of CFU/m^3. AR: Animal reception, SS: shocking and slaughter, HC: harslet cleaning, OR: ozonization room, FR: meat fragmentation room and PR: packing room.

Month	Day	AR	SS	HC	OR	FR	PR	Total
April	11	16	9	3	_	10	4	42
	25	14	8	3	_	1	1	27
May	16	12	2	9	_	2	2	27
	30	10	9	13	_	3	3	38
June	13	6	6	6	_	3	3	24
	27	7	4	5	_	3	2	21
July	11	7	3	3	_	1	1	15
	25	8	3	4	_	1	5	21
August	15	10	7	7	_	4	4	32
	29	10	7	5	_	4	4	30
September	12	9	6	7	_	4	3	29
	26	11	9	8	_	4	3	35
Total		120	73	73	_	40	35	**341**

The highest microfungal colonies were isolated in animal reception room (120 CFU/m^3, 35.19 %) followed by shocking and slaughter room, harslet cleaning room, meat fragmentation room and packing room with 73 CFU/m^3 (21.40 %), 73 CFU/m^3 (21.40 %), 40 CFU/m^3 (11.73 %) and 35 CFU/m^3 (10.26 %), respectively. The results showed that April was the month during which the highest number of microfungal colonies was isolated (69 CFU/m^3), followed by May, September, August, June and July with 65, 64, 62, 45 and 36 CFU/m^3, respectively.

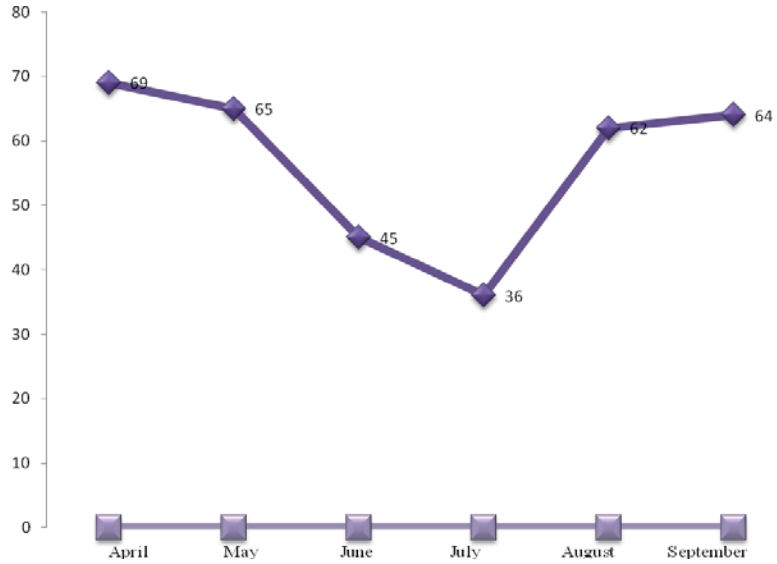

Figure 1. The montly distributions of microfungal colonies isolated during the whole study period. Values were given in terms of CFU/m^3.

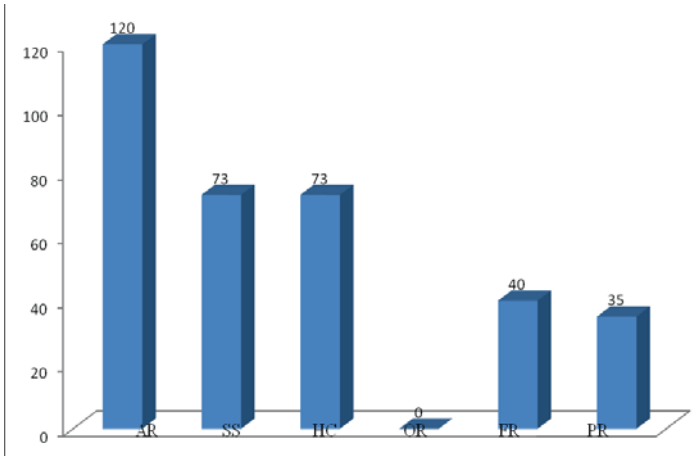

Figure 2. The numbers of isolated microfungal colonies according to sampling stations. Values were given in terms of CFU/m^3.

(Letters indicate: AR: Animal reception, SS: Shocking and slaughter, HC: Harslet cleaning, OR: Dry cooling and ozonization, FR: Meat fragmentation, PR: Packing rooms)

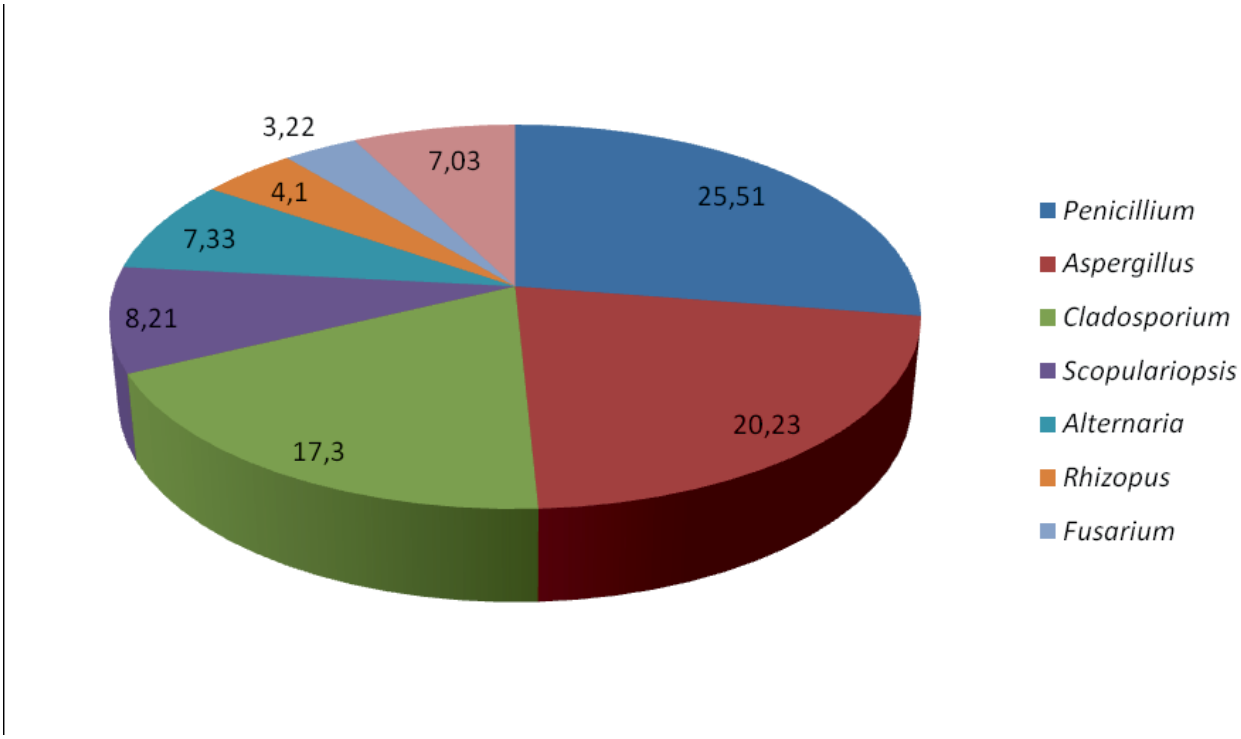

Figure 3. The abundances of isolated microfungal colonies during the study period in terms of percentages.

The identifications of isolated colonies were performed using relevant literature and a total of 46 species within 11 genera were identified (Tables 2 and 3). The genus *Penicillium* was represented with the highest number of colonies (87 CFU/m^3; 25.51 %) followed by *Aspergillus* (69 CFU/m^3; 20.23 %), *Cladosporium* (59 CFU/m^3; 17.3 %), *Scopulariopsis* (28 CFU/m^3; 8.21 %) and *Alternaria* (25 CFU/m^3; 7.33 %). Among the isolated genera, *Aspergillus, Cladosporium* and *Penicillium* members were observed in all months of the study period.

The sampling departments differed from each other in terms of the microfungal species isolated with the high CFU/m^3 values (Table 4). For instance, *Alternaria alternata* was the leading species in shocking and slaughter room with 8 CFU/m^3, followed by *Aspergillus flavus* and *Verticillum albo-atrum* with 7 and 5 CFU/m^3, respectively, while *Cladosporium cladosporioides* was isolated in animal reception room with 12 CFU/m^3, *Mycelia sterilia* in harslet cleaning room with 13 CFU/m^3, *Penicillium glabrum* in fragmentation room with 9 CFU/m^3 and *Scopulariopsis brevicaulis* in animal reception room with 16 CFU/m^3.

When the isolated genera are compared according to the representative species, it appeared that the most diversed genus was *Penicillium* with 25 species followed by *Cladosporium* and *Aspergillus* with 8 and 7 species, respectively.

Table 2. The isolated microfungal genara, the species numbers for each genus and the months they were isolated.

Genus name	Species number	Isolation month
Alternaria **Nees**	2	5, 8, 9
Aspergillus **Fr.:Fr**	7	4, 5, 6, 7, 8, 9
Cladosporium **Link**	8	4, 5, 6, 7, 8, 9
Fusarium **Link**	_	4, 7, 9
Geotrichum **Link**	1	4, 5, 7
Mucor **P. Micheli ex L.**	_	6, 9
Mycelia sterilia	1	4, 5, 6, 7, 8, 9
Penicillium **Link**	25	4, 5, 6, 7, 8, 9
Rhizopus **Ehrenberger**	_	4, 5, 6, 7
Scopulariopsis **Bainier**	2	4, 5, 6, 7, 9
Ulocladium **Preuss**	1	4, 6, 7
Verticillium **Nees**	1	6, 9

Table 3. Isolated microfungal species and their isolation months.

Species name	Isolation month
Alternaria alternata **(Fr.) Keissler**	5, 8, 9
A. citri **Ellis&N.Pierce**	5, 9
Aspergillus flavus **Link**	5, 6, 7, 8, 9
A. fumigatus **Fresen.**	7, 8
A. niger **VanTieghem**	5, 6, 8, 9
A. ornatus **Raper, Fennell & Tresner** (***Sclerocleista ornata*** (Raper, Fennell & Tresner) Subram., Curr. Sci. 41 (21): 757 (1972))	7
A. tamarii **Kita**	7
A. versicolor **(Vuill.) Tiraboschi**	4, 6, 9
A. wentii **Wehmer**	5, 9
Aspergillus sp.1	8
Aspergillus sp. 2	8
Cladosporium cladosporioides **(Fres.) De Vries**	4, 5, 6, 7, 8, 9
C. cucumerinum **Ellis &Arthur**	4, 5, 8, 9
C. elatum **(Harz) Nannf.** (***Ochrocladosporium elatum*** (Harz) Crous & U. Braun, in Crous, Braun, Schubert & Groenewald, Stud. Mycol. 58: 46 (2007))	4, 5, 6, 7, 8, 9
C. ramotenellum **Crouss & U.Braun**	5
C. uredinicola **Speg.**	4, 5, 9
C. spongiosum **Berk & Curt.**	5, 6, 7
C. variabile **(Cooke) G.A. de Vries** (***Davidiella variabile*** Crous, K. Schub. & U. Braun, in Schubert, Groenewald, Braun, Dijksterhuis, Starink, Hill, Zalar, de Hoog & Crous, Stud. Mycol. 58: 152 (2007))	8, 9
Fusarium sp.1	4, 7, 9
Fusarium sp. 2	9
Geotrichum candidum **Link.**	4, 5, 7
Mucor sp.	6, 9,

Table 3. (continues)

Mycelia sterilia	4, 5, 6, 7, 8, 9
Penicillium aurantiogriseum **Dierckx**	5, 8
P. brevicompactum **Dierckx**	4, 5, 8
P. citrinum **Thom**	6, 8, 9
P. chrysogenum **Thom**	6
P. decumbens **Thom**	8, 9
P. duclauxii **Delacroix**	7
P. echinulatum **Fasatiova**	4
P. expansum **Link**	4, 8, 9
P. fellutanum **Biourge**	8, 9
P. glabrum **(Wehmer) Westling**	4, 5, 7, 8, 9
P. griseofulvum **Dierckx**	4, 5, 6
P. implicatum **Biourge**	4, 5
P. lividium **Westling**	6
P. oxalicum **Currie & Thom**	9
P. piceum **Raper & Fennell**	9
P. purpurogenum **Stoll**	8
P. rugulosum **Thom**	6
P. simplicissimum **(Oudem) Thom**	8
P. solitum **Westling**	5
P. spinulosum **Thom**	4
P. thomii **Maire**	8
P. variabile **Sopp**	9
P. verruculosum **Peyronel**	9
P. viridicatum **Westling**	4, 5, 6, 7
P. waksmanii **K.M. Zalessky**	5
Rhizopus sp.	4, 5, 6, 7
Scopulariopsis brevicaulis **(Sacc.) Bain**	4, 5, 6, 7, 9
S. chartarum **Morton & G. Smith**	5, 7
Uladodium chartarum **(Preuss) Simmons**	4, 6, 7
Verticillium albo-atrum **Reinke & Berthold**	6, 9

Table 4. The isolated microfungal species with respect to the stations (CFU/m^3).

Genus and/or species name	AR	SS	HC	OR	FR	PR	TOTAL
Alternaria alternata	5	1	8	-	-	1	**15**
A. citri	3	2	4	-	1	-	**10**
Aspergillus flavus	2	5	7	-	1	3	**18**
A. fumigatus	2	3	2	-	-	2	**9**
A. niger	5	2	7	-	2	-	**16**
A. ornatus	-	1	-	-	2	-	**3**
A. tamarii	-	-	-	-	1	-	**1**
A. versicolor	6	4	1		2	1	**14**
A. wenti	1	5	-	-	-	-	**6**
Aspergillus sp.1	-	1	-	-	-	-	**1**
Aspergillus sp.2	-	-	1	-	-	-	**1**
Cladosporium cladosporioides	12	3	7	-	1	1	**24**
C. cucumerinum	8	1	-	-	-	-	**9**
C. elatum	7	1	1	-	-	1	**10**
C. ramonetellum	-	1	-	-	-	-	**1**
C. uredinicola	4	-	1	-	-	1	**6**
C. spongiosum	5	-	2	-	-	-	**7**
C. variabile	2	-	-	-	-	-	**2**
Fusarium sp.1	3	-	1	-	-	-	**4**
Fusarium sp.2	-	4	3	-	-	-	**7**
Geotrichum candidum	1	-	3	-	-	-	**4**
Mucor sp.	2	-	5	-	-	-	**7**
Mycelia sterilia	7	2	13	-	2	-	**24**
Penicillium aurantiogriseum	4	-	-	-	1	-	**5**
P. brevicompactum	2	5	2	-	1	1	**11**
P. citrinum	-	4	-	-	2	3	**9**
P. chrysogenum	-	-	-	-	1	1	**2**
P. decumbens	-	-	1	-	1	-	**2**
P. duclauxii	-	-	-	-	-	2	**2**
P. echinulatum	-	-	-	-	-	1	**1**
P. expansum	1	2	-	-	-	1	**4**
P. fellutanum	1	-	-	-	-	2	**3**
P. glabrum	-	-	1	-	9	3	**13**
P. griseofulvum	-	-	-	-	4	-	**4**

Table 4. (continues)

P. solitum	1	-	-	-	-	-	**1**
P. spinulosum	-	-	-	-	3	-	**3**
P. thomii	-	-	-	-	1	-	**1**
P. variabile	-	-	-	-	1	-	**1**
P. verruculosum	-	-	-	-	1	1	**2**
P. viridicatum	2	1	3	-	1	4	**11**
P. waksmanii	-	-	-	-	-	1	**1**
P. furcatum sp.	-	-	-	-	-	1	**1**
Rhizopus sp.	13	1	-	-	-	-	**14**
Scopulariopsis brevicaulis	16	9	1	-	-	-	**26**
S. chartarum	1	1	-	-	-	-	**2**
Ulocladium chartarum	-	1	1	-	-	1	**3**
Verticillium albo-atrum	-	5	1	-	-	1	**7**
Unidentified	1	2	-	-	-	-	**3**
TOTAL	**120**	**73**	**73**	-	**40**	**35**	**341**

Discussion

Microfungi are densely present in air environment and can make use of any kind of organic matter as a substrate. It is therefore environments in which food items exist provide a potential for growth of airborne fungal spores. Foods have pronounced importance in terms of both public health and economy. From this point of view, the present study was undertaken in a poultry farm to evaluate its airborne microfungal flora. Air samplings over a 6 month period from different parts of the farm showed that the microfungal flora of the sampled was represented with air 341 CFU/m^3 microfungi colonies from 12 genera and 47 species. The most common isolated genus was *Penicillium* with 87 CFU/m^3 (25.51 %) followed by *Aspergillus* with 69 CFU/m^3 (20.23 %), *Cladosporium* with 59 CFU/m^3 (17.3%), *Scopulariopsis* with 28 CFU/m^3 (8.21 %) and *Alternaria* with 25 CFU/m^3 (7.33 %). These five most common genera, also shown to be the common in- and outdoor airborne microfungal taxa in studies performed so far (Okten & Asan, 2011), constituted the 78.59 % of the microfungal colonies isolated.

Kaliner (1987) reported, as a similar pattern in our present study, that *Cladosporium, Alternaria, Penicillium, Aspergillus, Rhizopus, Chaetomium, Curvularia, Fusarium, Phoma, Rhodotorula, Aureobasidium* and *Trichoderma* were the most common isolated indoor airborne microfungi taxa. Members of the genera *Aspergillus, Cladosporium* and *Penicillium* were found to be present in the air of the farm during the whole study. The same parallelism in terms of the common and continually isolated taxa can be seen in studies performed in Turkey. For instance, Simsekli et al. (2000) reported that *Alternaria, Cladosporium* and *Penicillium*, in addition to sporeless microfungi, were isolated in all moths of their study period.

It is well established that the airborne spore concentrations depend on temperature and concentrations greatly increase with increasing air temperatures (Beamount et al. 1985; Davis 1986; Halwagy 1989; Li & Kendrick 1995). However, there is a limitation of temperature increase on spore concentrations. High temperature, low rainfall and humidity negatively affect spore concentrations. The combination of negative effects of the average temperature in June during our study (25^{0}C) and the generally high daytime temperature led to a pronounced decrease in spore concentrations in this month. The average temperature in July, recorded as 25^{0}C, led to a further decrease in spore counts and the lowest numbers of colonies were isolated in July.

The source for bioaerosoles in indoor air can be either internal or external environments. The presence of indoor microfungi in buildings in woody and wetland areas mainly depend on outdoor originating sources. The general sources for commonly isolated taxa such as *Aspergillus* and *Penicillium* in dry buildings were found to be of outdoor origin (Mentese & Gullu 2006). The dense and rich vegetation characteristics around the farm sampled in the present study support the conclusion that the commonly isolated *Aspergillus* and *Penicillium* members during our whole sampling period originated most probably from outdoor sources.

Penicillium members were reported to be isolated in high numbers in winter season during which temperature was low but humidity levels were high (Okten & Asan 2011). We found a positive correlation between the mean humidity values and the number of *Penicillium* colonies isolated (p=0.004, p=0.041) showing that increasing humidity increased the concentration of *Penicillium* in the air sampled. On the other hand, a negative correlation was found to exist between mean insolation time and *Penicillium* presence (p=0.015). These two results led us to conclude that the high presence of *Penicillium* in fragmentation nand packing rooms were related with the low environmental temperature (8°C) and relatively high humidity (70 %) of these two departments.

In the study performed in order to detemine the relationship between meteorogical factors and airborne fungal allergens, it was found that the species diversity was high in environments where relative humidity was high (Kalyoncu 2009). We also recorded the highest species diversity in fragmentation and packing rooms where temperature was low but humidity was high.

Cladosporium is the most dominant genus worldwide among the outdoor microflora. Members of this genus were found the represent almost 50 % of the microflora of some places in Spain particularly during spring period (Paya et al. 1984). In Italy, contrarily, *Alternaria* was the genus whose members were isolated in high numbers (15-17 %) during spring (D'amato et al., 1984). Spores of these two genera are dark in colour making them resistant to dryness and thus they are isolated in summer season in high numbers. In addition, they are isolated in indoor environments in low and in outdoor environments in high numbers since their spore sizes are larger compared to those of *Aspergillus* and *Penicillium.* The highest number of *Cladosporium* isolation took place in our study was in animal reception and whereas the resting departments were relatively poor in terms of *Cladosporium* spore counts. This fact and the fact that animal reception department was the only site where an outdoor connection existed support the conclusion that *Cladosporium* spores in the farm originated from outdoor sources. We found a positive correlation between *Cladosporium* spore counts and monthly average temperature values meaning that incresding temperature increased *Cladosporium* spore concentrations (p=0.014).

Klaric and Pepeljnjak (2006) reported that *Alternaria* members in Zagreb reached their peak levels in August and September under promoting affects of temperature and solar radiation. The same pattern was found for the members of this genus in our study in August and September isolations.

A total of 185 *Aspergillus* species have been identified so far (Kantarcioglu & Yucel 2003). *A. flavus, A. niger* and especially *Aspergillus fumigatus* are the most important pathogens species of the genus and were isolated in our study.

Human presence is known to be the most important parameter increasing indoor levels of bioaerosoles if no other in- and/or outdoor sources are present. The more the number of occupants of a building the more the microbial load of airborne microorganisms inside that building.

The members *Penicillium, Aspergillus, Cladosporium* and *Rhizopus* are known to have allergen and infectious affects. Therefore, the common indoor presence of representatives of these genera in the poultry farm studied can be considered as a potential source of any kind of health problems that might occur in future due to these pollutants.

These fungi may also be found in the air of refrigerators. (Altunalmaz et al. 2012). All of these genera were found in our study.

Food companies have importance in terms of monitoring their indoor air quality standards. The main aims of a monitoring study in such a company should be to find contamination sources and to determine the potential airborne agents that may pose a risk on both food quality and workers health.

In conclusion, poultry sector should yield commercial products paying attention to hygiene conditions by always putting human health to the top and identification and prevention of microbiological hazards that have the potential of affecting food safety should be among the primary duties of managers of this sector. Also, consumers should pay attention to hygiene rules in every step of meat storing and consumption and had better consume packed and well-known poultry products.

References

Altunalmaz S.S., Issa G, Aydın A., *Detection of airborne psychrotrophic bacteria and fungi in food storage refrigerators*, Braz J Microbiol. 43 (4) 1436–1443 (2012).

Atik S., *Eskisehir Merkez ilcesinde mikrobiyal hava kirliliği*. Yüksek Lisans Tezi-MSc Thesis, Anadolu University Fen Bilimleri Enstitusu, Biyoloji ABD., Eskisehir, Turkey (1993).

Ayhan K., *Gidalarda Bulunan Mikroorganizmalar*, Gıda Mikrobiyolojisi ve Uygulamaları. 2. Baskı-2nd Ed. Ankara: Sim Matbaacilik Ltd. Sti. pp 37-80 (2000).

Barnett H., Hunter B., *Illustrated Genera of Imperfect Fungi*, 4th Ed. 218 pp. APS Press, St. Poul, Minnesota, USA (1999)

Beamount F., Kauffman H., Van Der Mark TH., De Viries K., *Volumetric aerobiological survey of conidial fungus in the North-East Netherlands: 1 Seasonal patterns and influence of meteorological variables,* Allergy, 40: 173-180 (1985).

Booth C., *The Genus Fusarium.,* The Eastern Press Ltd. Londom and Reading, Common Wealth Mycological Institute Kew, Surrey, England (1971).

Crous P., Braun U., Schubert K., Groenewald J., *The genus Cladosporium and similar Dematiaceous Hyphomycetes*, Studies in Mycology 58: 1-253 (2007).

D'Amato G, Stonziola AA, Coccus G, Melillo G., *Mold Allergy: A three years investigation* (1980-1982) of the airborne fungal spores in Naples, Italy. *Annals of Allergy*. 52: 353-7. (1984).

Davis J.M., *Applying atmospheric trajector analysis to problems in epidemiology*, Plant Dis, 70: 490-497 (1986).

Ellis MB., *Dematiaceous Hyphomycetes*, 608 pp. The Eastern Press Ltd., London and Reading, Common Wealth Mycological Institute Kew, Surrey, UK (1971).

Erol I., *Gida Kaynakli Patojen Bakteriler: Gida Hijyeni ve Mikrobiyolojisi*, Pozitif Matbaacılık Ltd. Sti., Ankara, pp 57-173 (2007).

Gerlach W., Nirenberg H., *The Genus* Fusarium *a Pictorial Atlas*, Biologische Bundesanstalt für Lond und Forstwirtschaft Institut für Microbiologie, Berlin Dahlem (1982).

Halwagy M.H., *Seasonal airspora at three sites in Kuwait 1977-1982*, Mycological Research, 93: 208-213 (1989).

Kaliner M., Eeggleston P.A., Matthews K.P., *Allergic rhinitis and asthma*, *JAMA*, 2: 218-24. (1987)

Kalyoncu F., *Relationship between airbone fungal allergens and meteorological factors in Manisa City, Turkey*, Environmental Monitoring and Assessesment, 165 (1-4): 553-558 (2010).

Kantarcioglu AS, Yucel A., *Virulence factors of Cryptococcus neoformans. Cerrahpasa* J Medical. 34: 42-50 (2003).

Klaric M., Pepelnjak S., *A year-round aeromycological study in Zagreb area, Croatia.* Ann Agric Environ Med. 13: 55-64 (2006).

Klich MA., *Identification of Common* Aspergillus *species*, First Ed, 122 pp. Centra albureau voor Schimmel cultures, Utrecht, The Netherlands (2002).

Leslie J.F., Semmerell B.A., (Illustrator: Suzanne Bullock)., *The* Fusarium *Laboratory Manual*, 1st ed. 388 pp. Ames, Iowa: Blackwell Publishing (2006).

Li D., Kendrick B., *A year round comparison of fungal spores in indoor and outdoor air*, Mycologia. 87 (2): 190-195 (1995)

Mentese S, Gullu G., Variations and Sources of Formaldehyde Levels in Residential Indoor Air in Ankara, *Turkey*, *Indoor and Built Environment*. 15 (3): 273-281 (2006).

Nelson PE., Toussoun TA., Marasas WFO., *Fusarium species,* An illustrated manuel for identification, Pennsylvania: The Pennsylvania StateUniversity Press (1983).

Okten S,, Asan A., *Airborne fungi and bacteria in indoor and outdoor environment of the Pediatric Unit of Edirne Goverment Hospital,* Environmental Monitoring and Assessment. 184 (3) 1739-1751 (2012).

Onoglu N., Gungor G., *Fatih Bolgesi kreslerinde ic ortam havasının mikrobiyolojik acıdan degerlendirilmesi,* 12. Ulusal Halk Sagligi Kongresi, Turkey (2007).

Ozkaya FD., Comert M., *Gida Zehirlenmelerinde Etken Faktorler,* Turk Hijyen ve Deneysel Biyoloji Dergisi. 65 (3): 149-158 (2008).

Paya Vicens MJ, Suarez Fernandez G., *A contribution towards the study of Madrid air mycoflora II. Genus Cladosporium.* Allergol. Immunopathol. 12 (5): 397-402 (1984).

Pitt JI., *A Laboratory Guide to Common* Penicillium *Species*, 3rd Ed., 197 pp, Food Science, Australia (2000).

Pitt JI., *The Genus* Penicillium *and Its Teleomorphic States* Eupenicillium *and* Talaromyces, 634 pp. Academic pres. Inc. London (1979).

Raper KB., Fennell DI., *The Genus* Aspergillus. 686 pp., The Williams & Wilkins Comp. Baltimore-USA (1965).

Ray B., Bhunia A., *Fundamental Food Microbiology*, 4th Ed. 492 pp. CRC Press, London (2008).

Samson RA., Houbraken J., Thrane U., Frisvad JC., Aandersen B., *Food and Indoor Fungi*, CBS-KNAW Fungal Biodiversity Centre Utrecht, The Netherlands (2010)..

Simmons E.G., *Alternaria an Identification Manual Fully Illustrated and With Catalogue Raisonne 1796-2007*. 775 pp., CBS Fungal Biodiversity centre, Utrecht (2007).

Simsekli Y., Akkaya A., Gucin F., Unlu M., Yorgancigil B., *Isparta sehrinin havasinda bulunan alerjen fungus sporlari (The allergic fungal spores found in the air of Isparta City),* Akciger Arsivi- Arch Lung. 1 (1) 9-12 (2000).

Temiz A., *Gıda isletmelerinde Hijyen ve Sanitasyon. Gida Denetcisi Egitimi Semineri. T.C. Saglik Bakanligi Temel Saglik Hizmetleri Genel Mudurlugu,* 7-9 Subat 2001, Ankara. 19 pp. (2001).