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Determination of Mold Diversity of Some Fruits Sold in Eastern Turkey

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ABSTRACT: Fungi that contaminate the fruits at stages such as ripening, harvesting, storage, transportation may cause deterioration and economic losses, and even some strains can produce mycotoxins known to be harmful to health. In this respect, it was examined that the mold diversity of some fruits sold in eastern Turkey. A total of 113 different fruits, both non-moldy and moldy, were collected and 395 strains were isolated and identified using classical methods from different parts of the fruits (surfaces, core cavities and rotten parts). It was found the 11 different genera of fungi including *Penicillium* spp. (34.43%), *Cladosporium* spp. (22.53%), *Rhizopus* spp. (21.01%), *Alternaria* spp. (8.10%), *Botrytis* spp. (7.34%), *Aspergillus* spp. (2.27%), *Byssochlamys* spp. (1.52%), *Acremonium* spp. (0.76%), *Fusarium* spp. (0.76%), *Colletotrichum* spp. (0.76%), and *Geotrichum* spp. (0.51%) in the analysed strawberry, grape, apple, cherry, pear, plum, pomegranate, apricot, peach, orange, tangerine, and quince fruits. It is noteworthy that the fungi known to produce mycotoxins such as *Penicillium expansum* and *Penicillium italicum* are among the fungi isolated within the scope of the study.

Keywords: Fruit, fungi, contamination

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INTRODUCTION

Fruit has an important place in human nutrition with the sugar, vitamins, minerals and small amounts of protein and fat content. Inappropriate harvesting, transportation, packaging and storage can cause the development of microorganisms and decay by changing the physiological state of fruits. It is claimed that more than a third of fruit and vegetables are thrown away before reaching customers due to post-harvest deterioration. Due to low pH, high moisture content and nutrient composition, fruits can be easily spoiled by molds, and some molds can even produce mycotoxins. Molds, which are obligate aerobes, form the dominant microbiota on fruit surfaces with the effect of pH factor. *Penicillum*, *Fusarium*, *Aspergillus* and *Mucor* species are the most common molds on fruit surfaces (Oviasogie et al., 2015; Romanazzi et al., 2016; Turantaş and Sömek, 2018).

The most common mycotoxins found in food products are aflatoxins, ochratoxin A, patulin, fumonisins, zearalenone, and deoxynivalenol. These mycotoxins are produced by mold genera such as *Aspergillus*, *Penicillium*, *Fusarium* and *Alternaria* (Coppa et al., 2019). Patulin is the most detected mycotoxin in fruit, vegetables and products and is produced by some *Penicillium*, *Aspergillus* and *Byssochlamys* species. Patulin, which can occur in many vegetables, fruit and grains, has been detected most in apple and their products. The most important producer of patulin is *Penicillium expansum* (*P. expansum*), and this mycotoxin has been reported to have immunotoxic, neurotoxic, hepatotoxic, genotoxic, teratogenic and carcinogenic effects on the body (Anene et al., 2016; Erdoğan et al., 2018; Altunay et al., 2019). According to the Turkish Food Codex Communiqué on Maximum Limits of Contaminants in Foodstuffs (Anonymous, 2008) and European Commission Regulations (Anonymous, 2006), the maximum patulin limit for fruit juices and derivative products is 50 ppb, for solid apple products 25 ppb, for babies and young children it is determined as 10 ppb in produced foods. As well as the mycotoxins production, fungi also can cause allergic reactions and infection in humans and animals. In order to be protected from these harmful effects of molds, pre- and post-harvest precautions should be taken to control fungal contamination (Kłapeć et al. 2021, Sellitto et al. 2021).

It is known that there are many studies (Bokulich et al., 2014; Oviasogie et al., 2015; Turantaş and Sömek, 2018) on the determination of the diversity of mold that spoils the fruit, but there is no comprehensive study on the diversity of molds on the fruits offered for sale in Erzurum, Turkey. Therefore, in this study, a total of 113 samples were taken from 12 different fruits, including strawberry, grapes apple, cherry, pear, plum, pomegranate, apricot, peach, orange, tangerine and quince, and it was aimed to reveal the mold diversity of these fruits.

MATERIALS AND METHODS

Materials

In this study, 12 different fruits offered for sale in supermarkets and greengrocers in Erzurum were taken by random sampling. In this context, as seen in Table 1, a total of 113 samples were taken, both moldy and non-moldy. Three or five (Janisiewicz et al., 2013) and 250 g or at least 25 fruits (Zahavi et al., 2002) were sampled from large (apple, pomegranate, orange, tangerine, quince, apricot, plum, pear and peach) and smaller fruits (grape, cherry and strawberry), respectively. Each sample was taken into sterile stomacher bags and immediately brought to the laboratory for analysis. For moldy fruits, a single fruit was accepted as a sample.

Table 1. Information on fruit samples

Fruit Name	Number of Non-Molded Fruits	Number of Moldy Fruits	Total
Strawberry (*Fragaria × ananassa*)	6	8	14
Grape (*Vitis vinifera*)	7	6	13
Apple (*Malus domestica*)	9	3	12
Cherry (*Prunus avium*)	5	5	10
Pear (*Pyrus communis* L.)	4	5	9
Plum (*Prunus domestica* L.)	7	2	9
Pomegranate (*Punica granatum* L.)	4	4	8
Apricot (*Prunus armeniaca* L.)	8	-	8
Peach (*Prunus persica* L.)	5	3	8
Orange (*Citrus bergamia*)	5	3	8
Tangerine (*Citrus tangerine*)	4	3	7
Quince (*Cydonia oblonga*)	2	5	7
Total			**113**

Preparation of samples for analysis

Two large fruits (apple, pomegranate, orange, tangerine, quince, apricot, plum, pear and peach) were taken and placed in stomacher bags containing 250 mL sterile dilution solution (0.1% Tween 80 + 0.85% NaCl). 250 g of smaller sized strawberries and cherries were weighed and placed in stomacher bags containing 250 mL of sterile dilution solution (Narciso, 2005; Leff and Fierer, 2013). For grapes, 25 fruits were weighed and taken into stomacher bags containing dilution solution equal to the weight of the fruit (Zahavi et al., 2002). Then, each fruit sample was rinsed for 5 minutes and washed. Serial dilutions were prepared from the dilution liquid of each sample and cultivation was started. Experiments were performed in two replications for each sample.

Microbiological cultivation and obtaining pure culture

0.1 mL of the prepared serial dilutions were taken and inoculated on DRBC (Dichloran Rose Bengal Chloramphenicol; Merck, Darmstadt, Germany) agar medium by the spread plate method. For moldy samples, in case of visible hyphae, hyphae were removed with a sterile needle and inoculated into PDA (Potato Dextrose Agar; Merck, Darmstadt, Germany) medium with pH 3.5. For the analysis of mold diversity in the core parts of quince and pear fruits, the fruits were cut with a sterile knife and the seeds were placed on PDA medium. In cases where there was visible mold growth in the seeds, the molds were inoculated into PDA medium with an inoculation needle. Following the cultivation and inoculation procedures, the media were incubated at 25 ˚C for 5-7 days (Pitt and Hocking, 2009).

Following the incubation process, mold colonies that developed separately and differed from each other on DRBC and PDA media were inoculated into PDA media. The media were again incubated at 25 ˚C for 5 days and these procedures were repeated until a pure culture was obtained.

Identification of ısolates

CYA (Czapek Yeast Extract Agar), MEA (Malt Extract Agar) and G-25N (25% Glycerol Nitrate) agar media were used for the identification process. For inoculation, it was taken from 7 days old pure culture by needle and inoculated into the specified media. CYA media at 5 ˚C, 25 ˚C and 37 ˚C; MEA and G-25N media were incubated at 25 ˚C for 7 days (Pitt and Hocking, 2009).

After incubation, macroscopic and microscopic examinations were made for morphological characterization and Pitt and Hocking (2009) primary reference for identification of all isolates;

Frisvad and Samson (2004) for *Alternaria*, *Penicillium* and *Cladosporium* species; Bensch et al. (2012); Woudenberg et al., (2013) was used as a secondary reference.

RESULTS AND DISCUSSION

The distribution of mold genus obtained according to the analyzed fruit diversity is given in Figure 1. Accordingly, a total of 395 molds were isolated and identified from 113 fruit samples. The most isolated mold genus was *Penicillium* spp. (136, 34.43%) while *Cladosporium* spp. (89, 22.53%) and *Rhizopus* spp. (83, 21.01%) rank second and third, respectively. In addition, *Alternaria* spp. (32, 8.10%), *Botrytis* spp. (29, 7.34%), *Aspergillus* spp. (9, 2.27%), *Byssochlamys* spp. (6, 1.52%), *Acremonium* spp. (3, 0.76%), *Fusarium* spp. (3, 0.76%), *Colletotrichum* spp. (3, 0.76%) and *Geotrichum* spp. (2, 0.51%) was also detected.

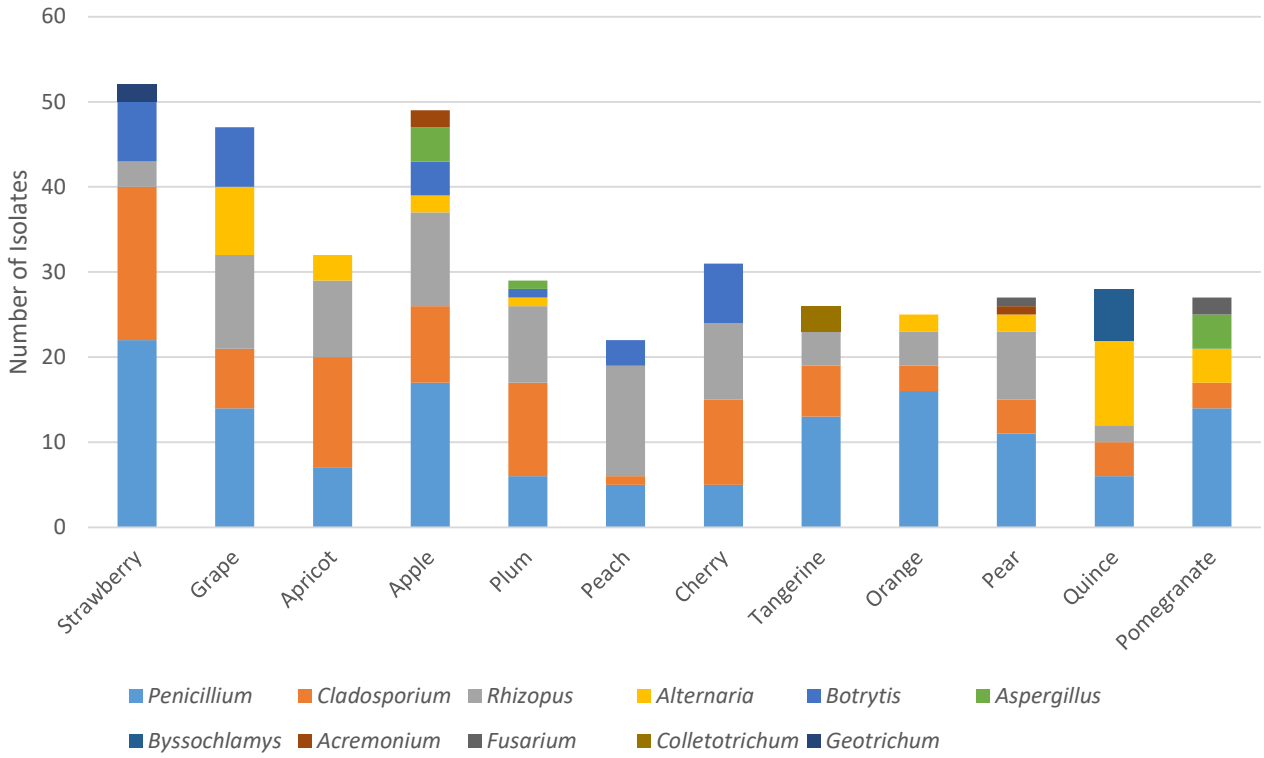

Figure 1. Distribution of mold diversity defined by fruit type

A total of 52 molds were isolated and identified from 14 strawberries analyzed. Of these isolates, 42.30%, 34.62%, 13.46%, 5.77% and 3.85% were identified as *Penicillium* spp., *Cladosporium cladosporioides* (*C. cladosporioides*), *Botrytis cinera* (*B. cinera*), *Rhizopus stolonifer* (*R. stolonifer*) and *Geotrichum candidum* (*G. candidum*), respectively. Six of the strawberry samples were not damaged (with no visible deterioration) and a total of 29 molds were isolated from them. A total of 12 *Penicillium* spp. strains were found, including 5 *Penicillium olsonii* (*P. olsonii*) in 4, 3 *Penicillium brevicompactum* (P. *brevicompactum*) in 2, 3 *P. expansum* in 3 and 1 *Penicillium solitum* (*P. solitum*) in 1 of these strawberry samples. However, a total of 11 *C. cladosporioides* were isolated in all six samples including 4 *B. cinerea* in four, and 1 *R. stolonifer* and 1 *G. candidum* in one. The 8 strawberry samples analyzed were named as moldy because they contained mold in a visible way, and a total of 23 mold were isolated and identified including 7 *C. cladosporioides* in 6, 5 *P. olsonii* in 5, 3 *P. expansum* in 2, 3 *B. cinerea* in 3, 2 *P. brevicompactum* in 1, 2 *R. stolonifer* in 2 and 1 *G. candidum* in 1 of these samples. When the strains isolated from moldy and non-mold strawberry samples were examined, it was found that mold diversity was similar in both; *C. cladosporioides* and *Penicillium*

type molds were found to be dominant. However, *B. cinerea* was found to be one of the common species that caused deterioration by being present in 7 of 8 samples. Similar to our results, Jensen et al., (2013) also found that dominant mold flora in strawberries was formed by *Cladosporium* and *Penicillium* molds. Moreover, in another study in which the diversity of molds in strawberries was determined, the molds causing spoilage were *Cladosporium* and *Botrytis* genera (Abdelfattah et al., 2016a).

Within the scope of the study, a total of 13 fresh grape samples, 6 of which were moldy and 6 were not, were taken and 47 molds were isolated and identified. 29.78%, 23.40%, 17.02%, 14.89% and 14.89% of the isolates obtained were identified as *Penicillium* spp., *R. stolonifer, Alternaria alternata* (*A. alternata*), *C. cladosporioides* and *B. cinerea*, respectively. Of the 14 isolated *Penicillium* spp., 7 were identified as *P. solitum*, 4 as *P. expansum* and 3 as *P. olsonii*. In addition to these strains, it was determined that 9 of the samples had *R. stolonifer*, 4 of them had *C. cladosporioides*, 5 of them had *A. alternata* and 2 of them had *B. cinerea*. When the moldy samples were examined, it was determined that 3 *B. cinerea* in 3, 3 *A. alternata* in 2, 2 *R. stolonifer* in 2, 1 *C. cladosporioides* in 1 and 1 *Penicillium* spp. in 1 of these samples. Similarly, in a study in which molds that cause spoilage in fresh grapes were determined, *Alternaria*, *B. cinerea* and *Cladosporium* species were found to be dominant (Tournas and Katsoudas, 2005). In another study in which mold diversity was determined in fresh grape juices, it was stated that *Cladosporium* spp., *B. cinerea* and *Penicillium* spp. species were dominant (Bokulich et al., 2014).

In order to determine the mold types causing spoilage in apricot samples, 8 unmolded samples were taken and 32 isolates were obtained. The analyzed species were identified by isolating 28.12% *C. cladosporioides*, 28.12% *R. stolonifer*, 12.5% *Penicillium chrysogenum* (*P. chrysogenum*), 12.5% *Cladosporium herbarum* (*C. herbarum*), 9.37% *A. alternata*, 6.25% *P. solitum* and *P. brevicompactum*. Pérez-Pastor et al. (2007) reported that, *Rhizopus*, *Monilinia, Penicillium*, *Alternaria*, *Botrytis* and *Cladosporium* genera were found during the cold storage period of apricot. This result is partially in agreement with our study.

A total of 12 apple samples were analysed and 49 molds were isolated and identified from them. Of these isolates, 34.70% were identified as *Penicillium* spp., 22.45% *Rhizopus* spp., 18.37% *Cladosporium* spp., 8.16% *Botrytis cinerea*, 8.16% *Aspergillus niger* (*A. niger*), 4.08% *A. alternata* and 4.08% *Acremonium* spp. 4 *P. expansum* molds were obtained from 2 of 3 partially or completely molded apple samples and 2 *Rhizopus sexualis* (*R. sexualis*) molds were obtained from 1 of them. In 2 samples in which apple seeds were examined, 2 *R. stolonifer*, 2 *A. alternata* and 1 *Penicillium* spp. strain were determined. Of the remaining 8 unmolded specimens, 5 of them were containing 5 *C. cladosporioides*, 4 of them 7 *R. stolonifer*, 4 of them 4 *Cladosporium sphaerospermum* (*C. sphaerospermum*), 4 of them 4 *B. cinerea*, 4 of them 4 *A. niger*, 3 of them 4 *P. expansum*, 2 of them 3 *Penicillium* spp., 2 of them 3 *P. solitum*, 2 of them 2 *Penicillium griseofulvum* (*P. griseofulvum*) and 2 of them were containing 2 *Acremonium* spp. Similar to these results, it was stated that *Cladosporium* (Vepštaitė-Monstavičė et al., 2018) and *Penicillium* (Juhneviča et al., 2011; Abdelfattah et al., 2016b) were the dominant molds found in apples.

Within the scope of the study, a total of 9 plum samples, 7 of which were not moldy and 2 were moldy, were taken and 29 molds were isolated and identified. Of these isolates, 37.93% *Cladosporium* spp., 31.03% *R. stolonifer*, 20.69% *Penicillium* spp., 3.44% *Botrytis* spp., 3.44% *Alternaria tenuissima* (*A. tenuissima*) and 3.44% was identified as *Aspergillus niger*. *R. stolonifer* was isolated from both two moldy samples. 7 *C. cladosporioides* from 5 samples, 6 *R. stolonifer* from 4 samples, 5 *P. expansum* from 4 samples, 3 *C. herbarum* from 2 samples and one *Cladosporium macrocarpum* (*C.*

macrocarpum), one *P. brevicompactum*, one *B. cinerea*, one *A. niger* and one *A. tennuissima* from each sample have been isolated and identified. In a study conducted by Grantina-Ievina and Stanke (2015), it was determined that *Monilinia* spp., *B. cinerea*, *Diaporthe eres* and *Colletotrichum* spp. molds were found in plums and caused spoilage. In another study carried out by Okigbo (2001), the primary/dominant flora was *A. niger* and *Penicillium* spp. molds in plums; *Botryodiplodia theobromae* and *P. chrysogenum* were found to constitute the secondary flora. In a study where plum fruit, fruit peel, flower and leaf were analyzed, *Mucor*, *Rhizopus*, *Botrytis*, *Fusarium*, *Aspergillus* and *Penicillium* types of molds were isolated and it was stated that the mold types found were related to the microbiota of the garden and the soil (Tuszyński and Satora, 2003).

A total of 22 molds were isolated and identified from the 4 undamaged 4 moldy peach samples analysed. Of these isolates, 59.10% were found to be *R. stolonifer*, 22.73% *Penicillium* spp., 13.63% *B. cinerea* and 4.54% *C. cladosporioides*. A total of 7 isolates were obtained from moldy samples, and 6 of these isolates were determined as *R. stololonifer* and one of them was *P. expansum*. A total of 15 strains were isolated from non-mold samples. 7 *R. stolonifer* from all samples, 3 *B. cinerea* from 3 samples, 3 *P. expansum* from 3 samples and 1 *Penicillium viridicaum* and 1 *C. cladosporioides* from one sample were isolated. In a similar study carried out by Singh and Mandal (2007), it was stated that the main mold type that spoils peach is *R. stolonifer*, and also *A. alternata*, *A. niger*, *A. flavus*, *P. expansum* and *Rhizopus macrosporus* molds can be found. This study is partially in agreement with Liu et al. (2020) who expressed that *B. cinerea, Monilinia fructicola*, and *R. stolonifer* are the most common mold species responsible for post-harvest decay in peach.

At the end of the analysis of 10 cherry samples, 4 moldy and 6 unmolded, 31 mold isolates were obtained and identified. Of these isolates, 32.26% *C. cladosporioides*, 29.03% *R. stolonifer*, 22.58% *B. cinerea*, 16.13% *Penicillium* spp. type of mold was determined. A total of 11 isolates were obtained from moldy samples. Of this 5 *C. cladosporioides* from all, 3 *B. cinerea* from 2, 2 *R. stolonifer* from 2 and 1 *P. solitum* from 1 were isolated. 7 *R. stolonifer* from 5, 5 *C. cladosporioides* from 4, 4 *P. expansum* from 3 and 4 *B. cinerea* from 3 of the non-mold samples were identified. In studies examining the mold diversity in cherry fruit, it was stated that *Penicillium* and *Cladosporium* genera are dominant, as well as *Botrytis*, *Rhizopus*, *Mucor*, *Alternaria* and *Monilia* species can cause spoilage in cherries (Chand-Goyal and Spotts, 1996; Valero and Serrano, 2010; Serradilla et al., 2013).

A total of 26 molds were isolated from a total of 8 tangerine samples, of which 3 were moldy and 5 were not. Of these isolates, 50.00% were found to be *Penicillium* spp., 23.08% *C. cladosporioides*, 11.54% *Colletotrichum* spp. and 15.38% of them were *R. stolonifer*. A total of 5 strains, 4 *Penicillium italicum* (*P. italicum*) from 2 of the moldy samples and 1 *P. expansum* from one of them, were isolated. For unmolded samples, 6 *C. cladosoporioides* from 4, 3 *P. italicum* from 3, 3 *P. expansum* from 2, 3 *Colletotrichum* spp. from 2, 2 *P. digitatum* from 2, 2 *R. stolonifer* from 2 and 1 *Penicillium* spp. from 1 of them were isolated. A total of 20 strains were isolated and identified. Saito and Xiao (2017) stated that *Penicillium digitatum* (*P. digitatum*) is the main mold that causes deterioration in tangerines stored in the cold, as well as *Mucor piriformis*, *P. italicum*, *B. cinerea*, *Geotrichum citriaurantii* molds. This finding is partially in agreement with our study.

25 mold isolates were obtained from a total of 8 orange samples, of which 3 were moldy and 5 were unharmed. It was determined that 64.00% of these isolates were *Penicillium* spp., 16.00% were *R. stolonifer*, 12.00% were *C. cladosporioides* and 8.00% were *A. alternata*. *P. digitatum* mold was isolated from all moldy samples. A total of 20 isolates were obtained including 5 *P. digitatum* from 3 of the unmolded samples, 4 *R. stolonifer* from 4 of them, 3 *P. solitum* from 3 of them, 3 *C. cladosporioides* from 3 of them, 2 *P. italicum* from 2 of them, 2 *A. alternata* from 2 of them and 1 *P.*

olsonii from 1 of them. In a study carried out by El-Gali and Hamed (2017), the dominant mold species of spoiled oranges were *P. digitatum*, *A. alternata* and *A. niger* respectively. In a similar study, it was determined that the molds cause spoilage on oranges belong to the genus *Aspergillus*, *Alternaria*, *Mucor*, *Penicillium* and *Rhizopus* (Oviasogie et al., 2015). The results were similar to these studies, but *Aspergillus* and *Mucor* were not found in this study.

27 molds were isolated and identified from a total of 9 pear samples, 4 unharmed and 5 moldy. 40.74% of these isolates were *Penicillium* spp., 29.63% *R. stolonifer*, 14.81% *Cladosporium* spp., 7.41% *A. alternata*, 3.70% *Acremonium*. spp. and 3.70% *Fusarium solani* (*F. solani*). A total of 14 isolates were obtained, including 9 *P. expansum* from all moldy samples, 3 *R. stolonifer* from 3, 2 *C. cladosporioides* from 2 and 1 *C. herbarum* from one of them. For uninjured samples, 3 *P. expansum* from 3, 3 *R. stolonifera* from 2, 2 *A. alternate* from 2, 1 *Acremonium* spp. from 1 and 1 *F. solani* from 1 were isolated. When the relevant literature is examined, it has been found that *Rhizopus*, *Aspergillus*, *Penicillium*, *Eurotium* and *Wallemia* genera form the mold microbiota on the pear surface (Volschenk et al., 2016). In a study conducted by Louw and Korsten (2014) in South Africa, it was determined that *P. expansum*, *P. crustosum* and *P. solitum* type molds are the most important pathogens that cause rot in pears.

A total of 28 mold isolates were obtained from the surface of 7 quince samples, 4 of them were unharmed and 3 of them were moldy, and from the core of 5 samples. Of these isolates, 35.71% *A. alternata*, 21.43% *Penicillium* spp., 21.43% *Byssochlamys nivea* (*B. nivea*), 14.29% *C. cladosporioides* and 7.14% *R. stolonifer* were found. 3 *P. expansum* from 2 of the moldy samples and 3 *A. alternata* from 2 of them were isolated and identified. 5 *A. alternata* species were isolated from 4 of the examined quince seeds, 2 *B. nivea* from 2, and 2 *C. cladosporioides* from 2 of them. It was identified by isolating 4 *B. nivea* molds from 3 of the non-mold samples, 2 *R. stolonifer* from 2 of them, 2 *C. cladosporioides* from 2 of them, 2 *A. alternata* from 2 of them, 2 *Penicillium glabrum* (*P. glabrum*) from 2 of them and 1 *P. expansum* from one. In a study conducted in India, it was found that the molds *Botryodiplodia theobromae*, *Corynascus sepedonium*, *Absidia corymbifera*, *Syncephalastrum racemosum*, *B. cinerea*, *Gliocladium roseum*, *F. solani*, *A. alternata*, *A. niger*, *A. flavus* and *P. expansum* were found on post-harvest quinces (Sharma and Sumbali, 1997). In a study conducted by Ürey (2012), it was determined that approximately 40% of different quince orchards in Edirne had *Monilia* disease. Similarly, in another study carried out in Spain, *Monilinia linhartiana* was stated to be the common mold type in quince orchards (Moral et al., 2011). The fact that *Monilinia* genus could not be isolated in this study shows that an effective protection method is applied against this species in quince orchards.

A total of 27 mold isolates were obtained from 8 pomegranate samples, 3 of which were unharmed, 2 of which had scars on the surface and 3 of which were partially moldy. Of these isolates, 51.85% *Penicillium* spp., 14.81% *A. niger*, 14.81% *A. alternata*, 11.12% *C. herbarum* and 7.41% *F. oxysporum* were found. A total of 11 strains were isolated, including 3 *Penicillium citrionigrum* (*P. citrionigrum)* from all unmolded samples, 2 *P. digitatum* from 2, 2 *A. niger* from 2, 2 *C. herbarum* from 2 and 1 *Fusarium oxysporum* (*F. oxysporum*) and 1 *A. alternata* from each sample. 2 *A. alternata* and 2 *Penicillium implicatum* (*P. implicatum*) molds were isolated from all of the samples with scars on the surface, and 1 *F. oxysporum* and 1 *C. cladosporioides* type mold from one each. A total of 9 strains were identified, 5 *P. citrionigrum* from all partially moldy samples, 2 *P. implicatum* from 2 of them, and 2 *A. niger* from 2 of them. In a study carried out in Antalya by Karaca and Ilgın (2016), The most common mold type in pomegranate samples taken from the gardens were *A. alternata* and *B. cinerea* on their sales points. Other common species in the samples taken from the gardens belonged to

the genus *Aspergillus* and *Penicillium*; other common molds in samples taken from sales points were *Penicillium* spp., *A. niger*, *A. alternata* and *Coniella granati*. Similar to our results, in other studies examining molds that spoil pomegranate, mold species such as *A. alternata*, *C. cladosporioides*, *F. oxysporum*, *Ceratocystis fimbriata*, *Coniella granati*, *P. glabrum*, *P. implicatum* can also be found (Huang et al., 2003; Labuda et al., 2004; Spadaro et al., 2010; Çeliker et al., 2012; Gat et al., 2012; Zhou et al., 2018).

CONCLUSION

According to the research results; It has been determined that molds that can spoil and/or produce mycotoxins can be found in 12 different fruits offered for sale in the Erzurum market. Necessary measures should be taken to prevent mold contamination and development during the harvest, storage, transportation and sale of the fruit. In this context, necessary training should be given to farmers, wholesalers, transporters and sellers to prevent mold growth of fruits and vegetables. In addition, since molds are the primary infection points, bruising that may occur on fruits and vegetables should be minimized and moldy ones should be removed. The presence of molds capable of producing mycotoxins, such as *P. expansum* and *P. italicum*, on fruits is a concern. Since the mycotoxin formed can penetrate from moldy tissues to intact tissues, moldy fruit should not be eaten and should not be processed into any product.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

Dipak GHİMİRE contributed to methodology, validation, investigation. Ahmet ERDOĞAN contributed to conceptualization, supervision, and validation. Alper BARAN contributed to methodology, investigation, writing –original draft, writing –review & editing. Mustafa GÜRSES contributed to conceptualization and validation. Hacer MERAL AKTAŞ contributed to writing – original draft, writing –review & editing, and visualization.

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