Atatürk Üniversitesi Vet. Bil. Derg. *Review/Derleme*
2019; 14(1): 90-97 *DOI: 10.17094/ataunivbd.449705*

Atatürk Üniversitesi Veteriner Bilimleri Dergisi
http://dergipark.gov.tr/ataunivbd

Mycotoxin Hazard in Meat and Meat Products

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Geliş Tarihi/Received	Kabul Tarihi/Accepted	Yayın Tarihi/Published
31.07.2018	17.01.2019	28.04.2019

Bu makaleye atıfta bulunmak için/To cite this article:
Kaynarca D, Hecer C, Ulusoy B: Mycotoxin Hazard in Meat and Meat Products. Atatürk Üniversitesi Vet. Bil. Derg.,14(1): 90-97, 2019. DOI: 10.17094/ataunivbd.449705

Abstract: Mycotoxin; is one of the problems threatening human and animal health in food industry. Mycotoxins have some serious harms on human health such as hepatotoxic, neurotoxic, mutagenic, carcinogenic and estrogenic effects. Aflatoxin, ochratoxin A, zearalenone, fumonisins and tricotheenes are mycotoxins which have agricultural and economic importance. According to the studies on these toxins, it appears that meat and meat products play an important role in delivering toxins to humans. Regarding to the mechanism of seconder contamination of toxins to meat, it is important to apply good hygiene practice and good manufacturing practice in food industry. It is important to avoid feding the food animals with contaminated feed in order to prevent from primer contamination of meat with mycotoxins.

Keywords: Aflatoxin, Meat Products, Mycotoxin, Ochratoxin, Public Health.

Et ve Et Ürünlerinde Mikotoksin Tehlikesi

Öz: Mikotoksinler; insan ve hayvan sağlığını tehdit eden sorunlardan birisidir. Mikotoksinlerin insan sağlığı üzerine hepatotoksik, nörotoksik, mutajenik, kanserojenik ve östrojenik gibi etkileri bulunmaktadır. Aflatoksin, okratoksin A, zearalenon, fumonisinler ve trikotesenler tarımsal ve ekonomik önemi olan mikotoksinlerdir. Bu toksinler üzerine yapılan araştırmalarda et ve et ürünlerinin toksinleri insanlara ulaştırmada önemli bir rol aldığı görülmektedir. Bunlar arasında aflatoksin ve okratoksinin sentezlenebilmesi için gerekli olan çevresel koşulların et ve et ürünleri tarafından oluşturulduğu görülmektedir. Et ve et ürünlerinin işlenmesinde sekonder kontaminasyonun önlenmesi adına hijyen koşullarının iyileştirilmesi bu konuda personelin bilgili ve bilinçli olması etlerde mikotoksin tehlikesinin ortadan kaldırılması için bir önlem olarak düşünülebilir. Et ve et ürünlerinin primer kontaminasyonun önlenmesi için hayvanların kontamine yemlerle beslenmesi engellenmelidir.

Anahtar Kelimeler: Aflatoksin, Et Ürünleri, Halk Sağlığı, Mikotoksin, Okratoksin.

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INTRODUCTION

Mycotoxin is the general name of the toxic compounds produced by molds. Among the other chemical agents found in food and feedstuffs, mycotoxins are the very important ones that threaten human and animal health. In this point of view; mycotoxin contamination of meat is one of the important hazards to be controlled in terms of food safety (1,2).

However it is impossibleto fully calculate, it is suggested that mycotoxin contaminationis the reason of big economic losses as well as food safety and public health problems (3,4).

The term of mycotoxin was first used in 1960 after a case in which 100.000 turkeys died by consuming the feed contaminated with secondary metabolites produced by *Aspergillus flavus* in UK. Mycotoxin is the combining of the words "myco" meaning "fungus" and "toxin" meaning poison. Mycotoxicosis is the name of the ilness caused by mycotoxins. It is reported that exposure to mycotoxins in humans and animals is mostly through food. The mycotoxins are classified as hepatotoxins, nephrotoxins, neurotoxins, and immunotoxins according to the organs that they affect. Depending on the way of affecting the cells; they are classified as teratogens, mutagens, carcinogens and allergens. They are also grouped as polyketides and amino acid derivatives according to their chemical origins (5-7).

Mycotoxins are transported to humans by consumption of meat obtained from animals fed with contaminated feeds and contaminated spices used during processing of these meats. Mycotoxins are thought to be responsible for various pathological syndromes in humans. For example, ochratoxin is associated with balkan endemic nephropathy and fumonisin B1 is associated with esophagus cancer (8,9).

Today, more than 300 mycotoxins are known. Aflatoxins, ochratoxin A (OTA), fumonisins, trichothecenes and zearalenone toxins are the groups of mycotoxins, which have the largest agricultural, economic and public health importance (10-12).

1. Aflatoxins

The toxins named as aflatoxin B1, B2, G1 and G2 of are synthesized by *A. flavus* and *A. parasiticus*. These aflatoxins can often be found in many herbal products such as cereals, peanuts, cotton seeds, dried fruits, spices (13). Optimal conditions for of *A. parasiticus* and *A. flavus* to produce toxin are reported to be 16-31 ℃ and 0.83-0.99 a_w (3,14,15). The Food and Agriculture Organization (FAO) determined the maximal daily intake of aflatoxin B1 to be 5 µg/kg and the total aflatoxin (B1 + B2 + G1 + G2) to be 10 µg/kg. This toxin has been classified by the International Agency for Research on Cancer (IARC) (16), in carcinogenic effect Group 1. Consuming meat products contaminated with aflatoxin can cause mutagenic, carcinogenic and teratogenic effects in consumers. Regarding this issue, it is important to evaluate the researches which show us the aflatoxin contamination of meat and meat products.

Darwish et al. (4) reported that the highest amount of aflatoxin was found in the liver and stomach after analyzing frozen chicken breasts, buttocks, stalk and liver samples from 80 chickens. Shaltout et al. (17) found that aflatoxin levels of 13.38 ± 1.52, 9.03 ± 1.14, 8.80 ± 0.95 and 4.53 ± 0.61 µg/kg, were obtained respectively, in a total of 100 meatballs, sausages, luncheon and pastrami samples collected from various butchers and grocery stores in Benha. They reported that the amount of aflatoxin found in meatball samples was above the limit, and that of sausages was very close to the limit.

Maktabi et al. (18) have used ELISA method to detect AFB1 in 45 sausage and 53 burger samples collected from various markets in Iran. As the conclusion of the related study, 2 sausage samples (%4.9) and 3 burgers (%6.3) were contaminated below >1 ng/g. However in, 4 burger samples (%8.9) *Aspergillus flavus*, *A. niger*, *A. mucor* and *Penicilium* contamination were observed. Sineque et al. (19) collected 100 broiler and 80 gizzard samples from industrial and local slaughterhouses. According to the results of this study conducted by ELISA method,

they detected AFB1 in %39 of liver and %13.8 of gizzards and the amount detected AFB1 were in the range of 1.73-1.07 ng/g. Hassan et al. (20), a total of 350 samples (frozen meat, minced meat, liver, kidney, luncheon, sausage, hawawchi) collected from 50 different butcher and supermarkets in Egypt and aflatoxins B1, B2, G1 and G2 contaminations were searched. As a result of this study; in the kidney samples 12.36 ± 1.89,9.84 ± 1.63, 5.38 ± 1.36, 6.84 ± 1.39± 1.36, 6.84 ± 1.39and 1.36 ± 0.38 in the liver samples, 3.71 ± 1.35, 3.59 ± 1.12, 5.24 ± 1.38 µg/kg, in the liver samples 13.81 ± 1.96, 3.26 ±0.92, 2.51 ± 0.63 and 1.36 ± 0.38 µg/kg, in the luncheon samples 3.71 ± 1.35, 3.59± 1.12, 5.24 ± 1.12, 6.77±1.49 µg/kg, in the hawawchi samples 11.03 ± 2.43, 2.25± 0.52, 2.54 ± 0.99, 2.56 ± 0.27 µg/kg, in the minced meat samples 3.62 ±0.88, 3.40 ± 0.82, 4.24 ± 0.85, 2.83 ± 0.60 µg/kg and in frozen meat samples 4.80 ± 0.89, 5.3 ± 2.1, 1.71 ± 0.60 µg/kg aflatoxin B1, B2, G1 and G2 were reported respectively for each. These values were over the limit when compared with the limits reported by World Health Organization (WHO), FAO and FDA. Ahmed et al. (21) collected 90 samples (30 sausage, 30 luncheon, 30 burger meat) from Zagazig markets. According to the results 4 of the sausage samples, 3 of the luncheon samples and 2 of the burger meat samples were contaminated with aflatoxin over the limit values (4 ppb) determined by the European Union. In Tabriz, Amirkhizi et al. (22) reported that %72 of the liver samples and %58 of the egg samples were contaminated with AFB1 in the analysis of 150 eggs and 50 chickens by the HPLC method. Murad et al. (23) collected 60 poultry samples from butcher shops in Sulaimani and analyzed AFB1 HPLC method. According to this study they reported that AFB1 was detected in all chicken meats and %65 of chicken lungs however amounts were below the limits.

Spices used in meat products can be shown as a source of mycotoxin contamination of those products. Pleadin et al. (24) reported that they found aflatoxin in their products because of the presence of aflatoxin residues in red pepper and black pepper, although mycotoxin was not found in the meat they used as raw material in experimental sausage production.

2. Ochratoxin A

Ochratoxin A, B and C are secondary metabolites produced by various *Aspergillus* species such as *A. ochraceus*, *A.alutaceus*, *A. melleus*, *A. alliaceus*, *A. ostianus*, *A. sclerotorium*, *A. albertensis*, *A. wentii*, *A. auricomus*, *A. niger* var. *niger*, *A. fresenii* and some of the *Penicillium* species such as *P. verrucousum*, *P.cyclopium*, *P. palitans*, *P. commune*. Among the other ochratoxins, ochratoxin A (OTA) is the most isolated one. This toxin is present as a contaminant of many foodstuffs, especially cereals, as well as wine and cabbage. If animals consume contaminated feed, meat and meat products obtained from those animals, may also contain OTA. It is emphasized that meat as the main source of human exposure to this toxin (25).

Mold species that can produce ochratoxin are known to be able to grow at low temperatures and low water activity values. *Penicillium* species can produce ochratoxin at temperatures of up to 5 °C (10). OTA contamination for cereals usually occurs during storage, especially when humidity and temperature are above the required level (26). The maximum tolerable dose for OTA was reported to be 16 µg/kg daily. The carcinogenic hazard by IARC (16) is classified in group 2B.

Studies show that OTA can be found in meats and offals, especially pig kidney, liver and other organs. It is known that pigs are particularly susceptible to OTA in farm animals, and pigs carry OTA not only in their kidneys also carry at low concentrations in their liver, muscle and fat tissues, However, the residence time of the toxin in blood is more compared to those tissues. It is known that the kidney, liver, muscle and fat tissues follow this, respectively. It has been reported that the contamination sources of meat products are not only pigs blood, plasma, kidneys and liver, but also contaminants in spices used in meat production. Studies have shown that products containing offal such as blood and liver sausages contain high levels

of OTA (27). Khalaileh (28) reported in his study on poultry meat (thig and legs, liver, gizzard, breast) that the amount of OTA was found to be 1.891 ± 0.007 and 7.687 ± 0.12µg/kg and the highest value was found in liver.

Markov et al. (29) conducted a survey study for OTA in semi-dried sausages and dried meat products which were collected from Croatian butcher shops and they obtainedochratratoxin in 21 of 25 semi-dried sausage samples and 23 of 50 dried meat samples. As a conclusion, 44 of the total 75 products were positive for ochratoxin contamination. Mitchell et al. (30) conducted a survey study in USA and fort his 2296 food items were collected. Of the 94 pigs in all samples collected, 3 were positive for ochtratoxin A. However the obtained amounts were ender the defined limits, it has been reported that those amounts were at risk level for children at 1-5 years of age. Iacumin et al. (31) performed a study on dried salami, which is frequently consumed in Northern Italy. They analyzed 100 dried and salted salami produced by traditional methods and 60 dried and salted salami produced by industrial methods. 37 of the traditional products and 35 of the industrial products were found to be positive and above the determined limits. Elghany (32) analyzed the OTA ready-to-eat luncheon and frozen burgersby immuno-affinity fluorimetry technique. Beef luncheons were reported to include 8.5-0.56 µg/kg and beef burgers were reported to include 7.6-2.7 µg/kg. Iqbal et al. (1) reported that %41 of poultry meat out of 115 samples and %35 of chicken eggs out of 80 found to be contaminated with OTA and 80 eggs, and the maximum value was 4.70 µg/kg. Armorini et al. (33) reported that they found OTA in 5 of 50 salami samples, but 1 of them was found to be over the defined limit. Murad (34) reported that 30 poultry meat samples and 30 chicken liver collected from supermarkets in Süleymaniye, 26 and 17 at the samples were found to contain OTA respectively. The amounts of OTA in positive samples were below the limit values.

Some treatments such as heating, salting, drying or storage are ineffective in reducing the OTA concentration in the final product. On the other hand, it has been reported that %20 of the toxin may be reduced by frying (26).

3. Zearalenone

Zearalenone (ZEA) is a mycotoxin with estrogenic activity produced by Fusarium species. Recently, it was reported that the toxin causes cancer and to reduce male fertility in humans and wildlife populations. Zearalenone is a non-steroid phenolic resorcinic acid lactone, which has estrogen-like activity in farm animals such as cattle, sheep, goats (35). IARC (16) classified zearalenone as Group 3 in terms of its carcinogenic effect.

Zearalenon was first isolated from the corn which is contaminated with *Fusarium graminearum* anamorph. It has been shown that it can be synthesized by various Fusarium species such as *F. graminearum, F. proliferatum, F. culmorum* and *F. oxysporum*. These are the fungal species that develop on plants. ZEA contamination occurs at harvest or early storage when drying is not enough. Fusarium development and mycotoxin production generally occur at high water activity (> 0.90). The optimum temperature for the development of ZEA production mycelium is reported to be about 20-25 ^{o}C (36).

There are a few studies on the potential presence of toxin in edible tissues of animals. In pigs, it appears that meat and other edible organs may not be contaminated with the toxin even after the animals exposed to high concentrations of toxin (37). In a study chickens were subjected to a long-term toxin exposure by feeding them with 1.58 mg ZEA/kg contaminated ration for 16 weeks. According to the results of this study; toxin was not detected in muscle, fat and egg of the animals (38).

On the other hand in the study of Iqbal et al. (1) which they collected 115 poultry samples in Pakistan, %52 of the samples was found to be positive in terms of zearalenone presence. Among the positive samples, the highest value was determined as 5,10 µg/kg in HPCL method. Mahmoudi (39) collected 210 samples including 70 liver, 70 milk, 70 meat in the North-west of Iran. According to the results of this

study zearalenone was detected in 92 samples and the highest amounts of toxin were obtained in liver samples (2.37 ± 1.18 ng/g) and followed by milk (1.34 ± 1.42 ng/ml) and meat (0.79 ± 1.27 ng/g). Danicke et al. (38) reported that in ruminants fed with ZEA at 0.1 ml/kg/day, β-zearalenol was found in %68, α-zearalenol in %24, and zearalenone in %8 in bile of the ruminants, but nometabolites were found in the muscles and kidney. Zearalenone production can not be observed in processed meats due to lack of optimum environmental conditions (especially water activity) required for Fusarium development and toxin production.

4. Trichothecenes

Trichothecenes are the secondary metabolites produced by various Fusarium species such as *F. graminearum, F. culmorum, F. poae* and *F. sporotrichioides*. More than 160 trichothecenes, including deoxynivalenol (DON), nivalenol (NIV), T-2 toxin, HT-2 toxin, diacetoxysirpenol (DAS) and fusarenon X were reported in scientific literature. Among these, the most frequent trichothecene is DON. It is known that these mycotoxins are toxic, immunotoxic and cytotoxic in animals. However, due to the metabolic pathways in the animals, it does not cause any residuein the muscle of food animals (40,41).

IARC (16) classified T-2 toxin, DON and NIV as Group 3 in terms of its carcinogenic effect. The daily tolerable dose determined depending on the toxic effects observed in pigs or rodents is 0.06, 1 and 0.7 mg/kg for T-2, DON and NIV, respectively. The present data discloses that meat and meat products are not considered as a potential source of trichothecenes for consumers. It has been reported that poultry can conquer trichothecenes at high levels and therefore humans are not infected by poultry products. For this reason, studies on toxin, indicate that transport in consuming edible parts of the animal is not a pathway of exposure to these toxins (42).

Wu et al. (43) conducted a study with 24 pigs which were fed with feed that has been contaminated by toxins experimentally. When they analyzed the samples, they reported that they found DON residues in the spleen, heart, and muscle and that the amounts were below 6 μg/kg which is the daily tolerable amount for humans. Zou et al. (44) analyzed 20 pigs dorsal muscle, 10 pigs back fatand 36 chicken meat and reported that they found trichothecene residues in 6, 8 and 6 rolls, respectively. The values they obtained were below the limits.

5. Fumonisins

There are seven types of fumonisin produced by Fusarium species, named as A1, A2, B1, B2, B3, B4 and C1. Especially their effects on the health of the horses has long been known. The most common and known one is fumonisin B1. Fumonisin B1 is synthesized by *F. verticillioide, F. proliferatum ve F. nygami* (42,45). However, due to its absorption and kinetics properties, it is reported that meat and meat products are not important sources for public health (11).

Fumonisin production occurs mostly in the period of harvest, at temperatures of about 20-25 °C and in high humidity of grains. In many studies, fumonisins are said to be contaminants of corn and corn products worldwide (45). IARC (16) classified FB1 as Group 2B in terms of its carcinogenic effect.
Regulations by the European Union have determined the maximum concentrations of fumonisin B1 and B2 in corn and corn derived products for human consumption. The maximum limits range from 200-4000 mg/kg depending on the type of the food. Taking into account the toxicokinetic parameters observed for FB1, edible parts of animals and especially muscles do not appear to be a source of FB1 hazard for human health (45).

CONCLUSION

Studies show that even though there are mycotoxins contaminating meat and meat products, incidence and toxic effects of aflatoxins and ochtratoxin makes those toxins more important in terms of food safety. There is a need to develop the legislation on the maximum limits of mycotoxins in meat and meat products. Contamination of meat and meat products with mycotoxins occurs in two ways. The first way is the feeding of the animals with contaminated feed which causes toxin residues in edible parts of the animals. The second way is the contamination that can occur during the processing, preservation and distribution of meat and meat products. Regarding to this mechanism of this seconder contamination, it is important to apply good hygiene practice and good manufacturing practice in food industry.

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