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Incidence of aflatoxins, ochratoxin A, zearalenone, and deoxynivalenol in food commodities from Turkey

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Abstract

Aspergillus, *Penicillium*, *Fusarium*, and *Alternaria* species which produce toxic metabolites, create a big problem in terms of the production of reliable human food and animal feeds. This study was conducted to determine the mycotoxin contents of foodstuff collected uniformly in each year of 2017, 2018, and 2019 in Şebinkarahisar, Turkey by enzyme-linked immunosorbent assay. The highest total aflatoxin, and aflatoxin B1 were determined in red pepper in 2018 with 6.47 ± 0.07 and 4.58 ± 0.01 μg kg^{-1}, respectively while the highest ochratoxin amount was obtained again in the red paper in 2019 with 7.97 ± 0.57 μg kg^{-1}. Contrarily, the highest incidence of zearalenone and deoxynivalenol was determined in wheat and corn flour with 12.49 ± 0.3 and 397.6 ± 7.34 μg kg^{-1}, respectively. Weather changes have also been found to affect the incidence of mycotoxin. But, determined mycotoxin values do not pose a risk according to the Turkish Food Codex Contaminants Regulation.

1 | INTRODUCTION

Mycotoxins are generally known as aflatoxins (AFs) (aflatoxin B_1 [AFB_1], aflatoxin B2 [AFB_2], aflatoxin G1 [AFG_1], aflatoxin G2 [AFG_2]) ochratoxin A (OTA), zearalenone (ZEN), and deoxynivalenol (DON). These substances are important secondary metabolites produced by particularly various strains of *Aspergillus*, *Penicillium*, *Fusarium*, and *Alternaria* (Kovač, Šubarić, Bulaić, Kovač, & Šarkanj, 2018). For instance *A. flavus*, *A. parasiticus*, *A. tamarii*, and *A. nomius* are mostly produced AFs, whereas to the formation of OTA is mostly caused by *A. ochraceus* and *P. verrucosum* (Bui-Klimke & Wu, 2015; Chun, Kim, Ok, Hwang, & Chung, 2007; Ghali, Hmaissia-Khlifa, Ghorbel, Maaroufi, & Hedili, 2008). Also, *Fusarium* strains are mostly responsible for the formation of ZEN and DON (Bryden, 2007; Gaumy, Bailly, Burgat, & Guerre, 2001; Sobrova et al., 2010).

Although these compounds are natural metabolites produced by microscopic fungi, some of them are immunotoxic, teratogenic, immuno-suppressive, mutagenic, and carcinogenic effects when they are represented in excess concentrations in human food and animal feed (Moss, 1998; Shukla, 2016). The aforesaid four AFs groups were classified as Group 1 carcinogens by the international agency for research on cancer (IARC, 2012). Among these, AFB_1 is defined as the most harmful one (Ghali et al., 2008). Studies with OTA carried out with laboratory animals shows its pronounced renal and hepatic toxicity, neurotoxicity, teratogenicity, and immunotoxicity (Fusi et al., 2010; Pfohl-Leszkowicz & Manderville, 2007). Therefore, according to IARC, OTA is in the Group 2B potential carcinogen group (IARC, 1993a, 1993b). On the other hand, ZEN has an estrogenic effect on animals. Since the mutagenic, genotoxic and carcinogenic effects of ZEN are still controversial on humans, it is classified as the third carcinogenic group by the IARC (1999). DON was related to irritation of the gastrointestinal tract, nervous system disturbances, and hemorrhage in the consumers (Rotter, Prelusky, & Pestka, 1996).

Mycotoxins are likely to occur in all foodstuffs of vegetable and animal origin used as human food. Among these substances, rice, cereal grains, maize, soybean, wheat, barley, walnut, nut, peanut, spices, dried fruit varieties, and processed products are all potentially vulnerable to mycotoxin producing organisms (Bryden, 2007; Edwards et al., 2011; Reddy, Reddy, Abbas, Abel, & Muralidharan, 2008; Rodrigues & Naehrer, 2011).

Mycotoxins can be found all over the world. But, some countries with warm climates, such as Turkey, Egypt, Argentina, Iran, and Australia have higher frequency of these compounds. Şebinkarahisar, located in Kelkit valley, is a transition zone connecting the central Anatolia and Eastern Black Sea region of Turkey. This region has hot climate in summers and cold and snowy winters. But in recent years,

especially the change of precipitation regimes caused changes in weather factors. Şebinkarahisar has an important place in regional foodstuff production such as mulberry leather, concentrated mulberry juice, variety of Şebinkarahisar walnut, named after the region and registered in 1993, local hazelnut paste, dried mulberry, apple, pear, plum, and sour cherry varieties, processed handmade dough products such as noodles, pasta, siron, Turkish flat bread, local products made with concentrated mulberry juice, hazelnut paste, and many local products due to its weather characteristics and the transition zone between the black sea region and the inner Anatolia. Most of the products produced in this region are consumed in the domestic market at different points in Turkey and also are exported in recent years. According to District Agricultural Directorate capacity reports, annual sales capacity of locally produced products in Şebinkarahisar for different years was given in Table 1.

TABLE 1 Annual sales capacity of locally produced products in Şebinkarahisar for different years

Samples	2017 (kg)	2018 (kg)	2019 (kg)
Walnut	71,800	73,000	75,000
Nut	78,300	80,000	82
Dried plum	250	300	350
Dried wild plum	2000	2000	2000
Dried apple	920	1,000	1,000
Dried white mulberry	33,000	33,000	35,000
Dried black mulberry	300	400	200
Dried pear	2,500	2,500	3,000
Dried sour cherry	3,400	3,500	3,400
Dried rosehip	15,200	16,000	15,200
Dried hawthorn	13,400	12,000	15,000
Hazelnut halva	98,300	100,000	105,000
Köme	133,300	135,000	140,000
Mulberry leather	105,000	103,000	110,000
Concentrated mulberry juice	126,700	130,000	140,000
Dried thyme	200	300	400
Dried knotweed	300	200	500
Dried mint	600	600	700
Red pepper	700	0.8	0.7
Pasta	1700	1,500	2000
Noodles	3,400	3,500	4,500
Siron	2,700	2,800	3,000
Turkish flat bread	100	200	200
Wheat flour	10,900	12,000	14,000
Corn flour	300	300	400
Crushed wheat	4,000	4,000	5,000
Crushed wheat-II	4,700	5,000	5,000
Red lentil	1,370	2000	2000
Green lentil	1,370	2000	2000
Dried bread	24,200	26,000	30,000
Tarhana	600	800	1,000

In recent years, due to changing weather factors all over the world the determination of these toxic metabolites which are threatening food safety, with different methods has gained importance. Among these, ELISA offers many alternative advantages over other methods of mycotoxin detection owing to its properties such as low cost, simplicity, the use of safe reagents, determination of contaminant in a large number of samples in a shorter time, and high precision results (Cheng et al., 2010; Reza, Masoud, Ali, Faranak, & Mahboob, 2012; Rodrigues & Naehrer, 2012).

It is impossible to avoid mycotoxin amounts in foodstuffs. However, it is possible to reduce it below the levels of mycotoxins determined by countries with the precautions. Therefore, this study was designed to the determine AFT, AFB_1, OTA, ZEN, and DON content of 31 Şebinkarahisar regional products for 2017, 2018, and 2019 by ELISA methods depending on the increasing food safety demand.

2 | MATERIALS AND METHODS

2.1 | Samples collection

Walnut, nut, dried plum, dried wild plum, dried apple, dried white mulberry, dried black mulberry, dried pear, dried sour cherry, dried rosehip, dried hawthorn, hazelnut halva, köme, mulberry leather, concentrated mulberry juice, dried thyme, dried knotweed, dried mint, red pepper, pasta, noodles, siron, Turkish flat bread, wheat flour, corn flour, crushed wheat, crushed wheat-II, red lentil, green lentil, dried bread, and tarhana samples were regularly supplied each year from different local food companies in Şebinkarahisar producing and selling regional products between November and December in 2017, 2018, and 2019 at the several months of storage stage. All specimens were supplied at the stage of storage and were individually placed in sterile plastic bags and their collection points were labeled then they were transferred to the laboratory and stored at +4°C several days until further analysis.

2.2 | Extraction procedure

Each sample was individually weighed 5 g for each treatment and put inside of the sterile stomacher blender bags with filter (Interscience, France). AFT and AFB_1 samples were extracted with 80% (v/v) methanol (MeOH) while OTA and ZEN samples were extracted with 70% (v/v) MeOH. Also, DON samples were extracted with distilled water. Each solvent (25 ml) was added onto each sample and kept in the stomacher device until completely smashed. The obtained mixture was filtered with Whatman cellulose filter paper (Sigma-Aldrich) to remove the large particles. An aliquot of the extract (1 ml) was taken from obtained homogeneous supernatant with Pasteur pipette and 9 ml of 80% MeOH was added onto each treatment except for DON and stored at +4°C until further analysis. Nine milli liter distilled water

was added for DON analysis. The final dilution was adjusted as 1:50 (w/v) for all applications. For the determination of all AF parameters above mention three different extracts were prepared and each experiment was repeated as triplicates.

2.3 | Reagents and tests

2.3.1 | Total aflatoxin (AFT) assay

Total Aflatoxin Assay—Low Matrix (AFT) test kit contains the following components: 96 wells (12 × 8 well strips) in a microwell holder coated with mouse anti-AF monoclonal antibodies; noncoated wells (96 pieces) in a microwell holder for the mixing wells. Standard solutions of AFT are at the following concentrations: 0.0, 0.02, 0.05, 0.1, 0.2, and 0.4 ng/ml in 50% MeOH. In addition to the standards, a 12 ml HRP conjugate of peroxidase in a buffer; 2 × 12 ml proprietary sample diluent; a unit of stabilized tetramethylbenzidine (TBM) substrate reagent solution; an acidic reagent for termination process; phosphate buffered saline for washing process (PBS 0.05%, Tween 20).

2.3.2 | AFB_1 assay

A set of AFB_1 Elisa Assay—Low Matrix (AFB_1) kit consists of 96 wells (12 × 8 well strips) in a microwell holder coated with antibodies to AF; one set of 12 × 8 noncoated mixing wells consisting of 96 pieces. Standard solutions of AFB_1 are at the following concentrations: 0.0, 0.02, 0.05, 0.1, 0.2, and 0.4 ng/ml in 50% MeOH. In addition to the standards a 12 ml HRP conjugate of peroxidase in a buffer; 2 × 12 ml proprietary sample diluent; a unit of stabilized TBM substrate reagent solution; an acidic reagent for termination process; a buffer for washing (PBS 0.05%, Tween 20).

2.3.3 | OTA assay

The OTA was carried out according to the HELICA Quantitative Assay for OTA in Coffee, Cocoa, and Spices procedure contains 96 wells (12 × 8 well strips). The kit has 96 noncoated microwells to mix standards and samples with assay diluent. Other microwells were coated with mouse anti-OTA antibody. Standards of the OTA were 0.0, 0.02, 0.05, 0.1, 0.2, and 0.4 ng/ml concentrations in 70% MeOH. The test kit had two proprietary assay diluent (2 × 12 ml); an OTA HRP conjugates (12 ml); a substrate reagent (12 ml); an acidic stop solution and wash buffer (12 ml, PBS with 0.05% Tween 20).

2.3.4 | ZEN assay

HELICA Zearalenone Elisa Assay (ZEN) was tested to achieve ZEN analysis. The aforesaid 96 wells (12 × 8 well strips) were coated with a mouse anti-ZEN monoclonal antibody and noncoated were used to complete the experiment. Standards of the ZEN were 0.0, 0.3, 0.6, 1.2, 3.0, and 10.0 ng/ml concentrations in 70% MeOH. In addition to the standards a ZEN HRP conjugate (conjugated to peroxidase in a buffer 12 ml); two proprietary sample diluent (2 × 12 ml); a unit (12 ml) of TBM substrate reagent solution; a unit 12 ml acidic reagent solution for termination process; a phosphate buffered saline for washing process (PBS 0.05%, Tween 20) were used to determine ZEN amounts.

2.3.5 | DON assay

HELICA DON assay was performed to realize DON analysis. Then, 96 wells (12 × 8 well strips) were coated with a mouse anti-DON monoclonal antibody and noncoated were used to complete the experiment. Standards of the DON were 0.0, 10.0, 20.0, 50.0, 100.0, and 200.0 ng/ml concentrations in deionized water. DON HRP conjugate (conjugated to peroxidase in a buffer 12 ml); a TBM substrate reagent solution (12 ml); an acidic reagent solution for termination process (12 ml); distilled water for the washing process was preferred to determine DON amounts.

ELISA method was used in this study to determine AFT, AFB_1, OTA, ZEN, and DON values by HELICA test kits (Helica Biosystems Inc., USA).

2.4 | Apparatus and equipment

DENVER SI-234 analytical balance (Denver Instrument, USA) was used to weigh samples. Automatic CLST-400D Stomacher mixer (USA) was preferred to homogeneously crush all samples in MeOH. All analyses were performed with antibody-coated special microwells included in the HELICA kit (Santa Ana, CA, USA). The standard and sample placement of the microwells was carried out with multipurpose sterile Pasteur pipettes and automatic pipettes with various volumes (Darmstadt, Germany). Washing of the test microwells applied was performed with a fully automated Biotech Elx50 device (Biotek Instruments Inc., USA). All samples and standards tested were read with ELx808 reading apparatus for ELISA tests at 450 absorbance ($OD_{450,}$ Biotek Instruments Inc., USA). The obtained values were evaluated according to the standard curve for AF included in the test kit.

2.5 | Experiment

All samples and reagents were taken to room temperature before use. The PBS-Tween packet was transferred by washing with distilled water into a 1-l bottle and dissolved completely. Initially mixing wells were placed in microwell holder for each standard and sample followed by adding 200 µl sample diluent into each mixing microwell.

One hundred micro liter of the standards included in test kits and an aliquot of the extracts were individually added into each microwell.

The mixture in the well was thoroughly homogenized with a micropipette. From this diluted homogeneous mixture, 100 ml of sample were transferred to antibody-coated wells and held in a dark place for 30 min at room temperature. The wells were placed fully automatic Biotech Elx50 strip washer and washed 3 times for AFT and AFB_1 and five times for ZEN with PBS. The wells were washed five times with distilled water in this equipment for DON analysis. Washed wells were kept in face-down position on towels to remove the residual wash buffer or water. All AF HRP conjugate in AFT, AFB_1, OTA, and ZEN kits were individually transferred to each coated well (100 µl) and left to incubate again in the darkness to avoid direct sunlight for 30 min with AFT, AFB_1, and OTA except for ZEN. This time was applied as 10 min in ZEN application. Following this process, the above-mentioned washing process was carried out again. The substrate (100 µl) was added to each microwell used all treatments and waited in darkness to incubate for 10 min for AFT, AFB_1, and ZEN. The same amount of substrate was applied as 5 min for DON analysis. The color changes occurring in the microwells of the samples were physically evaluated according to the color changes in the microwells containing the standards at the end of the incubation period. In the final step, 100 µl of stop solution was added to each microwell to terminate the reaction. Each microwell for each treatment was placed in a microtiter plate reader (Biotech ELx808) adjustable to 450 nm wavelength and the optical density (OD) of each microwell was determined with HELICA reader programmer within 15 min at the latest. During the incubation periods, mouths of all microwells were sealed with paraffin. All processes were carried out as triplicates for all experiments. The amounts of the AFT, AFB_1, ZEN, and DON were detected using the previously prepared standard curve.

2.6 | Statistical analysis

All experiments contained three strips were performed triplicates to the determination of AFT, AFB_1, OTA, ZEN, and DON contents of all specimens. the SPSS software (SPSS Institute Inc., 2000, Version 21.0) was used to calculate means, standard error and variances of the normal distribution of mycotoxins contents. Kolmogorov–Smirnov (K–S) test was preferred to evaluate the normality of data sets (Justel, Peña, & Zamar, 1997). Correlation and multiple regression analyses were performed to determine the relationship between the weather factors varying over the years and the incidence of mycotoxins. Correlations analyses were carried out according to the Spearman method (Spearman, 1904).

3 | RESULTS

3.1 | Determination of AFs content

The maximum acceptable mycotoxin levels differ according to different weather conditions all over the world. According to the Turkish Food Codex (2011), the maximum acceptable mycotoxin levels determined in some human food in Turkey is given in Table 2. Measurable levels of mycotoxins were determined in all 31 different products analyzed for 3 years, depending on changing weather factors. However, no contamination was found above the specified maximum mycotoxin levels in any these products analyzed for 3 years. In general, mycotoxin values in 2017 were higher than in 2019 but lower than in 2018 (Table 3). Compared the weather data and AFs contents, there was a remarkable increase in the rates of AFT and AFB_1 in 2018 when precipitation and humidity were high (Humidity is 7.67 and 4.61%, precipitation is 37.13 and 55.24% higher than in 2017 and 2019, respectively, Table 4). As a result of ELISA tests that do not include processes such as isolation and purification of the component to be tested and had simple extraction method, the highest AFT was detected in red pepper in 2018 with 6.47 ± 0.07 µg kg^{-1}. In general, among the products analyzed for 3 years, red pepper had higher AFT. Moreover, the highest AFB_1 value was determined from the red pepper sample of 2019 with 4.583 ± 0.01 µg kg^{-1} (Table 5). These results are consistent with 2018 with the highest humidity (Figure 1). A surprising result in terms of AFT and AFB_1 was obtained from the sample of köme with 3.81 ± 0.07 and 2.25 ± 0.0 4 µg kg^{-1} in 2018, respectively. It has been determined that concentrated mulberry juice and hazelnut halva samples used in the production of köme samples have lower AFT and AFB_1 ratios than the köme in all years. In 2018, the highest AFT and AFB_1 of concentrated mulberry juice sample were determined as 0.49 ± 0.01 and 0.40 ± 0.01 µg kg^{-1}, respectively, while the values of hazelnut halva were 0.40 ± 0.01 and 0.37 ± 0.01 µg kg^{-1} in the same year. It was observed that these values were approximately 800 and 500% higher than the results of AFT and AFB_1 obtained from the sample of köme. However, these values do not constitute a problem in terms of consumption as this product is far below the highest determined contamination values by the Turkish Food Codex (2011). These results indicate that more humid environments have higher AFs. The lowest AFs values were obtained from the samples offered for sale in 2019 when precipitation and humidity were the lowest between August and December which is production month of these foodstuffs. A strong correlation was found between AFT and AFB_1 for 3 years. In 2017, there was a strong correlation between AFT and AFB_1 with $r = .59$ ($p < .01$, Table 6). While this strong relationship was $r = .61$ in 2018, $r = .57$ in 2019 ($p < .01$, Tables 7 and 8).

3.2 | Determination of OTA content

From the point of view of OTA, which has increased significantly in recent years and reported to have serious toxic effects, the measurable level of OTA was detected in all 16 analyzed produced locally foodstuff. The samples consumed in Turkey were analyzed and found to be contaminated commodities with OTA in different years at an average of 1.12 and 7.97 µg OTA/kg, respectively. However, none of these values is above the values determined in the Turkish Food Codex Contaminants Regulation. The highest OTA detected was obtained from red paper with 7.97 ± 0.57 µg kg^{-1} in 2018. A statistically significant difference can be seen between red pepper and the lowest OTA value obtained from dry bread in the same year. Although

TABLE 2 The upper limits of mycotoxin content in some products according to Turkish Food Codex Regulation Contaminants in Turkey

Samples	AFT (μg kg^{-1})	AFB$_1$ (μg kg^{-1})	OTA (μg kg^{-1})	ZEN (μg kg^{-1})	DON (μg kg^{-1}))
Walnut	15.0	8.0			
Nut	15.0	8.0	nn	nn	nn
Dried plum	10.0	8.0	nn	nn	nn
Dried wild plum	10.0	8.0	nn	nn	nn
Dried apple	10.0	8.0	nn	nn	nn
Dried white mulberry	10.0	8.0	nn	nn	nn
Dried black mulberry	10.0	8.0	nn	nn	nn
Dried pear	10.0	8.0	nn	nn	nn
Dried sour cherry	10.0	8.0	nn	nn	nn
Dried rosehip	10.0	8.0	nn	nn	nn
Dried hawthorn	10.0	8.0	nn	nn	nn
Hazelnut halva	10.0	5.0	nn	nn	nn
Köme	10.0	5.0	nn	nn	nn
Mulberry leather	10.0	5.0	nn	nn	nn
Concentrated mulberry juice	10.0	5.0	nn	nn	nn
Dried thyme	10.0	5.0	15.0	nn	nn
Dried knotweed	10.0	5.0	15.0	nn	nn
Dried mint	10.0	5.0	15.0	nn	nn
Red pepper	10.0	5.0	15.0	nn	nn
Pasta	4.0	2.0	3.0	75.0	750.0
Noodles	4.0	2.0	3.0	75.0	750.0
Siron	4.0	2.0	3.0	75.0	750.0
Turkish flat bread	4.0	2.0	3.0	75.0	750.0
Wheat flour	4.0	2.0	3.0	75.0	750.0
Corn flour	4.0	2.0	3.0	75.0	750.0
Crushed wheat	4.0	2.0	3.0	75.0	750.0
Crushed wheat-II	4.0	2.0	3.0	75.0	750.0
Red lentil	4.0	2.0	3.0	75.0	750.0
Green lentil	4.0	2.0	3.0	75.0	750.0
Dried bread	4.0	2.0	3.0	50.0	500.0
Tarhana	4.0	2.0	3.0	50.0	500.0

Note: Turkish Food Codex Contaminants Regulation—December 29, 2011-Issue: 28157 (3rd repeated).
Abbreviations: AFB$_1$, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; nn, not necessary; OTA, ochratoxin, ZEN, zearalenone.

these levels are clearly below the maximum limit determined by Turkish Food Codex (2011), the European Commission (2006) legislation finds the value obtained from red pepper high. A decrease in OTA amounts was observed in 2017 and 2019 when humidity, temperature and precipitation were lower, as in AFs. This decrease was calculated as 13.2% in 2019, 4.3% in 2017 in red pepper, where the highest OTA value was obtained.

3.3 | Determination of ZEN and DON content

They are known to be found in wheat, barley and other cereal varieties or products made from these cereals. When 12 different food products were examined in terms of ZEN and DON, the highest prevalence of ZEN was determined in wheat flour with 12.49 ± 0.3 μg kg^{-1}, and the highest amounts of DON in corn flour with 397.6 ± 7.34 μg kg^{-1}. As in other mycotoxin data, it was not surprising to find the highest prevalence ZEN and DON values obtained in 2018 food commodities. The lowest ZEN and DON values of these 12 food products were obtained in 2019 Turkish flat bread and dry bread with 5.02 ± 0.1 and 36.3 ± 2.26 μg kg^{-1}, respectively. There were 32.17% and 19.52% significant difference between the highest ZEN in 2018 and the other 2 years, respectively. This difference was 3.36 and 11.16% in DON values, respectively. All other statistical differences between ZEN and DON values was shown in Tables 3–5. Correlation analysis reveals a relationship between AFB$_1$ and DON in

TABLE 3 The pooled prevalence of mycotoxins content of traditional Şebinkarahisar products in 2017

Samples	AFT (μg kg^{-1})	AFB$_1$ (μg kg^{-1})	OTA (μg kg^{-1})	ZEN (μg kg^{-1})	DON (μg kg^{-1})
Walnut	0.46 ± 0.01	0.36 ± 0.01	nt	nt	nt
Nut	0.41 ± 0.01	0.39 ± 0.01	nt	nt	nt
Dried plum	0.44 ± 0.01	0.35 ± 0.01	nt	nt	nt
Dried wild plum	0.39 ± 0.01	0.38 ± 0.01	nt	nt	nt
Dried apple	0.42 ± 0.01	0.35 ± 0.01	nt	nt	nt
Dried white mulberry	0.45 ± 0.01	0.38 ± 0.01	nt	nt	nt
Dried black mulberry	0.43 ± 0.01	0.38 ± 0.01	nt	nt	nt
Dried pear	0.70 ± 0.01	0.50 ± 0.01	nt	nt	nt
Dried sour cherry	0.45 ± 0.01	0.37 ± 0.01	nt	nt	nt
Dried rosehip	0.41 ± 0.01	0.35 ± 0.01	nt	nt	nt
Dried hawthorn	0.44 ± 0.01	0.34 ± 0.01	nt	nt	nt
Hazelnut halva	0.45 ± 0.01	0.37 ± 0.01	nt	nt	nt
Köme	3.00 ± 0.06	2.22 ± 0.04	nt	nt	nt
Mulberry leather	0.53 ± 0.01	0.47 ± 0.01	nt	nt	nt
Concentrated mulberry juice	0.45 ± 0.01	0.38 ± 0.01	nt	nt	nt
Dried thyme	0.47 ± 0.01	0.38 ± 0.01	3.46 ± 0.88	nt	nt
Dried knotweed	0.42 ± 0.01	0.36 ± 0.01	4.74 ± 0.16	nt	nt
Dried mint	0.47 ± 0.01	0.38 ± 0.01	3.27 ± 0.16	nt	nt
Red pepper	4.94 ± 0.04	3.75 ± 0.03	7.64 ± 0.66	nt	nt
Pasta	0.49 ± 0.01	0.35 ± 0.01	1.19 ± 0.22	8.87 ± 0.3	54.4 ± 2.61
Noodles	0.44 ± 0.01	0.37 ± 0.01	1.78 ± 0.19	8.45 ± 0.3	53.1 ± 2.48
Siron	0.40 ± 0.01	0.38 ± 0.01	1.81 ± 0.16	7.74 ± 0.2	52.4 ± 2.44
Turkish flat bread	0.47 ± 0.01	0.35 ± 0.01	1.13 ± 0.19	7.11 ± 0.2	52.7 ± 2.48
Wheat flour	0.47 ± 0.01	0.44 ± 0.01	1.66 ± 0.27	9.45 ± 0.2	378.4 ± 7.28
Corn flour	0.48 ± 0.01	0.43 ± 0.01	1.61 ± 0.19	10.21 ± 0.2	384.5 ± 6.15
Crushed wheat	0.46 ± 0.01	0.37 ± 0.01	1.12 ± 0.19	5.35 ± 0.1	55.0 ± 1.97
Crushed wheat-II	0.45 ± 0.01	0.38 ± 0.01	1.49 ± 0.19	5.14 ± 0.1	61.4 ± 3.64
Red lentil	0.49 ± 0.01	0.42 ± 0.01	1.77 ± 0.22	6.22 ± 0.1	54.7 ± 2.48
Green lentil	0.51 ± 0.01	0.41 ± 0.01	1.45 ± 0.24	6.29 ± 0.1	45.1 ± 3.27
Dried bread	0.41 ± 0.01	0.35 ± 0.01	1.55 ± 0.22	10.85 ± 0.2	37.5 ± 3.03
Tarhana	0.57 ± 0.01	0.47 ± 0.01	1.92 ± 0.26	9.48 ± 0.01	78.4 ± 4.01

Abbreviations: AFB$_1$, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; nt, not tested; OTA, ochratoxin; ZEN, zearalenone.

2018 with $r = .65$ ($p < .05$). All these values obtained do not pose any problem in terms of the maximum ZEN and DON values specified in the Turkish Food Codex Contaminants Regulation—December 29, 2011-Issue: 28157 (third repeated).

3.4 | Weather conditions

The whole world is facing a global weather change in recent years. This change has also increased noticeably in Turkey. In addition to the visible damages caused by weather changes in nature, their negative effects on production, transportation, storage, and consumption on human food are undeniable. Especially, rapid changes in humidity, precipitation, and temperature values cause increases in secondary toxic metabolites which have a seriously harmful effect on certain doses on humans. Therefore, the determination of the increasing amounts of mycotoxin depending on changing weather factor is important in terms of reliable healthy foodstuff production, storage, and transport conditions.

In the Şebinkarahisar region, where production activities are carried out, different humidity, precipitation, and temperature values have been observed in recent years. Weather data for the last 3 years could be seen in Figures 1–3. According to these data, all analyzed weather data in months of 2018 are higher than in 2017 and 2019. The average annual humidity content of 2018, which is the most important parameter in terms of mycotoxin formation, was higher than in 2017 and 2019 (Figure 1). The highest humidity rates in 2018 are the autumn months which are the production periods of the products. Looking at

TABLE 4 The pooled prevalence of mycotoxins content of traditional Şebinkarahisar products in 2018

Samples	AFT (μg kg^{-1})	AFB$_1$ (μg kg^{-1})	OTA (μg kg^{-1})	ZEN (μg kg^{-1})	DON (μg kg^{-1})
Walnut	0.49 ± 0.01	0.38 ± 0.01	nt	nt	nt
Nut	0.47 ± 0.01	0.39 ± 0.01	nt	nt	nt
Dried plum	0.48 ± 0.01	0.37 ± 0.01	nt	nt	nt
Dried wild plum	0.48 ± 0.01	0.39 ± 0.01	nt	nt	nt
Dried apple	0.49 ± 0.01	0.39 ± 0.01	nt	nt	nt
Dried white mulberry	0.53 ± 0.01	0.41 ± 0.01	nt	nt	nt
Dried black mulberry	0.49 ± 0.01	0.40 ± 0.01	nt	nt	nt
Dried pear	0.65 ± 0.01	0.51 ± 0.01	nt	nt	nt
Dried sour cherry	0.47 ± 0.01	0.39 ± 0.01	nt	nt	nt
Dried rosehip	0.49 ± 0.01	0.37 ± 0.01	nt	nt	nt
Dried hawthorn	0.44 ± 0.01	0.38 ± 0.01	nt	nt	nt
Hazelnut halva	0.48 ± 0.01	0.38 ± 0.01	nt	nt	nt
Köme	3.81 ± 0.07	2.25 ± 0.04	nt	nt	nt
Mulberry leather	0.50 ± 0.01	0.47 ± 0.01	nt	nt	nt
Concentrated mulberry juice	0.49 ± 0.01	0.40 ± 0.01	nt	nt	nt
Dried thyme	0.48 ± 0.01	0.38 ± 0.01	4.81 ± 0.75	nt	nt
Dried knotweed	0.43 ± 0.01	0.38 ± 0.01	5.75 ± 0.25	nt	nt
Dried mint	0.47 ± 0.01	0.38 ± 0.01	4.41 ± 0.25	nt	nt
Red pepper	6.47 ± 0.07	4.58 ± 0.01	7.97 ± 0.57	nt	nt
Pasta	0.46 ± 0.01	0.36 ± 0.01	1.71 ± 0.20	9.31 ± 0.3	56.2 ± 2.61
Noodles	0.48 ± 0.01	0.37 ± 0.01	1.88 ± 0.18	9.14 ± 0.3	54.5 ± 2.35
Siron	0.48 ± 0.01	0.39 ± 0.01	1.92 ± 0.15	8.37 ± 0.2	53.4 ± 2.44
Turkish flat bread	0.47 ± 0.01	0.40 ± 0.01	1.33 ± 0.18	7.83 ± 0.2	52.9 ± 2.48
Wheat flour	0.47 ± 0.01	0.41 ± 0.01	1.52 ± 0.28	12.49 ± 0.3	389.7 ± 6.45
Corn flour	0.50 ± 0.01	0.41 ± 0.01	1.76 ± 0.18	11.45 ± 0.3	397.6 ± 7.34
Crushed wheat	0.52 ± 0.01	0.40 ± 0.01	1.69 ± 0.19	6.87 ± 0.2	59.0 ± 0.93
Crushed wheat -II	0.49 ± 0.01	0.40 ± 0.01	1.51 ± 0.29	6.24 ± 0.2	61.8 ± 0.93
Red lentil	0.50 ± 0.01	0.37 ± 0.01	1.56 ± 0.22	7.76 ± 0.3	57.4 ± 1.88
Green lentil	0.61 ± 0.01	0.41 ± 0.01	1.47 ± 0.27	9.29 ± 0.1	49.1 ± 0.92
Dried bread	0.57 ± 0.01	0.38 ± 0.01	1.32 ± 0.41	12.19 ± 0.4	41.3 ± 1.94
Tarhana	0.57 ± 0.01	0.42 ± 0.01	2.02 ± 0.46	11.48 ± 0.03	79.5 ± 4.01

Abbreviations: AFB$_1$, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; nt, not tested; OTA, ochratoxin; ZEN, zearalenone.

the production months of 2017 and 2019, these values are 35.9 and 43.3% lower in the same months compared to 2018, respectively. The highest humidity was recorded in month of December with 78.8%. Again, the highest humidity rates in 2017 and 2019 were 63.6 and 66.7% in December, respectively. The lowest average humidity was measured in April 2018 with 39% humidity which is the lowest one measured over 3 years. When the amount of precipitation directly affected by the humidity rate is examined, it is seen that there is an irregular distribution between the months for 3 years. The highest average precipitation rate was determined with 168.6 kg/m^2 in May 2018 (Figure 2). This rate is 67.43% higher than May 2017. When the total average precipitation rate was examined between the years, it was determined that 2018 has received 37.13 and 55.07% more precipitation than in 2017 and 2019, respectively. The temperature values that were effective in toxic contamination, especially during postproduction storage and marketing, also reached the highest annual average values in 2018. The highest month has been determined in August 2017 with 22.4°C (Figure 3). Nevertheless, although average temperatures were close for the 3 years tested, 2018 was 8.7–5.6% warmer than other years. Correlation analysis showed us that there was a significant relationship between humidity and precipitation in 2017 and 2018. These relations were calculated as $r = .73$ ($p < .01$) in 2017 whereas, it was determined as $r = .76$ in 2018 ($p < .05$). These results reveal that precipitation and humidity affect each other positively. Humidity and temperature parameters influenced to each other negatively in all evaluated years ($r = -.75$ in 2017, $p < .01$, $r = -.68$ in 2018, $r = -.62$ in 2019, $p < .05$). While this correlation is very strong in 2017, it is slightly weaker in 2018 and 2019.

TABLE 5 The pooled prevalence of mycotoxins content of traditional Şebinkarahisar products in 2019

SAMPLES	AFT (μg kg^{-1})	AFB$_1$ (μg kg^{-1})	OTA (μg kg^{-1})	ZEN (μg kg^{-1})	DON (μg kg^{-1})
Walnut	0.43 ± 0.01	0.36 ± 0.01	nt	nt	nt
Nut	0.40 ± 0.01	0.38 ± 0.01	nt	nt	nt
Dried plum	0.40 ± 0.01	0.34 ± 0.01	nt	nt	nt
Dried wild plum	0.38 ± 0.01	0.34 ± 0.01	nt	nt	nt
Dried apple	0.41 ± 0.01	0.34 ± 0.01	nt	nt	nt
Dried white mulberry	0.45 ± 0.01	0.35 ± 0.01	nt	nt	nt
Dried black mulberry	0.42 ± 0.01	0.36 ± 0.01	nt	nt	nt
Dried pear	0.58 ± 0.01	0.48 ± 0.01	nt	nt	nt
Dried sour cherry	0.42 ± 0.01	0.37 ± 0.01	nt	nt	nt
Dried rosehip	0.39 ± 0.01	0.35 ± 0.01	nt	nt	nt
Dried hawthorn	0.43 ± 0.01	0.34 ± 0.01	nt	nt	nt
Hazelnut halva	0.40 ± 0.01	0.37 ± 0.01	nt	nt	nt
Köme	2.72 ± 0.06	2.12 ± 0.04	nt	nt	nt
Mulberry leather	0.49 ± 0.01	0.47 ± 0.01	nt	nt	nt
Concentrated mulberry juice	0.41 ± 0.01	0.37 ± 0.01	nt	nt	nt
Dried thyme	0.42 ± 0.01	0.38 ± 0.01	3.12 ± 0.95	nt	nt
Dried knotweed	0.40 ± 0.01	0.36 ± 0.01	3.92 ± 0.07	nt	nt
Dried mint	0.45 ± 0.01	0.37 ± 0.01	3.21 ± 0.06	nt	nt
Red pepper	5.77 ± 0.04	3.56 ± 0.03	7.04 ± 0.48	nt	nt
Pasta	0.48 ± 0.01	0.36 ± 0.01	1.71 ± 0.20	8.11 ± 0.3	53.7 ± 2.30
Noodles	0.44 ± 0.01	0.37 ± 0.01	1.36 ± 0.18	8.20 ± 0.3	51.4 ± 1.15
Siron	0.42 ± 0.01	0.38 ± 0.01	1.48 ± 0.15	7.43 ± 0.2	50.5 ± 1.80
Turkish flat bread	0.44 ± 0.01	0.35 ± 0.01	1.52 ± 0.48	6.84 ± 0.2	50.4 ± 1.80
Wheat flour	0.44 ± 0.01	0.41 ± 0.01	1.63 ± 0.28	10.45 ± 0.2	323.3 ± 6.45
Corn flour	0.45 ± 0.01	0.41 ± 0.01	1.36 ± 0.18	10.31 ± 0.2	357.5 ± 6.81
Crushed wheat	0.45 ± 0.01	0.39 ± 0.01	1.21 ± 0.19	6.52 ± 0.1	47.6 ± 0.93
Crushed wheat-II	0.47 ± 0.01	0.36 ± 0.01	1.21 ± 0.29	5.02 ± 0.1	47.0 ± 0.93
Red lentil	0.42 ± 0.01	0.40 ± 0.01	1.83 ± 0.22	7.64 ± 0.1	48.9 ± 1.92
Green lentil	0.44 ± 0.01	0.40 ± 0.01	1.47 ± 0.27	8.61 ± 0.2	48.3 ± 0.91
Dried bread	0.41 ± 0.01	0.36 ± 0.01	1.88 ± 0.14	11.62 ± 0.2	36.3 ± 2.26
Tarhana	0.54 ± 0.01	0.43 ± 0.01	1.18 ± 0.25	10.45 ± 0.02	77.4 ± 5.12

Abbreviations: AFB$_1$, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; nt, not tested; OTA, ochratoxin; ZEN, zearalenone.

3.5 | The relationship between weather data and AF

Statistically, annual mycotoxin changes were subject to change depending on weather changes. The correlation analysis results reveal that there was a relation between weather factors in some years and the prevalence of some mycotoxin type. AFB$_1$ (r = −.73), and ZEN (r = .71) has been strongly affected from precipitation in 2017. In the same year, ZEN was strongly affected by humidity at a rate of r = .76. Similar but more strong relations were obtained from 2018 due to the increasing the average humidity, precipitation and temperature content on an annual basis. Analysis results show that AFB$_1$, ZEN, and DON were affected by weather conditions. The increase in the prevalence of ZEN in food commodities in 2018 was supported by correlation results. The ratio between the humidity and ZEN was detected as r = .82. The same correlation between ZEN and precipitation was r = .78 (p < .01). In the same year, the frequency of AFB$_1$ was also affected by temperature with r = .62 (p < .05). As mentioned above, the decrease in weather parameters in 2019 is linearly proportional to the prevalence of mycotoxin formation. Statistical analyzes showed that the weather conditions were not effect on AFT, AFB$_1$, and ZEN in 2019. Only DON was weakly affected by precipitation with r = .64 (p < .05). Surprisingly, it is seen that all these weather changes did not cause any change in AFT for these 3 years.

When the significant results between the weather factors obtained from the correlation analysis and the prevalence of AFB$_1$ were compared in the multiple regression analysis, weather factors such as humidity, temperature and precipitation had a 13.4% impact

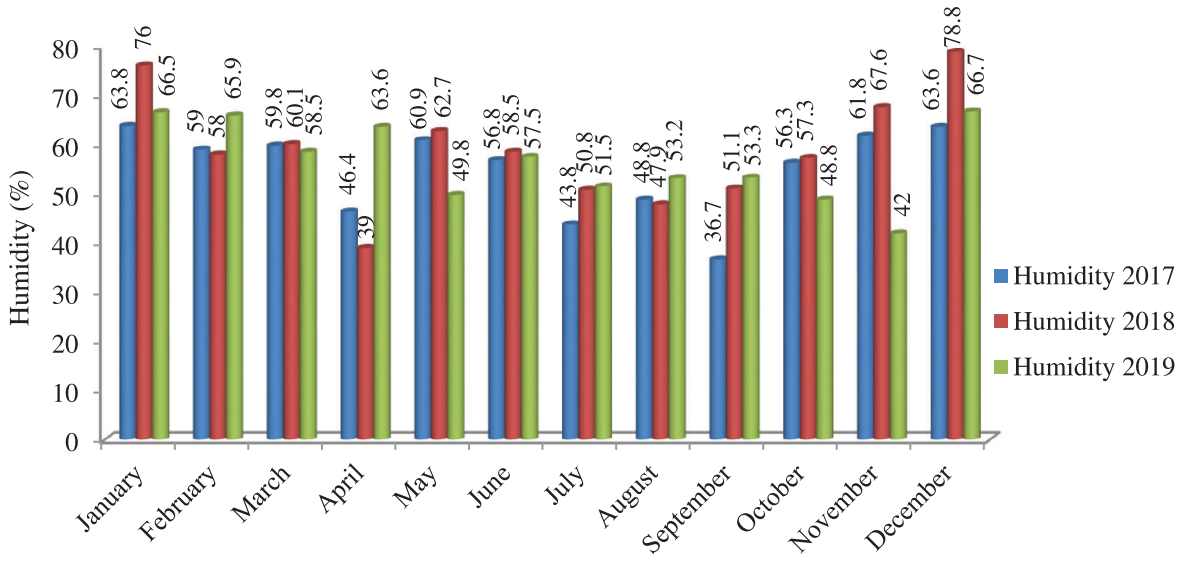

FIGURE 1 Mean values of monthly humidity distributions for different years

TABLE 6 Spearman correlation coefficient between weather factors and mycotoxin content of Şebinkarahisar regional commodities in 2017

	Humidity	Temperature	Precipitation	AFT	AFB_1	OTA	ZEN	DON
Humidity	1.00	−.75**	.73**				.76**	
Temperature	−.75**	1.00						
Precipitation	.73**		1.00		−.73**		.71*	
AFT				1.00	.59**			
AFB_1			−.73**	.59**	1.00			
OTA						1.00		
ZEN	.76**		.71*				1.00	
DON								1.00

Abbreviations: AFB_1, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; OTA, ochratoxin; ZEN, zearalenone.
*Correlation is significant at the .05 level (2- tailed).
**Correlation is significant at the .01 level (2- tailed).

TABLE 7 Spearman correlation coefficient between weather factors and mycotoxin content of Şebinkarahisar regional commodities in 2018

	Humidity	Temperature	Precipitation	AFT	AFB_1	OTA	ZEN	DON
Humidity	1.00	−.68*	.76*				.82**	
Temperature	−.68*	1.00			.62*			
Precipitation	.76*		1.00				.78**	
AFT				1.00	.61**			
AFB_1		.62*		061**	1.00			.65*
OTA						1.00		
ZEN	.82**		.78*				1.00	
DON					.65*			1.00

Abbreviations: AFB_1, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; OTA, ochratoxin; ZEN, zearalenone.
*Correlation is significant at the .05 level (2- tailed).
**Correlation is significant at the .01 level (2- tailed).

on AFB_1 formation for 3 years. The relationship between variables and AFB_1 was meaningless and random (p = .33). The formula relationship between AFB1 and weather factors was $F_{(4.31)}$ = 1.204; p < .05. When the effects of the weather factors on AFB_1 were investigated individually, the formula AFB_1 = −1.41 + 0.04 Humidity + 0.03 Temperature − 0.06 Precipitation − 0.04 Year was obtained. All of

TABLE 8 Spearman correlation coefficient between weather factors and mycotoxin content of Şebinkarahisar regional commodities in 2019

	Humidity	Temperature	Precipitation	AFT	AFB_1	OTA	ZEN	DON
Humidity	1.00	−.62*						
Temperature	−.62*	1.00						
Precipitation			1.00					.64*
AFT				1.00	.57**			
AFB_1				.57**	1.00			
OTA						1.00		
ZEN							1.00	
DON			.64*					1.00

Abbreviations: AFB_1, aflatoxin B1; AFT, total aflatoxin (B1 + B2 + G1 + G2); DON, deoxynivalenol; OTA, ochratoxin; ZEN, zearalenone.
*Correlation is significant at the .05 level (2- tailed).
**Correlation is significant at the .01 level (2- tailed).

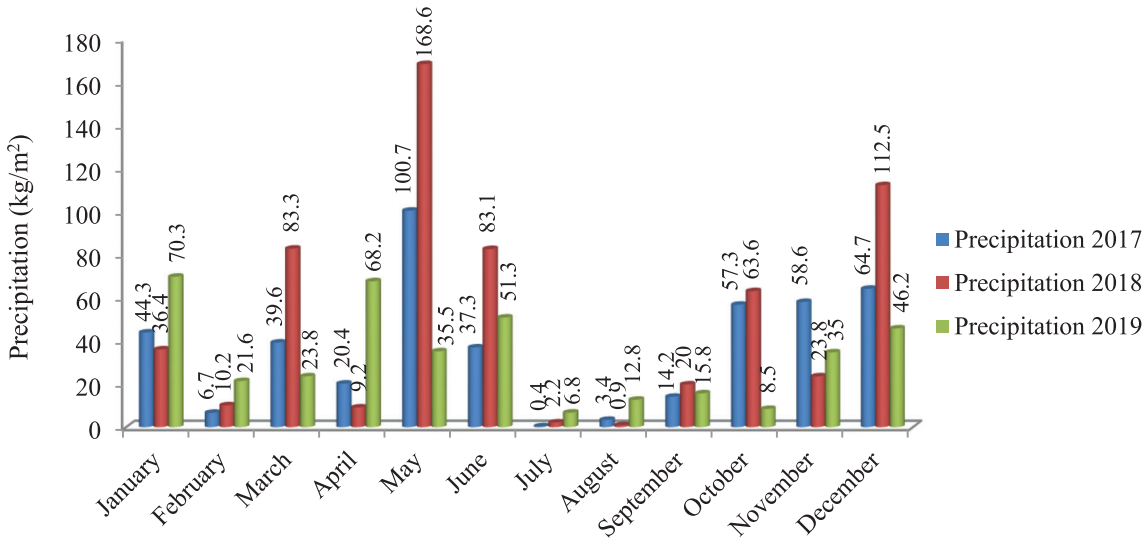

FIGURE 2 Mean values of monthly precipitation for different years

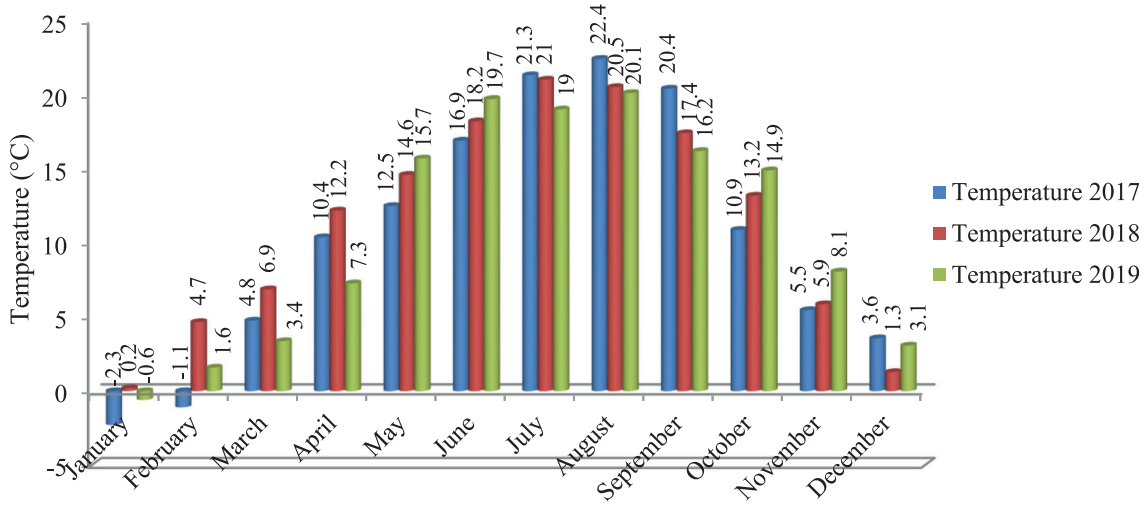

FIGURE 3 Mean values of monthly average temperature distributions for different years

these tested weather variables had a 29.1% effect on DON formation. Unlike AFB_1, while there was a significant relationship between ZEN and variables with $p = .002$, the effect of these variables on the prevalence of ZEN was 41.9%. This significant relationship had the formula of $F_{(4.31)} = 5.59$; $p < .05$. Weather factors varying depending on the years have a significant effect on the frequency of occurrence of ZEN and these effects were expressed as ZEN = 6.64 + 0.01 Humidity − 0.05 Temperature + 0.003 Precipitation − 0.34 Year. Similar significant results were also obtained regression analyses of DON and weather factors. All tested weather variables had a 29.1% impact on DON formation and there was a significant relationship between variables and DON ($p = .03$). The relation formula between DON and weather factors was $F_{(4.31)} = 3.18$; $p < .05$. DON = − 83.63 + 2.10 Humidity + 6.68 Temperature + 2.07 Precipitation − 32.34 Year formula revealed individually the effects of weather factors on DON. Statistical analyses reveal that the incidence of mycotoxins will decrease in foodstuff produced this region in the future if the trend concerning weather factors sustains as happened in the last 3 years.

4 | DISCUSSION

According to the Food and Agriculture Organization of the United Nations (FAO, 2004), the world population will increase to around 9 billion with this increasing rate in 2050 and current food production must be increased by 70% in order to feed this population (Odegard & van der Voet, 2014). Rapid weather changes cause a reduction in food quality. Therefore, countries have started to take some measures for good production practices. Weather changes are expected to increase the incidence of mycotoxins in foods due to the growth of fungi in the future. It is emphasized that these changes will play a key role in parameters such as adequate food production, access to this food, and the use of foods according to their nutritional habits and regional quality (FAO, 2004; Medina, Akbar, Baazeem, Rodriguez, & Magan, 2017). All these negative effects cause people to worry about accessing reliable foods day by day.

Turkey is a good point in terms of quality food production and safe access of foodstuffs to consumers. Hazelnuts, peanuts, walnuts, dried fruit, spice, tea and grain products, and so on are much more produced commodities than the other foodstuff in Turkey (Bashimov, 2017). The consumption potential of all these products in the domestic and foreign markets makes it necessary to evaluate them in terms of mycotoxin prevalence. The Şebinkarahisar region also plays an important role in this diversity, with annual production capacities of products such as walnuts, dried mulberry, concentrated mulberry juice, mulberry leather, dried fruits, and dough products given in Table 1. Especially variety of Şebinkarahisar walnut named after the region and registered in 1993, köme called "Sarma" produced with hazelnut and concentrated mulberry juice, dried bread called "Fırın kurusu" and many kinds of dried fruit are produced only in this region.

Studies to determine the mycotoxin content of food products produced in different countries and sold in markets have accelerated all over the world (Reddy et al., 2009; Houissa et al., 2019; Potortì et al., 2020; Costa et al., 2019). Li, Sun, Hong, Duan, and Du (2019) detected 88.7% contamination in their DON study on 328 agricultural products with ELISA, ranging from 0.2009 to 6.4806 μg kg^{-1}. In another study, El-Shanshoury, El-Sabbagh, Emara, and Saba (2014) investigated the AFT and AFB_1 values of cereal grains and peanut sold in central delta provinces markets, Egypt by using thin layer chromatography method. The researchers have found 85% AFs contamination. Among these contaminations, AFB_1 was found to be more dominant than others and the highest AFB_1 value was found at *Oryza sativa* L. Sakha 105 with 466 μg kg^{-1}. Abdallah, Krska, and Sulyok (2016) found that sugarcane grass and fruit juices were contaminated by 48 and 58% in terms of the AFB_1, respectively in Upper Egypt. In many other studies on human and animal foods in different years, AFB_1, AFB_2, OTA, Fumonisin, ZEN, AF M_1, and AF M_2 contaminations and their importance have been investigated, and up to 100% contaminations have been detected in some products. (Abdallah, De Boevre, Audenaert, Haesaert, & De Saeger, 2018; Abdallah, Girgin, & Baydar, 2019; Abdallah, Girgin, Baydar, Krska, & Sulyok, 2017; Abdallah, Krska, & Sulyok, 2018).

Also, the purpose of many of the other studies was to investigate the effects of weather changes on the formation of these toxic metabolites (Moretti, Pascale, & Logrieco, 2019; Shi, Schwab, & Yu, 2019). Magan, Medina, and Aldred (2011) stated that possible weather changes will cause changes in temperature/water availability in their study and this situation may change the frequency of many types of mycotoxins pre and postharvest. In many European countries such as Germany, Hungary, Poland, Romania, AF formation is reported to be low due to weather conditions (Lević et al., 2013). Although there were studies supporting this finding (Griessler, Rodrigues, Handl, & Hofstetter, 2010; Krnjaja et al., 2018), the literature had many studies with the higher AFs values above the EU regulation limits between 2002 and 2018 years (Kos et al., 2018; Moretti, Logrieco, Visconti, & Bottalico, 2004). In a study conducted in Northern Italy between 2012 and 2013, it was reported that favorable drought conditions caused an increase *A. flavus* infection, thereby elevating the presence of AFs in maize crops (Perrone, Gallo, & Logrieco, 2014). Likewise, Borbély et al. (2010) have reported AFB_1 contamination above the EU maximum limit (5 μg kg^{-1}) with 4.8% in cereal and feed samples in Hungary (European Commission, 2010). The researchers determined that the levels of AFs increased in different production stages of maize crops again due to the high temperature, dry season and low seasonal rains in Serbia in 2012 (Kos, Mastilović, Janić-Hajnal, & Šarić, 2012; Obradović et al., 2018). Researchers based this intense increase in AFs on certain environmental and weather changes, as in our study.

Many researchers studied the mycotoxin prevalence of different food commodities in Turkey (Aydin, Aksu, & Gunsen, 2011; Golge & Kabak, 2020; Nuroğlu et al., 2019). Lavkor et al. (2019) have conducted a study to determine the presence of mycotoxins in the harvest, drying, prestorage, and storage stages of peanuts growing in Turkey in 2016. In this study, the temperature, humidity, and precipitation values between July and November, which constitute the

phases of peanut from harvest to storage, were included the study and their effects on the incidence of mycotoxins were compared with the literature data. These researchers have detected AFs contamination in concentrations ranging from 0.2 to 2,177.2 μg kg^{-1} in 86 of the samples taken from 102 different points in total. This study supports our study about reliable food consumption and the effects of weather factors on the incidence of mycotoxins in foods. As a similar study, Cüce (2019) examined the AFT and AFB_1 ratios of the Şebinkarahisar walnut, which grows naturally in Şebinkarahisar and takes its name from the region, depending on the seasonal changes in 2016 and 2017. This researcher has reported that the weather changes did not change the incidence of AFs found in walnuts. Nevertheless, any detailed study was not reported to determine the incidence of mycotoxin of many different foodstuffs regionally produced in Şebinkarahisar. In this study, weather changes affected the incidence of mycotoxins content at a significant level.

5 | CONCLUSION

Mycotoxin contamination in food commodities is a dangerous situation from the field to consume. It is necessary to determine the daily intake of mycotoxin amounts in human food products and to follow these toxic metabolites that cause harmful effects at high concentrations. Moreover, the obtained all these data from in this study can guide to develop a risk assessment model or method, which may furthermore ideas the governments and industries to decrease the amounts of mycotoxins in human foodstuff that vary depending on weather factors.

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