Control Mycotoxin Contamination in Tarasas Food Using A Lab Fermentation

Baraa Jameel Al-Assil [1,2*], Taghreed Abed Wahwah [3]

Abstract

Background: Exposure to mycotoxins via contaminated plant foods can cause mycotoxicosis with the formation of more than 200 diseases in humans. Tarasas is a popular Kurdish fermented dish made by fermenting turnip roots and leaves with wheat grits and salt. This study showed the impact of fermentation on mycotoxin degradation in wheat grits. Objectives: The effects of fermentation on mycotoxin levels in the final Tarasas product was determined in this study. Methods: Tarasas was prepared using a traditional Kurdish recipe and subjected to spontaneous fermentation. Lactic acid bacteria (LAB) were identified, and mycotoxin levels were analyzed during fermentation. Results: pH decreased gradually during fermentation, with increased LAB count observed. Mycotoxin levels of Ochratoxin A (OTA), Zearalenone (ZEN), Aflatoxin B2 (AFB2), and Aflatoxin B1 (AFB1) decreased significantly from initial concentrations to 15-day fermentation. Conclusion: Spontaneous lactic acid fermentation in Tarasas effectively reduced levels of AFB1, AFB2, ZEN, and OTA mycotoxins. LAB play a crucial role in mycotoxin degradation during fermentation, highlighting the potential of LAB fermentation in enhancing food safety and quality.

Significance | By utilizing LAB-mediated fermentation, this study demonstrated a natural and effective method for controlling mycotoxin contamination in traditional Tarasas food.

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compared to those wearing them for 12, 6, or 1 hour, at 22%, 14%, and 7% respectively. Conclusion: In conclusion, the study demonstrated the importance of adherence to proper lens care practices to improve lens safety and reduce microbial contamination. Effective measures are essential to mitigate the risks associated with contact lens wear and maintain optimal eye health.

Keywords: Pseudomonas, Staphylococcus, Contact lenses, microbial contamination, antibiotic susceptibility, eye infections, disinfection solutions.

Introduction

Mycotoxins, poisonous substances generated by fungi that invade food crops, have deleterious health effects on both humans and animals, including cancer. Aflatoxins and fumonisins, two primary classes of foodborne mycotoxins, are particularly concerning in developing nations. These toxins, produced by certain Aspergillus and Fusarium fungi infecting crops like maize, thrive in warm climates, making them especially problematic in tropical and subtropical regions (Wu and Mitchell, 2016).

Tarasas, a traditional Kurdish delicacy, is a flavorful dish incorporating turnip root and leaves, cooked wheat grits, and a pinch of salt. Its production involves a gradual fermentation process facilitated by specific lactic acid bacteria (LAB), which significantly influence its sensory properties. The use of LAB in fermentation serves as an effective means to detoxify mycotoxins while preserving the nutritional content of the food. This approach finds

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broad application in fermenting various foods, including yogurt, cheese, sourdough bread, sauerkraut, and kimchi.

Mycotoxins, naturally occurring harmful compounds produced by certain molds, pose significant health risks when contaminating food items, particularly in tropical and subtropical regions. If ingested by humans, mycotoxins such as AF, ZEN, and OTA can lead to adverse health effects (HOA et al., 2022). The proficiency of LAB as mycotoxin degraders underscores the importance of LAB fermentation in ensuring food safety and maintaining the nutritional quality of fermented products (Nasrollahzadeh et al., 2022).

Health agencies are increasingly focused on eliminating mycotoxins from food and feed. Various initiatives have been launched to reduce mycotoxin levels in silage throughout pre-harvest, harvest, ensiling, and field stages (Nahle et al., 2022). Among these approaches, utilizing microorganisms or enzymes for biological decontamination and biodegradation holds promise for mycotoxin removal.

Mycotoxins can be enzymatically degraded by a diverse range of bacteria and fungi, making them attractive candidates for catalyzing processes essential for mycotoxin detoxification in feed and food. Fermentation has long been a crucial method for food preservation and flavor enhancement across different cultures (Steinkraus, 1997). Traditional food processing methods have relied on fermentation for its effectiveness in transforming raw materials into value-added products.

Tarasas fermentation is notable for its ability to reduce mycotoxin levels, harmful secondary metabolites produced by certain fungi, while enhancing flavor. The impact of fungal infestation on the hygienic quality and fermentation of corn silage is predicted to be negative. However, inoculating with L. plantarum and L. buchneri is expected to mitigate the potential harm caused by fungal infestation. Thus, our objective was to assess the influence of LAB inoculants on the fermentation process, microbial communities, and mycotoxin levels in corn silage infected with toxigenic fungi.

Lactic acid bacteria (LAB) produce various metabolites, including enzymes, bacteriocins, and organic acids, which can influence the viability and toxin production of molds. LAB also have the capability to directly bind to mycotoxins, thereby reducing their bioavailability and absorption in the gastrointestinal tract (Nahle et al., 2022).

Lactic acid fermentation plays a crucial role in reducing mycotoxin levels and improving the safety, quality, and nutritional value of fermented foods. This process lowers pH levels, inhibits the growth of harmful microorganisms, and enhances overall product characteristics (Lin et al., 2023).

The use of lactic acid bacteria (LAB) is essential in the ensiling fermentation process to remove mycotoxins from silages. Detoxifying bacteria, yeast, and fungi can be sourced from various origins. Lactobacillus plantarum and Lactobacillus buchneri are known to enhance the production of acetic acid (ACA) and lactic acid (LA), thus improving aerobic spoilage and fermentation quality. Certain LAB strains from species such as L. plantarum, L. buchneri, and P. acidilactici have been shown to bind to AFB1 in vitro (Ma et al., 2023).

However, the interaction between inoculants and infected fungus during maize ensiling remains unknown, and no studies have yet evaluated their impact on mycotoxin levels in corn silages.

Our research on tarasas was innovative as it combines cultural significance, fermentation techniques, and mycotoxin contamination. While existing literature has explored the impact of fermentation on reducing mycotoxin levels and examined mycotoxin contamination across various food types, few studies have specifically addressed this phenomenon within the context of tarasas (Park et al., 2022). Our study represented a pioneering effort to bridge disciplinary boundaries, offering a nuanced perspective that elucidates the broader socio-cultural implications of traditional food processing methods while deepening our understanding of mycotoxin dynamics.

Materials and methods

Chemical

Specimen extraction utilized HPLC-grade methanol and acetonitrile. Acetic acid for the mobile phase was sourced from Fisher Scientific, USA. Standards for AFB1, AFB2, ZEN, and OTA were obtained from Sigma-Aldrich USA.

Material

The analyses were purified using a Milli-Q treatment system by Millipore in the United States. Immune-affinity columns (IAC; AflaOChra HPLCTM multi-mycotoxins cartridges) were acquired from Millipore USA for specimen cleaning. Laboratory equipment including Erlenmeyer flasks, mason jars, fermentation locks, and various glassware and instruments necessary for extraction and analysis procedures were used. The scientific and ethical committees of Charmo University, Sulaimaniyah, Iraq, revised and approved this research proposal.

Tarasas preparation

In the traditional Kurdish recipe, the first step is to wash and cut 2.0 kg of fresh turnip roots and leaves into small sections or slices. Next, 1.0 kg of wheat grits is boiled until softened and then allowed to cool at room temperature (25° C). The cooled wheat grits are then added to the turnip roots and leaf slices mixture. Then, 225 g of iodine-free salt is added to the mix. Once the mixture is prepared, it is packed into sterilized mason jars. The jars are then tightly sealed with lids containing fermentation locks. The fermentation occurs naturally at normal temp (~24 degrees centigrade) and lasts

approximately 15 days. After five days of fermentation, the mixture undergoes phase separation. The upper layer is carefully removed and placed at the bottom, while the lower layer is returned to the top without agitation. The jars are sealed again and left at normal temp to complete the fermentation process. Throughout the fermentation period, samples are taken on days 0 (before fermentation), 5, 10, and 15 for chemical and microbial analyses. These analyses help to monitor the changes and progression of the fermentation process. The process of making Tarasas does not have a specific documented source. Instead, it relies on a traditional method handed down from generation to generation.

pH, and acidity determination

To determine the pH of the Tarasas sample, a pH meter (Orion, 420A, USA) was utilized after calibration, utilizing pH 4.1 and pH 7.0 buffers (Daji et al, 2022). The titrable acidity (TTA%) of the sample was determined utilizing the official method 962.12 (2000) from the Association of Official Analytical Chemists (AOAC) (Kim et al, 2017) and expressed as a percentage of lactic acid.

Determination of mycotoxin

The presence of zearalenone, ochratoxin A, and aflatoxins in fermented Tarasas samples was analyzed using high-performance liquid chromatography (HPLC) with a fluorescent detector. Mycotoxins AFB1, AFB2, Zearalenone, and OTA were separated using Fast Liquid Chromatography (FLC) with an HCMA-BIO 1000 C-18, 3 µm particle size (50 x 4.6 mm I.D) column. The separation was performed under optimal conditions using a gradient elution method with aqueous 0.1% acetonitrile, methanol, and acetic acid as mobile phases C, B, and A, respectively. The gradient was implemented with the following composition: 0 min—60% A, 30% B, and 10% C; 14 min—50% A and 50% C; and 5 to 10 min—60% A, 30% B, and 10% C. A fluorescent detector was configured with an excitation wavelength of 366 nm and an emission wavelength of 436 nm while maintaining an ambient temperature and an injection volume of 50 µl. The AFB1, AFB2, ZEN, and OTA reference standards were gained from Sigma-Aldrich USA). A mixed stock solution at an amount of 10 ug/ml was prepared in methanol: acetic acid (50:50, v/v) and used to prepare the calibration solutions. The calibration solutions at the 6-point calibration curve were prepared in the range that covered the existence of mycotoxin in the sample.

Procedure

The specimen extraction procedure described by Brera et al. (2011) was utilized (Brera et al, 2011). The technique underwent initial testing on a coriander specimen to examine its extraction ability and was evaluated based on the recovery. In summary, a 5 g specimen was put into a 100 ml Erlenmeyer flask, and 20 ml of methanol: water solution (80:20, v/v) was added. Next, 0.5 grams of sodium chloride were introduced into the flask, which was then agitated utilizing a Vision S Seriker II orbital shaker at 350 revolutions per minute for 30 minutes. Subsequently, 4 mL of the extract was mixed with 36 mL of a solution containing 0.1% Tween-20 in phosphate buffer saline (PBS) and agitated manually. The diluted extract underwent centrifugation at a speed of 5000 revolutions per minute for 15 minutes. Next, 20 millilitres of the liquid remaining after sedimentation was added to the ion exchange column (IAC) at a rate of 1 drop per second. The IAC was rinsed with 5 ml of a solution containing 0.1% Tween 20 in PBS, followed by 5 ml of water. Subsequently, the IAC was extracted utilizing 1 ml of methanol. The eluate was mixed with 1 ml solution containing 0.1% acetic acid. The mixture underwent filtration utilizing a 0.45-µm PVDF syringe filter and was, after that, transferred into HPLC vials before being injected under the most favourable separation conditions (Thompson et al, 2002).

Microbial Enumeration

Microbial enumeration involved the quantification and isolation of lactic acid bacteria (LAB) present in Tarasas specimens collected at different fermentation time points. 10 grams of Tarasas specimens collected at 0, 5, 10, and 15 days were transferred without contamination into individual flasks containing 90 millilitres of sterile 0.1% peptone water (pH 6.3±0.2, Oxoid-L37, Basingstoke, Hampshire, England). The samples were then blended utilizing a Stomacher Lab-Blender 400 (Seward Medical, London, UK). 0.1 mL samples from suitable dilutions were evenly scattered over pre-solidified MRS medium (pH 6.2±0.2, Oxoid-CM361) and M17 medium (pH 6.9±0.2, Oxoid-CM785). The plates were then incubated at 30 degrees Celsius for 48-72 hours. Ten to twenty colonies of LAB were randomly selected from MRS and M17 agar plates and purified via repeated streak-plating on MRS and M17 medium; each performed three times. The uncontaminated samples were preserved on MRS and M17 agar slants at a temperature of 4 degrees Celsius and transferred to new cultures every four weeks until they were analyzed (WU et al, 2011).

Statistical analysis

The findings were analyzed utilizing the Statistical Package for Social Science (SPSS), specifically version 25, developed in Chicago, USA. The fermentation procedure's impact on mycotoxins' identification was tested using a one-way variance analysis. Duncan's multiple range test assessed the substantial disparities between the treatment means at the significance level of $p < 0.05$.

Results

pH, titrable acidity and NaCl estimation

The pH level plays a pivotal role in lactic acid fermentation. Initially, the pH of Tarasas' specimen measured 5.7 with a titratable acidity of 1.05%. After 5 days of fermentation, the pH dropped to 3.2, accompanied by an acidity level of 1.96%. Over the subsequent 10 days, the pH fluctuated between 3.2 and 3.1, while acidity remained consistently high at 1.97% (see Figure 1).

Total Titratable Acidity (TTA) started relatively low at the beginning of fermentation but showed a significant increase as fermentation progressed. This rise can be attributed to the conversion of carbohydrates from shredded vegetables into lactic acid, primarily facilitated by LAB. TTA% serves as a crucial parameter for assessing the impact of lactic acid fermentation. An increase in TTA% throughout the fermentation process indicates the proliferation of LAB and their utilization of sugars in plant materials to produce lactic acid and other secondary products. Tarasas undergoing fermentation for 5 to 10 days exhibited a notable and statistically significant ($p < 0.05$) increase in TTA percentage.

Mycotoxin level

Turnip roots and leaves, along with wheat grits before cooking, were quantified using HPLC. Mycotoxin levels were assessed both before fermentation (day 0) and at various intervals (5, 10, and 15 days) throughout the fermentation process. Wheat grits are known to be susceptible to several mycotoxins, including AFB1, AFB2, ZEN, and OTA (Nada et al., 2022). In our study, mycotoxin levels in raw wheat grits (pre-cooking) were measured, resulting in 20.88 µg/kg for AFB1, 17.32 µg/kg for AFB2, 30.82 µg/kg for ZEN, and 18.2 µg/kg for OTA. Additionally, mycotoxin levels in turnip roots and leaves were found to be 3.6 µg/kg for AFB1, 2.8 µg/kg for AFB2, 0 µg/kg for ZEN, and 3.7 µg/kg for OTA (Table 1).

During the fermentation period, mycotoxin levels decreased (Table 2 and Figure 2), with AFB1, AFB2, ZEN, and OTA decreasing from 21.43 µg/kg, 18 µg/kg, 30.3 µg/kg, and 18.4 µg/kg, respectively, to 5.21 µg/kg, 0 µg/kg, 9.26 µg/kg, and 9.16 µg/kg after 15 days of fermentation. This reduction may be attributed to LAB, which create an environment during fermentation that discourages mold growth and reduces conditions conducive to mycotoxin production. Additionally, LAB increase acidity by producing lactic acid, which inhibits mold growth and mycotoxin production.

Fumonisin levels in ogi were notably lower than levels in the raw material (turnip roots and leaves) across all cities, with a significant difference observed in samples from Ibadan ($p < 0.05$) according to the Mann-Whitney U test.

Previous studies have highlighted the prevalence of mycotoxin contamination in wheat grits, with 94% of samples containing at least one mycotoxin, most commonly deoxynivalenol, ZEN, and aflatoxins (Geary et al., 2016).

LAB counts during Tarasas fermentation

The quantification of LAB from Tarasas was conducted on two distinct mediums, both pre- and post-fermentation. Table 3 presents the logarithm of colony-forming units per gram (CFU/g) of LAB measured on MRS and M17 medium after incubation at 37 degrees Celsius for one day. Samples from Tarasas were collected at 0, 5, 10, and 15 days. Generally, LAB counts obtained on MRS were higher than those on M17. LAB quantities on MRS medium ranged from 6.36 to 8.96 log10 CFU/g, depending on the fermentation duration. The highest LAB count on MRS medium for Tarasas specimens occurred after 15 days of fermentation. However, counts on M17 medium exhibited significant variations compared to MRS as fermentation progressed.

LAB presence was detected in Tarasas specimens before fermentation, ranging from 6.36 log CFU/g to 6.22 log CFU/g, indicating their natural occurrence in raw material throughout fermentation. The initial LAB population at day 0 was minimal, experiencing growth between day 0 and day 5 of fermentation. However, growth was limited in the final 10 fermentations. The highest CFU/g magnitudes were typically observed during the first 5 days of fermentation. In later stages, LAB counts showed minimal development, suggesting a potential deficiency of essential resources such as vitamins, amino acids, sugars, and minerals necessary for their growth and reproduction. Prolonged fermentation periods may lead to nutrient depletion, thereby restricting Lactobacillus growth (Abrunhosa et al., 2016).

LAB effect on MRS and M17 during various periods of Tarasas fermentation

Table 3 illustrates the fermentation process at four time points (zero-day, 5th day, 10th day, and 15th day) for two different media types: MRS and M17. The pH magnitude, indicating the acidity or alkalinity of the medium, is recorded alongside each time point.

For both MRS and M17 media, there is a consistent trend of increasing pH magnitude as fermentation progresses. At the zero-day mark, the pH magnitude for MRS is 6.36a, and for M17, it is 6.22a. As fermentation advances, the pH magnitude consistently rises across subsequent time points. By the 15th day, the pH magnitude for MRS reaches 8.96a, while for M17, it reaches 7.70a.

The results reveal a significant increase in pH magnitude over the fermentation period for both MRS and M17 media types. The pH magnitude consistently rose from the initial measurement to the 15th day across all samples. Statistical analysis confirmed the significance of these changes, with p-values ≤ 0.05 for both media types, indicating that the observed alterations in pH magnitude were unlikely to occur by chance. These findings demonstrate the shift in acidity or alkalinity as fermentation progresses, highlighting the dynamic nature of microbial metabolic processes within the media.

Discussion

The observed decrease in pH and rise in acidity during the fermentation of the Tarasas sample suggest the generation of organic acids, primarily lactic acid produced by lactic acid bacteria (LAB) (Tamang et al., 2016). This finding is consistent with previous studies that reported similar pH levels in red cabbage undergoing LAB fermentation (Joshi et al., 2009).

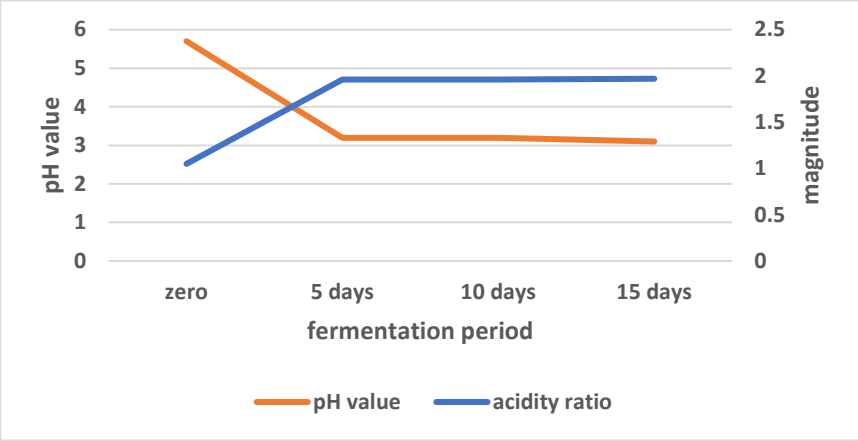

Figure 1. Changes in pH and acidity of Tarasas during and after 15 days of fermentation at 25°C.

Table 1. The mycotoxin concentration level in the raw materials utilized for processing Tarasas.

Raw material	Concentration (µg/kg)			
	Aflatoxin B1	Aflatoxin B2	Zearalenone	Ochratoxin
Wheat grits	20.88	17.32	30.82	18.2
Turnip root and leaves	3.6	2.8	0	3.7

Table 2. The mycotoxin concentration (µg/kg) at different periods of fermentation.

Mycotoxin	Concentration (µg/kg)				
	Day 0	Day 5	Day 10	Day 15	p-magnitude
Aflatoxin B1	21.43	15.40	9.35	5.21	≤0.05*
Aflatoxin B2	18.0	16.12	0.0	0.0	≤0.05*
Zearalenone	31.30	12.37	9.76	9.26	≤0.05*
Ochratoxin	18.4	13.88	9.76	9.16	≤0.05*

*Substantial variance utilizing multiple Duncan's range test

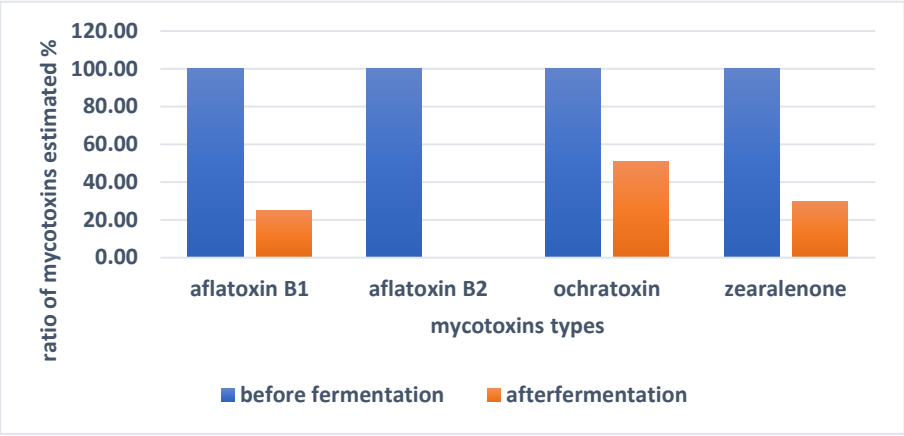

Figure 2. The mycotoxin levels before and at the fermentation duration end.

Table 3. Shows Log_{10} (CFU/g) of LAB on MRS and M17 during various periods of Tarasas fermentation.

Media	Fermentation time				
	Zero-day	5th day	10th day	15th day	p-magnitude
MRS	6.36[a]	8.88[a]	8.91[a]	8.96[a]	≤0.05*
M17	6.22[a]	7.56[a]	7.67[a]	7.70[a]	≤0.05*

* Substantial variance utilizing multiple Duncan's range test

Our results indicate that the initial pH of the Tarasas specimen was 5.7 with a titratable acidity of 1.05%. After 5 days of fermentation, the pH decreased to 3.2, accompanied by an acidity level of 1.96%. Throughout the final 10 days of fermentation, the pH ranged between 3.2 and 3.1, while acidity remained high at 1.97%, indicating a significant parameter for assessing the impact of lactic acid fermentation.

Previous research by Hunaefi et al. (2009) recorded pH levels around 4.3 and 3.8 in red cabbage fermented with LAB for 7 days. Another study noted a significant decrease in pH during the initial 5 days of fermentation, likely due to the increased concentration of fermentable sugars present in the Tarasas specimen. After the fifth day, the fermentation process began to reach its conclusion (Jabłońska-Ryś et al., 2023).

Essentially, the production of lactic acid persisted until all available fermentable substrates were exhausted. Consequently, the concentration of lactic acid in the specimens reached a plateau once all fermentable substrates were utilized. The observed decrease in pH during fermentation serves as crucial evidence of microbial activity and organic acid production, particularly lactic acid generated by LAB within the food medium (Tamang et al., 2016).

Moreover, the functional roles of microorganisms in fermented foods, along with pH changes, were examined. It was noted that the increase in acidity during fermentation plays a vital role in controlling the growth of pathogenic and spoilage microorganisms and inactivating mycotoxins (Boon et al., 2010). Therefore, our study observed a reduction in pH and an increase in titratable acidity in the Tarasas sample after 15 days. This finding is significant as it underscores the importance of acidity in the fermentation process, ensuring the preservation of Tarasas and enhancing its unique flavor, texture, and nutritional profile.

Furthermore, the concentration of added salt remained constant throughout the fermentation period. Salt is commonly incorporated during fermentation to inhibit the growth of harmful bacteria and promote the growth of beneficial ones (Ross et al., 2002). Maintaining a consistent salt concentration ensures the product's preservation and facilitates uninterrupted fermentation (Joint et al., 2017).

Lactobacillus, a beneficial bacteria commonly found in fermented foods, has been investigated for its potential effects on mycotoxins such as AFB1, ZEN, and OTA (Nada et al., 2022). Although research in this field is ongoing, there is evidence to suggest that certain strains of Lactobacillus may possess the ability to bind or degrade mycotoxins, thereby reducing their toxicity (Huang et al., 2017). However, the effectiveness of Lactobacilli in mitigating mycotoxin contamination may vary depending on several factors, including the specific strain of Lactobacillus, the concentration of mycotoxins, and the fermentation conditions.

Daglioğlu et al. (2022) observed that the counts of LAB in Tarhana increased from 10^3 to 10^5 –10^6 CFU/g in the initial 3 days of fermentation. However, during the later stages of fermentation, the counts declined to 10^4 CFU/g. Subsequent to drying, the counts were further reduced to 10^2 –10^3 CFU/g. These findings suggest that LAB counts can vary depending on the specimen, fermentation duration, conditions, and isolation medium. Including LAB in fermented foods enhances flavor, texture, and shelf life while contributing to improved preservation (Ibrahim et al., 2021).

In this study, mycotoxin reduction was observed to be 75% for AFB1, 100% for AFB2, and 70.4% and 49.22% for ZEN and OTA, respectively (see Figure 3). The significant decrease in mycotoxin levels is directly proportional to the fermentation period, with longer fermentation periods resulting in more substantial mycotoxin reduction (Phokane et al., 2019). Microorganisms including fungi, yeast, and bacteria play a role in reducing mycotoxin levels in fermented foods during fermentation.

The primary source of mycotoxins in the Tarasas product is the added wheat grits. A comparison of mycotoxin levels in wheat grits alone and in the non-fermented Tarasas product reveals significantly higher levels in the former, indicating a substantial reduction in mycotoxin levels during fermentation. Additionally, a small percentage of mycotoxins were present in the turnip roots and leaves before fermentation, including AFB1, AFB2, and OTA.

During fermentation, microorganisms may produce enzymes that break down mycotoxins or bind to them, thereby reducing their toxicity. For instance, LAB has been shown to degrade AFB1, OTA, and other mycotoxins in food products (Nasrollahzadeh et al., 2022). Furthermore, fermentation can alter pH levels and other environmental conditions, potentially inhibiting the growth of mycotoxin-producing fungi and reducing mycotoxin production.

Certain strains of Lactobacillus have been shown to bind AFB2 and OTA, thereby reducing their bioavailability and toxicity. These mechanisms may involve physical adsorption or enzymatic degradation by the bacteria (Saeed et al., 2013). However, the effectiveness of binding or degradation can vary among different strains of Lactobacillus (Daglioglu et al., 2002).

Enzymes secreted by LAB can transform AFB1, AFB2, ZEN, and OTA into less toxic compounds that may not be detectable by analytical devices, a process known as mycotoxin transformation or masking (Wang et al., 2022). The presence of mycotoxins in fermented foods can originate from various food components, such as wheat grains used in products like bread, beer, and sake, which may become contaminated with mycotoxins during storage, harvest, and processing (Muhialdin et al., 2020).

Lactobacillus plantarum, known for its probiotic properties, contributes to the fermentation process, influencing the taste, texture, and safety of the final product. This finding is consistent with previous research (Christensen et al., 2022), which also

highlights the ability of L. plantarum to reduce mycotoxin levels (Gänzle et al., 2015).

One limitation of our research is that when assessing variations in mycotoxin levels between the raw material and the finished product (maize), we considered the entire ogi processing procedure. Instead of examining mycotoxin levels at each stage of fermentation, we determined the initial and final mycotoxin levels by accounting for the storage conditions of the ogi processors in various facilities, differing durations of storage, steeping times, and the lactic acid fermentation step.

In future studies, it would be beneficial to investigate how mycotoxin levels fluctuate at each stage of the process. Okeke et al. (2015) observed that longer storage times can lead to increased mycotoxin levels, a finding supported by a previous study by Liverpool-Tasie et al. (2019).

Conclusion

In conclusion, the utilization of LAB in food fermentation showed considerable promise for reducing mycotoxin levels. LAB possess enzymatic capabilities and metabolic pathways that facilitate the degradation, modification, or sequestration of mycotoxins during fermentation. Through mechanisms such as enzymatic degradation, adsorption onto bacterial cell walls, and modification of environmental conditions, LAB effectively mitigate mycotoxin contamination in fermented foods.

Author contribution

B.J.A. T.A.W. conducted analysis, analyzed data, reviewed, edited, and prepared the manuscript. All authors approved the manuscuprt for publication.

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Competing financial interests

The authors have no conflict of interest.

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