# The Presence of Some Mycotoxins in Corn Grown in Turkey

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Abstract—This study aimed to determine the presence of major mycotoxins of human and animal importance, namely total aflatoxins, fumonisin, deoxynivalenol, zearalenon, T-2 toxin and HT-2 toxin in samples from corn grown in different regions in Turkey. 770 corn samples in total were taken from Çukurova, Sakarya (Adapazarı), Bursa (Karacabey), İzmir (Torbalı), Mersin (Tarsus), Adana (Kozan) ve Şanlıurfa regions between August and November 2015. 625 of the samples were used for total aflatoxin analyses by LC-MS/MS. For other toxin analyses (Fumonisin B1, Fumonisin B2, DON, Zearalenone, T-2 and HT-2) 29 samples were blended for each toxin. The results showed that the highest contamination and risk arises from fumonisin toxins (2652 µg/kg). Mycotoxin contamination in analysed samples was found to be 1.03%. Total aflatoxin was detected as 3.44% (1 of 625), total fumonisin as 17.24% (5 of 29) and zearalenon as 6.89% (2 of 29). None of the samples were found to contain more than one of the analysed mycotoxins. Also, no DON, T-2 or HT-2 toxin was found. In conclusion, the findings of our study on corn produced in Turkey shows that in some regions contamination levels of corn by mycotoxins exceed the legal limits. Supplying contaminated corn and corn products to human and animal consumption may result in serious health problems, moreover it is known that some toxicogenic fungi may cause decrease in quality and yield in corn production.

Index Terms—corn, mycotoxin, LC-MS/MS

#### I. INTRODUCTION

The importance and share of corn in agricultural production is closely related to its usage in human and animal nutrition. In general, 27% of the corn produced globally is used in human nutrition, whereas 73% is utilized as feed in livestock production. Corn usage ratios also depend on the development level of a country; a larger portion (54%) of corn is used in human nutrition compared to animal feed (46%) in underdeveloped

countries. On the contrary, industrialized countries show a different ratio; feed use is 90%, while usage as food and raw material in the industry is 10% [1].

On the other hand, increase in the usage of corn in production of "starch" and "sugars produced from starch" has led to a change in the geographical use of corn plantations and established a balance shifted to the corn side. Consequently geographical use of corn plantations has led to a competition with cotton, sorghum and other crops that are cultivated in alternation. Also the extent of use of corn as the feed additive "Dried Distillers Grains with Solubles" (DDGS) and as source of "biofuel" has changed the supply and demand balances and increased the importance of corn globally. As a result of these, the global actors in the corn trade agreed on the necessity of evaluating the developments regarding corn and monitoring corn production [2].

As low molecular weight natural materials, mycotoxins can accumulate especially on crops like corn, rice, barley, wheat and sorghum in different levels. Mycotoxins are produced naturally, following the contamination of grains, and cause technological difficulties and production wastes, especially for corn and rice. The industrial losses are hard to estimate but are thought to be in the range of 0.5-1.5 billion US Dollars per year, only in USA [3]-[6].

Growth and toxin production capacities of toxicogenic fungi are variable on different ecological environments. Some of the fungi adapted to certain regions are known to be more aggressive. Consequently, they are more infective in plantations and under storage conditions. This is not only limited to geography and climate, but also depend on many factors regarding storage conditions of the product [7]-[10].

As an example; the zearalenone, deoxynivalenol, fumonisin  $B_1$ , aflatoxin  $B_1$  and ochratoxin A minimum and maximum levels produced by toxicogenic fungi on corn in Po region, Italy, between 2000-2004 were found as 0.0-82.6, 0.0-95.8, 90.0-98.6, 0.0-14.3 and 1.5-50 ppb (150 specimens) respectively [11]. As can be seen from

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the results of this study, the type and levels of mycotoxins on a product may differ.

If highly nutritious grains come into contact with toxicogenic fungi during production process, biological toxic material can be formed which are called mycotoxins. Mycotoxins are regarded as non-enzymatic metabolites of fungi. Most well-known and industrially important ones are aflatoxins (AF), ochratoxins (OT), trichothecenes (TC), zearalenone (ZEN), fumonisins (F), tremorgenic toxins and ergot alkaloids. Our current knowledge indicates that there are at least 350 toxicogenic fungi in the wild, and that these produce 400 types of mycotoxins. Many health problems caused by these mycotoxins include carcinogenic, hepatotoxic, teratogenic and mutagenic effects.

AF, OT, trichothecenes, ZEN, and F are listed as natural and potential carcinogens in humans and animals in Group 1, 2B and 3 by World Health Organization International Agency for Research on Cancer (WHO-IARC). These toxins may especially accumulate in meat, milk and eggs, may cause endocrine and neuroendocrine disruptions, suppression of the immune system and many related damages to the organism. Mycotoxins also may lead to toxic effects on the liver and other organs. Humans and animals may be exposed to the mycotoxins through digestive tract, skin or inhalation. As the secondary metabolites of toxicogenic fungi, mycotoxins cause the condition called mycotoxicosis. Taken along with feed material, mycotoxins cause above disorders in animals along with developmental disorders in hens and chicks, reduction in egg yield, loss of appetite, weakness, fluffing of feathers in turkeys and ducks [5, 12, 13].

This study aims to determine the presence of major mycotoxins of human and animal importance, namely total aflatoxins, fumonisin, deoxynivalenol, zearalenon, T-2 toxin and HT-2 toxin in samples from corn grown in different regions in Turkey.

#### II. MATERIALS AND METHODS

# A. Sampling

Corn samples were collected from fields in Adana, Adapazarı, Şanlıurfa, Mersin, İzmir regions in 2015, right before harvest time, regarding the defined method. For aflatoxin analyses, 625 corn samples were used as material, whereas for fumonisin ( $B_1$ - $B_2$ ) (FT), deoxynivalenol (DON), zearalenone (ZEN), T-2 toxin and HT-2 toxin samples were blended and 29 samples were taken for each toxin (770 samples in total).

For each region, 4 non-neighboring fields were selected and corn cobs were collected from at least 30 meters inside these fields. Samples from four different fields were put in separate bags, and these were put in one bag which is then sealed and labelled with the relevant detailed information (date, village, county etc.).

If samples were to be collected from more than one region in one village, regions were selected in separate locations like northern, southern, western and eastern parts of the village. This helped us to get rid of factors related to regional effects and provided regional diversity. Moreover, weather conditions were also taken into account and sampling was not performed during rainy periods. Collected corn samples were transferred to the laboratory in shortest time under suitable conditions and blending was performed in the laboratory. Table I shows the modeling of corn samples.

TABLE I. THE NUMBER OF SAMPLES COLLECTED FROM ÇUKUROVA AND GAP-2 REGION 2015 HARVEST AND THE MYCOTOXINS ANALYSED

Analyzed Mycotoxins	Number of Samples	
Total Aflatoxin (AFT)	625	
Total Fumonisin (FT)	29	
Deoxynivalenol (DON)	29	
Zearalenone (ZEN)	29	
T-2 Toxin	29	
HT-2 Toxin	29	
Total	770	

### B. Extraction of Corn Samples

Homogenously blended corn samples were divided into 25 g batches and put into blender. 5 g sodium chloride and 125 ml extracting solution were added and homogenized in blender for 2 minutes under high speed. As the extracting solution, 7:3 (v/v) mixture of methanol and HPLC grade water was used. The liquid was passed through layered filter paper. 15 ml of filtrate was collected with a suitable pipette and transferred to an erlenmeyer with lid. 30 ml of water was added, lid was closed and the liquid was mixed. The diluted extract was filtered through glass microfiber filter paper until it becomes clear before the affinity column chromatography.

A 10 ml disposable syringe was attached on an immunoaffinity column containing special antibodies for aflatoxin  $B_1$ ,  $B_2$ ,  $G_1$  and  $G_2$ . Column solution was poured into the immunoaffinity column. 15 ml of prepared filtrate was drawn into the syringe. 1-2 drops/second flow was maintained during the immunoaffinity process. In order to clean the column, 10 ml water was passed through, twice. Methanol was passed through the column at a pace of 1 drops/second, in order to recover aflatoxin ( $B_1$ ,  $B_2$ ,  $G_1$  and  $G_2$ ) retained by the column. The eluent was collected and 1 ml of water was added. Once it is thoroughly shaken, samples were transferred to vials and injected to LC-MS/MS equipment

# C. LC-MS/MS Method

LC-MS/MS procedure was defined as; mobile phase rate: 0.4 ml/min; column temperature 35 °C; injection volume 20  $\mu$ l; mobile phase A: 5 mM ammonium formate + 0.5% formic acid; mobile phase B: ethanol; analysis time: 10 min; chromatographic column: SB-C18 (3.0 x 100 mm, 3.5  $\mu$ m).

<u>Fumonisin (FT) Assay</u> Fumonisin assay was done based on AOAC 2001.04; R-Biopharm A2-P31.V7 method. This method gives results with to 1  $\mu$ g/kg sensitivity. LOQ limits for both, Fumonisin B<sub>1</sub> and B<sub>2</sub> is 50  $\mu$ g/kg.

<u>Preparation of Samples</u> for <u>FT Analysis</u> Samples were extracted with acetonitrile-methanol-water solution. Toxin was adsorbed using immunoaffinity column and eluted into vials for analysis. <u>Preparation of Fumonisin Standard</u> A calibration curve for the analyses was built using 4 different concentrations. Lowest and highest values of the curve were  $25 \mu g/l$  and  $800 \mu g/l$  respectively. Samples were quantified by using this curve.

- Equipment:
- Analytic scale with sensitivity of 0,1 mg
- Blender
- Vacuum manifold and pump
- Immunoaffinity column specific for fumonisin analysis.
- HPLC-FLD
- Operating conditions: A working environment with temperatures between 15-30 ℃.

<u>Deoxynivalenol (DON) Assay</u> DON assay on corn samples was done based on R-Biopharm P50.V10 Cereal Donprep Application Note method. This method gives results with to 1  $\mu$ g/kg sensitivity. LOQ limit for DON was determined to be 50  $\mu$ g/kg.

<u>Preparation of Samples for DON Analysis</u> Samples were extracted with distilled water and toxin was adsorbed using immunoaffinity column. Adsorbed toxin was eluted into vials for analysis.

<u>Preparation of DON toxin standard</u> A calibration curve for the analyses was built using 4 different concentrations. Lowest and highest values of the curve were 25  $\mu$ g/l and 500  $\mu$ g/l respectively. Samples were quantified by using this curve.

Equipment:

- Analytic scale with sensitivity of 0,1 mg
- Blender
- Vacuum manifold and pump
- Immunoaffinity column specific for DON toxin analysis.
- HPLC-UV
- Operating conditions: A working environment with temperatures between 15-30 °C.

<u>Zearalenone Assay</u> DON assay on corn samples was done based on R-Biopharm RP91/RP90.V13 Cereal Easi-Extract Zearalenone Application Note method. This method gives results with to 1  $\mu$ g/kg sensitivity. LOQ limit for DON was determined to be 4  $\mu$ g/kg.

<u>Preparation of Samples for Zearalenone Assay</u> Samples were extracted with acetonitrile- water solution. Toxin was adsorbed using immunoaffinity column and was eluted into vials for analysis.

<u>Preparation of Zearalenon standard</u> A calibration curve for the analyses was built using 4 different concentrations. Lowest and highest values of the curve were 1.5  $\mu$ g/l and 30  $\mu$ g/l respectively. Samples were quantified by using this curve.

Equipment:

- Analytic scale with sensitivity of 0,1 mg
- Blender
- Vacuum manifold and pump
- Immunoaffinity column specific for Zearalenone analysis.
- HPLC-FLD

Operating conditions: A working environment with temperatures between 15-30 C.

<u>T-2 Toxin, HT-2 Toxin</u> Analyses were made by in house method (CHELAB MP-0081). LC MS MS 6410 and 6460 were used.

## D. Statistical Analysis

The experiments were carried out in triplicate and the data was analyzed statistically with SPSS software version 14.0 (SPSS Inc., Chicago, USA) to determine mean and standart deviation values.

### III. RESULTS AND DISCUSSION

770 corn samples in total were taken from Çukurova, Sakarya (Adapazarı), Bursa (Karacabey), İzmir (Torbalı), Mersin (Tarsus), Adana (Kozan) ve Şanlı Urfa regions between August and November 2015. 625 of the samples were used for total aflatoxin analyses. For other toxin analyses (Fumonisin  $B_1$ , Fumonisin  $B_2$ , DON, Zearalenone, T-2 and HT-2) 29 samples were blended for each toxin. Toxin types and levels regarding different regions were given in Tables 2, 3 and 4.

In general, mycotoxin contamination in analysed samples was found to be 1.03%. Total aflatoxin was detected as 0.16% (1 of 625), total fumonisin as 17.24% (5 of 29) and zearalenon as 6.89% (2 of 29). None of the samples were found to contain more than one of the analysed mycotoxins. Also, no DON, T-2 or HT-2 toxin was found.

Both total aflatoxin and fumonisin were calculated as  $B_1$  and  $B_2$ . Only aflatoxin contamination was found positive in samples taken from Şanlı Urfa Merkez (2.6-132.3 µg/kg). Most prevalent contamination was fumonisin, where samples from 5 different regions were found positive. Maximum fumonisin levels on corn samples as B<sub>1</sub>, B<sub>2</sub> and total were found in Adapazarı (2059 µg/kg), Tarsus (630 µg/kg) and Adapazarı (2652 µg/kg) respectively. Zearalenone is found only in two regions, Harran Plain and Adapazarı as 33 and 549.4 µg/kg. Regarding the results, none of the regions of sample collection showed DON, T-2 or HT-2 toxin residues. Most prevalent contaminant was found to be fumonisins and highest level of contamination was in Adapazarı. The region with lowest fumonisin level was found to be İzmir (Torbalı) region.

The fumonisin-positive samples from İzmir, Bursa and Adana region were found to be suitable for human consumption, whereas the positive samples from Adapazarı and Tarsus were found to be above legal limits set by Turkish Food Codex (TGK) in regards of total fumonisin. Also, the total aflatoxin contents of positive samples were found to be above the limit of 10 µg/kg set by TGK (2008) for corn which is subject to physical processes like classification and separation before being supplied for direct consumption or used as food ingredient. Of the two zearalenone-positive samples, the one from Adapazarı region which has a contamination level of 549.4 µg/kg was found to be above legal limits whereas the one form Harran Plain that contains 33 µg/kg zearalenone was within legal limits for processed and unprocessed corn according to TGK.

TABLE II. TOTAL AFLATOXIN LEVELS IN SOME REGIONS IN	TURKEY
(N=625).	

Region	Positive Samples (%)	Aflatoxin B <sub>1</sub> (µg/kg)	Aflatoxin B <sub>2</sub> (µg/kg)	Total Aflatoxin (µg/kg)
Şanlıurfa	1 (0.16)	132.3	2.6	134.9

TABLE III. FUMONISIN LEVELS IN SOME REGIONS IN TURKEY (N=29).

Regions	Positive	Fumonisin	Fumonisin	Total
	Samples	$B_1(\mu g/kg)$	$B_2 (\mu g/kg)$	Fumonisin
	(%)			(µg/kg)
Kozan	1	552	151	703
(Adana)				
Adapazarı	1	2059	593	2652
(Sakarya)				
Karacabey	1	494	137	631
(Bursa)				
Torbalı	1	82	-	82
(İzmir)				
Tarsus	1	1672	630	2302
(Mersin)				
Total	5 (17.24)			

 TABLE IV. ZEARALENONE LEVELS IN SOME REGIONS IN TURKEY

 (N=29)

Region	Positive Samples (%)	Zearalenone (µg/kg)
Harran Plain	1	33
Adapazarı	1	549.4
(Sakarya)		
Total	2 (6.89)	

Mycotoxins are secondary metabolites of toxicogenic fungi. They cause serious health problems for in animals and humans, as well as other risks and hazards like production and quality losses in animal and plant production which may cause economic losses. This study analyses corn samples (N=770) that were collected from corn producing regions of Turkey in 2015, in terms of some mycotoxins. The results showed that the highest contamination and risk arises from fumonisin toxins (2652  $\mu$ g/kg). This coincides with the findings of Altınok et al. [14] which also showed that fumonisins are the most abundant disease factors in corn. and cause serious toxicosis incidents in humans and animals. The highest results for other toxins in the study are 134.9µg/kg for total aflatoxin and 549.4 µg/kg for zearalenone. The fumonisin-positive corn samples produced in İzmir, Bursa and Adana were found to be within the allowable limits set in TGK for direct human consumption, while total fumonisin in samples from Adapazarı and Tarsus were above the legal limits. Findings of the study showed that the total aflatoxin level in aflatoxin-positive samples were above the limit of 10 µg/kg set by TGK [15] for corn which is subject to physical processes like classification and separation before being supplied for direct consumption or used as food ingredient. Of the two zearalenone-positive samples, the one from Adapazarı region which has a contamination level of 549 µg/kg was found to be above legal. Deoxynivalenol, T-2 toxin and HT-2 toxin were not detected.

This study is related to the study by Topal *et al.* [17] to identify the agricultural mycotoxin profile of Turkey. In that study, the writers divided Turkey into 9 regions, isolated 3456 molds from samples of food and agricultural products native to Turkey and classified them

according to their specific mycotoxins. The study showed that roquefortine and sterigmatocystin were the most important mycotoxins in Turkey, based on their prevalence. The writers also reported that they did not come across any molds which produce deoxynivalenol, T-2 toxin and HT-2 toxin, and additionally, zearalenone. The difference between our results and this study may be explained by different analysis methods utilized and different sampling regions [16]. Bakirci et al. [17] who analyzed some grains and grain products in terms of mycotoxins also found fumonisins to be most prevalent contamination in corn and corn products, and stated contamination levels between 118-9589.9 µg/kg. Three samples in the respective study were found to contain contamination levels above the legal limits. In the same study, the zearalenone levels in zearalenone-positive corn samples were found as ranging between 25-74 µg/kg. Although these results and the results of our study show similarities in terms of fumonisin and zearalenone, there are differences as the writers did not detect any aflatoxins, and found deoxynivalenol ranging from 132.4 and 9589.4 µg/kg in contrast to our result. This difference may be the result of variations in sampling, variations in regional climate, pre- and postharvest conditions, and hygiene. Ocak et al. [18] reported that they did not detect fumonisin contamination above TGK limits in corn and corn products supplied for human consumption in İstanbul. Research showed that samples of corn flakes and canned corn do not contain fumonisin at levels threatening public health, but corn flour may pose a potential risk. In our study, harvested corn was found to be extensively contaminated with fumonisin hence it poses important risk to animal and human health, which is in accordance with the study above in terms of the potential threat. This leads to the following conclusions, that the legal limit levels should be controlled especially in the foods consumed as human food, and at the same time, good agricultural practices and control and inspections should be done.

In Canada, Kuiper-Goodman *et al.* [19] found in their survey on corn and corn products (fresh, frozen, dried corn, corn meal, semolina, flour, corn flakes and snacks made of corn), 64 of 361 samples checked for FB<sub>1</sub> had contamination levels of  $\leq 0,1 \ \mu g/g$ , and 10 samples had  $\geq 1 \ \mu g/g$ . Comparing these results to ours, fumonisins may be regarded as the most common mycotoxin in corn and corn products, and their contamination levels may vary depending on product types, production processes, climate differences and agricultural applications utilized.

The study performed by Glenn [20] supports our results as it concludes that the predominant mycotoxins in corn and corn products are diacetoxyscirpenol, deoxynivalenol, nivalenol, T-2 toxin, zearalenone, fumonisins, fusarin C, beauvericin, moniliformin and fusaproliferin, which are all chemical variants of toxins from Fusarium species exclusively. This conclusion was reached with detailed studies on morphological, physiological and genomic differences between Fusarium species, especially during last 25 year. Bottalico *et al.* [21] found zearalenon and derivatives produced by Fusarium species at levels up to 7,433 ng/g and deoxynivalenol at

668ng/g, in samples of corn grown in Italy. This study concludes that corn grown in Europe and especially Italy are subject to contamination with toxicogenic Fusarium species, and this result supports findings of Glenn [20] and our study. Glenn reached crucial information about product quality, safety and product value, using the data from this study. Our study also suggests that corn in Turkey is contaminated at significant levels with toxicogenic Fusarium species.

A survey by Janardaha et al [22] was conducted in Karnatka region, India, about mycotoxigenic factors on 197 corn samples taking the seasonal climate changes into account. Samples were representing a period between 1994 and 1997. Study found that the toxicogenic fungi with highest incidence are Aspergillus flavus (55-62%), Aspergillus flavus columnaris (30-50%), A. candidus (30-33%), A. fumigatus (18-33%), A. terreus (10-11%), Peniciluum spp (53-100%), F. moniliforme (50-83%) and Trichoderma spp (30-80%). Of the 197 species, 69 were found as positive regarding mycotoxins. Positive samples were classified as aflatoxin  $B_1$  (35), zearalenone (19), T-2 toxin (9) and deoxynivalenol (2) in terms of mycotoxins found. Their levels were determined as 0.0-26.8 µg/kg, 0.0-41 µg/kg, 0.0-40 µg/kg respectively [22].

In another study in Po region, Italy, mycotoxins produced by toxicogenic fungi on corn were examined, and the minimum-maximum levels of zearalenone, deoxynivalenol, fumonisin B<sub>1</sub>, aflatoxin B<sub>1</sub>, ochratoxin A were determined as 0.0-82.6, 0.0-95.8, 90.0-98.6, 0.0-14.3 and 1.5-50 ppb respectively (in 150 samples) (9). As can be seen from this study, the mycotoxin types and levels on products can vary.

Nijs *et al.* [23] found  $FB_1$  in 93% of 349 corn samples from 8 different countries, where the mean  $FB_1$  level was calculated as 1,359ng/g.

Another survey was performed in 1997 in western part of Romania covering Arad, Bihor and Timis agricultural regions, where toxins from fungi were sought on agricultural products including corn. Presence of mycotoxins was checked using a combined enzyme immunoassay and HPLC method. Study analyzed wheat and corn samples for presence of deoxynivalenol (DON), 3-acetyl DON, 15-acetyl DON, fusarenone X (FX), T-2 Toxin (T-2), diacetoxyscirpenol (DAS), zearalenone (ZEA), fumonisin  $B_1$  (FB<sub>1</sub>), aflatoxin  $B_1$  (AFB<sub>1</sub>), ochratoxin A (OA) and citrinin (CT). The study found mycotoxin contamination in 100% of wheat samples and 46% of corn samples in varying amounts. Highest level of contamination was found in corn as 180-890 µg/kg DON, 140  $\mu$ g/kg FB<sub>1</sub> (in one sample), 10-250  $\mu$ g/kg ZEN. This study is regarded as the first natural research made in Romania. The low levels of fumonisin toxins may be attributed to absence of contamination, regional differences and the differences between methods preferred in analyses. The writers concluded that improving storage conditions and ensuring traceability of products may help in solving the problems arising from mycotoxin contamination [24].

Scudamore *et al.* [25] examined 140 corn samples from UK for aflatoxin  $B_1$ ,  $B_2$ ,  $G_1$  and  $G_2$ , ochratoxin A,

zearalenon, and fumonisin  $B_1$ ,  $B_2$  and total B, by HPLC. Maximum concentration was found to be ochratoxin A with 1.5 µg/kg, and all samples were found to be contaminated with zearalenone and fumonisin. 41.7% of zearalenone-positive samples were found to be contaminated at levels over 100 µg/kg, and 48% of fumonisin-positive samples were found to have contamination levels over 1000 µg/kg. These results show similarities to our study in terms of high contamination levels in some samples.

In another study between 2005 and 2010, 409 corn DDGS samples from animal farms or feedstuff were examined for 5 different mycotoxins. The origins of corn DDGS varied extensively: 47% is from USA, 30% from Northern Asia, 15% from South Western Asia, 2% Oceania, and 2% from central and southern Europe. Analyses were made for presence of toxicogenic mycotoxins aflatoxin (AFB1, AFB2, AFG1, AFG2), zearalenone (ZEA), deoxynivalenol (DON), fumonisin  $(FB_1, FB_2)$  ve ochratoxin A (OTA). Maximum residue limits were calculated as 89 µg/kg for aflatoxin, 10.3  $\mu$ g/kg for zearalenone, 24.2  $\mu$ g/kg for deoxyvivalenol, 9.0  $\mu$ g/kg for total fumonisin and 68  $\mu$ g/kg for ochratoxin A. Although these results are parallel to ours in general, there are slight differences because the samples were corn products and were subjected to different production processes. Corn DDGS is a byproduct of corn processing industry which is used as feed raw material [26].

Sahindokuyucu et al. [27] collected 60 corn silage samples from Burdur region of Turkey and analyzed for total aflatoxin, ochratoxin A, T-2 toxin, deoxynivalenol, zearalenone and fumonisin. According to their results, contamination percentage of the samples were 30%, 13.3%, 35%, 38.3%, 38.3% and 1.7% respectively. Writers found the contamination levels as 4.33-19.92 µg/kg for aflatoxin, 1.76-3.26 µg/kg for okratoksin A, 3.85-15.40 µg/kg for T-2 toxin, 24.20-100.30 µg/kg for deoxynivalenol, 2.84-40.64 µg/kg for zearalenone and 2690 µg/kg for fumonisins. Silage samples were found to be mostly contaminated with deoxynivalenol and zearalenone. The difference between this study and ours is in maximum levels of deoxynivalenol and zearalenone but the results are similar in general. The differences may have occurred because of sampling in winter and spring periods, technological differences between food grade corn and corn silage production, and hygiene applications. On the other hand, Aydin et al. [28] did not detect aflatoxin B<sub>1</sub> and zearalenone in 260 samples from corn silage collected in 2007. This may be the result of methodological differences, and the suppressive effect of the fermentation products produced during silage formation. Despite the low AFB<sub>1</sub> levels detected in this study, it is considered that climatic factors are significant, in addition to product variety and method differences.

#### IV. CONCLUSION

The findings of our study on corn produced in Turkey shows that in some regions contamination levels of corn by mycotoxins exceeds the legal limits. Supplying contaminated corn and corn products to human and animal consumption may result in serious health problems, moreover it is known that some toxicogenic fungi may cause decrease in quality and yield in corn production. In this context, the findings of this study should be evaluated also taking data in literature into consideration, and national agricultural policies should be developed accordingly. In order to achieve this, research to identify toxicogenic fungi that may pose a risk in corn production should be supported; national projects should be developed by legal authorities to assess contamination levels, types of toxic fungi and mycotoxins, to develop relevant biological systems to fight fungal contamination. and to ensure monitoring of these measures in the field. The legal authority also should ensure the traceability of products intended for human and animal consumption in terms of mycotoxins, perform controls and audits, and prevent products from entering the consumption chain if legal limits are passed. Besides, it is thought to be beneficial in preventing or reducing the world agricultural waste, serious public and animals health problems and the national economic losses that may occur in the production of corn, to establish risk assessment of mycotoxins in the storage, marketing, processing and distribution stages as far as production, and the efforts to realize good agriculture, production and hygiene practices. In Turkey, Good Agricultural Practices that were started in recent years helped to limit mycotoxin problems to certain regions and the quality of corn is increasing constantly.

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