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Original article

Investigation of aflatoxin levels in chips by HPLC using post-column UV derivatization system

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Summary. This study was designed to investigate the aflatoxin B1 (AFB1), B2 (AFB2), G1(AFG1), G2(AFG2) and total aflatoxin levels in 27 samples of several packaged chips randomly obtained from various markets in Istanbul using immunoaffinity chromatography and post-column UV derivatization system by HPLC. Seventeen of the samples contained some aflatoxins at detectable levels, whereas 10 did not. The levels of aflatoxin ranged between 1 and 39 μg/kg. AFB1 and AFB2 were detected in 63% and 41% in analyzing chip samples respectively. The levels of AFB1 varied from 1 to 24 μg/kg in chip samples and the levels of AFB2 varied from 1 to 16 μg/kg in chip samples. Low levels of AFG2 ranging from 0 to 3 μg/kg were found in chips. Groundnut chips showed high aflatoxin concentrations and recorded relatively higher AFB1, AFB2, AFG2 and Total aflatoxin levels ranging from 1 to 39 μg/kg, indicating that groundnut is potentially causing serious health risks to consumers of these products than other chips. The aim of this study is to determine the presence and amount of aflatoxin B1, B2, G1, G2 in various chips samples consumed in Istanbul.

Key words: aflatoxin, chips, HPLC, mycotoxin, post-column UV derivatization system

Introduction

Chips are nutrients with high energy and low nutritive value. Chips products have a huge potential as a snack for children and young people and depending on this its market is increasing and also export of these products is growing day by day in the World and Turkey (1). Aflatoxins are mycotoxins, which are considered to be toxic metabolites, produced mainly in foods by some fungi such as *Aspergillus flavus* and *Aspergillus parasiticus* (2, 3). In the United States daily calorie intake for children between the ages of 2 and 5 increased by 30% with the contribution of snack foods in between 1977 and 1996. It is also reported in several publications that there is an association between the increase in consumption of these snack foods and the increase in obesity and other chronic diseases related to obesity in children and adolescents (4).

Worldwide obesity has shown a threefold increase compared to 1975 and it has been appointed that there are 1.9 billion adults over the age of 18 being overweight and 650 million of them are obese in 2016. In other words, while 39% of adults over 18 years old were overweight, 13% of them determined to be obese (5). Obesity is increasingly widespread among children and has increased 10-fold over the past 40 years. 41 million children between 0-4 years of age and 340 million children aged 5-19 years were found to be overweight or obese in 2016 (5, 6). If the current situation continues, the number of overweight or obese children aged 0-5 years is expected to increase globally to 70 million by 2025 (7).

In 2016 Turkey Health Interview Survey conducted by the Turkish Statistical Institute (Turkstat), Body Mass Index (BMI) was calculated using height and weight values. It has been determined in this study that the proportion of obese individuals aged 15 years and over has declined from 19.9% in 2014 to 19.6% in 2016 (8). It has been stated in 'Turkey School-age Children (Age 6-10) Growth Monitoring Project' in 2009 that being obese and overweight status among the children of this age was found 14.3% and 6.5%, respectively (9). Additionally, according to the another study of the same age group which was the COSI-TUR research, 14.9% of the children between this age group has been identified as overweight and 9.9% as obese in 2016 (6).

Over the last few years, the growth in the sales of salty snacks in the US continues to be steady. Sales in 2015 reached 22 billion dollars with an increase of 3.5%. The best salty snack was potato chips, which remained unchanged at 2015 and had a share of 7.5 billion dollars. Prospectively, an annual growth rate of 4% is predicted in the salted snack market between 2015 and 2020 (10). Considering the number of people consuming potato chips in the US based on years, the number of people in 2011 was 257 million and it reached to 276 million in 2017. Consumption of 16 packets or more per year, which is the highest amount of these in annual consumption, covered 19.9 million people in 2011 and rose to 32.8 million people in 2017 (11, 12).

When considering the chip market development over the years in Turkey, the market, which has a size of approximately 233 million dollars in 2004, reached a turnover of 1.1 billion dollars in 2012 and about 1.3 billion dollars in 2013. The sales volume of the market in 2012 reached 90 thousand tons with a growth of 300% has reached 105 thousand tons of sales volume in 2013. With the increased production, the consumption of chips, which was 400 g per capita in 2004, has increased to about 1 kg by 2012 (13). In 'Turkey Childhood Obesity Research' (COSI-TUR 2013) research, the nutritional behaviours of children in Turkey are determined according to the declarations of families in 2013 for the first time. When classified according to the frequency of consumption, it was found that chips and popcorn were consumed in 1-3 days a week with the highest rate of 59.6% (14). In repetitive work in 2016, three years later, salted nut consumption was included and salted snacks consumption of children within the frequency of 1-3 days in a week was found 29.6%. They consumed less than once in a week with the highest rate (34.6%) (6).

Mycotoxins are found in various foods which were stored in hot, humid and unhealthy conditions such as cereals, especially maize and rice, some animal source foods such as milk and cheese, hard-shelled fruits such as walnuts, hazelnuts and peanuts, oilseeds such as sunflower and soybean, dried fruits and spices (red pepper, black pepper, turmeric, ginger, coriander) which are highly toxic compounds (15-17). It is estimated that mycotoxins contaminate about 25% of the world's nutrients each year and that approximately 4.5 billion people are chronically exposed to mycotoxins, according to the US Centers for Disease Control and Prevention. Among the different type of mycotoxins; aflatoxins are widespread in major food crops such as groundnuts, maize, dried fruits and spices as well as milk and meat products (17-20).

Aflatoxins are the most dangerous ones in between known 400 toxins. Aflatoxin B_1, aflatoxin B_2, aflatoxin G_1 and aflatoxin G_2 are the main ones produced naturally between 20 types of aflatoxins (21). Among these aflatoxin B_1 (AFB1) is the most predominant and toxic mycotoxin that seriously threatens the human health. Many experimental, clinical and epidemiological studies indicate that the aflatoxins have been found to be carcinogenic, genotoxic, mutagenic, teratogenic, immunotoxic, hepatotoxic, nephrotoxic and they also inhibit several metabolic systems of humans and animals (15, 16, 22-24). Prolonged exposure to aflatoxin contamination even at low levels in the crops, affecting the main functions of the organism, can lead to immune system disorders as well as liver damage or can cause cancer in various organs, especially liver and kidney (25). Aflatoxins, along with other mycotoxins, are thought to play a role in the pathogenesis of malnutrition and kwashiorkor in children, as well as in the development of edema in malnourished people (26, 27). High doses of aflatoxin exposure can result in vomiting, abdominal pain and even death (28).

Regarding these negative effects, many countries and some international organizations have made important regulations on "Acceptable health risk" to control aflatoxin contamination in foods and to ban the trading of contaminated products. These regulations generally depend on the level of economic development of a country, the rate of consumption of high-risk products and the susceptibility of crops to contamination (25, 29). The safe limits of aflatoxin for human consumption was determined as 4-30 µg/kg. The EU has indicated that no direct human consuming product should be present at levels greater than 2 µg/kg for AFB1 and greater than 4 µg/kg for total aflatoxin (30, 31). Therefore, controls of these risky nutrients, especially risky in the context of aflatoxin (such as corn, peanut, oilseeds, dried fruits and spices) and like chips, which can be contain aflatoxin have a high importance in terms of food safety, protecting consumer health especially children and economics (15, 23, 32). In the literature, there are studies based on the aflatoxin content of foods that focused on cereals, particularly maize, oilseeds like groundnut and spices (33-42) but studies on the aflatoxin content of chips are limited (43-48) and more important these limited number studies are based on traditional foods. This study was conducted in order to determine the presence and levels of aflatoxins, which have been proven to have adverse effects on health and the residues of aflatoxin B_1 (AFB1), B_2 (AFB2), G_1 (AFG1), G_2 (AFG2) and total aflatoxin in 27 chips which are purchased from various markets in the province of Istanbul, Turkey.

Materials and methods

This study has focused on the aflatoxin levels of chips. Immunoaffinity chromatography and post-column UV derivatization system by HPLC were used to determine the presence and levels of AFB1, AFB2, AFG1 and AFG2 in the 27 chips samples.

The following chemicals; methanol (MeOH), acetonitrile (ACN), sodium chloride (NaCI), potassium dihydrogen phosphate (KH_2PO_4), sodium hydroxide (NaOH) and aflatoxin mix 4 solutions (B_1+B_2+G_1+G_2) were obtained from Sigma (St. Louis, MO, U.S.A). Immunoaffinity column (AFLAPREP, Product Code: P07) was obtained from R-Biopharm (Glasgow, UK) for the purification of aflatoxins. Teflon tube "tubing" (length: 20 m diameter: 0.25 mm) was purchased from Supelco Analytical. UVA lamp (20W, 60cm) was supplied by Sylvania. In this study, all other chemicals were used in high purity.

Sampling and sample preparation

27 different kinds of chips were sampled which are obtained from different markets in Istanbul according to the sampling protocol of Turkish Food Composition Table (49) The samples were homogenized by grinding. Then, 50 g of each sample was weighed and placed in a 250 mL plastic beaker. Then, 5 g of sodium chloride and 100 mL of distilled water were added and thoroughly mixed in a high speed mixer for 1 min. After that, 150 mL of methanol was added to the prepared mixture and mixed again in the high-speed mixer for 2 minutes. The mixture was filtered through a filter paper and centrifuged at 4000 rpm for 10 minutes and then adjusted to pH 7.4 with a 2M NaOH solution. After purification 5 mL of this obtained liquid was taken and 5 mL of buffer solution was added onto this (50)

Immunoaffinity chromatography

The extract obtained in the preparation of the sample was passed through the immunoaffinity column in a volume of 2 mL per minute with the prepared pump system. After the sample loading was completed, the column was rinsed with 20 mL of buffer solution to remove residual impurities. The toxins were eluted with 1 mL of methanol at a flow rate of approximately 5 mL per minute and then filtered through a 0.22 µm cellulose-based filter and injected into the HPLC.

HPLC conditions

The content of aflatoxins was determined by HPLC, consisting of Shimadzu Nexera-İ LC-2040C 3D pump with a Shimadzu RF-20A fluorescence detector (Shimadzu Corporation, Kyoto, Japan) according to the procedure described by (51) with some modifications. The Mobile phase consisted of a mixture of water/acetonitrile/methanol (60/15/30 //v/v/v). Excitation and emission wavelengths 365 nm and 460 nm for aflatoxins, respectively. The separation was performed with a Luna (5µm, 250x4.6 mm), C18 100 Å analytical column (Phenomenex, USA) and the flow rate was 1.2 mL/ min. The column oven temperature was maintained at 35°C, the analysis time was 30 min and the injection volume was 50 mL.

Derivatization System

As an alternative to the post-column derivatization system of Kobra Cell, the photochemical derivatization system was established in a laboratory environment. The derivatization system was formed by wrapping a 60 cm long UV-A lamp with a length of 20 m and a 0.5 mm diameter Teflon tube.

Results and Discussion

In this study, 27 packaged chip samples were analyzed for aflatoxin B_1 (AFB1), B_2 (AFB2), G_1 (AFG1), G_2 (AFG2) and total aflatoxin. They were obtained from various markets in Istanbul. The presence and concentration range of AFB1, AFB2, AFG1 and AFG2 in the samples were investigated by HPLC using immunoaffinity chromatography and post-column UV derivatization system. Figure 1 shows the HPLC chromatogram of aflatoxins mix standard (B_1, B_2, G_1, G_2) and Figure 2 shows the HPLC chromatogram of aflatoxins in chips.

The limit value for aflatoxin B_1, which can be found in human food according to the legal limits of aflatoxins in the European Union (EU) member countries, is accepted at 2-4 µg/kg (30, 31) Table 1 shows the legal limits for aflatoxins of foods like chips in Turkey, European Union member states and the United States.

The maximum acceptable value is determined as 5 µg/kg for aflatoxin B_1 and 10 µg/kg for Total aflatoxin ($B_1 + B_2 + G_1 + G_2$) content for processing snacks containing peanut, other oilseeds and spices in the Turkish Food Codex Legislation (52, 53)

Table 2 lists the results of determining aflatoxin values in chips. According to this, AFB1 was detected in 63% of analyzing chip samples. AFB1 has been detected in 17 chip samples and 5 of them were found above the maximum limits. In other words, 19% of the chips products are above the maximum limits considering AFB1. It has been known for many years that aflatoxin B_1 is the most carcinogenic form of aflatoxin that occurs naturally and has toxigenic properties in living organisms (54) The levels of aflatoxin B_1 varied from 1 to 24 µg/kg in chip samples. According to the results of the analysis, the amount of 24 µg/kg of AFB1 is close to about five times to legal tolerance limits applied in Turkey at 5 µg/kg.

However, AFB2 was detected in 41% of chip samples. AFB2 was found in 11 chips. AFB2 was detected in 41% in chips. The levels of aflatoxin B_2 varied from 1 to 16 µg/kg in chip samples.

AFG1 was not detected at all. However, according to the Table 2, the results of the analysis of 27 samples in total indicate that aflatoxin G_2 was found in only 1 of the samples. Low levels of AFG2 ranging from 0 to 3 µg/kg were found in chips.

With regards to Total aflatoxin, it detected in 63% of the samples. When the amount of Total aflatoxin ($B_1 + B_2 + G_1 + G_2$) in chips products is considered the results of the analysis obtained as 39 µg/kg is approximately twice as much as the tolerable level of 20 µg/kg (55) as determined by the FDA which is an international organization as well as it is approximately quadrupled of 10 µg/kg which is the legal tolerance limits applied in Turkey. In addition, 2 samples with 33 µg/kg and 39 µg/kg were well above the FDA limits whose tolerable level is 20 µg/kg. And more importantly, 39 µg/kg total aflatoxin level is almost 10 times higher than the limit values determined by the EC. However, according to the Table 2, Total aflatoxin in 41% of the analyzed samples were above the limit values determined by the EC.

With regard to Turkish Food Codex; when the amounts of aflatoxin found in the analysis of chip samples compared with the maximum acceptable val-

Table 1. Legal limits for aflatoxins of groundnut-chips in Turkey, European Union member states and United States.

Aflatoxins	Maximum acceptable levels in Turkey (µg/kg) (TFC)	Maximum acceptable levels in EU Member States (µg/kg) (EC)	Maximum acceptable levels in United States (µg/kg) (FDA)
AFB1	5	2	-
Total aflatoxin (AFB1+AFB2+AFG1+AFG2)	10	4	20

Table 2. Aflatoxin levels in chips

Chips samples	B_1 (µg/kg)	B_2 (µg/kg)	G_1 (µg/kg)	G_2 (µg/kg)	Total (µg/kg)
1*	14	16	-	3	33
2	2	1	-	-	3
3*	-	-	-	-	-
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	1
9*	5	6	-	-	11
10*	24	15	-	-	39
11	2	1	-	-	3
12*	1	-	-	-	1
13*	4	2	-	-	6
14	-	-	-	-	-
15	1	-	-	-	1
16	2	1	-	-	3
17	12	6	-	-	18
18	-	-	-	-	-
19	-	-	-	-	-
20	1	-	-	-	1
21	3	1	-	-	4
22	-	-	-	-	-
23	2	1	-	-	3
24	-	-	-	-	-
25	5	2	-	-	7
26	1	-	-	-	1
27*	1	-	-	-	1

*-: not detected; *Groundnut containing chips*

ues for aflatoxin in Turkey; it can be seen that the 15% of the chips products is above the maximum limits in terms of Total aflatoxin.

However, Total aflatoxin was detected in 17 chips. 17 of the samples contained some aflatoxins at detectable levels, whereas 10 did not. The levels of aflatoxin ranged between 1 and 39 µg/kg. Total aflatoxin levels were found above the maximum limits in 3 chips, according to the Turkish Food Codex and more importantly all of them were groundnut-containing chips.

Remarkably, 75% of the Total aflatoxin detected chips were groundnut-chips.

When we assess the groundnut-containing chips;

- Aflatoxin was detected in 86% of them and could not be detected in only 1 groundnut containing chips.
- AFB1 levels were found above the limits in 3 of the groundnut chips. In other words, 43% of the groundnut chips were found above limits considering AFB1 level.
- AFB2 was detected in 57% of the groundnut chips. Table 2 provides the AFB2 levels that there are 3 groundnut-chips in the range of 6-16 µg /kg.
- Total aflatoxin levels were detected in 3 groundnut-chips above the maximum limits as 11 µg/kg, 33 µg/kg and 39 µg/kg as can be seen in Table 2.
- 10 numbered samples (groundnut-chips) was almost 2 times the limit of 20 µg/ kg that the FDA has determined with the 39 µg/kg.
- Groundnut-chips showed high aflatoxin concentrations, with means ranging from 5 to 39 µg/kg potentially causing serious health risks to consumers of these products.
- Groundnut chips recorded relatively higher AFB1, AFB2, AFG2 and Total aflatoxin levels ranging from 1 to 39 µg/kg, indicating that groundnut is potentially a more serious risk to consumer health than other constituents.

Groundnut (Arachis hypogaea L.) is an important crop for domestic markets as well as for foreign trade in several developing and developed countries. It is also one of the most valuable crop for snack foods like chips. Inadequate hygiene conditions during drying, transport and storage stages in the production of groundnut could cause microbiological and Mycological growth which could result in the formation of mycotoxins. However, groundnut can easily be damaged by fungi, especially by *Aspergillus* species, which cause quantitative losses and produce highly toxic and carcinogenic chemical substances known as aflatoxins (15, 32)

Aflatoxin contamination is one of the main problems about dried foods and groundnuts are also suitable for aflatoxin contamination. Therefore, controlling of aflatoxins in groundnuts and groundnut-contained products such as chips has a great importance for protecting consumers.

Njumbe et al., reported in their study done in Cameroon that 74% of the maize samples were being contaminated with one or more toxins while 62% of the groundnut samples were contaminated. In the same study, aflatoxin B1 was found to be one of the most common contaminants in maize (6-645 μg/kg). Aflatoxin B1 (6-125 μg/kg) was detected as one of the main contaminants in groundnut samples (56)

Tosun and Arslan, showed that the AFB1 levels of 41 organic spice samples were found above the EU regulation limit (5 μg/kg). In a study, 93 pieces of organic spices were selected randomly from organic markets and organic shops in Turkey. In 58 organic spices AFB1 was detected. The maximum value was determined by cinnamon sample between organic spice samples (53 μg/kg). AFB1 was not detected in thyme samples. A recent study has shown that stricter measures must be taken in order to prevent mold contamination in the production of organic spices (57)

The present study evaluated the aflatoxin presence in chips obtained from markets in İstanbul. Number of samples was 27. Number of positive samples was 17. Number of samples exceeding EU limits was 11. More importantly, the results of this study also indicate that a person can easily exceed these limits. When a person consumes 1 package from the sample which numbered 1 (product pack 130 g), the EC daily intake limit for aflatoxin is excessively exceed. However, when a person consumes 2 packages from the sample which numbered 10 (product pack 55 g), the EC daily intake limit for aflatoxin is also exceeded. If we take into account that aflatoxin intake will occur also from other foods, we may have a better understanding of the seriousness of this risky situation.

In 2013, Republic of Turkey Ministry of Health Turkish Public Health Institution, Department of Obesity, Diabetes and Metabolic Diseases performed 'Obesity Surveillance Initiative' for the first time as part of WHO European Childhood Obesity Surveillance Initiative – COSI (14) In this study, the nutritional behaviours of children (Ages 7-8) in Turkey are determined according to the declarations of families.

Table 3 provides the nutritional behaviours of children for snacks consumption, such as chips and popcorn based on localities. According to the table 3, the frequency of consumption for chips and popcorn between 1-3 in a week with the highest percentage (59.6%), 60.5% in urban areas and 54.8% in rural areas. It has been reported that the frequency of consumption of foods such as chips and popcorn between 4 and more in a week more in rural areas than in urban areas with 27.7% and 21.0%, respectively. Besides, it has been stated that nearly twenty percent of children, never consume such foods (18.3%). While approximately three out of every four schools can be reached the wafers and chocolates, foods such as chips and snacks can be reached in one out of every seven schools. Accessibility is much higher in schools in the urban areas. This shows that the possibility of reaching unhealthy foods at schools is high. The data of this study were compared with the findings of the TOÇBİ (Research Report of the School-age Children (Age 6-10) Growth Monitoring Project in Turkey) research (9) While the chips and popcorn consumption frequency every day was 8.7% in this study, it was 19.0% in TOÇBİ Research. It has been suggested in a recent review that establishing of reliable and effective low-cost testing methods to monitor aflatoxin contamination levels in rural areas is necessary (25)

Table 4 provides the distribution of the salty snacks (potato chips, corn chips, snack) consumption frequency of children in Turkey and in Istanbul (6) According to the results of 'Turkey Childhood Obesity Research (2016)' 7.6% of children consume salty snacks (potato chips, corn chips, cookies) every day, 13.7% frequently (4-6 days a week), 29.6% rarely (1-3 days a week) and 34.6% consume less than once a week. However, 14.5% of children, never consume. It

Table 3. The nutritional behaviours of children in Turkey, according to the declarations of families (%), Turkey, 2013 (Republic of Turkey Ministry of Health Turkish Public Health Institution, Department of Obesity, Diabetes and Metabolic Diseases. Turkey Childhood (Ages 7-8) Obesity Surveillance Initiative) (COSI-TUR, 2013).

Nutrition	Locality	Every day	4-6 times a week	1-3 times a week	Never	Total
Chips, popcorn	Urban	8.1	12.9	60.5	18.5	3795
	Rural	11.5	16.2	54.8	17.4	788
	Total	8.7	13.4	59.6	18.3	4583

Table 4. Distribution of the salty snacks (potato chips, corn chips, snack) consumption frequency of children in Turkey and in Istanbul (COSI-TUR, 2017).

Consumption frequency	Turkey (%)	Istanbul (%)
Never	14.5	17.7
Less than once a week	34.6	38.3
1-3 day	29.6	26.4
4-6 day	13.7	11.7
Every day	7.6	5.9
Total	100.0	100.0

can be seen from the table that the levels of consumption frequency of chips and snacks in Istanbul, one of the most populous cities in Turkey.

Aflatoxins are a critical problem for food safety in many developing countries. Groundnuts are one of the most important oilseed crops and snack foods in the agro-processing sector in the industrialised world trade market. Aflatoxin contamination in groundnut is both a pre-harvest and postharvest problem (58) Preserving foods by drying is an effective and ancient method, but inefficient drying and inappropriate storage conditions, may cause aflatoxin production in dried foods. Aflatoxins are not only a problem during cropping, but also during storage, transport, processing, and handling steps due to their high stability. Aflatoxin contamination of groundnuts is one of the most important factors determining the quality of groundnuts and has caused significant financial losses for producing and exporting countries. In addition, aflatoxins pose serious public health issues in many developing countries, since the occurrence of these toxins can be considerably common and even extreme. In the literature studies have shown that raw material selection and drying process parameters are the key elements in food drying. It is known that mycotoxin formation which have negative effects on human health can be prevented by providing adequate and appropriate drying conditions (59) The best way to control aflatoxin contamination of groundnuts is to get under control and prohibit it in the first place (60) Recent studies have shown that aflatoxin levels during drying and pre-storage were significantly higher than those during harvest and post-harvest. In other words the drying and pre-storage terms are the most critical periods for aflatoxin contamination (59) It is evident that, alternative technologies necessary at pre- and post-harvest levels, aiming to minimize contamination of commercial foods and food commodities, at least to ensure that aflatoxin levels remain below safe limits (61) and providing the required control systems which create an effective regulatory environment for ensuring domestic food safety in rural and urban areas.

The occurrences of mycotoxins as food contaminants in different localities, especially in developing countries and the inevitable exposure of populations and particularly children to these toxins with probable adverse outcomes need be scientifically assessed.

This study was undertaken to determine the presence and levels of aflatoxin B_1, B_2, G_1, G_2 and total aflatoxin in chips consumed in the province of Istanbul, Turkey. High levels of aflatoxin in the finished product show that there is inadequate control for aflatoxin in chips.

As a result, the aflatoxin levels were high regarding the tolerance level in food for human consumption in chips, which are snack products with high energy and low nutritional value, may have some potential risks to human and causes negative impacts on human life. It is clear that high aflatoxin levels caused human health risks and created an obstacle to expanding trade both internally and internationally. In order to reduce aflatoxin contamination, it is necessary for monitoring contamination levels in different snack products like chips and raising the awareness of public health impacts associated with aflatoxin contamination.

Conclusions

In this study, aflatoxin B_1, B_2, G_1 and G_2 were analyzed in 27 chips with an effective analytical method for the safe determination of aflatoxins in food samples. Results regarding aflatoxin levels in chips show that high levels of aflatoxin in the finished product show that there is inadequate control for aflatoxin in chips, remarkably for groundnut-chips. Aflatoxin levels of the groundnut-chips and the difficulty of meeting tolerance limits by importers and food processors must lead to the rejection of the groundnut for chip production and the reduction in market demand of the chips. Groundnuts shall be subjected to sorting or other physical treatment to reduce aflatoxin contamination before human consumption or use as an ingredient in chips. Therefore, new methods of detoxification are necessary to prevent health risks and economic losses that result from aflatoxin contamination. It was concluded that the widespread presence of aflatoxins in chip samples were considered to be possible hazards to public health especially, children. On account of this, chips products have to be controlled continuously for the presence of aflatoxin contamination by the Turkish public health authorities. Moreover, multidisciplinary and comprehensive research is required to effectively control and minimizing aflatoxin contamination maintaining healthy living and economic development.

Raising public health awareness is crucial regarding aflatoxin to;

- improved health conditions of human and animals
- increase food safety and security
- enhance the quality of foods
- conserve natural resources
- increase economic benefits and reduce related costs.

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