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# Aflatoxin Reduction Mechanism of Probiotics

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## Abstract

Mycotoxins are secondary metabolites produced by various toxigenic fungi such as *Aspergillus*, *Fusarium,* and *Penicillium*. They have mutagenic, teratogenic, carcinogenic effects for both humans and animals. Among the different mycotoxins, aflatoxins (AFs) are the most potent and primarily produced by *Aspergillus flavus and Aspergillus parasitic* in agricultural food stuffs like peanuts, maize grains, cereals, and animal feed. The most occurrence and stability to physical and chemical factors of these mycotoxins during food and feed processing pose serious health problems in humans and animals. Therefore, to overcome this problem using the biological detoxification method is the best way**.** This review aims to explore the use of biological methods to control aflatoxins contamination and their reduction mechanisms. Probiotics are one of the biological control methods of mycotoxin and which are regulated as dietary supplements and food consisting of yeast or bacteria. Probiotics can reduce aflatoxins' bioavailability and their absorption in the gut. The action of microorganisms on mycotoxins and their mechanism of action has based on competition for nutrients with entering pathogens, interactions, the competitive exclusion for adhesion sites (barrier function of the intestinal epithelium), by binding with the cell wall of the bacteria, and by changing its toxicity to non-toxic substances. Aflatoxin reduction potentials of probiotic bacteria are different depending on the type of the bacteria, the concentrations of the bacteria, and pH conditions. It is important to study the chemical interactions between the cell wall of probiotic bacteria, and its related components with aflatoxin that could be satisfied to provide further justification of probiotics as adsorbent of aflatoxin. The best way to prevent the aflatoxin prevalence in agricultural products are making suitable conditions of harvesting and storage but if that could be impossible, it is better to eat fermented foods (yogurt or dairy drinks) or taking probiotics which are available as capsules, tablets, or powders to reduce the effect of toxicity.

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## Keywords

Aflatoxin; Probiotics;Mycotoxin; Intestinal Epithelium.

## Introduction

A huge amount of the world's food and feed production are spoiled due to the contamination by several food borne microorganisms (Atehnkeng *et al.*, 2016). One of the major causes that spoil food and that bring unhealthy system for the human being is a fungus. Molds play a major role in the spoilage of food products since it is estimated that 5 to 10% of the world food's production is lost due to fungal contamination (Pitt and Hocking, 2009). The growth and survival of these fungi cause losses in dry matter, quality, and economic value of the stored food and feed products (Amaike and Keller, 2011; Roze *et al.*, 2013). When the fungus grows on a food product, it might produce a toxic substance called mycotoxins, which are harmful to human and animal

health (Taye *et al.*, 2013). As a result, reducing or eliminating either fungus or toxic substances is a critical issue, besides reducing the health problem aspect, it will also help the world to reduce food loss and food insecurity.

There are many biological toxins present in the natural environment, which is dangerous for human and animal health. But mycotoxins are currently considered to be among the most dangerous ones, which can cause various diseases leading to death in animals and humans. It is a secondary metabolite of fungal origin, and some species of filamentous fungi, mainly belonging to the genera *Aspergillus, Penicillium, and Fusarium*(Ostry *et al.*, 2017).

## Mycotoxins

Climate change in the world as well as inappropriate storage conditions in developing and non-developing countries have resulted in elevated levels of toxic mycotoxins entering the food chain (Serrano *et al.*, 2012). Mycotoxins are health-damaging metabolites which can be carcinogenic, hepatotoxic, teratogenic or immunosuppressing for human and animals (Muñoz *et al.*, 2010). Accordingly, Food and Agricultural Organization (FAO) estimated that around 25% of the world's agricultural commodities are contaminated with mycotoxins, leading to significant economic losses (Kabak *et al.*, 2006). Moreover, mycotoxins can cause a variety of toxic effects including acute as well as chronic in humans and animals, therefore, they are one of the most relevant and irritating problems about food safety (Sforza *et al.*, 2006). Mycotoxicosis, like other toxicological syndromes, can be considered acute or chronic. Acute toxicity generally has a rapid onset of symptoms and an obvious toxic response, while chronic toxicity is characterized by low-dose exposure over a long period, resulting in DNA damage, cancers, and other generally irreversible effects (James, 2005). Major mycotoxins present in food are aflatoxins, ochratoxins, fumonisins, trichothecenes, and zearalenone (Zain, 2011). Among them the most widely known mycotoxins are Aflatoxins. It produced by *Aspergillus parasiticus, Aspergillus flavus, and Aspergillus nomius*, are of great importance because of their biological and biochemical effects on living systems (Naseem *et al.*, 2018). Aflatoxins are carcinogenic contaminants of food and feed that are frequently responsible for health and economic problems in many countries (Negash, 2018). There are more than 20 biologically active molecules termed as Aflatoxins, however these four (AFB1,AFB2,AB2,AFG1 and ADG2) are most common and naturally occurring which is produced by *Aspergillus flavus* in food and feed staff (Reddy *et al.*, 2010).

Among the four aflatoxins, aflatoxin AFB1 is the most dangerous, as it is produced in high concentrations and was recognized to be the most potent hepatotoxin and carcinogen (Adhikari *et al.*, 2016). The consumption of food contaminated by aflatoxin AFB1 increases the risk of developing hepatocellular carcinoma (Tayel *et al.*, 2013). Several epidemiological studies indicated that AFB1 intake is associated with a high incidence of primary liver cancer in men in Africa and Asia ((Shephard, 2008; Wang, *et al.*, 2009). Animal feed and AFs-contaminated diet showed a significant increase in MDA level in the liver and kidney, which indicates hepatic and kidney damage (Shyamal *et al.*, 2010). The occurrence and stability to several physical and chemical treatments of these mycotoxins during food and feed processing pose serious health problems in humans and animals, in addition to reduces the post-harvest loss, therefore protection against aflatoxins is a critical need.

Appropriate harvesting and storage conditions of crops and feed play important role in the mycotoxin(aflatoxin) reduction potential but it could not be in a control due to lack of suitable storage and harvesting conditions. Therefore, to eliminate, inactivate or reduce the bioavailability of AFs, several strategies including physical, chemical, and biological methods have been investigated. Physical approaches to aflatoxin destruction involve treating with heat, ultraviolet light, and adsorption from solution, or ionizing radiation, but none of these is entirely effective due to nutritional quality loss and its price aspect. Chemical degradation of aflatoxins is usually carried out by the addition of chlorinating, oxidizing, or hydrolytic agents. Chemical treatments require expensive equipment and may result in losses of the nutritional quality of treated commodities. Also, the undesirable health effects of such treatments have not been fully evaluated. The third and very important aspect of the reduction of mycotoxin is biological control. Biological control of mycotoxin is a promising approach for reducing both pre-harvest and post-harvest mycotoxin contamination in food crops (Velazhahan *et al.*, 2010). In general, the success in detoxification of aflatoxins with physical, chemical, and biological methods depends on many factors such as aflatoxins concentration, composition and physicochemical properties of food sample (moisture content, fat content, acidity, texture, and so on), and source of contamination (natural or artificial).

## Probiotics

Probiotics one of the biological control methods of mycotoxin and which are regulated as dietary supplements and foods, consist of yeast or bacteria. These are available as capsules, tablets, or powders and are contained in various fermented foods, most commonly yogurt or dairy drinks. Probiotic products may contain a single microorganism or a mixture of several species. According to the World Health Organization (WHO) working groups, probiotics are defined as "live microorganisms which when administered in adequate amounts confer health benefits on the host" (Joint, 2001). Probiotic bacteria used for food applications may have a human origin (feces, breast milk) or they can be derived from food (artisanal fermented products) (Fontana *et al*., 2013).There are many microorganisms used as probiotics are listed below in table 1.

## Health benefits of probiotic

Probiotics have many beneficial health effects, for example, several studies have shown that probiotic treatment can improve intestinal functions and integrity, relieve constipation-related symptoms, and improved the microbiota environment (De Preter *et al.,* 2007; Krammer *et al.,* 2011; Matsumoto *et al.,* 2010). The other beneficial modulation of the gut microbiota activity by the reduction of the risk-associated with mutagenicity and carcinogenicity, alleviation of lactose intolerance, reinforcement of gut mucosal immunity, acceleration of intestinal mobility, prevention of colon cancer (Kansandee, 2015; M. E. Sanders *et al.,* 2014). Furthermore, it is also believed that the application of probiotics in the area of detoxification and decontamination has recently been studied. Its application in the food industry is of great significance. So, in addition to their health, probiotics have a significant application on the toxin reduction potentials in agricultural products. This thing makes interesting and the attentions of probiotics towards toxin reduction is increasing and it is the current researchable area. Therefore the present review aims to assess the effectiveness of probiotics on the mycotoxin reduction potential and its reduction mechanism of aflatoxin.

## Biological detoxification of mycotoxins

Biological detoxification of mycotoxins in food, raw material, and concentrated feed, as well as inhuman and animal organisms, is a new and very useful method. In this method, the way that the probiotics entering into the aflatoxin infected host is by ingestion. Ingestion of probiotics exerts a beneficial effect on the host organism beyond inherent general nutrition (Sanders *et al.,* 2007) and holds great promise for reducing the bioavailability of consumed AFs.

**Table.1** Microorganisms used as Probiotics

| Bacteria | | | Yeast |
|---|---|---|---|
| *Lactobacillus* species | *Bifidobacterium* species | Other bacteria | |
| *L. acidophilus*<br>*L. bulgaricus*<br>*L. casei*<br>*L. crispatus*<br>*L. fermentum*<br>*L. gasseri*<br>*L. johnsonii.L. lactis*<br>*L. plantarum*<br>*L. reuteri*<br>*L. rhamnosus* | *B.adolescentis*<br>*B.animalis*<br>*B.bifidum*<br>*B.breve*<br>*B.infantis*<br>*B.lactis*<br>*B. longum* | *Bacillus cereus*<br>*Enterococcus faecalisa*<br>*Enterococcus faeciuma*<br>*Escherichia coli Nissle*<br>*Streptococcus thermophilus* | *Saccharomyces boulardii* |

Source; *Doron & Gorbach, 2006; Santosa, Farnworth, & Jones, 2006; Senok, Ismaeel, & Botta, 2005*

**Table.2** Some *in Vitro* Experiments Investigated the Efficacy of Probiotic Bacteria to reduction Aflatoxin

| Probiotic bacteria | Summary of results | References |
|---|---|---|
| *Lactobacillus reuteri* *Bifidobacterium bifidum* *Lactobacillus casei*Shirota *L. johnsonii* *L. caseidefensis* | Five bacteria strain capabilities to bind $AFB_1$ were investigated, and *L. reuteri* (Lr) and *L. casei* Shirota (LcS) were the most efficient strains. After 4 h incubation with $AFB_1$, Lr and LcS retained 85.3% and 93.8% of the $AFB_1$ and the binding increased to 90% at 12 h of incubation. This study also indicated that teichoic acid may play a role in the binding of $AFB_1$ to the bacterial cell wall. | Hernandez-Mendoza *et al.*, (2009) |
| *Bifidobacterium longum* *L. rhamnosus* *Bifidobacterium* species 420 *Lactobacillus acidophilus* *L. acidophilus* NCFM 150B *L. casei*Shirota | $AFB_1$, $AFB_2$, $AFG_1$, and $AFG_2$ binding capacity of bacteria was examined using an in-vitro digestion model under fed condition for evaluation of reduction of toxins' bioaccessibility. Bioaccessibility of AFB1, $AFB_2$, $AFG_1$, and $AFG_2$ by adding probiotic bacteria to the digestion model reduced from 18.1–35.6%, 17.3–35.5% , 13.5–31.9%, and 10.5–33.6%, respectively. Better reduction of bioaccessibility of aflatoxin metabolites was found from *L. acidophilus* NCFM 150B. | Kabak and Ozbey (2012) |
| *Saccharomyces cerevisiae* | The ability of *S. cerevisiae* isolated from fresh broiler feces to bind $AFB_1$ was investigated. The cells were incubated 30 min at 37 °C in 1 mL phosphate buffer saline (PBS) containing $AFB_1$. The binding of *S. cerevisiae* to $AFB_1$ was concentration and strain-dependent. At a high concentration (500 ng/mL), *S. cerevisiae* RC 016 bound 65.5% of $AFB_1$present in the PBS solution, but S. cerevisiae 08 was an efficient binder of AFB1 at a concentration of 100 ng/mL. | Pizzolitto*et al.*, (2012) |
| *L. acidophilus* NRRL B-4495 *L. reuteri*NRRL B-14171 *L. rhamnosus*NRRL B-442 *L. johnsonii*NRRL B-2178 *B. bifidum* NRRL B-41410 | The $AFM_1$– binding assay and assessment of $AFM_1$bioaccessibility reduction in an in vitro digestive model were investigated. The amount of $AFM_1$ bound was specific for each bacterium and ranged from 19.95 - 25.43%. After 4 h of incubation, *L. rhamnosus* and *L. acidophilus* had the highest $AFM_1$bound (23.88% and 24.09%). Nevertheless, following 12 h incubation, L. reuteri showed the highest binding ability (25.43%). In vitro digestive model, the bacteria reduced $AFM_1$bioaccessibility of spiked-milk ranging from 22.72% - 45.17%, where *B. bifidum* was the efficient binder. | Serrano-Niño *et al.*, (2013) |
| *L.acidophilus*ATCC 20552 *L. rhamnosus*TISTR 541 *B. angulatum*DSMZ 20098 *Lactobacillus plantrium* *Streptococcus thermophiles* *Lactobacillus bulgarius* | Bacteria binding and removals capabilities of $AFM_1$ from yogurt and milk powder used for the production of yogurt were investigated. *L.plantrium*had the highest ability to degrade $AFM_1$from contaminated MRS broth in the viable and heated stage. It was found that the degradation of $AFM_1$ in yogurt varied with the type of bacteria used for the starter. After 1 day of yogurt preparation, *S. thermophiles*, *L. bulgaricus*, and *L. plantrium*degraded $AFM_1$about 31.5–87.8%, which was the highest compared to the other two starter types. | Elsanhoty *et al.*, (2014) |

**Table.3** Some findings from Some Animal Models Investigated the Efficacy of Probiotic Bacteria in Reducing the Effects of Aflatoxin Exposure

| Probiotic bacteria | Summary of results | **References** |
|---|---|---|
| *Lactobacillus casei*Shirota | Studies were conducted to evaluate the effects of *L. casei* Shirota to bind $AFB_1$ and prevent $AFB_1$ intestinal uptake in exposed rats to high $AFB_1$ exposure. It was found that the level of $AFB_1$-lysine was decreased compared to the control with the probiotic treatment after 21 days of the intervention. The authors indicated that the reduction of AFB1-lysine adduct in blood samples could be attributable to the ability of L. casei Shirota to bind AFB1 molecules under chronic toxin exposure in the small intestine. | Hernandez-Mendoza *et al*., (2010) |
| *Lactobacillus reuteri* | The binding effects of *L. reuteri* to $AFB_1$ in the intestinal tract, as to decrease intestinal AFB1 absorption were observed in rats. The probiotic bacteria were able to bind AFB1 mostly in the duodenum. The level of $AFB_1$-lysine adduct was also decreased with the probiotic treatment which indicated that L. reuteri bound AFB1 and prevented AFB1 absorption in the small intestine. It was suggested that probiotic bacteria could be used as a biological barrier to prevent aflatoxin exposure and thereby reduce $AFB_1$ bioavailability and toxicity. | Hernandez-Mendoza *et al*., (2011) |
| Probiotic fermented milk containing *Lactobacillus rhamnosus*GG and *L.casei*Shirota | The effect of probiotic fermented milk on gene expression and genotoxicity during $AFB_1$-induced hepatocellular carcinoma in rats was also reported. A mixture of probiotics together with chlorophyllin significantly lowered oncogene expression and genotoxicity as compared to the $AFB_1$-control group. The treatments were able to inhibit or delay liver cancer and showed lower genotoxicity or DNA damage and oncogene expression. | Kumar *et al*., (2011) |

For this, the specific strain, the food matrix used as a vehicle, the dose, the period, and the way of administration (continuous or in a cyclical way) seems to be crucial for the achievement of the desired health benefit. Different organisms, including bacteria especially, probiotics and dairy strains of lactic acid bacteria (LAB), yeast strains of *Saccharomyces cerevisiae*, and non-toxigenic *Aspergillus* fungi, have been tested for their ability the control of AFs contamination (Yin *et al.,* 2008). Among them particular attention paid to lactic acid bacteria because of their favorable influence on human organisms (probiotic bacteria), the widespread use in the production of fermented foods, and the ability to inhibit the growth of molds as well as mycotoxins production (Niderkorn *et al.*,2006).

The effective performance of the probiotic depends on their strong adherence and colonization of the human gut, which in turn improves the host immune system (Lebeer *et al.,* 2008).Accordingly, (Kabak *et al.,* 2009) research report has been conducted *in vivo* methods on aflatoxin B1 (AFB1) and ochratoxin A (OTA) in the gastrointestinal tract in the absence and presence of probiotics, a possible adsorbent. In this research finding average bioaccessibility of AFB1 and OTA without probiotics was found to be 90% and 30%, but in the presence of six probiotic bacteria showed a reduction to a maximum of 37% and 73%, respectively. The bacterial strains' binding capacity to AFB1 and OTA were different. In Gratz *et al.,* 2005) research report also using *Lactobacillus* and *Propionibacterium* strains of probiotic bacteria in chicken duodenum the aflatoxin B1 reduction covered from 57-66 %. In another research report (Fazeli *et al.,* 2009) in Lactobacillus fermentum, Lactobacillus easel, Lactobacillus plantarum in Liquid media the aflatoxin B1 was reduced from 25-61 %.

Accordingly, (Abdelmotilib *et al.,* 2018) research report on aflatoxin M1 reduction in milk in both probiotic bacterial and yeast species (*Lactobacillus Plantarum, Lactobacillus acidophilus, Bifidobacterium bifidum, Kluyveromyces lactis,* and *Saccharomyces cerevisiae*) found that the highest AFM1 removal was 80.56%, 86.64%, 88.60% and 90.88% in the treated milk samples in a respective manner. This probiotic bacteria binding

capacity is different from each other due to different reasons. It is also interesting to note that the toxin-removal capacity of the combination of the 4 strains was not the sum of their individual capacities.

The removal of other mycotoxins beyond AFB1 by lactic acid bacteria and bifidobacteria was studied as well. AFB1, removal capacity was variable among strains (reduction in the supernatant ranged from 2 to 82%)and depending on the strain-mycotoxin considered as well, but not too much on PAT or OTA concentration.

For instance, *B. animalis*VM12 reduced 82% of PAT and 22% of OTA whereas *B. animalis*LA17 reduced less than 12% of both toxins. On the contrary, some *B. longum*, *L. acidophilus* and *L. plantarum* strains reduced much more OTA than PAT (Fuchs *et al.,* 2008). The strain-specific capacity to bind AFB1 was confirmed by (A Hernandez-Mendoza *et al.,* 2009) where the removal capacity ranged from 14-50% among 8 strains of *L. casei* assessed.

The aflatoxin binding capacities of probiotics also depend on the pH of the environment. As regards the effect of pH on mycotoxin binding, results seem to be contradictory or, maybe, strain-mycotoxin combination dependent. In the work of (Haskard *et al.,* 2000) adapting pH from 2.5 to 8.5 did not affect AFB1 binding capacities. However, (Fuchs *et al.,* 2008) revealed that binding was much more effective at pH 5 compared to pH 7 or 8 for removal of PAT and OTA from the liquid medium by *B. animalis*VM12 and *L. acidophilus* VM20, respectively. The results of (Topcu *et al.,* 2010) are somehow situated between these previous reports since, for one strain AFB1 binding was not pH-dependent (pH range 3-7), whereas PAT binding was higher at higher pH values, while the opposite situation (binding higher at lower pH) was observed for the other strain.

## Mechanism of binding

To date, several studies have demonstrated that the structure and components of the cell wall are responsible for the microbial binding of aflatoxins, though the mechanism of binding by a specific strain is still unclear. Accordingly (Adebo *et al.,* 2017; Dalié *et al.,* 2010), these LAB can reduce the aflatoxins through the two main degradation mechanisms including an enzymatic pathway-dependent reaction or a physical binding process. Further investigations showed that some LAB strains reduced aflatoxins uptake, hydrolyzed the toxin with no new toxic products formed, along protected themselves against membrane and DNA damage during these reactions. But some researchers stated that the esterified glucomannan (EGM) and manno-oligosaccharide (MOS) have been proposed to be responsible for yeast cell walls. While in LAB, for AFB1 binding suggested a physical union, an adhesion to bacterial cell wall components (polysaccharides and peptidoglycans), instead of covalent binding or degradation (Guan *et al.,* 2011). But cell wall components of probiotic bacteria such as peptidoglycans and polysaccharides have been proposed to be the most crucial elements responsible for Aflatoxin binding.

The main mechanism of action for the majority of the health benefits attributed to probiotic bacteria is perhaps the adequate activation of the gut-associated immune response (Hardy *et al.,* 2013).It is said that probiotics remove aflatoxin by binding to the bacterial cell wall. For example, (Shetty & Jespersen, 2006) stated that mycotoxin removal is by adhesion to cell wall components, rather than by covalent bindings or metabolism, as non-viable and dead bacteria do not lose their binding ability. Moreover, (Adrián Hernandez-Mendoza *et al.,* 2010) showed that AFB1 binding to the bacterial cell wall involved a physical interaction. However, the mechanism by which aflatoxin binds to the bacterial cell wall is unclear. The binding and interaction of AFB1 molecule to the bacterial cell wall using a computer-generated simulation model was assessed in a study by (Yiannikouris *et al.,* 2006). The authors examined the interaction between β-D-glucan structures of *Saccharomyces cerevisiae* and AFB1 molecules found that the binding involved a 2-step mechanism process. Firstly, the AFB1 molecule is trapped inside the single helix of the (1➔3)-β-D-glucan chain, then the AFB1 molecule is covered by the branched (1➔6)-β-D-glucan chain, where it is maintained inside the helix. Hydrogen bonds only account for a small portion (-3.8 kcal/mol) of the docking energy for the binding, therefore finally the authors concluded that Van der Waals interaction plays a major role in the binding of AFB1 (Yiannikouris *et al.,* 2006).

Another mechanism by which probiotic bacteria-induced their protective effect was suggested by (Kodali & Sen, 2008) who reported that these bacteria synthesize extracellular polysaccharides with significant physiological and therapeutic activities, which have substantial antioxidant and free radical scavenging activities. Several reports indicated that AFs are capable to induce oxidative damage in the cells and produce reactive oxygen species, such as superoxide radicals, hydroxyl radicals, and hydrogen peroxides which are

involved in AFB1-induced cell injury in rat hepatocytes in vitro and in vivo (Abdel-Wahhab *et al.,* 2010; Abdel-Wahhab *et al.,* 2005). Besides, the elevation of reactive oxygen species levels causes inhibitory effects on biological processes including DNA synthesis, DNA-dependent RNA synthesis, DNA repair, and protein synthesis (Alpsoy & Yalvac, 2011). On the other hand, the current research in the antioxidant ability of LAB has shown that some LAB strains are not only able to decrease the risk of reactive oxygen species accumulation through food ingestion but can also degrade the superoxide anion and hydrogen peroxide ((Liu & Pan, 2010). So among the probiotics as studies reveals that in vivo assays LAB may be a safe means to reduce the absorption and increase excretion of AFB1 from the body when administered in a single dose (Gratz *et al.,* 2006).

In general, The action of microorganisms on mycotoxins and their mechanism of action has based the competition for nutrients with entering pathogens, bioconversion of available sugars to acids (lowering the intestinal pH and inhibiting pathogens), interactions, antibiosis production of vitamins, and butyric acid (that acts as fuel for enterocytes for an enhanced intestinal barrier), a competitive exclusion for adhesion sites (barrier function of the intestinal epithelium) and the beneficial immune stimulation of the gut-associated lymphoid tissue(Fazeli *et al.,* 2009 & Oelschlaeger, 2010). Therefore, the complex formed between the bacteria and $AFB_1$ was stable under luminal conditions suggesting that dietary decontamination can be accomplished by the addition of specific non-viable probiotic LAB to animal feeds, enabling the binding of AF in the gastrointestinal tract and its removal via the feces, without harmful effects to the host animal.

Probiotic bacteria have many beneficial health effects, and one of them is their ability to bind aflatoxins. Evidence from *in vitro*, animal studies has supported the potential ability of probiotic bacteria as an adsorbent of aflatoxin. The ability of aflatoxin reduction potentials of probiotics bacteria is different depending on the type of the bacteria, the concentrations of the bacteria, and the $P^H$ conditions. Even if some kinds of literature are described the mechanism slightly detailed mechanism of which probiotic bacteria bind to aflatoxin is unclear and literature on the mechanism is scarce.

## Recommendation

It is important to study the chemical interactions between the cell wall of probiotic bacteria, and its related components with aflatoxin molecules that could be satisfied to provide further justification of probiotics as adsorbent of aflatoxin. The best way to prevent the aflatoxin prevalence in agricultural products are making suitable conditions of harvesting and storage but if that could be impossible and assuming that consuming toxin foods, it could be better to eat fermented foods (yogurt or dairy drinks) or taking probiotics since they are available as capsules, tablets, packets, or powders.

## References


Abdel-Wahhab, M. A., Hassan, N. S., El-Kady, A. A., Khadrawy, Y. A., El-Nekeety, A. A., Mohamed, S. R.,... Mannaa, F. A. (2010). Red ginseng extract protects against aflatoxin B1 and fumonisins-induced hepatic pre-cancerous lesions in rats. *Food and chemical toxicology*, *48*(2), 733-742.

Abdel-Wahhab, M. A., Abdel-Galil, M. M., & El-Lithey, M. (2005). Melatonin counteracts oxidative stress in rats fed an ochratoxin A contaminated diet. *Journal of pineal research*, *38*(2), 130-135.

Abdelmotilib, N. M., Hamad, G. M., Elderea, H. B., Salem, E. G., & El Sohaimy, S. A. (2018). Aflatoxin M1 reduction in milk by a novel combination of probiotic bacterial and yeast strains. *European Journal of Nutrition & Food Safety*, 83-99.

Adebo, O., Njobeh, P., Gbashi, S., Nwinyi, O., Mavumengwana, V., 2017. Review on microbial degradation of aflatoxins. Critical reviews in food science and nutrition 57, 3208-3217.

Adhikari, B. N., Bandyopadhyay, R., & Cotty, P. J. (2016). Degeneration of aflatoxin gene clusters in Aspergillus flavus from Africa and North America. *Amb Express*, *6*(1), 1-16.

Alpsoy, L., & Yalvac, M. E. (2011). Key roles of vitamins A, C, and E in aflatoxin B1-induced oxidative stress. In *Vitamins & Hormones* (Vol. 86, pp. 287-305): Elsevier.

Amaike, S., & Keller, N. P. (2011). Aspergillus flavus. *Annual review of phytopathology*, *49*, 107-133.

Atehnkeng, J., Donner, M., Ojiambo, P. S., Ikotun, B., Augusto, J., Cotty, P. J., & Bandyopadhyay, R. (2016). Environmental distribution and genetic diversity of vegetative compatibility groups determine biocontrol strategies to mitigate aflatoxin contamination of maize by A spergillus flavus. *Microbial biotechnology*, *9*(1), 75-88.

Bueno, D. J., Casale, C. H., Pizzolitto, R. P., Salvano, M. A., & Oliver, G. (2007). Physical adsorption of

aflatoxin B1 by lactic acid bacteria and Saccharomyces cerevisiae: a theoretical model. *Journal of food protection*, *70*(9), 2148-2154.

Dalié, D., Deschamps, A., Richard-Forget, F., 2010. Lactic acid bacteria–Potential for control of mould growth and mycotoxins: A review. Food control 21, 370-380

Doron, S., & Gorbach, S. L. (2006). Probiotics: their role in the treatment and prevention of disease. *Expert review of anti-infective therapy*, *4*(2), 261-275.

Elshanhoty, R. M., Salam, S. A., Ramadan, M. F., Badr, F. H., 2014. Detoxification of aflatoxin in yoghurt using probiotics and lactic acid bacteria. Food Control 43, 129–134.

Fazeli, M. R., Hajimohammadali, M., Moshkani, A., Samadi, N., Jamalifar, H., Khoshayand, M. R.,... Pouragahi, S. (2009). Aflatoxin B1 binding capacity of autochthonous strains of lactic acid bacteria. *Journal of food protection*, *72*(1), 189-192.

Fontana, L., Bermudez-Brito, M., Plaza-Diaz, J., Munoz-Quezada, S., & Gil, A. (2013). Sources, isolation, characterisation and evaluation of probiotics. *British Journal of Nutrition*, *109*(S2), S35-S50.

Fuchs, S., Sontag, G., Stidl, R., Ehrlich, V., Kundi, M., & Knasmüller, S. (2008). Detoxification of patulin and ochratoxin A, two abundant mycotoxins, by lactic acid bacteria. *Food and chemical toxicology*, *46*(4), 1398-1407.

Gratz, S., Mykkänen, H., & El-Nezami, H. (2005). Aflatoxin B1 binding by a mixture of Lactobacillus and Propionibacterium: in vitro versus ex vivo. *Journal of food protection*, *68*(11), 2470-2474.

Gratz, S., Täubel, M., Juvonen, R., Viluksela, M., Turner, P., Mykkänen, H., & El-Nezami, H. (2006). Lactobacillus rhamnosus strain GG modulates intestinal absorption, fecal excretion, and toxicity of aflatoxin B1 in rats. *Appl. Environ. Microbiol.*, *72*(11), 7398-7400.

Guan, S., Gong, M., Yin, Y., Huang, R., Ruan, Z., Zhou, T., & Xie, M. (2011). Occurrence of mycotoxins in feeds and feed ingredients in China. *J Food Agric Environ*, *9*(2), 163-167.

Hardy, H., Harris, J., Lyon, E., Beal, J., & Foey, A. (2013). Probiotics, prebiotics and immunomodulation of gut mucosal defences: homeostasis and immunopathology. *Nutrients*, *5*(6), 1869-1912.

Haskard, C., Binnion, C., & Ahokas, J. (2000). Factors affecting the sequestration of aflatoxin by Lactobacillusrhamnosus strain GG. *Chemico-biological interactions*, *128*(1), 39-49.

Hernandez-Mendoza, A., Garcia, H., & Steele, J. (2009). Screening of Lactobacillus casei strains for their ability to bind aflatoxin B1. *Food and chemical toxicology*, *47*(6), 1064-1068.

Hernandez-Mendoza, A., Guzman-De-Peña, D., González-Córdova, A. F., Vallejo-Córdoba, B., & Garcia, H. S. (2010). In vivo assessment of the potential protective effect of Lactobacillus casei Shirota against aflatoxin B1. *Dairy Science & Technology*, *90*(6), 729-740.

Hernandez-Mendoza, A., Guzman-De-Peña, D., González-Córdova, A. F., Vallejo-Córdoba, B., & Garcia, H. S. (2010). In vivo assessment of the potential protective effect of Lactobacillus casei Shirota against aflatoxin B1. *Dairy Science & Technology*, *90*(6), 729-740.

Hernandez-Mendoza, A., Rivas-Jimenez, L., Garcia, H. S., 2011. Assessment of aflatoxin B1 binding to Lactobacillus reuteri by microscopy and fluores-cence techniques. Food Biotechnol. 25, 140–150.

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B.,... & Sanders, M. E. (2014). Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature reviews Gastroenterology & hepatology*, *11*(8), 506.

James, B. (2005). Public awareness of aflatoxin and food quality control in Benin. *International Institute of Tropical Agriculture*.

Joint, F. (2001). WHO Expert consultation on evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria. *Córdoba, Argentina. October*, 1-4.

Kabak, B., Brandon, E. F., Var, I., Blokland, M., & Sips, A. J. (2009). Effects of probiotic bacteria on the bioaccessibility of aflatoxin B1 and ochratoxin A using an in vitro digestion model under fed conditions. *Journal of Environmental Science and Health, Part B*, *44*(5), 472-480.

Kabak, B., Ozbey, F., 2012. Assessment of the bioaccessibility of aflatoxins from various food matrices using an *in vitro* digestion model, and the efficacy of probiotic bacteria in reducing bioaccessibility. J. Food Compos. Anal. 27, 21–31.

Kabak, B., Dobson, A. D., & Var, I. l. (2006). Strategies to prevent mycotoxin contamination of food and animal feed: a review. *Critical reviews in food science and nutrition*, *46*(8), 593-619.

Kansandee, W. (2015). Health Benefi ts of Probiotic Microorganisms. *Journal of Science and Technology Mahasarakham University*, *34*(2), 196-201.

Krammer, H. J., Von Seggern, H., Schaumburg, J., & Neumer, F. (2011). Effect of Lactobacillus casei Shirota on colonic transit time in patients with chronic constipation. *coloproctology*, *33*(2), 109-113.

Kumar, M., Verma, V., Nagpal, R., Kumar, A., Gautam, S.K., Behare, P.V., Grover, C.R., Aggarwal, P.K., 2011. Effect of probiotic fermented milk and chlorophyllin on gene expression and genotoxicity during AFB1-induced hepatocellular carcinoma. Gene 490, 54–59.

Kumar, M., Verma, V., Nagpal, R., Behare, P.V., Singh, B., Aggarwal, P.K., 2012. Anticarcinogenic effect of probiotic fermented milk and chlorophyllin on aflatoxin-B1-induced liver carcinogenesis in rats. Br. J. Nutr. 107, 1006–1016.

Kodali, V. P., & Sen, R. (2008). Antioxidant and free radical scavenging activities of an exopolysaccharide from a probiotic bacterium. *Biotechnology Journal: Healthcare Nutrition Technology*, *3*(2), 245-251.

Lebeer, S., Vanderleyden, J., & De Keersmaecker, S. C. (2008). Genes and molecules of lactobacilli supporting probiotic action. *Microbiol. Mol. Biol. Rev.*, *72*(4), 728-764.

Liu, C.-F., & Pan, T.-M. (2010). In vitro effects of lactic acid bacteria on cancer cell viability and antioxidant activity. *Journal of Food and Drug Analysis*, *18*(2).

Madrigal-Santillán, E., Madrigal-Bujaidar, E., Márquez-Márquez, R., & Reyes, A. (2006). Antigenotoxic effect of Saccharomyces cerevisiae on the damage produced in mice fed with aflatoxin B1 contaminated corn. *Food and chemical toxicology*, *44*(12), 2058-2063.

Matsumoto, K., Takada, T., Shimizu, K., Moriyama, K., Kawakami, K., Hirano, K., & Nomoto, K. (2010). Effects of a probiotic fermented milk beverage containing Lactobacillus casei strain Shirota on defecation frequency, intestinal microbiota, and the intestinal environment of healthy individuals with soft stools. *Journal of bioscience and bioengineering*, *110*(5), 547-552.

Muñoz, R., Arena, M. E., Silva, J., & Gonzalez, S. N. (2010). Inhibition of mycotoxin-producing Aspergillus nomius VSC 23 by lactic acid bacteria and Saccharomyces cerevisiae. *Brazilian Journal of Microbiology*, *41*(4), 1019-1026.

Naseem, M. N., Saleemi, M. K., Abbas, R. Z., Khan, A., Khatoon, A., Gul, S. T.,... Sultan, A. (2018). Hematological and Serum Biochemical Effects of Aflatoxin B1 Intoxication in Broilers Experimentally Infected with Fowl Adenovirus-4 (FAdV-4). *Pakistan Veterinary Journal*, *38*(2).

Negash, D. (2018). A review of aflatoxin: occurrence, prevention, and gaps in both food and feed safety. *J. Appl. Microbiol. Res*, *1*, 35-43.

Niderkorn, V., Boudra, H., & Morgavi, D. (2006). Binding of Fusarium mycotoxins by fermentative bacteria in vitro. *Journal of Applied Microbiology*, *101*(4), 849-856.

Oelschlaeger, T. A. (2010). Mechanisms of probiotic actions–a review. *International Journal of Medical Microbiology*, *300*(1), 57-62.

Ostry, V., Malir, F., Toman, J., & Grosse, Y. (2017). Mycotoxins as human carcinogens—the IARC Monographs classification. *Mycotoxin research*, *33*(1), 65-73.

Pitt, J. I., & Hocking, A. D. (2009). *Fungi and food spoilage* (Vol. 519): Springer.

Prado, G., Cruz Madeira, J., Morais, V., Oliveira, M., Souza, R., Peluzio, J.,... Pimenta, R. (2011).

Reduction of aflatoxin B1 in stored peanuts (*Arachis hypogaea* L.) using Saccharomyces cerevisiae. *Journal of food protection*, *74*(6), 1003-1006.

Pizzolitto, R. P., Armando, M. R., Combina, M., Cavaglieri, L. R., Dalcero, A. M., Salvano, M. A., 2012. Evalution of Saccharomyces cerevisiae strains as probiotic agent with aflatoxin $B_1$ adsorption ability for use in poultry feedstuffs. J. Environ. Sci. Health B 47, 933–941.

Reddy, K., Salleh, B., Saad, B., Abbas, H., Abel, C., & Shier, W. (2010). An overview of mycotoxin contamination in foods and its implications for human health. *Toxin reviews*, *29*(1), 3-26.

Roze, L. V., Hong, S.-Y., & Linz, J. E. (2013). Aflatoxin biosynthesis: current frontiers. *Annual review of food science and technology*, *4*, 293-311.

Sanders, M., Gibson, G., Gill, H., & Guarner, F. (2007). Probiotics: their potential to impact human health. CAST issue paper No. 36, October 2007. In.

Santosa, S., Farnworth, E., & Jones, P. J. (2006). Probiotics and their potential health claims. *Nutrition Reviews*, *64*(6), 265-274.

Senok, A., Ismaeel, A., & Botta, G. (2005). Probiotics: facts and myths. *Clinical Microbiology and Infection*, *11*(12), 958-966.

Serrano, A., Font, G., Ruiz, M., & Ferrer, E. (2012). Co-occurrence and risk assessment of mycotoxins in food and diet from Mediterranean area. *Food chemistry*, *135*(2), 423-429.

Serrano-Niño, J. C., Cavazos-Garduño, A., Hernandez-Mendoza, A., Applegate, B., Feruzzi, M.G., Martin-González, M.F.S., Garcĭa, H.S., 2013. Assessment of probiotic strains ability to reduce the bioaccessibility of aflatoxin M1 in artificially contaminated milk using an in vitro digestive model. Food Control 31, 202–207

Sforza, S., Dall'Asta, C., & Marchelli, R. (2006). Recent advances in mycotoxin determination in food and feed by hyphenated chromatographic techniques/mass spectrometry. *Mass Spectrometry Reviews*, *25*(1), 54-76.

Shephard, G. S. (2008). Risk assessment of aflatoxins in food in Africa. *Food Additives and Contaminants*, *25*(10), 1246-1256.

Shetty, P. H., & Jespersen, L. (2006). Saccharomyces cerevisiae and lactic acid bacteria as potential mycotoxin decontaminating agents. *Trends in Food Science & Technology*, *17*(2), 48-55.

Shyamal, S., Latha, P., Suja, S., Shine, V., Anuja, G., Sini, S.,... Rajasekharan, S. (2010). Hepatoprotective effect of three herbal extracts on aflatoxin B1-intoxicated rat liver. *Singapore medical journal*, *51*(4), 326.

Tayel, A. A., El-Tras, W. F., Moussa, S. H., & El-Agamy, M. A. (2013). Antifungal action of Pichia anomala against aflatoxigenic Aspergillus flavus and its application as a feed supplement. *Journal of the Science of Food and Agriculture*, *93*(13), 3259-3263.

Topcu, A., Bulat, T., Wishah, R., & Boyacı, I. H. (2010). Detoxification of aflatoxin B1 and patulin by Enterococcus faecium strains. *International journal of food microbiology*, *139*(3), 202-205.

Velazhahan, R., Vijayanandraj, S., Vijayasamundeeswari, A., Paranidharan, V., Samiyappan, R., Iwamoto, T.,... Muthukrishnan, S. (2010). Detoxification of aflatoxins by seed extracts of the medicinal plant, Trachyspermum ammi (L.) Sprague ex Turrill–structural analysis and biological toxicity of degradation product of aflatoxin G1. *Food Control*, *21*(5), 719-725.

Wang, J., Liu, X., & Zhang, Z. (2009). Exposure assessment of liver cancer attributed to dietary aflatoxins exposure in Chinese residents. *Zhonghua yu fang yi xue za zhi [Chinese journal of preventive medicine]*, *43*(6), 478-481.

Yiannikouris, A., André, G., Poughon, L., François, J., Dussap, C.-G., Jeminet, G.,... Jouany, J.-P. (2006). Chemical and conformational study of the interactions involved in mycotoxin complexation with β-D-glucans. *Biomacromolecules*, *7*(4), 1147-1155.

Yin, Y.-n., Yan, L.-y., Jiang, J.-h., & Ma, Z.-h. (2008). Biological control of aflatoxin contamination of crops. *Journal of Zhejiang University Science B*, *9*(10), 787-792.

Zain, M. E. (2011). Impact of mycotoxins on humans and animals. *Journal of Saudi Chemical Society*, *15*(2), 129-144.

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