

Isolation and identification of indoor airborne fungal contaminants of food production facilities and warehouses in Bursa, Turkey

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Abstract

In this study, we aimed at the isolation and identification of indoor airborne fungal contaminants of 16 different food production facilities and warehouses located in Bursa province (Turkey). Numbers and kinds of microfungi were investigated by exposing a Petri dish of malt extract agar medium for 15 minutes and then counting the number of colonies which develop. Sampling procedure for microfungi was performed 8 times at an interval of 45 days between Dec. 1st 1995–Oct. 15th 1996. A total of 3152 colonies was counted on 864 petri plates in a one year period. As a result, 63 mould species and 4 varieties belonging to 20 genera were isolated by means of pure culture methods. Of these, 7 species and 1 variety belonging to *Aspergillus* and *Penicillium* genera are new records for Turkey.

1. Introduction

Studies on the airborne fungi in both the outdoor and indoor air have immensely increased recently since the earlier works done in the years 1859, 1922 and 1924, which only include outdoor air (Mohovic et al., 1988). These studies have been mainly conducted in Europe and North America. Studies on the Indoor air appear to have started in 1947 (Reynolds et al., 1990).

Investigations on indoor air fungi of food production facilities and on food and fungal metabolites have been reported in some studies (Savino and Caretta, 1992; Uçar and Güneri, 1996).

Bursa is an important city in terms of the food industry because of the many food production facilities located in different parts of the city. The outdoor air of the city has high humidity due to the Mediterranean climate (Akman, 1990). Therefore, this research was undertaken to determine the effects of a city's humid outdoor air on the indoor air of the food production facilities as well as on the concentration of fungi and fungi species that can contaminate food

products, thereby, providing useful data in order to take necessary actions to preserve food products.

2. Materials and methods

Studies were carried out in 16 different food production facilities, of which four were located in the centre of city, and the rest located in gardens in the outer parts of the city.

We selected 6 food groups on which fungi could have negative effects. These are: flour products, milk, meat, sweet, olive and canned products. In dairy production facilities, the yogurt processing department was somewhat isolated from the outdoor environment, having high humidity rate (80%) and temperature was approximately 40–45 °C. Entering and exiting the outdoor environment was not controlled properly in the cheese processing department. The meat production department was partially isolated from the outdoor environment, temperature was low (10–15 °C). Bread paste and bread paste products depart-

ment were not well isolated from the outdoor environment. The sweet products department was partially isolated from the outdoor environment. The canning department was not very well isolated from the outdoor environment; humidity was rather high (78–80%), but there was an obvious amount of steam occasionally coming from autoclaves. The olive processing and packing department was not very well isolated from the outdoor environment.

Two samples were taken 8 times at 1.5 monthly intervals from the facilities between December 1st 1995–October 15th 1996, because the frequency of the collection of fungi (e.g., daily, twice a month or twice a week) is an essential factor for airborne fungal survey (Takahashi, 1997). To take each sample, 5 petri plates were used in the facilities of sweet products, and 3 petri plates were used in the other facilities. Thus, a total of 864 petri plates were used in 16 food facilities. Food facilities and the number of samples are presented in Table 1.

In whole facilities, samples were taken from workbenches, which were fixed 1 m above from the floor level, between 11:00 am–14:00 pm. The time of day for the collection of fungi is an essential factor for airborne fungal survey (Takahashi, 1997). The Petri Plate Method (Verhoeff et al., 1990; Savino and Caretta, 1992) was used for fungus sampling. Malt Extract Agar (MEA) medium in Petri dishes is exposed to the air for 15 minutes [we used MEA (*malt extract: 2 gr., peptone: 0.1 gr., dextrose: 2 gr., agar agar: 2 gr., distilled water: 100 ml.*) for molds (Raper and Thom, 1949), and a different MEA (*malt extract: 3 gr., mycological peptone: 0.5 gr., agar agar: 1.5 gr., distilled water: 100 ml.*) for yeasts (Campbell, 1988). In addition, we used both media with 20% dextrose for osmophilic fungi]. We used 3 petri plates for sampling in all products, but 5 in sweet products, because of isolation of the osmophilic fungi (2 petri plates are used for determination of total mold enumeration, 1 is for yeasts, 1 contained 20% dextrose for osmophilic fungi and 1 also contained 20% dextrose for osmophilic yeasts).

Petri plates containing samples were incubated for 5–7 days at room temperature (25 °C–27 °C). Subsequently, mould and yeast colonies were transported to tubes containing MEA.

Malt Extract Agar, Czapek – Dox Agar and Potato Dextrose Agar media were used to identify fungal species. Stereomicroscope and light microscopes were used for the determination of colonial characteristics and morphological structures of fungi. Also,

lactophenol was used for the slide media (Ekmekçi, 1974). Fungi were identified to genus and grouped in genus category using Barnett's work (1972). "A Manual of the Penicillia" (Raper and Thom, 1949) and "Soil Fungi" (Hasenekoğlu, 1991) were used for the identification of *Penicillium* species, "The genus *Aspergillus*" (Raper and Fennell, 1965) and "Soil Fungi" (Hasenekoğlu, 1991) were used for identification of *Aspergillus* species. "Soil Fungi" (Hasenekoğlu, 1991) and "Dematiaceous Hyphomycetes" (Ellis, 1971) were used for the identification of other fungal species.

3. Results

A total of 20 genera, 63 species and 4 varieties were determined. Seasonal distribution of microfungi in food facilities and warehouses, and colony numbers (percentage of them) are shown in Table 2. *Cladosporium* was isolated more frequently (35.41%) than the genera of *Penicillium* (28.74%), *Alternaria* (12.06%) and *Aspergillus* (7.46%).

It was found that Mycobiota of the food facilities have varied depending on the humidity, temperature, organic materials, products and sensitivity of raw food materials. Seasonal distribution of fungi presented in our study demonstrated that a high of fungal concentration was observed in the summer (with 1056 colonies) (Table 2).

The indoor air of the food facilities was especially investigated in terms of the density of fungal contamination, and the highest contaminated section was found to be the canned production department with 451 colonies. The density of the fungal contamination found in the other departments are as follows: 383 colonies in the production department of flour products, 282 colonies in the production department of sweet foods, 261 colonies in the olive production department, 226 colonies in the milk production department and 72 colonies in the meat production department.

The highest fungal concentration found in warehouses was the warehouse of flour products with 445 colonies. The density of the fungal contamination found in the other warehouses are as follows: 343 colonies in canned warehouse, 272 colonies in olive warehouse, 250 colonies in sweet products, 13 colonies in milk product and 32 colonies in meat product warehouses respectively (Table 3).

Table 1. Selected facilities and the number of samples taken.

Product name	Name of facility	Number of samples	Number of petri plates for one sampling			Annual total
			Facility	Warehouse	Total	
Milk	A	8	3	3	6	48
	B	8	3	3	6	48
	C	8	3	3	6	48
Meat	D	8	3	3	6	48
Flour products	E	8	3	3	6	48
	F	8	3	3	6	48
	G	8	3	3	6	48
Sweet products	H	8	5	5	10	80
	I	8	5	5	10	80
	J	8	5	5	10	80
Canned	K	8	3	3	6	48
	L	8	3	3	6	48
	M	8	3	3	6	48
Olive	N	8	3	3	6	48
	O	8	3	3	6	48
	P	8	3	3	6	48
Total		128	54	54	108	864

4. Discussion

It is well known that microfungi can live in extreme conditions in almost all regions and all climates. They usually live in soil and can spread out into the atmosphere by various factors (Burge, 1989). In addition, Klironomos et al. (1997) indicates that higher atmospheric CO₂ concentration will induce greater sporulation in common soil fungi, leading to higher concentrations of fungal spores in the atmosphere.

In recent years, aerobiologists have shown more interest in atmospheric microfungi due to both their constant existence in the air and increases in allergenic cases (Palali, 1979; Banerjee et al., 1987; Garrison et al., 1993). The places where abundant food materials measured for the contamination of atmospheric fungi.

We used the Petri Plate Method (Based on gravitational) (Kang and Frank, 1989; Strachan et al., 1990; Rosas et al., 1993) for the isolation of atmospheric fungi because of both its practical and easy usage and low cost. This method is useful for enumeration of fungal spores, but presents only a rough approximation of the kinds and numbers of airborne fungi (Pelczar et al., 1993).

The results demonstrate that the most widespread species belong to *Cladosporium*, *Penicillium*, *Altern-*

aria and *Aspergillus*. These results are in broad agreement with other studies concerning indoor and outdoor air (Larsen and Gravesen, 1991; Pasanen, 1992; Li and Kuo, 1994; Kuo and Li, 1994; Şimşekli et al., 1998). *Cladosporium* was most predominant and occurred in large numbers in air. This result is agreeable to other studies such as Larsen (1982); Abdel-Hafez (1984); Youssef and Karam El-Din (1988); Vittal and Krishnamoorthi (1988) and Takahashi (1997).

It is known that outdoor air fungi can enter indoor air that is not well isolated and it can be dominant in mycobiota (Banerjee et al., 1987). In our study, considering seasonal distribution of fungi, the highest fungal concentration was observed in the summer followed by autumn, winter and spring, respectively. This situation can be explained by temperature and because windows are open, thus, outdoor air is transferred to indoor air. These results are not in agreement with other studies on outdoor air fungi in Bursa. Also in a study (Singh et al., 1987), July through October has been observed as the period of predominant outdoor fungal spores as compared to other months. One explanation could be that when direct seasonal conditions are present in outdoor air in Bursa during winter the indoor air in facilities can be different (i.e. higher temperature in indoor air in comparison

Table 2. Seasonal distribution of fungal spores in food facilities and its warehouses.

<i>Alternaria alternata</i> (Fr.) Keissler	13 mp, 8 rw, 13 sp, 14 sw, 92 mp, 86 mw, 50 ap, 43 aw. T: 319 (10.12%).
<i>A. pluriseptata</i> (Karst. & Har.) Jorstad	18 rp, 13 rw, 8 sp, 8 sw, 10 ap, 4 aw. T: 61 (1.93%).
<i>Aspergillus asperescens</i> Stolk	1 rw, T: 1 (0.03%).
<i>A. carbonarius</i> (Bainier) Thom	1 rp, 2 sp, 6 sw, 4 ap, 1 aw. T: 14 (0.44%).
<i>A. candidus</i> Link ex Link	1 rp, 2 mp, 5 mw, 1 ap, 1 aw. T: 10 (0.31%).
* <i>A. citrisporus</i> (Von Höhnelt) Raper, Fennell & Tresner	1 ap, 1 aw. T: 2 (0.06%).
<i>A. clavatus</i> Desm.	1 rp, 3 rw, 2 sp, 3 sw, 40 mp, 30 mw, 4 ap, 4 aw. T: 87 (2.76%).
<i>A. flavipes</i> (Bain. & Sart.) Thom & Church.	2 sp, 3 ap. T: 5 (0.15%).
<i>A. flavus</i> Link ex Gray.	2 sp, 2 mp, 5 mw, 11 ap, 2 aw. T: 22 (0.69%).
<i>A. montevicensis</i> Talice & Mackinnon	9 rw, 8 sp, 3 sw, 27 mp, 4 ap, 6 aw. T: 57 (1.80%).
<i>A. niger</i> Van Tieghem	1 rp, 1 rw. T: 2 (0.06%).
<i>A. ochraceus</i> Wilhelm	4 ap. T: 4 (0.12%).
<i>A. repens</i> De Bary	6 rp, 8 rw, 1 ap, 2 aw. T: 17 (0.53%).
<i>A. penicilloides</i> Spegazzini	1 rp, 2 rw. T: 3 (0.09%).
* <i>A. spinulosus</i> (Warcup) Raper & Fennel	7 rp, 1 sp, 1 sw. T: 9 (0.28%).
<i>A. wentii</i> Wehmer	1 sp, 1 ap. T: 2 (0.06%).
<i>Botrytis cinerea</i> Pers. ex Nocca & Balb.	4 rp, 5 rw, 2 sp, 6 mp, 1 mw, 9 ap, 5 aw. T: 32 (1.01%).
<i>Chaetomium umbonatum</i> Brewer	1 rp, 1 rw, 1 ap. T: 3 (0.09%).
<i>Cladosporium cladosporioides</i> (Fresen.) de Vri	43 rp, 87 rw, 17 sp, 19 sw, 71 mp, 86 mw, 60 ap, 49 aw. T: 432 (13.70%).
<i>C. herbarum</i> (Pers.) Link ex Gray	26 rp, 7 rw, 1 sp. T: 34 (1.07%).
<i>C. oxysporum</i> Berk & Curt.	42 rp, 30 rw, 39 sp, 42 sw, 135 mp, 156 mw, 104 ap, 62 aw. T: 610 (19.35%).
<i>C. sphaerospermum</i> Penz.	4 rp, 12 rw, 9 sp, 7 ap, 8 aw. T: 40 (1.26%).
<i>Cylindrotrichum oligospermum</i> (Corda) Bonord.	7 rw, 1 sw, 1 mw. T: 9 (0.28%).
<i>Drechslera rostrata</i> (Drechsler) Richardson & Fraser	3 rp, 16 sp, 12 sw, 3 mp, 3 mw, 4 ap, 2 aw. T: 43 (1.36%).
<i>Fusarium moniliforme</i> Sheldon	2 rp, 5 sp, 3 sw, 2 mp, 4 mw, 1 ap. T: 17 (0.53%).
<i>Gliocladium roseum</i> Bain.	9 rp, 10 rw, 2 sw, 8 mp, 1 ap, 1 aw. T: 31 (0.98%).
<i>G. viride</i> Matr.	7 rp, 10 rw, 1 sp, 2 sw, 3 mp, 1 ap. T: 24 (0.76%).
<i>Helicospirium panacheum</i> Moore	1 ap, 3 aw. T: 4 (0.12%).
<i>Mucor racemosus</i> Fres.	1 rp, 4 rw, 2 sp, 2 sw, 5 mp, 5 mw, 2 ap, 4 aw. T: 25 (0.79%).
<i>Mycelia sterilia</i>	17 rp, 4 rw, 23 sp, 16 sw, 26 mp, 21 mw, 25 ap, 31 aw. T: 163 (5.17%).
<i>Oidiodendron truncatum</i> Barron	1 rp. T: 1 (0.03%).
* <i>Penicillium. atramentosum</i> Thom	4 rp, 2 sw, 9 mp, 14 mw. T: 29 (0.92%).
<i>P. botryosum</i> Batista & Maia	18 rp, 8 rw, 2 sw. T: 28 (0.88%).
<i>P. brevicompactum</i> Dierckx	17 rp, 13 rw, 8 sp, 34 sw, 4 mp. T: 76 (2.41%).
<i>P. chrysogenum</i> Thom	4 sp, 34 sw, 3 mp, 2 mw, 29 ap, 24 aw. T: 96 (3.04%).
<i>P. citreoviride</i> Biourge	6 rp, 5 ap, 1 aw. T: 12 (0.38%).
<i>P. claviforme</i> Bainier	1 sw. T: 1 (0.03%).
<i>P. commune</i> Thom	14 rp, 6 rw, 1 sw, 10 mp, 5 mw, 1 ap, 1 aw. T: 38 (1.20%).
* <i>P. coralligerum</i> Nicot & Pionnat	1 rp, 6 rw, 10 mp, 4 mw. T: 21 (0.66%).
<i>P. corylophilum</i> Dierckx	13 rp, 9 rw, 5 sp, 4 mp, 2 mw, 16 ap, 3 aw. T: 52 (1.64%).
* <i>P. giganteum</i> Roy & Singh	6 sp, 4 sw, 5 mp, 16 mw, 1 aw. T: 32 (1.01%).
<i>P. griseum</i> Bonorden	25 mp, 41 mw, 2 ap, 3 aw. T: 71 (2.25%).
* <i>P. indicum</i> D. Sandhu & R. Sandhu	2 rp, 3 rw. T: 5 (0.15%).
<i>P. islandicum</i> Sopp.	1 rw. T: 1 (0.03%).
<i>P. italicum</i> Wehmer var. <i>italicum</i> Samson, Stolk & Hadlok	1 mw, 1 ap, 1 aw. T: 3 (0.09%).
<i>P. lanosum</i> Westling	1 rw, 7 ap, 8 aw. T: 16 (0.50%).
<i>P. mali</i> Novobranova	1 mp. T: 1 (0.03%).
<i>P. multicolor</i> Grigorieva – Manollava & Prodielova	7 rp, 14 sp, 15 sw, 3 mp, 1 mw, 2 ap, 4 aw. T: 46 (1.45%).
<i>P. oxalicum</i> Currie & Thom	8 rw, 6 sp, 9 sw, 9 ap, 6 aw. T: 38 (1.20%).
<i>P. raperi</i> Smith	6 sp, 7 sw, 1 mp, 5 aw. T: 19 (0.60%).
<i>P. rubrum</i> Stoll	2 rp, 2 rw, 6 sp, 1 sw, 4 ap, 1 aw. T: 16 (0.50%).
<i>P. stoloniferum</i> Thom	2 rp, 2 rw, 8 sp, 5 sw, 12 mp, 6 mw, 2 ap. T: 37 (1.17%).
<i>P. thomii</i> Maire	1 rp, 2 rw, 1 sw. T: 4 (0.12%).
* <i>P. verrucosum</i> Dierckx var. <i>album</i> (Smith) Samson, Stolk & Hadlok	24 sp, 3 sw, 5 ap, 2 aw. T: 34 (1.07%).
<i>P. verrucosum</i> Dierckx var. <i>cyclopium</i> (Westling) Samson, Stolk & Hadlok	46 rp, 9 rw, 21 sp, 14 sw, 2 mp, 9 mw, 8 ap, 9 aw. T: 118 (3.74%).
<i>P. verrucosum</i> Dierckx var. <i>verrucosum</i> (Westling) Samson, Stolk & Hadlok	10 rp, 7 rw, 22 sp, 24 sw, 10 mp, 3 aw. T: 76 (2.41%).
<i>P. yarmokense</i> Baghdadi	5 rp, 5 rw, 9 sp, 14 sw, 3 mw. T: 36 (1.14%).
<i>Phialophora fastigiata</i> (Lagerb., Lundberg & Melin) Conant	1 rw, 2 sp, 2 sw, 8 mp, 7 mw, 1 ap, 6 aw. T: 39 (1.23%).
<i>P. malorum</i> (Kidd & Beaum.) McCulloch	2 rp, 2 rw, 1 sp, 1 sw, 1 mw, 2 ap, 2 aw. T: 11 (0.34%).
<i>Pithomyces chartarum</i> (Berk. & Curt.) M.B. Ellis	3 sp, 2 aw. T: 5 (0.15%).
<i>Rhinoctadiella spinifera</i> (Nielsen & Conant) de Hoog.	1 rp, 2 mp. T: 3 (0.09%).
<i>Rhizopus stolonifer</i> (Ehrenb.: Fr.) Vuill.	5 rp, 6 rw, 4 sw, 2 mp, 3 mw, 1 ap, 8 aw. T: 29 (0.92%).
<i>Scopulariopsis sphaerospora</i> Zach.	1 rp, 1 sp, 1 ap. T: 3 (0.09%).
<i>S. fimicola</i> (Cost & Matr.) Vuillemin	1 mw. T: 1 (0.03%).
Yeasts	3 rp, 4 sp, 11 sw, 3 mp, 8 ap, 2 aw. T: 72 (2.28%).
Total of fungi numbers in production place and warehouses for seasons:	r: 683, s: 666, m: 1056, a: 747. T: 3152.

Letters indicate: **r**: Winter; **s**: Spring; **m**: Summer; **a**: Autumn; **p**: Production place; **w**: Warehouse; **T**: Total; *It is likely to be recorded newly for Turkey.

Table 3. The distribution of fungal spores in production places of facilities and its warehouses.

<i>Alternaria alternata</i>	37 kp, 12 kw, 9 ep, 34 tw, 72 cp, 57 cw, 30 fp, 44 fw, 33 vp, 29 vw.
<i>A. pluriseptata</i>	4 kp, 1 kw, 7 tp, 6 tw, 8 cp, 5 cw, 10 fp, 8 fw, 7 vp, 5 vw.
<i>Aspergillus asperescens</i>	1 vw.
<i>A. candidus</i>	1 fp, 3 vp, 6 vw.
<i>A. carbonarius</i>	1 kw, 4 tp, 2 tw, 1 cp, 4 cw, 2 fp.
<i>A. citrisporus</i>	1 vp, 1 vw.
<i>A. clavatus</i>	2 kp, 3 kw, 3 ep, 20 tp, 6 tw, 17 cp, 6 cw, 2 fp, 16 fw, 3 vp, 9 vw.
<i>A. flavipes</i>	5 vp.
<i>A. flavus</i>	2 kw, 1 cp, 14 fp, 5 fw.
<i>A. montevidensis</i>	35 tp, 5 tw, 1 cp, 4 cw, 1 fp, 2 vp, 9 vw.
<i>A. niger</i>	1 cp, 1 cw.
<i>A. ochraceus</i>	4 fp.
<i>A. repens</i>	7 fp, 10 fw.
<i>A. penicilloides</i>	1 tp, 1 tw, 1 cw.
<i>A. spinulosus</i>	3 cp, 5 fp, 1 fw.
<i>A. wentii</i>	1 kp, 1 cp.
<i>Botrytis cinerea</i>	15 tp, 6 tw, 5 cp, 4 cw, 1 vp, 1 vw.
<i>Chaetomium umbonatum</i>	1 tp, 1 tw, 1 cp.
<i>Cladosporium cladosporioides</i>	28 kp, 14 kw, 19 ep, 6 ew, 18 tp, 24 tw, 51 cp, 44 cw, 42 fp, 66 fw, 33 vp, 87 vw.
<i>C. herbarum</i>	2 kp, 2 kw, 1 ep, 1 ew, 3 cp, 3 cw, 13 fp, 1 fw, 8 vp.
<i>C. oxysporum</i>	61 kp, 40 kw, 21 ep, 5 ew, 57 tp, 34 tw, 73 cp, 70 cw, 58 fp, 101 fw, 50 vp, 40 vw.
<i>C. sphaerospermum</i>	1 tp, 19 fp, 20 fw.
<i>Cylindrotrichum oligospermum</i>	2 fw, 7 vw.
<i>Drechslera rostrata</i>	11 kp, 5 kw, 3 ep, 3 ew, 1 tp, 2 tw, 1 cp, 4 cw, 10 vp, 3 vw.
<i>Fusarium moniliforme</i>	7 kp, 2 kw, 3 tw, 1 cp, 2 cw, 1 vp, 1 vw.
<i>Gliocladium roseum</i>	8 tp, 5 tw, 9 cp, 8 cw, 1 fp.
<i>G. viride</i>	1 kp, 1 tp, 1 tw, 9 fp, 4 fw, 1 vp, 7 vw.
<i>Helicospodium panacheum</i>	1 cp, 3 vw.
<i>Mucor racemosus</i>	1 kp, 2 kw, 1 tp, 1 tw, 2 cp, 2 cw, 3 fp, 9 fw, 3 vp, 1 vw.
<i>Mycelia sterilia</i>	18 kp, 6 kw, 10 ep, 5 ew, 10 tp, 17 tw, 15 cp, 16 cw, 11 fp, 16 fw, 27 vp, 12 vw.
<i>Oidiodendron truncatum</i>	1 cp.
<i>Penicillium atramentosum</i>	1 kp, 2 kw, 6 tp, 1 tw, 4 cp, 13 cw, 2 fp.
<i>P. botryosum</i>	3 kw, 14 cp, 5 cw, 4 fp, 2 fw.
<i>P. brevicompactum</i>	3kp, 5 ew, 6 tp, 19 tw, 3 cp, 14 cw, 12 fp, 7 fw, 5 vp, 2 vw.
<i>P. chrysogenum</i>	3 kp, 3 kp, 5 tp, 1 tw, 13 cp, 10 fp, 47 fw, 5 vp.
<i>P. citreoviride</i>	7 cp, 2 fp, 2 vp, 1 vw.
<i>P. claviforme</i>	1 tw.
<i>P. commune</i>	5 kp, 4 kw, 2 tp, 3 tw, 13 cp, 1 cw, 2 fw, 5 vp.
<i>P. coralligerum</i>	1 kp, 3 kw, 3 tw, 2 cp, 8 vp, 4 vw.
<i>P. corylophilum</i>	8 kp, 6 kw, 5 tw, 14 cp, 2 cw, 9 fp, 1 fw, 7 vp.
<i>P. giganteum</i>	1 kp, 3 ew, 5 cp, 14 cw, 5 fp, 4 vw.
<i>P. griseum</i>	2 kp, 1 kw, 15 tp, 11 tw, 6 cp, 13 cw, 4 fp, 1 fw, 5vw.
<i>P. indicum</i>	2 kp, 3 cw.
<i>P. islandicum</i>	1 fw.
<i>P. italicum</i> var. <i>italicum</i>	1 kp, 1 kw, 1 cw.
<i>P. lanosum</i>	1 kw,
2 tp, 2 tw, 6 cp, 4 cw, 1 vp. <i>P. mali</i>	1 tp.
<i>P. multicolor</i>	3 kp, 1 kw, 5 ep, 3 ew, 4 tp, 8 tw, 12 cp, 2 cw, 4 fw, 2 vp, 2 vw.
<i>P. oxalicum</i>	4 kp, 5 kw, 3 tp, 1 cp, 7 fp, 16 fw, 2 vw.
<i>P. raperi</i>	1 kp, 3 tw, 2 cp, 6 cw, 1 fp, 1 fw, 3 vp, 2 vw.
<i>P. rubrum</i>	5 tp, 4 tw, 1 cp, 4 fp, 2 vp.
<i>P. stoloniferum</i>	3 kw, 4 tp, 2 tw, 8 cp, 3 fp, 4 fw, 9 vp, 4 vw.
<i>P. thomii</i>	1 ep, 2 cw, 1 fw.
<i>P. verrucosum</i> var. <i>album</i>	6 kp, 3 kw, 3 tp, 2 tw, 1 cp, 2 fp.
<i>P. verrucosum</i> var. <i>cyclopium</i>	1 ew, 14 tp, 9 tw, 27 cp, 17 cw, 32 fp, 10 fw, 4 vp, 4 vw.
<i>P. verrucosum</i> var. <i>verrucosum</i>	3 kp, 2 kw, 2 tp, 6 tw, 17 cp, 2 cw, 1 fp, 5 fw, 19 vp, 19 vw.
<i>P. yarmokense</i>	3 tw, 3 cp, 2 cw, 7 fp, 17 fw, 4 vp.
<i>Phialophora fastigiata</i>	1 kp, 5 kw, 4 tp, 3 tw, 18 cp, 5 cw, 3 fw.
<i>P. malorum</i>	1 kp, 2 kw, 1 tp, 2 tw, 2 cp, 2 cw, 1 vp.
<i>Pithomyces chartarum</i>	3tp, 2 vw.
<i>Rhinocladiella spinifera</i>	3 tp.
<i>Rhizopus stolonifer</i>	3 tp, 10 tw, 7 cw, 5 fp, 2 fw, 2 vw.
<i>Scopulariopsis sphaerospora</i>	2 kp, 1 fp.
<i>S. fimicola</i>	1 tw.
Yeast	9 kp, 1 kw, 1 cp, 46 fp, 12 fw, 3 vp.
Total	361 k, 104 e, 532 t, 794 c, 828 f, 533 v.

Letters indicate: **k**: Milk; **e**: Meat; **t**: Sweet; **c**: Canned; **f**: Flourey products; **v**: Olive; **p**: Production place; **w**: Warehouse.

to outdoor air). Thus, negative effects of the lower temperature on fungal growth disappeared. The lower fungal concentration in spring can be explained by the decrease in production rate in the facilities. It can be said that autumn is the most appropriate season in terms of both suitable conditions for fungal growth and increases in the production rate in facilities.

Fungal concentration was greater in the production department of canned foods because of the suitable conditions for the growth of fungi. Moreover, vegetables brought to the facility were already contaminated by certain fungi in the outdoor soil. In addition, vegetables are usually kept waiting in facility before processing and during this time steam coming out from autoclaves induces fungal growth. Temperature was found to be rather high in the production department of flour products and also the existence of an obvious dust layer may increase fungal growth. It was observed that waste materials was not being removed from the preparation area in the production department of sweet foods. It was determined that there was no good isolation from outdoor environment in the olive administrations that may cause increases in fungal growth.

Warehouses of flour products have suitable conditions for fungal growth. The warehouses of canned products have no deep freeze facility and necessary isolation from the outdoor environment, thus, these factors may be partially responsible for fungal development. Olive warehouses are not well isolated from outdoor environment and the surfaces of the olive ponds may be favourable for fungal growth. The fungi that grow during production and within warehouses of foods may spoil product quality and cause undesirable changes, resulting in great economical losses. Furthermore, mycotoxins produced by some fungi may cause serious public health problems.

The species of *A. flavus*, *A. niger*, *A. ochraceus*, *A. wentii*, and *P. chrysogenum* determined in our study are widespread in Turkey. *A. niger* was determined in 60 different studies carried out in Turkey, *A. flavus* was 44, *A. wentii*, *P. chrysogenum* and *A. ochraceus* were 25, respectively. Accordingly, we observed that species adapt to ecological conditions better than the other microfungus species.

In conclusion, this study suggests that necessary prevention should be taken to keep fungal concentration to an acceptable level in food facilities. Prevention techniques include: better isolation between outdoor and indoor air, the use of filter systems if necessary (Garrison et al., 1993), painting the walls to prevent

fungal growth (Katircioğlu and Gürcan, 1987; Nugari et al., 1993), developing systems that prevent the accumulation of organic materials, and controlling the indoor air humidity as proposed by Burge (1989) who stated that keeping the indoor air dry is essential to prevent fungal growth.

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