Chapter

Food Safety: The Risk of Mycotoxin Contamination in Fish

Constanze Pietsch

Abstract

Mycotoxins are commonly found in animal feeds, and fish feeds are no exception to this. The need to feed fish in aquaculture with compounded feeds leads to the increasing inclusion of plant-derived feed ingredients that have a higher probability of containing mycotoxins. Since fish appear to be quite sensitive to mycotoxins, further research on mycotoxin toxicity in fish is recommended. Depending on the chemical characteristics of an individual mycotoxin and the biotransformation abilities of the different fish species, certain mycotoxins can be found in the edible parts of a fish. Thus, the consumption of fish products increases the potential risk of mycotoxin exposure for humans. This chapter reviews the risks associated with different groups of mycotoxins and makes recommendations on how to minimize these risks in the future.

Keywords: fish, aquaculture, mycotoxin toxicity, toxin residues

1. Introduction

Estimating risk requires sufficient knowledge of the frequency with which mycotoxins occur and the levels that can be expected. However, sufficiently detailed information on the actual levels of contamination in fish feeds is often not available. In addition, there is a high degree of variability between mycotoxins due to differences in fungal distribution and climatic conditions worldwide. Nevertheless, the following sections will summarize our current knowledge of mycotoxin occurrence in feed ingredients, fish feeds, and fish tissues in order to compile sufficient evidence to prove that some mycotoxins pose a considerable risk for consumers due to their high prevalence, incidence, toxicity, and/or stability as they pass into the food chain.

2. Exposure of fish to mycotoxins

Fish production in aquaculture has increased rapidly over the previous decades. Consequently, increasing numbers of fish have to be fed in aquaculture, which requires an increasing amount of fish feed. Since the global availability of fishmeal, which is a major ingredient in fish feed, is limited, cereals are common alternatives. Based on recent estimations, it has been determined that fishmeal is still a major component in fish feed in Europe [1], despite the fact that its percentage in commercial feeds has decreased over the last decades. The disadvantage of plant-based ingredients is that there is a higher probability of them being contaminated with mycotoxins. The second most prominent feed ingredient in aquaculture feeds in
Europe is wheat flour [1], followed by soybean products. Other feed ingredients are often present in fish feeds at average percentages of less than 10%, and these ingredients may also contain considerable amounts of mycotoxins. One example of such a problematic feed ingredient may be distillers’ grain with solubles (DDGS) [1, 2].

The most important mycotoxins in feed ingredients in terms of risk to fish and consumers, since they are either known to be toxic and/or occur at high concentrations, include aflatoxin B1 (AFB1), deoxynivalenol (DON), nivalenol (NIV), zearalenone (ZEN), ochratoxin A (OTA), T-2 toxin (T2), fumonisins B1 (FB1), moniliformin (MON), enniatins (ENNs), and beauvericin (BEA). Nevertheless, there are a number of reasons why mycotoxin contamination levels in feed ingredients can vary widely, for example, different fungal species or strains often grow on specific feed ingredients. Especially, high OTA levels have been found in corn (up to 1850 μg/kg, [3]), followed by wheat (up to 1024 μg/kg, [4]), soybean, and sunflower products (up to 350 and 240 μg/kg, respectively, [3]). Furthermore, Fusarium mycotoxins can contaminate peas and soybeans [5], and FB1 can be found in significant amounts in corn [6].

The occurrence of mycotoxins in feed ingredients is also known to vary as a result of climate effects and differences in the distribution of various fungal species and strains that have differing abilities to form toxins [7–9]. The problem with mycotoxin contamination in feed ingredients is thought to have increased as a result of climate changes and the shipping of commodities on a global scale, which has led to the worldwide distribution of many fungal species, often resulting in higher contamination in cereals [9–11]. However, the presence of mycotoxins in feed ingredients does not mean that these substances will also be present in compounded animal feeds, since a number of mycotoxins have been reported to possess different degrees of stability when thermally processed and extruded [12]. Furthermore, the processing of feed ingredients, which includes cleaning, sorting, milling, and the application of thermal processes, also influences the mycotoxin load in the final products [13–16]. Nevertheless, the extent of the reduction in mycotoxin contamination during these procedures differs widely for each mycotoxin [15, 17–20]. Generally, mycotoxins that are most stable and widely distributed and, in most cases, occur at high concentrations in certain feed ingredients are problematic for fish production. Two mycotoxins that are already problematic at relatively low concentrations in fish feeds and will be reviewed in the section on fish toxicity are AFB1 and OTA due to their high toxicity.

The most prominent member of the fumonisins in naturally contaminated animal feeds is FB1 [21], which often occurs at high concentrations in feed ingredients (e.g., [22, 23]). However, since fumonisins are relatively unstable and easily affected by feed production processes, they are assumed to be less problematic than other mycotoxins. Nonetheless, feed processing may yield mycotoxin metabolites, in some cases resulting in increased toxicity [24].

ZEN is a mycotoxin that commonly occurs after crops have been infected have been infected with Fusarium species in the field, but this toxin can also develop during the storage of the cereals [25, 26]. ZEN contamination appears to be common in commercial fish feeds [27, 28], which raises concerns about the effects of chronic exposure to this mycotoxin, since besides exhibiting toxic characteristics, it is also a potent natural estrogen [29].

The trichothecenes include some very important mycotoxins, such as T-2 toxin, DON, and NIV. Recent research has focused on DON since it is known for its high prevalence and incidence in feed ingredients and animal feeds in Europe [30]. However, Fusarium fungi are also known to produce some less commonly described mycotoxins, known as emerging mycotoxins, which include BEA, ENNs, and MON [31, 32]. Although ENNs and BEA have been reported to be extremely prevalent in cereals [33], there has not been enough detailed research into their presence in feed components, compounded animal feeds, or farmed animals that have been exposed
to these mycotoxins. The other important *Fusarium*-related mycotoxin is MON. Up to 1.2 mg/kg MON has been detected in feeds for higher vertebrates [34], whereas the levels present in commercial fish feeds remain unknown.

As mentioned above, mycotoxin contamination often occurs on crop fields, but improper storage of feed ingredients and feeds also contributes to the final toxin levels in fish diets. Toxin production depends on the fungi's ability to produce certain chemical compounds as well as environmental factors, such as physical, chemical, and biological factors [35]. Accordingly, similar to the aflatoxins, the occurrence of OTA seems to be connected to temperature and humidity in the environment during growth and harvesting of crops, and the storage of feed ingredients and feeds. However, for most investigated fish feeds, low OTA levels have been observed [28]. In contrast, recent research has shown that inappropriate storage over a period of 6 weeks of a commercial feed for salmonids can lead to the development of considerable amounts of OTA (up to 400 μg/kg feed, unpublished results, C. Pietsch).

Although dietary contamination is the main route of exposure for fish in aquaculture, mycotoxins may also be introduced to aquatic environments directly. For example, levels of 90 μg/L OTA have been reported in waste water originating from wine production. Furthermore, ZEN can be found in surface waters and in waste-water treatment plants at ng/L levels, which may be environmentally relevant due to the estrogeic effects of this mycotoxin [36–38]. Thus, the stability of mycotoxins in water may also have an effect on relevant exposure concentrations in aquatic environments [39].

When data on contamination levels and incidence in common feed ingredients are compiled, there may be significant uncertainties due to the fact that these studies use different methodologies for mycotoxin detection and quantification. Another problem when compiling data from scientific studies is that several studies have not reported accuracy and reliability parameters for their methods, meaning the measured toxin values probably contain uncertainties, since the sample preparation and detection procedures differed. Furthermore, actual mycotoxin concentrations in feed components, animal feeds, and animal tissues are often underestimated, since matrix effects and the problems of detecting masked mycotoxins, which can often not be detected by routine measurement techniques. Since research is continuously improving detection methods for mycotoxins, an increased number of comparative studies addressing the advantages and disadvantages of detection methods for more commonly and emerging mycotoxins, such as can be found in the study by Pascale [40], should be conducted.

Another problem with estimating actual contamination levels in feeds and animal tissues is that metabolites of even commonly occurring mycotoxins are often not analyzed together with their parent compound, although metabolites may occur in significant amounts as has been shown for DON [41]. Furthermore, toxin levels in the control diets used in experimental fish studies have often been reported to contain no mycotoxins, despite the fact that the necessary toxin analyses were rarely performed to provide proof for this assumption. This may lead to an underestimation of the actual toxin levels in both control diets and experimental diets if only a restricted number of mycotoxins are measured. As a result, actual mycotoxin exposure data for fish contain various uncertainties. Therefore, more complete feed contamination databases are required so that risk assessments can be improved.

3. Presence of mycotoxins and their toxicity in fish

If the risk to humans by consuming fish products is to be calculated, the first step would be to estimate the uptake and retention of mycotoxins in different fish
species and in different parts of the fish (Figure 1). Therefore, the following sections will summarize what is known about chemical characteristics in fish bodies and the toxicity in the animals resulting from the most important mycotoxins.

DON has a mean lowest-observable effect level (LOEL) in fish of $3541 \pm 776 \mu g/kg$ (±SEM; Figure 2), whereas the contamination levels in commercial fish feeds range from 0 to 825 $\mu g/kg$ [27, 28, 41]. Similar to findings in chickens, DON appears to be excreted rapidly by carp (*Cyprinus carpio*), leaving no relevant residues in the edible parts [42, 43]. FB$_1$ metabolism also occurs quickly in chicken and the remaining values in tissues stay low. However, exact information on the kinetics or biotransformation of fumonisins in fish is not available [44, 45]. Due to this and the large differences in the toxicity of fumonisins in fish (Figure 2), no exact risk can be calculated for farmed fish [1]. Typical disorders in higher vertebrates resulting from FB$_1$ exposure have often been linked to the disruption of the sphingolipid metabolism [46], and similar effects have also been observed in fish [47]. Nevertheless, a low potential risk has been assumed for most vertebrates, with the exception of pigs [45]. Despite the fact that the guidance values for fumonisins in complete fish feeds have been set by the European Commission and the US to 10 mg/kg based, some countries have chosen to set different guidance levels [48, 49]. Although FB$_1$ can affect fish at low concentrations, for example in carp (exposed to 500 $\mu g/kg$ [50, 51]), the concentration range of the lowest-observable effects in fish is relatively broad, with a mean range of 26,480 $\pm$ 7124 $\mu g/kg$ (±SEM; Figure 2), a level that is not achieved for either actual or estimated natural contamination of fish feeds [1, 52].

Previous studies have reported lethal concentrations of OTA that lead to 50% mortality ($L_{C50}$) ranging from 2 to 58 mg/kg body weight in various higher vertebrate species [53, 54]. Fish species appear to be particularly sensitive to OTA, and since disposition appears to mainly take place in the kidneys of fish and not in muscles [55], this not only affects its toxicity, but is also relevant for food safety. High sensitivity to OTA in fish has been demonstrated in several studies. The $L_{C50}$ value for OTA in adult seabass (*Dicentrarchus labrax* L.) was found to be 280 $\mu g/kg$ body weight [56], 360 $\mu g/l$ for zebrafish (*Danio rerio*) embryos [57], and 5.53 mg/kg

---

**Figure 1.**
Exposure routes and factors influencing mycotoxin retention in fish.
body weight in rainbow trout (*Oncorhynchus mykiss*) [58]. However, the route of exposure may play a role when comparing these different studies. Furthermore, the absorption efficiency in the gut also determines the bioavailability of the mycotoxins in fish, as has been demonstrated for oral exposure to OTA in common carp [59]. If the LOEL for exposure of fish to OTA are summarized (Figure 2), the mean range is $1077 \pm 566 \ \mu g/kg$ (±SEM), which indicates that the currently recommended guidance value for OTA in cereals and cereal products intended for animal feed of $250 \ \mu g/kg$ does not protect fish from potential damage [48]. This is in stark contrast to the guidance level of $20 \ \mu g/kg$ that exists in some non-EU countries [49].

ZEN has a mean toxicity value of $2389 \pm 1285 \ \mu g/kg$ (±SEM), based on the LOEL calculations for five different fish species shown in Figure 2. Although the number of studies reporting effects of ZEN in fish is very limited, they may indicate that fish are more sensitive to water-borne ZEN than to dietary ZEN, which is why the mean LOEL level, including both, dietary and water-borne exposure for fish, shows quite a high standard error of the mean. ZEN concentrations above the LOEL levels in water samples have not been reported for aquatic environments [36–38]. Although the actual ZEN contamination of commercial fish feeds appears not to exceed the current guidance level for this mycotoxin in cereals and cereal products in the EU of $2000 \ \mu g/kg$ [27, 48], dietary exposure to this mycotoxin may still do harm to farmed fish. The guidance values in other countries that recommend maximum ZEN levels of 20–1000 $\mu g/kg$ have a higher probability of protecting fish from damage [49], since the ZEN levels in fish feeds often do not exceed concentrations of $200 \ \mu g/kg$ [27, 60]. Nevertheless, more exact reports on ZEN toxicity in fish and the actual contamination levels in commercial fish feeds are needed to support these assumptions.

T-2 toxin has a mean toxicity of $3201 \pm 1236 \ \mu g/kg$ (±SEM) in fish, based on the currently available LOEL for different fish species (Figure 2). This level is considerably higher than the actual contamination level found in salmonid fish feed.
in South America [28], and much lower than the guidance levels of 250 mg/kg for T-2 toxin set by the European Commission for cereal products in compound feeds [61] and individual recommendations in other countries (max. 80–100 mg/kg) for T-2 toxin in complete feed and all grains [49]. From these data, it can be assumed that fish do not regularly suffer from T-2 toxicity, and there have been no reports of accumulation of this mycotoxin in edible parts of the fish.

The situation for AFB1 is, however, quite different. The mean LOEL for fish has been calculated to be 1248 ± 275 μg/kg (±SEM) (Figure 2). However, AFB1 appears to be readily absorbed by the intestine [62] and a LOEL of less than 1 μg/kg has been observed in Nile tilapia (Oreochromis niloticus) and rainbow trout [63, 64], which shows that this mycotoxin can be a problem for farmed fish. In commercial fish feeds, AFB1 levels are commonly less than 10 μg/kg [65, 66], but may be considerably higher in some cases [67–69]. Critical levels for fish have been estimated to be a mean of 4.30 μg/kg in commercial feeds [1], which indicates that farmed fish are exposed to a risk from AFB1 intoxication.

Less information is available on the toxicity of ENNs and BEA in fish, but from initial experiments it can be assumed that at least some ENN toxins have toxic effects on zebrafish embryos (unpublished results, C. Pietsch). However, how relevant this toxicity is in comparison to the actual ENN contamination in commercial feeds remains unclear. Similar to other emerging mycotoxins, these substances have already been detected in the plasma of pigs after exposure to ENNs [196], indicating that the uptake of these substances occurs in vertebrates. In addition, it has been shown that food processing affects the presence on ENNs and BEA in bread [197, 198], and thermal processes, in particular, also appear to influence the ENN content in fish tissue [199]. Finally, the presence of high ENN and BEA levels in feed ingredients appears to overestimate the actual risk of fish feed contamination and the potential effects on farmed fish [1]. Thus, more research is needed on the toxicology and the biotransformation of ENNs and BEA in vertebrates.

An issue that also makes mycotoxin research difficult is the fact that we do not know enough about mycotoxin mixtures and their effects. Natural contamination of feed ingredients leads to the occurrence of several mycotoxins at the same time and their interactions remain mostly unknown.

4. Fish products and food safety

Exposure assessments are often based on a deterministic approach, which obtains the estimated daily intake (EDI) levels by assuming a human body weight of 60 kg for an adult. The EDI of each mycotoxin is commonly calculated as μg/kg body weight per day for each mycotoxin. Accordingly, the Joint FAO/WHO Expert Committee and Food Additives and Scientific Committee on Food have established a tolerable weekly intake (TWI) levels for humans for OTA of 120 ng/kg body weight and tolerable daily intake (TDI) levels of 250 ng/kg body weight for ZEN, 100 ng/kg body weight for T-2 and HT-2 toxins together, and 1000 ng/kg body weight for DON [200, 201]. For aflatoxins, no tolerable intake levels have been set since these toxins are listed as human carcinogens. The tolerable intake levels should be compared to the actual contamination levels found in fish products. However, the frequency of mycotoxin occurrence in fish products has not been investigated in detail. Recent studies indicate that less than 10% of fish and meat food samples are contaminated with mycotoxins, with DON contamination occurring in 17% of the 29 fish samples [202]. In addition, the accuracy of the reports also strongly depends on the accuracy and the number of samples that were analyzed.
Even if fish are exposed to feed-borne mycotoxins, and the resulting effects are not great, possible retention of these toxins in edible parts of the fish may pose a risk for human consumption. A risk to humans is assumed when the toxin concentrations in food exceed the safety limits. For AFB$_1$, this level has been set at 2 μg/kg by the European Union for food designated for human consumption [49]. However, the exact risk to humans is difficult to predict, since the behavior of the chemicals in the fish strongly depends on the chemical structures of the mycotoxins. In addition, toxin concentration in the feeds and duration of exposure also play an important role, therefore different studies may lead to different results. One example is the absence of accumulation of aflatoxin in the musculature of common carp in the study by Svobodova and Piskac [136], which contradicts the findings of Akter et al. [91]. The AFB$_1$ content in the hepatopancreas of gibel carp (Carassius auratus gibelio) was found to be considerably higher than in their muscle tissues (2.4–11.8 μg/kg) after 12 weeks of oral exposure [104]. An extrahepatic deposition of AFB$_1$ has also been confirmed in trout [62, 203], but the detection of this toxin in kidneys is more relevant from a toxicological point of view than from a food safety point of view. The study by Selim et al. [121] showed that exposure to 200 μg/kg AFB$_1$ for 2 weeks was sufficient to lead to detectable toxin residues in fish musculature (>20 μg/kg AFB$_1$), which increased to levels of more than 90 μg/kg AFB$_1$ after 10 weeks of exposure. Furthermore, feeding European seabass (Dicentrarchus labrax L.) with 18 μg/kg body weight AFB$_1$ resulted in toxin concentrations of 2.5 μg/kg AFB$_1$ in the fish musculature after 28 days of feeding, and even higher levels of 4.25 μg/kg AFB$_1$ after 42 days of exposure [94]. Compared to this, oral exposure of lambari fish (Astyanax altiparanae) to AFB$_1$ increased the body residues after feeding for at least 90 days [204]. In addition, this study showed that feeding an AFB$_1$ concentration of 50 μg/kg feed for 120 days also resulted in aflatoxin accumulation in muscle and liver tissues that were as high as in the feed. In other fish species, residues exceeding the safety limit were detected in the liver but not in the fish musculature [89, 104]. From these studies, it can be concluded that aflatoxin contamination can be a threat to humans after fish have been fed AFB$_1$ contaminated diets for certain duration. These values show that consuming fish can considerably add to the toxicological burden that can already be expected from consuming cereals, for which the daily intake through consumption of cereal-based products has been reported to reach levels of up to 79 ng/kg body weight [205] and 3 ng/kg body weight if peanuts are consumed [206]. An interesting finding was described in a study using walleye (Sander vitreus) which had been exposed to considerable amounts of AFB$_1$ that had accumulated in their edible parts. The accumulation of AFB$_1$ in the musculature may be reversible by feeding mycotoxin-free diets for 2 weeks [107], which also confirms similar findings in other fish species [104].

Fish muscle did not contain OTA in a Polish study [207]. In seabass (Dicentrarchus labrax) and sea bream (Sparus aurata) muscles, only low OTA levels have been detected [208]. It has already been reported that contaminated cereals and feed ingredients lead to the introduction of OTA into the food chain, posing a risk for humans [209]. Consuming fish appears to contribute to the presence of OTA in the food chain and also adds to the detectable levels of OTA in humans [2]. However, compared to the daily intake through direct consumption of cereal-based products that has been reported to be up to 22.2 ng/kg body weight for OTA [205], the amount that fish products may contribute to the toxicological burden appears to be lower. Nevertheless, this adds to the earlier assumption that naturally contaminated feeds also lead to the introduction of this mycotoxin into the food chain which may pose a risk to human consumers [210, 211]. The knowledge presented here on the presence and toxicity of this toxin in fish supports this assumption. The potential risk due to OTA exposure is probably caused by the fact that OTA is even more stable in the environment than aflatoxins [212, 213].
In contrast, the presence of fumonisins in fish appears not to be relevant for consumers, since they rarely occur in farmed fish (e.g., in a survey in Switzerland in only one fillet sample containing less than 0.06 μg/kg FB$_1$ + FB$_2$, personal communication C. Pietsch). In addition, it was not possible to identify a high risk to humans as a result of consuming fish products contaminated with other mycotoxins, such as ZEN and DON, since no relevant toxin levels could be detected in the musculature of DON- or ZEN-treated rainbow trout and common carp [42, 214, 215]. Interestingly, ZEN exposure did result in retention in the ovaries of farmed trout [184]. Furthermore, the study by Nácher-Mestre et al. [216] found no detectable mycotoxin levels in gilthead sea bream or Atlantic salmon (Salmo salar) after 8 months of dietary exposure to DON levels of up to 79.2 μg/kg and fumonisins at levels of up to 754 μg/kg. A study into fish as food reported mean DON levels of 1.19 μg/kg [202]; and since DON was the major mycotoxin in the fish samples analyzed in this study, it was also assumed to be the main contributor to the daily human mycotoxin exposure. ZEN retention in human breast milk has already been related to consuming meat, fish, dry fruits, and spices [217]. However, compared to the presence of Fusarium toxins in cereals, it can still be assumed, based on the fact that rapid metabolization takes place in fish, that the retention of DON and ZEN in fish is low. Therefore, there can be no assumption of a higher risk to humans of consuming these mycotoxins in fish compared to the risk of exceeding the toxicological reference values by consuming cereal products directly [202, 206, 218].

In the 29 fish samples in the study by Carballo et al. [202], mean ENN A concentrations of 0.89 μg/kg were observed. ENNs were also detected in 20% of the salmon flesh samples and 10% of rainbow trout samples in the study by Tolosa et al. [199], but further processing including cooking or smoking appears to mitigate the toxin content [219]. In contrast, fish from Egypt contained predominant xerophilic molds with Aspergillus species being the major ones (58.2%), followed by Penicillium species (32.7%) in salted products and also in smoke-cured bonga shad and African catfish (Ethmalosa fimbriata and Clarias gariepinus) [220, 221]. However, a study in Kenya only showed aflatoxins in dried fish, and not in fresh ones [222]. Smoked-dried fish from Nigeria may also contain potential mycotoxin producing fungi and aflatoxins [223–226]. Similar results from Egyptian smoked fish confirmed that the moisture and salt concentrations that occur during food processing influence the OTA and AFB$_1$ contents in the fish products, possibly exceeding the permissible limits for both mycotoxins [227].

Mycotoxins can also occur in sun-dried fish products, which are typically found in tropical and subtropical regions where high temperatures and humidity considerably influence fungal growth and toxin formation. Accordingly, samples of dried seafood contained high levels of ZEN and OTA (317.3 and 1.9 μg/kg, respectively). Furthermore, low amounts of AFB$_2$ (1.2 μg/kg) were also observed in the muscle of crucian carp (Carassius carassius), even after storage for 3 months at room temperature [228], emphasizing the high stability of aflatoxins.

5. Conclusions

Taken together, mycotoxin contamination in feed ingredients and fish feeds is an increasing problem that will have to be addressed by crop farmers, feed producers, and researchers. One step that could be taken is to prevent heavily contaminated raw materials being introduced into the feed production processes, which would lower potential mycotoxin contamination levels. Nevertheless, other mycotoxins are still formed during storage, and improved guidelines and recommendations for storage of feed ingredients and animal feeds should be published. Since mycotoxins
are present in animal feeds, in some cases at toxicological relevant levels, this may cause health problems in fish and limit production in aquaculture. More data on the presence of mycotoxins in fish would allow better risk assessments for human consumers to be carried out. Furthermore, the data sets for some mycotoxins indicate that more strict guidance levels are needed for fish feeds to protect farm animals from harm and prevent accumulation of potentially problematic mycotoxins such as AFB$_1$ and OTA in the food chain.

**Acknowledgements**

Darren Mace’s (ZHAW, Wädenswil, Switzerland) work on checking the language in the entire manuscript is highly appreciated.

**Conflict of interest**

The author declares that there are no conflicts of interest regarding the publication of this chapter.
References

[1] Pietsch C. Risk assessment for mycotoxin contamination in fish feeds in Europe. Mycotoxin Research. 2019. pp. 1-22. DOI: 10.1007/s12550-019-00368-6

[2] Mortensen A, Granby K, Eriksen FD, Cederberg TL, Friis-Wandall S, Simonsen Y, et al. Levels and risk assessment of chemical contaminants in byproducts for animal feed in enmark. Journal of Environmental Science and Health—Part B Pesticides, Food Contaminants, and Agricultural Wastes. 2014;49(11):797-810. DOI: 10.1080/03601234.2014.938546

[3] Rafai P, Bata Á, Jakab L, Ványi A. Evaluation of mycotoxin-contaminated cereals for their use in animal feeds in Hungary. Food Additives and Contaminants. 2000;17:799-808

[4] Czerwiecki L, Czajkowska D, Witkowska-Gwiazdowska A. On ochratoxin A and fungal flora in Polish cereals from conventional and ecological farms. Part 2: Occurrence of ochratoxin A and fungi in cereals in 1998. Food Additives and Contaminants. 2002;19:1051-1057

[5] Ivić D, Domijan AM, Peraica M, Miličević T, Cvjetković B. Fusarium spp. contamination of wheat, maize, soybean, and pea grain in Croatia. Arhiv za Higijenu Rada i Toksikologiju. 2009;60:435-442

[6] Nelson PE, Desjardins AE, Plattner RD. Fumonisins, mycotoxins produced by Fusarium species: Biology, chemistry, and significance. Annual Review of Phytopathology. 2003;31:233-252

[7] Schatzmayr G, Streit E. Global occurrence of mycotoxins in the food and feed chain: Facts and figures. World Mycotoxin Journal. 2013;6(3):213-222

[8] Anater A, Manyes L, Meca G, Ferrer E, Luciano FB, Pimpão CT, et al. Mycotoxins and their consequences in aquaculture: A review. Aquaculture. 2016;451:1-10

[9] Levic J, Gosis-Dondov S, Ivanovic D, Stankovic S, Krnaja V, Bocarov-Stancevic A, et al. An outbreak of Aspergillus species in response to environmental conditions in Serbia. Pestic i Fitomedicina. 2013;28(3):167-179

[10] Dobolyi C, Sebök F, Varga J, Kocsubé S, Szigeti G, Baranyi N, et al. Occurrence of aflatoxin producing Aspergillus flavus isolates in maize kernel in Hungary. Acta Alimentaria. 2013;42(3):451-459

[11] Tóth B, Török O, Kótai É, Varga M, Toldiné Tóth É, Pálfi X, et al. Role of Aspergilli and Penicillia in mycotoxin contamination of maize in Hungary. Acta Agron Hungarica. 2012;60(2):143-149

[12] Bullerman LB, Bianchini A. Stability of mycotoxins during food processing. International Journal of Food Microbiology. 2007;119(1-2):140-146

[13] Kaushik G. Effect of processing on mycotoxin content in grains. Critical Reviews in Food Science and Nutrition. 2015;55:1672-1683

[14] Kushiro M. Effects of milling and cooking processes on the deoxynivalenol content in wheat. International Journal of Molecular Sciences. 2008;9:2127-2145

[15] Cheli F, Pinotti L, Rossi L, Dell’Orto V. Effect of milling procedures on mycotoxin distribution in wheat fractions: A review. LWT—Food Science and Technology. 2013;54:307-314

[16] Mmongoyo JA, Wu F, Linz JE, Nair MG, Mugula JK, Tempelman RJ,
et al. Aflatoxin levels in sunflower seeds and cakes collected from micro- and small-scale sunflower oil processors in Tanzania. PLoS One. 2017;12(4):e0175801

[17] Lancova K, Hajslova J, Kostelanska M, Kohoutkova J, Nedelnik J, Moravcova H, et al. Fate of trichothecene mycotoxins during the processing: Milling and baking. Food Additives & Contaminants. Part A, Chemistry, Analysis, Control, Exposure & Risk Assessment. 2008;25:650-659

[18] Neuhof T, Koch M, Rasenko T, Nehls I. Occurrence of zearalenone in wheat kernels infected with Fusarium culmorum. World Mycotoxin Journal. 2008;1:429-435

[19] Edwards SG, Dickin ET, MacDonald S, Buttler D, Hazel CM, Patel S, et al. Distribution of Fusarium mycotoxins in UK wheat mill fractions. Food Additives & Contaminants. Part A, Chemistry, Analysis, Control, Exposure & Risk Assessment. 2011;28:1694-1704

[20] Pascale M, Haidukowski M, Lattanzio VMT, Silvestri M, Ranieri R, Visconti A. Distribution of T-2 and HT-2 toxins in milling fractions of durum wheat. Journal of Food Protection. 2011;74:1700-1707

[21] Grierresler K, Encarnacao P. Fumonisins—Mycotoxins of increasing importance in fish. Aquaculture Asia Magazine. 2009;XIV:24-26

[22] Grajewski J, Blajet-Kosicka A, Twaruzek M, Kosicki R. Occurrence of mycotoxins in Polish animal feed in years 2006-2009. Journal of Animal Physiology and Animal Nutrition. 2012;96(5):870-877

[23] Stanković S, Lević J, Ivanović D, Krnjava V, Stanković G, Tančić S. Fumonisin B1 and its co-occurrence with other fusariotoxins in naturally-contaminated wheat grain. Food Control. 2012;23(2):384-388

[24] Scott P. Recent research on fumonisins: A review. Food Additives & Contaminants. Part A. 2012;29(2):242-248

[25] Caldwell RW, Tuite J, Stob M, Baldwin R. Zearalenone production by Fusarium species. Applied Microbiology. 1970;20(1):31-34

[26] Milano GD, Lopez TA. Influence of temperature on zearalenone production by regional strains of Fusarium graminearum and Fusarium oxysporum in culture. International Journal of Food Microbiology. 1991;13(4):329-333

[27] Pietsch C, Kersten S, Burkhardt-Holm P, Valenta H, Dänicke S. Occurrence of deoxynivalenol and zearalenone in commercial fish feed: An initial study. Toxins (Basel). 2013;5:184-192

[28] Greco M, Pardo A, Pose G. Mycotoxigenic fungi and natural co-occurrence of mycotoxins in rainbow trout (Oncorhynchus mykiss) feeds. Toxins (Basel). 2015;7:4595-4609. DOI: 10.3390/toxins7114595

[29] Gupta RC, Mostrom MS, Evans TJ. Chapter 76—Zearalenone. In: Gupta RC, editor. Veterinary Toxicology. Basic and Clinical Principles. 3rd Edition. Section XV Mycotoxins. Academic Press; 2018. pp. 1055-1063. DOI: 10.1016/B978-0-12-811410-0.00076-3

[30] Rodrigues I, Naehrer K. A three-year survey on the worldwide occurrence of mycotoxins in feedstuffs and feed. Toxins (Basel). 2012;4(9):663-675

[31] Polido OM, Gill S. Chapter 35—Food and toxicologic pathology: An overview. In: Haschek WM, Rousseaux CG, Wallig MA, editors. Haschek and Rousseaux's Handbook of Toxicologic Pathology. 3rd ed. Elsevier
Inc. Academic Press; 2013. pp. 1051-1076. DOI: 10.1016/C2010-1-67850-9

[32] Escrivá L, Font G, Manyes L. In vivo toxicity studies of fusarium mycotoxins in the last decade: A review. Food and Chemical Toxicology. 2015;78:185-206

[33] Lindblad M, Gidlund A, Sulyok M, Börjesson T, Krška R, Olsen M, et al. Deoxynivalenol and other selected fusarium toxins in swedish wheat—Occurrence and correlation to specific fusarium species. International Journal of Food microbiology. 2013;167(2):284-291. DOI: 10.1016/j.ijfoodmicro.2013.07.002

[34] Labuda R, Parich A, Vekiru E, Tančinová D. Incidence of fumonisins, moniliformin and Fusarium species in poultry feed mixtures from Slovakia. Annals of Agricultural and Environmental Medicine. 2005;12(1):81-86

[35] Piotrowska M, Slizewska K, Biernasiak J. Mycotoxins in Cereal and Soybean-Based Food and Feed, Soybean - Pest Resistance. In: El-Shemy HA editor. IntechOpen; February 13th 2013. DOI: 10.5772/54470. Available from: https://www.intechopen.com/books/soybean-pest-resistance/mycotoxins-in-cereal-and-soybean-based-food-and-feed

[36] Bucheli TD, Erbs M, Hartmann N, Vogelgsang S, Wettstein FE, Forrer H-R. Estrogenic mycotoxins in the environment. Mitteilungen aus Lebensmitteluntersuchung und Hygiene. 2005;96:386-403

[37] Gromadzka K, Waśkiewicz A, Świetlik J, Bocianowski J, Golinski P. The role of wastewater treatment in reducing pollution of surface waters with zearalenone. Arhiv za Higijenu Rada i Toksikologiju. 2015;66(2):159-164. DOI: 10.1515/aiht-2015-66-2606

[38] Spengler P, Körner W, Metzger J. Substances with estrogenic activity in effluents of sewage treatment plants in southwestern Germany. 1. Chemical analysis. Environmental Toxicology and Chemistry. 2001;20:2133-2141

[39] Nogueira R, Estevinho I, Abrunhosa L, Mendonça C, Machado P, Carballa M, et al. Assessing the degradation of ochratoxin a using a bioassay: The case of contaminated winery wastewater. Water Science and Technology. 2007;56(2):55-61

[40] Pascale M. Detection methods for mycotoxins in cereal grains and cereal products. Zbornik Matice srpske za prirodne nauke. 2009;117:15-25. DOI: 10.2298/ZMSPN0917015P

[41] Mirocha CJ, Abbas HK, Windels CE, Xie W. Variation in deoxynivalenol, 15-acetyldeoxynivalenol, 3-acetyldeoxynivalenol, and zearalenone production by Fusarium graminearum isolates. Applied and Environmental Microbiology. 1989;55(5):1315-1316

[42] Pietsch C, Michel C, Kersten S, Valenta H, Dänicke S, Schulz C, et al. In vivo effects of deoxynivalenol (DON) on innate immune responses of carp (Cyprinus carpio L.). Food and Chemical Toxicology. 2014;68:44-52

[43] Awad WA, Ghareeb K, Böhm J, Razzaazi E, Hellweg P, Zentek J. The impact of the Fusarium toxin deoxynivalenol (DON) on poultry. International Journal of Poultry Science. 2008;7(9):827-842

[44] Vudathala DK, Prelusky DB, Ayroud M, Trenholm HL, Miller JD. Pharmacokinetic fate and pathological effects of 14C-fumonisin B1 in laying hens. Natural Toxins. 1994;2(2):81-88

[45] CONTAM P. (EFSA Panel on Contaminants in the Food Chain). Risks for animal health related to the presence of fumonisins, their modified forms and hidden forms in feed. EFSA Journal. 2018;16(5):5242
[46] Wang E, Ross PF, Wilson TM, Riley RT, Merrill AH. Increases in serum sphingosine and sphinganine and decreases in complex sphingolipids in ponies given feed containing fumonisins, mycotoxins produced by Fusarium moniliforme. The Journal of Nutrition. 1992;122:1706-1716

[47] Goel S, Lenz SD, Lumlertdacha S, Lovell RT, Shelby RA, Li M, et al. Sphingolipid levels in catfish consuming Fusarium moniliforme corn culture material containing fumonisins. Aquatic Toxicology. 1994;30(4):285-294

[48] European Commission. Commission Recommendation 2006/576/EC of 17 August 2006 on the presence of deoxynivalenol, zearalenone, ochratoxin A, T-2 and HT-2 and fumonisins in products intended for animal feeding. Official Journal of the European Union. 2006:L229/7-L229/9

[49] Van Egmond H, Jonker M. Worldwide Regulations for Mycotoxins in Food and Feed in 2003. Vol. 81. Rome, Italy: FAO Food and Nutrition Paper; 2004

[50] Pepeljnjak S, Petrinec Z, Kovacic S, Segvic M. Screening toxicity study in young carp (Cyprinus carpio L.) on feed amended with fumonisin B1. Mycopathologia. 2003;156(2):139-145

[51] Abu-Hassan FMA, Khalil RH, Saad TT, Amer M, Abdel-Latif R. Histopathological outcomes designating the toxicological aspects of Fumonisin B1 on cultured Nile tilapia, Oreochromis niloticus. International Journal of Fisheries and Aquatic Studies. 2016;4(3):52-60

[52] Rodríguez-Cervantes C, Girón-Pérez M, Robledo-Marenco M, Marín S, Velázquez-Fernández J, Medina-Díaz I, et al. Aflatoxin B1 and its toxic effects on immune response of teleost fishes: A review. World Mycotoxin Journal. 2010;3(2):193-199

[53] Kuiper-Goodman T, Scott PM. Risk assessment of the mycotoxin ochratoxin A. Biomedical and Environmental Sciences. 1989;2:179-248

[54] Peckham JC, Doupnik B, Jones OH. Acute toxicity of ochratoxins A and B in chicks. Applied Microbiology. 1971;21:492-494

[55] Fuchs R, Appelgren L-E, Hult K. Distribution of 14C-ochratoxin A in the rainbow trout (Salmo gairdneri). Acta Pharmacologica et Toxicologica. 1986;59:220-221

[56] El-Sayed YS, Khalil RH, Saad TT. Acute toxicity of ochratoxin-A in marine water-reared sea bass (Dicentrarchus labrax L.). Chemosphere. 2009;75(7):878-882

[57] Tschirren L, Siebenmann S, Pietsch C. Toxicity of ochratoxin to early life stages of zebrafish (Danio rerio). Toxins (Basel). 2018;10(7):264

[58] Doster RC, Sinnhuber RO, Pawlowski NE. Acute intraperitoneal toxicity of ochratoxin a and B derivatives in rainbow trout (Salmo gairdneri). Food and Cosmetics Toxicology. 1974;12:499-505

[59] Hagelberg S, Hult K, Fuchs R. Toxicokinetics of ochratoxin A in several species and its plasma-binding properties. Journal of Applied Toxicology. 1989;9(2):91-96

[60] Kokic B, Cabarkapa I, Levic J, Mandic A, Matic J, Ivanov D. Screening of mycotoxins in animal feed from the region of Vojvodina. Matica Srpska Proceedings for Natural Sciences. 2010;117:87-96

[61] European Commission. Commission Recommendation No 2013/165/EU of March 2013 on the presence of T-2 and HT-2 toxin in cereals and cereal products. Official Journal of the European Union. 2013;91:12-15
[62] Ngethe S, Horsberg TE, Ingebrigtsen K. The disposition of $^3$H-aflatoxin B1 in the rainbow trout (Oncorhynchus mykiss) after oral and intravenous administration. Aquaculture. 1992;108(3-4):323-332

[63] El-Enbaawy M, Adel M, Marzouk M, AA S. The effect of acute and chronic aflatoxicosis on the immune functions of Oreochromis niloticus in Egypt. Veterinary Medical Journal-Giza. 1994;42:47-52

[64] Imani A, Salimi Bani M, Noori F, Farzaneh M, Moghanlou KS. The effect of bentonite and yeast cell wall along with cinnamon oil on aflatoxicosis in rainbow trout (Oncorhynchus mykiss): Digestive enzymes, growth indices, nutritional performance and proximate body composition. Aquaculture. 2017;476:160-167

[65] Marí N, Gonçalves-Nunes C, Gomes-Pereira MM, Raposo-Costa AP, Da Rocha-Rosa CA, Pereyra CM, et al. Screening of aflatoxin B1 and mycobiota related to raw materials and finished feed destined for fish. Latin American Journal of Aquatic Research. 2015;43(3):595-600. DOI: 10.3856/vol43-issue3-fulltext-22

[66] Samuel TO, Odunigba O. Aflatoxins associated with storage fungi in fish feeds. IFE Journal of Science. 2015;17(2):519-523

[67] Altug G, Beklevik G. Level of aflatoxin in some fish feeds from fish farming processes, feed factories and imported feeds. Turkish Journal of Veterinary and Animal Sciences. 2003;27:1247-1252

[68] Gonçalves RA. Aflatoxins: A threat to yellow catfish production. World Aquaculture Society. 2016;47(1):56-57

[69] Marijani E, Wainaina JM, Charo-Karisa H, Nzayisenga L, Munguti J, Joselin Benoit Gnonlonfin G, et al. Mycoflora and mycotoxins in finished fish feed and feed ingredients from smallholder farms in East Africa. Egyptian Journal of Aquatic Research. 2017;43:169-176

[70] Ayyat MS, Abd Rahman GA, El-Marakby HI, El-Hakem NAB, Hessan AAA. Toxicity and biochemical hazards induced by exposure of Nile tilapia to aflatoxin and their amelioration. Global Journal of Environmental Sciences and Toxicology. 2014;1:1-19

[71] Ayyat MS, Ayyat AMN, Al-Sagheer AA, El-Hais AEAM. Effect of some safe feed additives on growth performance, blood biochemistry, and bioaccumulation of aflatoxin residues of Nile tilapia fed aflatoxin-B1 contaminated diet. Aquaculture. 2018;495:27-34

[72] Baglodi V, EG J, KM N, PB A. Effect of dietary incorporated aflatoxin (AFB1) on the survival and growth performance of Labeo rohi. Journal of Experimental Zoology, India. 2015;18(2):603-607

[73] Bailey GS, Goeger DE, Hendricks JD. Factors influencing experimental carcinogenesis in laboratory fish models. In: Varanasi U, editor. Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. Boca Raton: CRC Press; 1989. p. 253

[74] Bailey GS, Price RL, Park DL, Hendricks JD. Effect of ammoniation of aflatoxin B1-contaminated cottonseed feedstock on the aflatoxin M1 content of cows’ milk and hepatocarcinogenicity in the trout bioassay. Food and Chemical Toxicology. 1994;32(8):707-715

[75] Bailey GS, Dashwood R, Loveland MP, Pereira C, Hendricks DJ. Molecular dosimetry in fish: Quantitative target organ DNA
adduction and hepatocarcinogenicity for four aflatoxins by two exposure routes in rainbow trout. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis. 1998;399(2):233-244

[76] Bailey GS, Williams DE, Hendricks JD. Fish models for environmental carcinogenesis: The rainbow trout. Environmental Health Perspectives. 1996;104(Suppl 1):5-21

[77] Bastardo H, Sofia S, Nava L, Rangel C. Effects of aflatoxin B1 concentration and exposure time on hepatic condition in the rainbow trout. Interciencia. 2006;31(6):437-440

[78] Bauer DH, Lee DJ, Sinnhuber RO. Acute toxicity of aflatoxins B1 and G1 in the rainbow trout (Salmo gairdneri). Toxicology and Applied Pharmacology. 1969;15(2):415-419

[79] Bedoya-Sernal CM, Michelin E, Massocco M, Carion L, Godoy S, Lima C, et al. Effects of dietary aflatoxin B1 on accumulation and performance in matrinxã fish (Brycon cephalus). PLoS One. 2018;13(8):e0201812

[80] Abd-Allah GA, El-Fayoumi RI, Smith MJ, Heckmann RA, O’Neill KL. A comparative evaluation of aflatoxin B1 genotoxicity in fish models using the comet assay. Mutation Research—Genetic Toxicology and Environmental Mutagenesis. 1999;446(2):181-188

[81] Black JJ, Maccubbin AE, Schiffert M. A reliable, efficient, microinjection apparatus and methodology for the in vivo exposure of rainbow trout and salmon embryos to chemical carcinogens. Journal of the National Cancer Institute. 1985;75(6):1123-1128

[82] Breinholt V, Hendricks J, Pereira C, Arbogast D, Bailey G. Dietary chlorophyllin is a potent inhibitor of aflatoxin B1 hepatocarcinogenesis in rainbow trout. Cancer Research. 1995;55(1):57-62

[83] Cagauan AG, Tayaban RH, Songa JR, Bartolome RM. Effect of aflatoxin-contaminated feeds in Nile tilapia (Oreochromis niloticus L.). In: Abstract of the 6th International Symposium on Tilapia in Aquaculture (ISTA 6) Section: Health Management and Diseases Manila, Philippines; 12-16 September 2014. pp. 172-178

[84] Carpenter HM, Zhang Q, El Zahr C, Selivonchick DP, Brock DE, Curtis LR. In vitro and in vivo temperature modulation of hepatic metabolism and DNA adduction of aflatoxin B1 in rainbow trout. Journal of Biochemical Toxicology. 1995;10(1):1-10

[85] Chávez-Sánchez MC, Martínez Palacios CA, Osorio Moreno I. Pathological effects of feeding young Oreochromis niloticus diets supplemented with different levels of aflatoxin B1. Aquaculture. 1994;127(1):49-60

[86] Curtis LR, Zhang Q, El-Zahr C, Carpenter HM, Miranda CL, Buhler DR, et al. Temperature-modulated incidence of aflatoxin B1-initiated liver cancer in rainbow trout. Toxicological Sciences. 1995;25(1):146-153. DOI: 10.1093/toxsci/25.1.146

[87] Ottinger CA, Kaattari SL. Long-term immune dysfunction in rainbow trout (Oncorhynchus mykiss) exposed as embryos to aflatoxin B1. Fish & Shellfish Immunology. 2000;10(1):101-106

[88] Dashwood RH, Fong AT, Williams DE, Hendricks JD, Bailey GS. Promotion of aflatoxin BI carcinogenesis by the natural tumor modulator indole-3-carbinol: Influence of dose, duration, and intermittent exposure on indole-3-carbinol promotional potency. Cancer Research. 1991;51(9):2362-2365

[89] Deng SX, Tian LX, Liu FJ, Jin SJ, Liang GY, Yang HJ, et al. Toxic effects
and residue of aflatoxin B1 in tilapia (*Oreochromis niloticus × O. aureus*) during long-term dietary exposure. Aquaculture. 2010;307(3-4):233-240

[90] El-Barbary MI. Detoxification and antioxidant effects of garlic and curcumin in *Oreochromis niloticus* injected with aflatoxin B1 with reference to gene expression of glutathione peroxidase (GPx) by RT-PCR. Fish Physiology and Biochemistry. 2016;42(2):617-629. DOI: 10.1007/s10695-015-0164-4

[91] Akter A, Rahman M, Hasan M. Effects of aflatoxin B1 on growth and bioaccumulation in common carp fingerling in Bangladesh. Asia-Pacific Journal of Rural Development. 2010;20(2):1-13

[92] El-Banna R, Teleb H, Hadi MM, Fakhry FM. Performance and tissue residue of tilapias fed dietary aflatoxin. Veterinary Medical Journal Giza. 1992;40(3):17-23

[93] El-Boshy M, El-Ashram A, Abd El-Ghany N. Effect of dietary beta1,3 glucan on immunomodulation of diseased *Oreochromis niloticus* experimentally infected with aflatoxin B1. In: 8th International Symposium on Tilapia in Aquaculture. Cairo, Egypt; 2008. pp. 1109-1127

[94] El-Sayed YS, Khalil RH. Toxicity, biochemical effects and residue of aflatoxin B1 in marine water-reared sea bass (*Dicentrarchus labrax* L.). Food and Chemical Toxicology. 2009;47:1606-1609

[95] Thorgaard GH, Arbogast DN, Hendricks JD, Pereira CB, Bailey GS. Tumor suppression in triploid trout. Aquatic Toxicology. 1999;46(2):121-126

[96] Goeger DE, Shelton DW, Hendricks JD, Pereira C, Bailey GS. Comparative effect of dietary butylated hydroxyanisole and β-naphthoflavone on aflatoxin b1 metabolism, DNA adduct formation, and carcinogenesis in rainbow trout. Carcinogenesis. 1988;9(10):1793-1800

[97] Gonçalves RA, Do Cam T, Tri NN, Santos GA, Encarnação P, Hung LT. Aflatoxin B1 (AFB1) reduces growth performance, physiological response, and disease resistance in Tra catfish (*Pangasius hypophthalmus*). Aquaculture International. 2018;26(3):921-936

[98] Han D, Xie S, Zhu X, Yang Y, Guo Z. Growth and hepatopancreas performances of gibel carp fed diets containing low levels of aflatoxin B1. Aquaculture Nutrition. 2010;16(4):335-342

[99] Hatanaka J, Doke N, Harada T, Aikawa T, Enomoto M. Usefulness and rapidity of screening for the toxicity and carcinogenicity of chemicals in medaka *Oryzias latipes*. The Japanese Journal of Experimental Medicine. 1982;52:243-253

[100] Hegazi S, El-Sabagh M, El-Keiedy A, Zein El-Dein A. Aflatoxin in feed and its effect on fish health. Kafr El-Sheikh Veterinary Medical Journal. 2013;11(2):317-329

[101] Hendricks JD, Wales JH, Sinnhuber RO, Nixon JE, Loveland PM, Scanlan RA. Rainbow trout (*Salmo gairdneri*) embryos: A sensitive animal model for experimental carcinogenesis. Federation Proceedings. 1980;39(14):3222-3229

[102] Farabi SMV, Youssefian M, Hajimoradloo A. Aflatoxicosis in juvenile *Huso huso* fed a contaminated diet. Journal of Applied Ichthyology. 2006;22(S1):234-237

[103] Hendricks JD, Arbogast DN, Pereira CB, Bailey GS. Long-term, high-dose dietary exposure of rainbow trout to butylated hydroxyanisole in non-carcinogenic. Cancer Letters. 1994;78(1-3, 193):189
[104] Huang Y, Han D, Zhu X, Yang Y, Jin J, Chen Y, et al. Response and recovery of gibel carp from subchronic oral administration of aflatoxin B₁. Aquaculture. 2011;319(1-2):89-97

[105] Hussain D, Mateen A. Alleviation of aflatoxin-B₁ toxicity by using clay adsorbent in nila tilapia (Oreochromis niloticus) diets. Pakistan Journal of Zoology. 2017;49(2):425-431

[106] Hussein S, Mekkawy I, Moktar Z, Mubarak M. Protective effect of Nigella sativa seed against aflatoxicosis in Oreochromis niloticus. In: Mycotoxin Conference Mycotoxins & Environ. Poland Bydgoszcz. 2000. Vol. 25-27. pp. 109-130

[107] Hussain M, Gabal MA, Wilson T, Summerfelt RC. Effect of aflatoxin-contaminated feed on morbidity and residues in walleye fish. Veterinary and Human Toxicology. 1993;35(5):396-398

[108] Jantrarotai W, Lovell RT, Grizzle JM. Acute toxicity of aflatoxin B₁ to channel catfish. Journal of Aquatic Animal Health. 1990;2(4):237-247

[109] Jantrarotai W, Lovell RT. Subchronic toxicity of dietary aflatoxin B₁ to channel catfish. Journal of Aquatic Animal Health. 1990;2(4):248-254

[110] Lim HA, Ng WK, Lim SL, Ibrahim CO. Contamination of palm kernel meal with Aspergillus flavus affects its nutritive value in pelleted feed for tilapia, Oreochromis mossambicus. Aquaculture Research. 2001;32(11):895-905

[111] Madhusudhanan N, KavithaLakshmi SN, Shanmugasundaram KR, Shanmugasundaram E. Oxidative damage to lipids and proteins induced by aflatoxin B-1 in fish (Labeo rohita)-protective role of Amrita Bindu. Environmental Toxicology and Pharmacology. 2004;17(2):73-77

[112] Mahfouz ME. Ameliorative effect of curcumin on aflatoxin B₁-induced changes in liver gene expression of Oreochromis niloticus. Molecular Biology. 2015;49(2):275-286

[113] Al Faragi JK. The efficacy of prebiotic (β-glucan) as a feed additive against toxicity of aflatoxin B₁ in common carp, Cyprinus carpio L. Journal of Aquaculture Research and Development. 2014;5(4):1000240-1000246

[114] Mahfouz ME, Sherif AH. A multiparameter investigation into adverse effects of aflatoxin on Oreochromis niloticus health status. Journal of Basic and Applied Zoology. 2015;71:48-59

[115] Magouz F, Eweedah N, Salem M, AA A. Detoxification of aflatoxin contaminated ration by chemical, biological and spices methods in Nile tilapia (Oreochromis niloticus) diets. Journal of Agricultural Research. Kafr El-Shaikh University. 2016;42(4):102-119

[116] Marijani E, Nasimolo J, Kigadye E, Gnonlonfin GJB, Okoth S. Sex-related differences in hematological parameters and organosomatic indices of Oreochromis niloticus exposed to aflatoxin B₁ diet. Scientifica (Cairo). 2017 Article ID 4268926, 7 pages

[117] Mohapatra S, Sahu NP, Pal AK, Prusty AK, Kumar V, Kumar S. Haemato-immunology and histomorphological changes in Labeo rohita fingerlings: Effect of dietary aflatoxin and mould inhibitor. Fish Physiology and Biochemistry. 2011;37(1):177-186

[118] Shelton DW, Goeger DE, Hendricks JD, Bailey GS. Mechanisms of anti-carcinogenesis: The distribution and metabolism of aflatoxin B₁ in rainbow trout fed aroclor 1254. Carcinogenesis. 1986;7(7):1065-1071
Mycotoxins and Food Safety

[119] Shahafve S, Banaee M, Haghi B, Mohseni M. Histopathological study of common carp (Cyprinus carpio) fed aflatoxin-contaminated diets. International Journal of Aquatic Biology. 2017;5(2):63-70

[120] Sepahdari A, Ebrahimzadeh Mosavi HA, Sharifpour I, Khosravi A, Motallebi AA, Mohseni M, et al. Effects of different dietary levels of AFB1 on survival rate and growth factors of Beluga (Huso huso). Iranian Journal of Fisheries Sciences. 2010;9(1):141-150

[121] Selim KM, El-hofy H, Khalil RH. The efficacy of three mycotoxin adsorbents to alleviate aflatoxin B1-induced toxicity in Oreochromis niloticus. Aquaculture International. 2014;22(2):523-540

[122] Schoenhard G, Hendricks J, Nixon J, Lee D, Wales J, Sinnhuber R, et al. Aflatoxicol-induced hepatocellular carcinoma in rainbow trout (Salmo gairdneri) and the synergistic effects of cycloprophenoid fatty acids. Cancer Research. 1981;3:1011-1014

[123] Sato S, Matsushima T, Tanaka N, Sugimura T, Takashima F. Hepatic tumors in the guppy (Lebistes reticulatus) induced by aflatoxin B1, dimethylnitrosamine, and 2-acetylaminofluorene. Journal of the National Cancer Institute. 1973;50(3):767-778. DOI: 10.1093/jnci/50.3.767

[124] Andleeb S, Ashraf M, Hafeez-Ur-Rehman M, Jabbar MA, Abbas F, Younus M. Effect of aflatoxin B1-contaminated feed on growth and vital organs of advance fry of Catla catla. Journal of Animal and Plant Sciences. 2015;25(3):816-825

[125] Sahoo P, Mukherjee S, Jain A, Mukherjee A. Histopathological and electron microscopic studies of gills and opisthophospheres of rohu, Labeo rohita to acute and subchronic aflatoxin B1 toxicity. Asian Fisheries Science. 2003;16:257-268

[126] Sahoo PK, Mukherjee SC. Immunosuppressive effects of aflatoxin B1 in Indian major carp (Labeo rohita). Comparative Immunology, Microbiology and Infectious Diseases. 2001;24(3):143-149

[127] Sahoo PK, Mukherjee SC. The effect of dietary immunomodulation upon Edwardsiella tarda vaccination in healthy and immunocompromised Indian major carp (Labeo rohita). Fish & Shellfish Immunology. 2002;12(1):1-16

[128] Sahoo PK, Mukherjee SC. Immunomodulation by dietary vitamin C in healthy and aflatoxin B1-induced immunocompromised rohu (Labeo rohita). Comparative Immunology, Microbiology and Infectious Diseases. 2003;26(1):65-76

[129] Royes J-AB, Yanong RPE. Molds in fish feeds and aflatoxicosis. In: Fact Sheet FA-95 [Internet]. 2002. Available from: http://edis.ifas.ufl.edu

[130] Shelton D, Hendricks J, Coulombe R, Bailey G. Effect of dose on the inhibition of carcinogenesis/mutagenesis by Aroclor 1254 in rainbow trout fed aflatoxin B1. Journal of Toxicology and Environmental Health. 1984;13:649-657

[131] Sinnhuber R, Wales J, Ayres J, Engebrecth R, DL A. Dietary factors and hepatoma in rainbow trout (Salmo gairdneri). 1. Aflatoxins in vegetable protein feedstuffs. Journal of the National Cancer Institute. 1968;41:711-718

[132] Spring P, Fegan DF. Mycotoxins—A rising threat to aquaculture. Nutritional biotechnology in the feed and food industries. In: Proceedings of Alltech’s 21st Annual Symposium, Lexington, Kentucky, USA, 22-25 May 2005. pp. 323-331
[133] Weigt S, Huebler N, Strecker R, Braunbeck T, Broschard TH. Zebrafish (Danio rerio) embryos as a model for testing proteratogens. Toxicology. 2011;281(1-3):25-36. DOI: 10.1016/j.tox.2011.01.004

[134] Svobodova Z, Piskac A, Havlikova J, Groch L. Influence of feed with different contents of B1 aflatoxin on the carp health condition. Zivocisna Vyroba–UVTIZ. 1982;27(11):811-820

[135] Arana S, Tabata YA, Sabino M, Rigolino MG, Hernandez-Blazquez FJ. Differential effect of chronic aflatoxin B1 intoxication on the growth performance and incidence of hepatic lesions in triploid and diploid rainbow trout (Oncorhynchus mykiss). Archivos de Medicina Veterinaria. 2002;XXXIV(2):253-263

[136] Svobodova Z, Piskac A. Effect of feeds with a low content of aflatoxin B1 on the health of carp Cyprinus carpio. Zivocisna Vyroba–UVTIZ. 1980;25(11):809-814

[137] Tilton SC, Gerwick LG, Hendricks JD, Rosato CS, Corley-Smith G, Givan SA, et al. Use of a rainbow trout oligonucleotide microarray to determine transcriptional patterns in aflatoxin B1-induced hepatocellular carcinoma compared to adjacent liver. Toxicological Sciences. 2005;88(2):319-330

[138] Troxel CM, Reddy AP, O’Neal PE, Hendricks JD, Bailey GS. In vivo aflatoxin B1 metabolism and hepatic DNA adduction in zebrafish (Danio rerio). Toxicology and Applied Pharmacology. 1997;143(1):213-220

[139] Varior S, Philip B. Aflatoxin B1 induced alterations in the stability of the lysosomal membrane in Oreochromis mossambicus (Peters, 1852). Aquaculture Research. 2012;43(8):1170-1175

[140] Wang X. Response of yellow catfish (Pelteobagrus fulvidraco) to different dietary concentrations of aflatoxin B1 and evaluation of an aflatoxin binder in offsetting its negative effects. Ciencias Marinas. 2016;42(1):15-29

[141] Zhang Q, Suorsa-Super K, Curtis LR. Temperature-modulated aflatoxin B1 hepatic disposition and formation and persistence of DNA adducts in rainbow trout. Toxicology and Applied Pharmacology. 1992;113(2):253-259

[142] Zychowski KE, Rodrigues Hoffmann A, Ly HJ, Pohlenz C, Buentello A, Romoser A, et al. The effect of aflatoxin-B1 on red drum (Sciaenops ocellatus) and assessment of dietary supplementation of NovaSil for the prevention of aflatoxicosis. Toxins (Basel). 2013;5(9):1555-1573. DOI: 10.3390/toxins5091555

[143] Zychowski KE, Pohlenz C, Mays T, Romoser A, Hume M, Buentello A, et al. The effect of NovaSil dietary supplementation on the growth and health performance of Nile tilapia (Oreochromis niloticus) fed aflatoxin-B1 contaminated feed. Aquaculture. 2013;376-379:117-123

[144] Zhou H, George S, Li C, Gurusamy S, Sun X, Gong Z, et al. Combined toxicity of prevalent mycotoxins studied in fish cell line and zebrafish larvae revealed that type of interactions is dose-dependent. Aquatic Toxicology. 2017;193:60-71

[145] Lopes PRS, Pouey JLOF, Enke DBS, Mallmann CA, Kich HA, Soquetta MB. Utilização de adsorvente em rações contendo aflatoxina para alevinos de jundiá Use of adsorbent in diets containing aflatoxin for silver catfish fingerlings. Revista Brasileira de Zoologia. 2009;38(4):589-595

[146] Ayres JL, Lee DJ, Wales JH, Sinnhuber RO. Aflatoxin structure and hepatocarcinogenicity in rainbow trout (Salmo gairdneri). Journal
of the National Cancer Institute. 1971;46(3):561-564. DOI: 10.1093/jnci/46.3.561

[147] Kövesi B, Pelyhe C, Zándoki E, Mézes M, Balogh K. Changes of lipid peroxidation and glutathione redox system, and expression of glutathione peroxidase regulatory genes as effect of short-term aflatoxin B1 exposure in common carp. Toxicon. 2018;144:103-108

[148] Sherif A, Abdel-Maksoud AS, Mustafa S. Study on toxicity of Oreochromis niloticus with aflatoxin B1. Egyptian Journal of Aquatic Biology and Fisheries. 2013;17:107-119. DOI: 10.12816/0011065

[149] Ayyat MS, Rhman GAA, El-Marakby HI, Hessein AAA. Aflatoxin B1 toxicity and its reduction by using coumarin and vitamin E in Nile tilapia. Zagazig Journal of Agricultural Research. 2017;41(1):20

[150] Haq M, Gonzalez N, Mintz K, Jaja-Chimmedza A, De Jesus CL, Lydon C, et al. Teratogenicity of ochratoxin a and the degradation product, ochratoxin α, in the zebrafish (Danio rerio) embryo model of vertebrate development. Toxins (Basel). 2016;8(2):40. DOI: 10.3390/toxins8020040

[151] Manning BB, Ulloa RM, Li MH, Robinson EH, Rottinghaus GE. Ochratoxin A fed to channel catfish (Ictalurus punctatus) causes reduced growth and lesions of hepatopancreatic tissue. Aquaculture. 2003;219(1-4):739-750

[152] Zahan E, Manning B, Seo JK, Noga EJ. The effect of Ochratoxin A on antimicrobial polypeptide expression and resistance to water mold infection in channel catfish (Ictalurus punctatus). Fish & Shellfish Immunology. 2016;57:60-67

[153] Gbore FA, Adewole AM, Oginni O, Oguntolu MF, Bada AM, Akele O. Growth performance, haematology and serum biochemistry of African catfish (Clarias gariepinus) fingerlings fed graded levels of dietary fumonisin B1. Mycotoxin Research. 2010;26(4):221-227

[154] Kovačić S, Pepeljnjak S, Petrinec Z, Klarić MŠ. Fumonisin B1 neurotoxicity in young carp (Cyprinus carpio L.). Archives of Industrial Hygiene and Toxicology. 2009;60(4):419-426

[155] Li MH, Raverty SA, Robinson EH. Effects of dietary mycotoxins produced by the mold Fusarium moniliforme on channel catfish Ictalurus punctatus. Journal of the World Aquaculture Society. 1994;25(4):512-516

[156] Yildirim M, Lim C, Wan PJ, Klesius PH. Growth performance and immune response of channel catfish (Ictalurus puctatus) fed diets containing graded levels of gossypol-acetic acid. Aquaculture. 2003;219(1-4):751-768

[157] Cirra Scaff RM, Scussel VM. Ultra-structural and histochemical analysis of channel catfish (Ictalurus punctatus) liver treated with fumonisin B1. Brazilian Archives of Biology and Technology. 2008;51(2):333-344. DOI: 10.1590/S1516-89132008000200013

[158] Claudino-Silva SC, Lala B, Mora NHAP, Schamber CR, Nascimento CS, Pereira VV, et al. Challenge with fumonisins B1 and B2 changes IGF-1 and GHR mRNA expression in liver of Nile tilapia fingerlings. World Mycotoxin Journal. 2018;11(2):237-245

[159] Adeyemo BT, Tamiyu LO, Ayuba VO. Serum biochemistry and lipids profiling in experimental dietary exposure of Heterobranchus longifilis catfish juveniles to graded concentrations of fumonisin B1. International Journal of Aquaculture. 2017;7(5):31-41. DOI: 10.5376/ija.2017.07.0005
[160] Carrera García E. Effects of fumonisin B1 on performance of juvenile Baltic salmon (Salmo salar) [thesis]. Finland: Master of Science in Sustainable Management of Inland Aquatic Resources; 2013. DOI: 10.13140/RG.2.1

[161] McKean C, Tang L, Tang M, Billam M, Wang Z, Theodorakis CW, et al. Comparative acute and combinative toxicity of aflatoxin B1 and fumonisin B1 in animals and human cells. Food and Chemical Toxicology. 2006;44:868-876

[162] Tuan NA, Manning BB, Lovell RT, Rottinghaus GE. Responses of Nile tilapia (Oreochromis niloticus) fed diets containing different concentrations of moniliformin or fumonisin B1. Aquaculture. 2003;217:515-528

[163] Petrinec Z, Pepeljnjak S, Kovacic S, Krznaric A. Fumonisin B1 causes multiple lesions in common carp (Cyprinus carpio). Deutsche Tierärztliche Wochenschrift. 2004;111:358-363

[164] Lumlertdacha S, Lovell RT. Fumonisin-contaminated dietary corn reduced survival and antibody production by channel catfish challenged with Edwardsiella ictaluri. Journal of Aquatic Animal Health. 1995;7(1):1-8

[165] Lumlertdacha S, Lovell RT, Shelby RA, Lenz SD, Kemppainen BW. Growth, hematology, and histopathology of channel catfish, Ictalurus punctatus, fed toxins from Fusarium moniliforme. Aquaculture. 1995;130:201-218

[166] Bernhoft A, Høgåsen HR, Rosenlund G, Ivanova L, Berntsson MHG, Alexander J, et al. Tissue distribution and elimination of deoxynivalenol and ochratoxin A in dietary-exposed Atlantic salmon (Salmo salar). Food Additives & Contaminants: Part A: Chemistry, Analysis, Control, Exposure & Risk Assessment. 2017;34(7):1211-1224

[167] Woodward B, Young LG, Lun AK. Vomitoxin in diets for rainbow trout (Salmo gairdneri). Aquaculture. 1983;35:93-101

[168] Döll S, Valenta H, Baardsen G, Möller P, Koppe W, Stubhaug I, et al. Effects of increasing concentrations of deoxynivalenol, zearalenone and ochratoxin A in diets for Atlantic salmon (Salmo salar) on performance, health and toxin residues. In: Proceedings of 33rd Mycotoxin Workshop. Freising, Germany: Society for Mycotoxin Research; 2011

[169] Gonçalves RA, Navarro-Guillén C, Gilannejad N, Dias J, Schatzmayr D, Bichl G, et al. Impact of deoxynivalenol on rainbow trout: Growth performance, digestibility, key gene expression regulation and metabolism. Aquaculture. 2018;490:362-372

[170] Manning BB, Abbas HK, Wise DJ, Greenway T. The effect of feeding diets containing deoxynivalenol contaminated corn on channel catfish (Ictalurus punctatus) challenged with Edwardsiella ictaluri. Aquaculture Research. 2013;45(11):1782-1786

[171] Matejova I, Vicenova M, Vojtek L, Kudlackova H, Nedbalcova K, Faldyna M, et al. Effect of the mycotoxin deoxynivalenol on the immune responses of rainbow trout (Oncorhynchus mykiss). Veterinarni Medicina. 2015;60(9):515-521

[172] Ryerse IA, Hooft JM, Bureau DP, Hayes MA, Lumsden JS. Purified deoxynivalenol or feed restriction reduces mortality in rainbow trout, Oncorhynchus mykiss (Walbaum), with experimental bacterial Coldwater disease but biologically relevant concentrations of deoxynivalenol do not impair the growth of Flavobacter.
Mycotoxins and Food Safety

[173] Ryerse IA, Hooft JM, Bureau DP, Anthony Hayes M, Lumsden JS. Diets containing corn naturally contaminated with deoxynivalenol reduces the susceptibility of rainbow trout (Oncorhynchus mykiss) to experimental Flavobacterium psychrophilum infection. Aquaculture Research. 2016;47(3):787-796

[174] Sanden M, Jørgensen S, Hemre GI, Ørnsrud R, Sissener NH. Zebrafish (Danio rerio) as a model for investigating dietary toxic effects of deoxynivalenol contamination in aquaculture feeds. Food and Chemical Toxicology. 2012;50(12):4441-4448

[175] Šišperová E, Modrá H, Ziková A, Kloas W, Blahová J, Matejová I, et al. The effect of mycotoxin deoxynivalenol (DON) on the oxidative stress markers in rainbow trout (Oncorhynchus mykiss, Walbaum 1792). Journal of Applied Ichthyology. 2015;31(5):855-861

[176] Pietsch C, Junge R. Physiological responses of carp (Cyprinus carpio L.) to dietary exposure to zearalenone (ZEN). Comparative Biochemistry and Physiology—Part C: Toxicology & Pharmacology. 2016;188:52-59

[177] Pietsch C. Zearalenone (ZEN) and its influence on regulation of gene expression in carp (Cyprinus carpio L.) liver tissue. Toxins (Basel). 2017;9:283-300

[178] Arukwe A, Grotmol T, Haugen TB, Knudsen FR, Goksøyr A. Fish model for assessing the in vivo estrogenic potency of the mycotoxin zearalenone and its metabolites. Science of the Total Environment. 1999;236(1-3):153-161

[179] Bakos K, Kovács R, Staszny Á, Sipos DK, Urbányi B, Müller F, et al. Developmental toxicity and estrogenic potency of zearalenone in zebrafish (Danio rerio). Aquatic Toxicology. 2013;136-137:13-21

[180] Chen H, Hu J, Yang J, Wang Y, Xu H, Jiang Q, et al. Generation of a fluorescent transgenic zebrafish for detection of environmental estrogens. Aquatic Toxicology. 2010;96(1):53-61

[181] Johns SM, Denslow ND, Kane MD, Watanabe KH, Orlando EF, Sepúlveda MS. Effects of estrogens and antiestrogens on gene expression of fathead minnow (Pimephales promelas) early life stages. Environmental Toxicology. 2011;26(2):195-206

[182] Schwartz P, Thorpe KL, Bucheli TD, Wettstein FE, Burkhardt-Holm P. Short-term exposure to the environmentally relevant estrogenic mycotoxin zearalenone impairs reproduction in fish. Science of the Total Environment. 2010;409(2):326-333

[183] Woźni M, Brzuzan P, Gusiatin M, Jakimiuk E, Dobosz S, Kuźmiński H. Influence of zearalenone on selected biochemical parameters in juvenile rainbow trout (Oncorhynchus mykiss). Polish Journal of Veterinary Sciences. 2012;15(2):221-225

[184] Woźni M, Obremski K, Jakimiuk E, Gusiatin M, Brzuzan P. Zearalenone contamination in rainbow trout farms in North-Eastern Poland. Aquaculture. 2013;416-417:209-211

[185] Yuan G, Wang Y, Yuan X, Zhang T, Zhao J, Huang L, et al. T-2 toxin induces developmental toxicity and apoptosis in zebrafish embryos. Journal of Environmental Sciences (China). 2014;26(4):917-925

[186] Balogh K, Heincinger M, Fodor J, Mézes M. Effect of long term feeding of T-2 and HT-2 toxin contaminated diet on the glutathione redox status and lipid peroxidation processes in
common carp (*Cyprinus carpio* L.). Acta Biologica Szegediensis. 2009;53

[187] Pelyhe C, Kövesi B, Zándoki E, Kovács B, Szabó-Fodor J, Mézes M, et al. Effect of 4-week feeding of deoxynivalenol- or T-2-toxin-contaminated diet on lipid peroxidation and glutathione redox system in the hepatopancreas of common carp (*Cyprinus carpio* L.). Mycotoxin Research. 2016;32(2):77-83. DOI: 10.1007/s12550-016-0242-1

[188] Pelyhe C, Kövesi B, Zándoki E, Kovács B, Szabó-Fodor J, Mézes M, et al. Short-term effects of T-2 toxin or deoxynivalenol on lipid peroxidation and the glutathione system in common carp. Acta Veterinaria Hungarica. 2016;64(4):449-466

[189] Matejova I, Faldyna M, Modra H, Blahova J, Palikova M, Markova Z, et al. Effect of T-2 toxin-contaminated diet on common carp (*Cyprinus carpio* L.). Fish and Shellfish Immunology. 2017;60:458-465

[190] Kravchenko L, Galash V, Avrenova L, Kranauskas A. On the sensitivity of carp, *Cyprinus carpio*, to mycotoxin T-2. Journal of Ichthyology. 1989;29:156-160

[191] Modra H, Sisperova E, Blahova J, Enevova V, Fictum P, Franc A, et al. Elevated concentrations of T-2 toxin cause oxidative stress in the rainbow trout (*Oncorhynchus mykiss*). Aquaculture Nutrition. 2018;24(2):842-849

[192] Marasas WFO, Bamberg JR, Smalley EB, Strong FM, Ragland WL, Degurse PE. Toxic effects on trout, rats, and mice of T-2 toxin produced by the fungus *Fusarium tricinctum* (Cd.) Snyd. et Hans. Toxicology and Applied Pharmacology. 1969;15(2):471-482

[193] Manning BB, Li MH, Robinson EH, Gaunt PS, Camus AC, Rottinghaus GE. Response of channel catfish to diets containing T-2 toxin. Journal of Aquatic Animal Health. 2003;15(3):229-238

[194] Gonçalves R, Tarasco M, Schatzmayer D, Gavaia P. Preliminary evaluation of moniliformin as a potential threat for teleosts. Fishes. 2018;3(1):4. DOI: 10.3390/fishes3010004

[195] Yildirim M, Manning BB, Lovell RT, Grizzle JM, Rottinghaus GE. Toxicity of moniliformin and fumonisin B₁ fed singly and in combination in diets for young channel catfish *Ictalurus punctatus*. Journal of the World Aquaculture Society. 2010;31(4):599-608

[196] Devreese M, De Baere S, De Backer P, Croubels S. Quantitative determination of the Fusarium mycotoxins beauvericin, enniatin A, A₁, B and B₁ in pig plasma using high performance liquid chromatography-tandem mass spectrometry. Talanta. 2013;106:212-219. DOI: 10.1016/j.talanta.2012.11.068

[197] Meca G, Ritieni A, Mañes J. Influence of the heat treatment on the degradation of the minor Fusarium mycotoxin beauvericin. Food Control. 2012;28(1):13-18

[198] Hu L, Koehler P, Rychlik M. Effect of sourdough processing and baking on the content of enniatins and beauvericin in wheat and rye bread. European Food Research and Technology. 2014;238(4):581-587

[199] Tolosa J, Font G, Mañes J. Mitigation of enniatins in edible fish tissues by thermal processes and identification of degradation products. Food and Chemical Toxicology. 2017;101:67-74

[200] Joint FAO/WHO Expert Committee on Food Additives (JECFA). Safety evaluation of certain mycotoxins in food. WHO Food Addit. 2001;Ser. 47
[201] European Committee Scientific Committee on Food. Opinion on Fusarium toxins. Part 6: Group evaluation of T-2 toxin, HT-2 toxin, nivalenol and deoxynivalenol. Eur Comm. 2002;1-12

[202] Carballo D, Moltó JC, Berrada H, Ferrer E. Presence of mycotoxins in ready-to-eat food and subsequent risk assessment. Food and Chemical Toxicology. 2018;121:558-565

[203] Larsson P, Ngethe S, Ingebrigtsen K, Tjälve H. Extrahepatic disposition of 3H-aflatoxin B1 in the rainbow trout (Oncorhyncus mykiss). Pharmacology & Toxicology. 1992;71(4):262-271

[204] Michelin EC, Massocco MM, Godoy SHS, Baldin JC, Yasui GS, Lima CG, et al. Carryover of aflatoxins from feed to Lambari fish (Astyanax altiparanae) tissues. Food Additives & Contaminants: Part A: Chemistry, Analysis, Control, Exposure & Risk Assessment. 2017;34(2):265-272

[205] Huong BTM, Tuyen LD, Tuan DH, Brimer L, Dalsgaard A. Dietary exposure to aflatoxin B1, ochratoxin A and fumonisins of adults in Lao Cai province, Viet Nam: A total dietary study approach. Food and Chemical Toxicology. 2016;98(Pt B):127-133. DOI: 10.1016/j.fct.2016.10.012

[206] Caldas ED, Jardim ANO. Exposure to toxic chemicals in the diet: Is the brazilian population at risk. Journal of Exposure Science and Environmental Epidemiology. 2012;22(1):1-15. DOI: 10.1038/jes.2011.35

[207] Wiśniewska-Dmytrow H, Zmudzki J, Burek O, Pietsch C, Kersten S, Valenta H, Dänicke S, Schulz C, Burkhardt-Holm P, et al. Effects of dietary exposure to zearalenone (ZEN) on carp (Cyprinus carpio L.). Toxins (Basel). 2015;7(9):3465-3480

[208] Guardone L, Tinacci L, Luci G, Meucci V, Intorre L, Armani A. Determination of ochratoxin A in European seabass and gilthead seabream in Italy. In: Poster by the European College of Veterinary Public Health. 2018. DOI: 10.13140/RG.2.2.31611.77604

[209] Reddy L, Bhoola K. Ochratoxins-food contaminants: Impact on human health. Toxins. 2010;2(4):771-779

[210] Duarte SC, Lino CM, Pena A. Food safety implications of ochratoxin A in animal-derived food products. Veterinary Journal. 2012;192:286-292

[211] Duarte SC, Lino CM, Pena A. Ochratoxin A in feed of food-producing animals: An undesirable mycotoxin with health and performance effects. Veterinary Microbiology. 2011;154(1-2):1-13

[212] Duarte SC, Pena A, Lino CM. A review on ochratoxin A occurrence and effects of processing of cereal and cereal derived food products. Food Microbiology. 2010;27:187-198

[213] Moss MO. Risk assessment for aflatoxins in foodstuffs. International Biodeterioration and Biodegradation. 2002;50(3-4):137-142

[214] Pietsch C, Kersten S, Valenta H, Dänicke S, Schulz C, Burkhardt-Holm P, et al. Effects of dietary exposure to zearalenone (ZEN) on carp (Cyprinus carpio L.). Toxins (Basel). 2015;7(9):3465-3480

[215] Woźny M, Dobosz S, Obremski K, Hliwa P, Gomulka P, Łakomiak A, et al. Feed-borne exposure to zearalenone leads to advanced ovarian development and limited histopathological changes in the liver of premarket size rainbow trout. Aquaculture. 2015;448:71-81

[216] Nácher-Mestre J, Serrano R, Beltrán E, Pérez-Sánchez J, Silva J, Karalazos V, et al. Occurrence and potential transfer of mycotoxins in gilthead sea bream and Atlantic salmon by
use of novel alternative feed ingredients. Chemosphere. 2015;128:314-320

[217] Dinleyici M, Aydemir O, Yildirim GK, Kaya TB, Carman KB. Human mature milk zearalenone and deoxynivalenol levels in Turkey. Neuroendocrinology Letters. 2018;39(4):325-330

[218] Raad F, Nasreddine L, Hilan C, Bartosik M, Parent-Massin D. Dietary exposure to aflatoxins, ochratoxin A and deoxynivalenol from a total diet study in an adult urban lebanese population. Food and Chemical Toxicology. 2014;73:35-43

[219] Tolosa J, Barba FJ, Font G, Ferrer E. Mycotoxin incidence in some fish products: QuEChERS methodology and liquid chromatography linear ion trap tandem mass spectrometry approach. Molecules. 2019;24:527. DOI: 10.3390/molecules24030527

[220] Ahmed AM, Ismail SA, Abd-El-Rahman HAE. Quantitative, qualitative and toxigenic evaluations of xerophilic mold in traditional Egyptian salted fish, Molouha. Journal of Food Safety. 2005;25(1):9-18

[221] Edema MO, Agbon AO. Significance of fungi associated with smoke-cured Ethmalosa fimbriata and Clarias gariepinus. Journal of Food Processing & Preservation. 2010;34(S1):355-363

[222] Orony DNA, Laloh JO, Jondiko IO. Determination of carcinogenic polycyclic aromatic hydrocarbons (PAHs), aflatoxins, and nitrosamines in processed fish from the Winam Gulf area of Kenya and estimated potential exposure in human. Polycyclic Aromatic Compounds. 2016;36:295-317

[223] Akinyemi AA, Adejola AQ, Obasa SO, Ezeri GNO. Aflatoxins in smoked-dried fish sold in Abeokuta, Ogun State, South-west Nigeria. COLERM Proceedings. 2012;2:478-487

[224] Olajuyigbe OO, Akande GR, Ezekiel CN, Ezekiel MO. Aflatoxigenic moulds and aflatoxin contamination of retailed fishery products in Lagos markets. Mycotoxicology Society of Nigeria Mycotoxicology. 2014;1:57-63

[225] Adebayo-Tayo BC, Onilude AA, Patrick UG. Mycofloral of smoke-dried fishes sold in Uyo, Eastern Nigeria. World Journal of Agricultural Sciences. 2008;4:23

[226] Job M, Agina S, Dapiya H. Occurrence of aflatoxigenic fungi in smoke-dried fish sold in Jos Metropolis. British Microbiology Research Journal. 2015;11(1):1-7. Article no. BMRJ. 21465

[227] Farag HEM, El-Taiby AA, Hassan HM. Assessment of ochratoxin A and aflatoxin B, levels in the smoked fish with special reference to the moisture and sodium chloride content. Research Journal of Microbiology. 2012;6(12):813-825

[228] Sun W, Han Z, Aerts J, Nie D, Jin M, Shi W, et al. A reliable liquid chromatography–tandem mass spectrometry method for simultaneous determination of multiple mycotoxins in fresh fish and dried seafoods. Journal of Chromatography. A. 2015;1387:42-48