

Aflatoxin Contamination Level of Different Crops in Ethiopia

Aserse Yenasew

Biology, Food Science and Nutrition Division, Ethiopia Institute of Agricultural Research, Addis Ababa, Ethiopia

Email address:

asresyenasew@gmail.com

To cite this article:

Aserse Yenasew. Aflatoxin Contamination Level of Different Crops in Ethiopia. *International Journal of Bioorganic Chemistry*.

Vol. 4, No. 1, 2019, pp. 42-46. doi: 10.11648/j.ijbc.20190401.16

Received: February 16, 2019; **Accepted:** March 22, 2019; **Published:** April 18, 2019

Abstract: This review paper was conducted to show the current status of aflatoxin contamination level of some selected crop commodities. Different data sources were collected from January, 2018 up to February, 2019 from published, unpublished and other scientific research reports. The results reported by different authors indicated that total aflatoxin, AFB1, AFB2, AFG1 and AFG2 are the aflatoxin types that contaminate groundnut, red pepper, maize, malt barely, sorghum and other types of crop commodities. According to different authors and research reports showed AFB1 is the most common aflatoxin type that contaminates different crops. Based on the review, the current aflatoxin contamination level of some Ethiopian crops were above permissible level according to the FAO/WHO and EU standards. This indicates that most Ethiopia people consume different crops that contaminated by aflatoxin due to lack of awareness about the cause and the effects of aflatoxin. The increment of temperature and moisture content were favorable for the growth of aflatoxigenic fungi. Different authors reported that the moisture and temperature increases, the aflatoxin contamination level of crops also increases.

Keywords: Aflatoxin, Aflatoxigenic Fungi, Increment

1. Introduction

Aflatoxin is toxic secondary products of mycotoxin produced by certain moulds of the genus aspergillus, penicillium and fusarium. Aspergillus is a large genus of mould which grows at an optimum range of temperature of 28-33°C and water activity of about 0.83-0.97. The major fungi that produce aflatoxins are aspergillus flavus, aspergillus nomius and aspergillus parasiticus [1]. These species contaminate various agricultural commodities either before harvest or at post-harvest stages under favorable conditions of temperature and humidity.

Around 18 types of aflatoxin have been identified [2]. Among these four classes of aflatoxin such as AFB1, AFB2, AFG1 and AFG2 are the most dominant in nature. These aflatoxin distinguished by their fluorescent color under ultraviolet light. Aflatoxin is odorless, tasteless and colorless. Chemically, they are stable in foods and resistant to degradation under normal cooking procedures.

The occurrence of aflatoxin influenced by source of food, specific enzyme of the fungus and favorable environmental conditions such as high moisture content and temperature [3]. Post-harvest contamination can occur during storage if the

moisture content is above optimum value [4].

Cereals and its products are the main food for human consumption through the world. Rice, wheat, maize, sorghum and millet are the most important cereal crop in the world. The cereal grains belong to maize, sorghum, millet, rice, wheat and barley is found susceptible to aflatoxin accumulation by aflatoxigenic fungi.

Aflatoxins are a family of toxins which produced from aspergillus fungi that contaminate different foods and feed products in the field, at harvest, and during storage [5]. Aflatoxins are mostly associated with produced in warm and humid regions of agricultural crops like maize, rice, and sorghum, barley, rye, wheat, groundnut, soybean and cotton seed [6]. It also present in cereals, nuts, spices and fruits. Favorable conditions for the contamination of Hot peppers by aflatoxins are atmospheric temperature, humidity, drying and storage conditions [7].

The contamination of agricultural crop and animal products via aflatoxins has great impact on human and animal health and also economic losses. People can be exposed to aflatoxins by consuming plant products, meat and dairy products [8]. Aflatoxin B1 is the most common in food and the most known genotoxic and carcinogenic aflatoxin. Aflatoxin can cause both acute and chronic toxicity in

humans and animals. Some of the effects of are acute liver damage, liver cirrhosis, and induction of tumours, teratogenic and other genetic effects. The level of AFB1 is much higher than AFB2. This shows that AFB2 is less toxic effect on human and animal health than AFB1 [5]. IARC has classified AFB1 is the group of carcinogenic agent [9]. It causes acute and chronic toxicity [10].

Aflatoxin contamination can also affect agricultural livelihoods in various ways. Aflatoxin can cause crop loss due to low yields, the market value of and uses for a contaminated crop decrease, farm animals can have stunted growth and lower yields of by-products such as milk and eggs and expose to health care costs and smallholder farmer families are mostly likely to consume contaminated crops. The aim of this research review paper was to show the aflatoxin contamination level of aflatoxin susceptible agricultural crop commodities in Ethiopia.

2. Materials and Methods

Data sources were collected from January, 2018 through February, 2019. A range of literature sources were used for this review including journal articles, books, book chapters, workshop proceeding, FAO reports, legal documents and unpublished reports were including Ph.D. dissertations as well as MSc thesis. The documents were collected from Ethiopia institute of agricultural research and universities, individual researcher, and from the internet data bases.

3. Aflatoxin Contamination Levels of Susceptible Crop Commodities

The aflatoxin contamination level of most agricultural crop commodities that exposed by aflatoxin are groundnut, maize, malt barely and sorghum were listed below.

3.1. Aflatoxin Contamination Level of Groundnut

The AFB1, AFB2, AFG1 and AFG2 level were 1.7ng/g-2368ng/g, 0.2ng/g-237ng/g, 102.495ng/g and 8.05-96.9ng/g respectively as indicated on table 1. In addition to this, Ayalew indicated that the total aflatoxin levels of groundnut seeds were 5µg/kg-250µg/kg [11]. Similarly, Amare detected total aflatoxin level in groundnut samples and ranged from 5ppb-250ppm in eastern parts of Ethiopia [12]. The lowest aflatoxin level of AFB1, AFB2, AFG1 and AFG2 were recorded on groundnut seed at Fedis, Gurusum, Babile, and Bible districts respectively while the highest aflatoxin level of AFB, AFB2, AFG1, and AFG2 recorded at Fedis.

Table 1. Showed the aflatoxin level of groundnut seed in eastern parts of Ethiopia.

| Districts | Aflatoxin type | Aflatoxin level (ng/g) |
|-----------|----------------|------------------------|
| Babile | AFB1 | 4.45-1624.5 |
| | AFB2 | 0.2-88.25 |
| | AFG1 | LOD |
| | AFG2 | LOD |

| Districts | Aflatoxin type | Aflatoxin level (ng/g) |
|-----------|----------------|------------------------|
| Darolabu | AFB1 | 3.05-719.1 |
| | AFB2 | 0.35-106.9 |
| | AFG1 | 102.495-398.95 |
| | AFG2 | 8.05-89.6 |
| Fedis | AFB1 | 1.7-2368 |
| | AFB2 | 0.3-237 |
| | AFG1 | 238-477 |
| | AFG2 | 53-96.9 |
| Gurusum | AFB1 | 4.5-682 |
| | AFB2 | 0.1-35.5 |
| | AFG1 | 187.1 |
| | AFG2 | 14.9 |

Source [13]

As indicated on the table 2, the level of AFB1 and AFB2 of groundnut cake in major cities of eastern parts of Ethiopia were 0.7ng/g-158.1ng/g and 0.2ng/g-15.3ng/g respectively. The lowest levels of AFB1 and AFB2 of groundnut cake were recorded at Haramaya city where as the highest level of AFB1 and AFB2 were recorded at Diredawa city. Besrat and Gebre showed that the mean level of AFB1 of 34.7µg/kg and 105µg/kg in samples of groundnut and peanut butter respectively [14].

Table 2. Showed the aflatoxin level of groundnut cake in eastern part of Ethiopia.

| Districts | Aflatoxin type | Aflatoxin levels (ng/g) |
|---------------|----------------|-------------------------|
| Babile | AFB1 | 0.7-39.1 |
| | AFB2 | 0.2-4.6 |
| Diredawa city | AFB1 | 1.5-158.1 |
| | AFB2 | 0.2-15.3 |
| Haramaya city | AFB1 | LOD |
| | AFB2 | LOD |
| Harar city | AFB1 | LOD |
| | AFB2 | LOD |
| Jijiga city | AFB1 | 2.8-9.4 |
| | AFB2 | 0.2-0.8 |

Source [13]

Chala have been collected different samples from different districts at different storage conditions as well as from the market and analyzed the total aflatoxin level as indicated below on table 3. The highest levels of total aflatoxin of groundnut seeds were recorded at both sampled conditions and different districts. Gurusum distirict was less grain contamination as compared to Babile and Darolabu districts. From Gurusum distirict, a total of 41 groundnut samples were tested for total aflatoxin concentration and 24 samples were positive. However, positive samples from the market and storage houses of this district have higher aflatoxin level than those from Darolabu. Positive samples from the markets of this district had aflatoxin concentration ranging between 16 µg/kg and 10,100 µg. Aflatoxin concentrations in the positive groundnut samples from the stores varied from 15 mg/kg to 5560 µg/kg.

At all districts the total aflatoxin levels were above the permissible level of EU (4µg/kg), FAO/WHO (15µg/kg). In addition to that Chala have been assessed the total aflatoxin level of different groundnut varieties in southern parts of

Ethiopia, but the results showed that the total aflatoxin level of groundnut varieties were under permissible level according to the EU and FAO standards limits [15]. Generally, different researcher's reports indicated that aflatoxin

contamination of groundnut occurs above safe level in eastern part of Ethiopia which is higher in EU and FAO/WHO limits.

Table 3. Indicated the aflatoxin concentration in groundnut samples from eastern parts of Ethiopia.

| Districts | Number of samples analyzed | Positive samples (%) | Negative samples (%) | Store ($\mu\text{g}/\text{kg}$) | Markets ($\mu\text{g}/\text{kg}$) |
|-----------|----------------------------|----------------------|----------------------|-----------------------------------|-------------------------------------|
| Babile | 39 | 34 (87.2) | 5 (12.8) | 157-11,900 | 15-9770 |
| Darolabu | 40 | 35 (87.5) | 5 (12.5) | 15 - 1980 | 15 - 4940 |
| Gursum | 41 | 24 (58.5) | 17 (41.5) | 15 - 5560 | 16 - 10,100 |

Source: Chala et al 2013[16]

3.2. Aflatoxin Contamination Level of Maize Aflatoxin

The aflatoxin contamination levels in maize, recorded from minimum to maximum incidence of different types of aflatoxins. According to different researcher reports showed that the mean total aflatoxin level of maize samples in Ethiopia is $3.13\mu\text{g}/\text{kg}$.

Amare showed the total aflatoxin level of maize that has been collected around Adama, Direedawa and Ambo was $< 5\mu\text{g}/\text{kg}$ [17]. According to Maserasha reported the mean total aflatoxin levels of $18.38\mu\text{g}/\text{kg}$ and $43.43\mu\text{g}/\text{kg}$ for pre harvest and post-harvest maize respectively [18]. In addition to that Maserasha indicated the pre harvest maize of AFB1, AFB2, AFG1, and AFG2 were $5\mu\text{g}/\text{kg}$, $1.17\mu\text{g}/\text{kg}$, $10.10\mu\text{g}/\text{kg}$ and $2.10\mu\text{g}/\text{kg}$ respectively and the results of post-harvest maize samples of AFB1, AFB2, AFG1, and AFG2 were $9.86\mu\text{g}/\text{kg}$, $7.2\mu\text{g}/\text{kg}$, $18.11\mu\text{g}/\text{kg}$,

and $8.14\mu\text{g}/\text{kg}$ respectively.

The level of AFB1 at Babile, Kersa, and Haramaya were ranges between $5\mu\text{g}/\text{kg}$ - $16.126\mu\text{g}/\text{kg}$, $5\mu\text{g}/\text{kg}$ - $33\mu\text{g}/\text{kg}$ and $5\mu\text{g}/\text{kg}$ - $11.826\mu\text{g}/\text{kg}$ respectively underground pit storage conditions [19]. Other finding shows that $4.1\mu\text{g}/\text{kg}$ of total aflatoxin was detected from maize in Ethiopia [17]. Similarly, AFB1 contamination in maize in South Ethiopia was $22.72\mu\text{g}/\text{kg}$ [20].

3.3. Aflatoxin Contamination Level of Sorghum

The northern parts of Ethiopia farmers were interviewed for their knowledge regarding aflatoxin contamination in their areas. The total aflatoxin contamination level of sorghum sampled above ground storage and underground storage systems for less than 12 months, 1-2 years, and greater than two years storages period's indicated below.

Table 4. Shows the total aflatoxin content of under different storage conditions and periods.

| Storage condition | Above ground | | | Under ground | | |
|--|--------------|--------------|--------------|--------------|--------------|----------|
| | <12 months | 1-2 years | >2 years | < 12 months | 1-2 years | >2 years |
| Total aflatoxins ($\mu\text{g}/\text{kg}$) | 16.59-183.16 | 46.48-177.33 | 44.27-210.53 | 11.44-344.26 | 65.17-247.92 | 21.47 |

Source [21]

This reviewed showed total aflatoxin contamination level ranges from $11.44\mu\text{g}/\text{kg}$ - $344\mu\text{g}/\text{kg}$ and the mean total aflatoxin values of $23.85\mu\text{g}/\text{kg}$ [21]. Ayalew also reported a small proportion (6%) of Sorghum field samples to be contaminated with AFB1 up to $26\mu\text{g}/\text{kg}$ [11].

Table 5. Indicates the AFB1 contamination level of underground pit storage conditions of sorghum grains at different temperature and relative humidity.

| Districts | Babile | Kersa | Haramaya |
|---|----------------------------------|---------------------------------|----------------------------------|
| The mean AFB1 freshly harvested sorghum grain ($\mu\text{g}/\text{kg}$) | 684 | 624 1157 | 907 1193 |
| The mean AFB1 level of stored sorghum grain ($\mu\text{g}/\text{kg}$) | 1302 | | |
| The mean moisture content freshly harvested sorghum grain (%) | 12.7 \pm 0.5 | 13.9 \pm 0.6 | 12.1 \pm 0.3 |
| The mean of underground pit temperature and relative humidity (%) | Temperature Relative humidity | 281 \pm 2.0 77.9 \pm 4.7 | 24.6 \pm 1.5 65.9 \pm 3.3 |
| | | | 25.5 \pm 1.9 71.3 \pm 4.5 |

Source [19]

The optimum temperature for the growth of mould producing fungi were in the range of about 25-30oc at stored grain [22]. Drying agricultural products especially cereals until the moisture content reaches 10-13% were critical because it creates less favorable condition for fungal growth [23]. As shown on table 5, AFB1 level increased in stored sorghum grain when compared to freshly harvested grain. This is due to the higher moisture content and high storage

temperature condition of the sorghum grain because both moisture and temperature are the key environmental factors that influence the growth of fungi and aflatoxin contamination levels. In addition to this, Chala also reported maximum and minimum levels of AFB1 sorghum grains samples collected from farmer's stores in various locations of south, east and northwest Ethiopia were $62.5\mu\text{g}/\text{kg}$ and $29.5\mu\text{g}/\text{kg}$ respectively [24].

3.3. Aflatoxin Contamination Level of Malt Barely

Extensive survey has been performed in different parts of Ethiopia with regard of aflatoxin contamination in malt barely. Different authors have reported that total aflatoxin contamination level of traditional malt barely in Ethiopia ranges from 0.27 μ g/kg-23.6 μ g/kg as well as the local and imported industrial malt barely from 3.67 μ g/kg-5.06 μ g/kg [25]. This review result indicated the traditional malt barely more contaminated than industrial malt barely. The traditional malt barely aflatoxin contamination levels were due to poor pre harvest and post –harvest management.

4. Conclusion

Generally, most reports indicates that the total aflatoxins contamination level of major grains such as groundnut, maize and sorghum occurs above the safe level according to international standards in many parts of Ethiopia. So we should give greater emphasis on aflatoxins contamination because it has greater impact on human and animal health, food safety, markets and income and also occurs in diverse foods and animal feeds. Aflatoxins, potent carcinogens in humans and animals mainly get into the biological system via diets . The human health impacts resulting from acute and chronic aflatoxins exposure adds losses in cost of illness, contributing to the cycle of poverty which may contribute to further ill-health. However, several methods are available for reducing the adverse impact of aflatoxins such as proper agronomic and crop management practices, competitive biological control using non-aflatoxins producing strains of *A. flavus* and others. The review paper results contribute to understand the cause and effects of aflatoxins on humans and animals, to know the appropriate control measures and also used to create awareness on the aflatoxigenic fungi and associated mycotoxins. The proper management methods that reduce the fungi infection and level of aflatoxins contamination are drying properly to safe moisture levels after harvesting and storing under appropriate conditions.

Acknowledgements

I acknowledge the research authors regarding aflatoxin contamination level reported by the earlier journal authors and express my appreciation for permitting to use the required data from their journals.

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