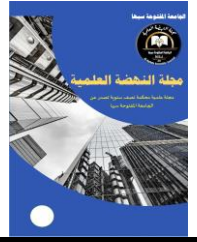




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Detection of Aflatoxigenic fungi in dried fruits from the commercial markets in Ajdabiya city.

Tofaha Abdalhamed Salem Abdalrazig¹ and Abdalla M. El-Alwany²

¹Higher Institute of Medical Sciences and Technology, Ajdabiya.

²Department of Plant Protection, Faculty of Agriculture, University of Benghazi

* Email: tofaalmogrby@gmail.com

Abstract

This study was conducted to detect fungal contamination in dried fruits sold in commercial markets in Ajdabiya, with a focus on identifying Aflatoxigenic fungi. A total of 29 samples of yellow raisins, black raisins, dried figs, and dried apricots were collected from local markets between July and October 2024. Fungal examinations were performed using culture-based techniques and chemical detection methods, including the Ammonium Hydroxide Vapor Test and the Lateral Flow Immunoassay (LFIA) test for aflatoxin detection. The results revealed widespread fungal contamination, particularly *Aspergillus flavus* and *Aspergillus niger*, which are known for their mycotoxin production. The Ammonium Hydroxide Vapor Test indicated the presence of aflatoxin-producing fungi in 100% of dried fig and dried apricot samples, 62.5% of yellow raisin samples, and 50% of black raisin samples. However, the LFIA test did not detect aflatoxins in any of the samples, suggesting that toxin levels may be below the detection threshold or that environmental conditions were not conducive to aflatoxin production. This study highlights the importance of improved storage conditions and regular monitoring to ensure food safety.

Keywords: Dried fruits, fungal contamination, aflatoxins, *Aspergillus flavus*, *Aspergillus niger*.

الكشف عن الفطريات المنتجة للأفلاتوكسينات في الفواكه المجففة من الأسواق التجارية في مدينة اجدابيا

تفاحة عبدالحامد سالم عبدالرازق¹ و عبدالله محمد صالح العلواني²

¹المعهد العالي للعلوم الطبية والتقنية، أجدابيا

²قسم وقاية النبات، كلية الزراعة، جامعة بنغازي

* البريد الإلكتروني: tofaalmogrby@gmail.com

المخلص

أجريت هذه الدراسة للكشف عن التلوث الفطري في الفواكه المجففة المباعة في الأسواق التجارية بمدينة إجدابيا مع التركيز على تحديد الفطريات المنتجة للأفلاتوكسين. تم جمع 29 عينة من الزبيب الأصفر، الزبيب الأسود، التين المجفف، والمشمش المجفف من الأسواق المحلية خلال الفترة من يوليو إلى أكتوبر 2024. تمت الفحوصات الفطرية باستخدام تقنيات الزراعة المخبرية واختبارات الكشف الكيميائي، بما في ذلك اختبار بخار هيدروكسيد الأمونيوم واختبار التدفق الجانبي المناعي السريع (LFIA) للكشف عن الأفلاتوكسين. أظهرت النتائج انتشاراً واسعاً للتلوث الفطري، خاصة من نوعي *Aspergillus flavus* و *Aspergillus niger*، المعروفين بقدرتهم على إنتاج السموم الفطرية. أشار اختبار بخار هيدروكسيد

الأمونيوم إلى وجود فطريات منتجة للأفلاتوكسين بنسبة 100% في عينات التين والمشمش المجففين، و 62.5% في الزبيب الأصفر، و 50% في الزبيب الأسود. ومع ذلك، لم يتم الكشف عن وجود الأفلاتوكسين عبر اختبار LFIA، مما قد يشير إلى أن مستويات السموم كانت دون حد الكشف أو أن الظروف البيئية لم تكن مناسبة لإنتاجها. تؤكد هذه الدراسة أهمية تحسين ظروف التخزين وإجراء مراقبة دورية لضمان سلامة الأغذية.

الكلمات المفتاحية: الفواكه المجففة، التلوث الفطري، الأفلاتوكسين، *Aspergillus niger*، *Aspergillus flavus*.

Introduction

Dried fruits are measured as the best source of "essential nutrients" as they provide "protein, fatty acids, potassium, dietary fibres, and bioactive compounds". They also promote human health by lowering the risk of "obesity, cardiovascular disease, and diabetes (Carughi et al. 2015). Dried fruits have a longer shelf life than "fresh fruits"; they are the best alternative to fresh fruits for long-term storage. They had been contaminated through or after harvesting, storage, and transition (Masood et al. 2015). Fungi are extraordinary in their ability to produce numerous natural products known as fungal secondary metabolites, which exhibit various biological activities (Boruta, 2017; Naranjo and Gabaldón, 2020). Considering the reported biological properties of fungi toward human health, they can be classified as toxic "mycotoxins" or non-toxic metabolites (Eshelli et al. 2018).

Mycotoxins are natural contaminants of food commodities and pose a measurable health risk to animal and human health (Peraica et al. 1999). Health risks are classified based on organs that are affected by the toxins, for instance, they possess carcinogenic, immunosuppressive, hepatotoxic, nephrotoxic, and neurotoxic effects (Peraica et al. 1999 & Bennett and Klich, 2003). Hundreds of mycotoxins have been identified. (Eshelli et al. 2018 & Janik et al. 2020). The production of toxic secondary metabolites (mycotoxins) is the main problem associated with fungal attacks in dried fruits, particularly aflatoxin. The International Agency for Research on Cancer (IARC) classifies Aflatoxins (AFs) as Group I carcinogens produced by *Aspergillus flavus* and *A. parasiticus* (Scott, 1993). Mycotoxins are toxic secondary metabolites produced by certain filamentous fungi (molds) these low molecular weight compounds (usually less than 1000 Daltons), these metabolites are stable chemical compound and persist during processing and heat treatment so they contaminate food and animal feed causing a broad spectrum of adverse effects both in human and animals (Alshannaq & Yu, 2017). Laboratory and field experiments showed that many common fungi that cause both food spoilage and plant disease can produce a vast array of more or less toxic metabolites. The most commonly induced diseases include liver cancer, kidney failure, and effects on the brain or nervous system. Perhaps the most important point is that acute toxicity is rare: toxicity due to mycotoxins is usually insidious, without any overt indication of effects on health in the short term. For this reason, the health effects of mycotoxins are among the most neglected areas of medical science, it is generally agreed that the most important mycotoxins are: aflatoxins, Ochratoxin A, fumonisins, deoxynivalenol, and zearalenone. (John I. Pitt, 2013). Aflatoxin is the most commonly known mycotoxin associated with storage development, however, a variety of other mycotoxins can also cause problems, the storage temperature, presence of oxygen, humidity, and gaseous composition are the major important factors influencing the development of fungi during storage (Campbell et al., 2003; Janik et al., 2020)

Mycotoxins are non-protein compounds that give off bright colors when separated on chromatographic separation plates and exposing the plates to ultraviolet rays. Some of them give off a blue fluorescence, like aflatoxin toxins, and some give off a green fluorescence, like

Ochratoxin. It dissolves well in organic solvents such as phenol and methanol, but its solubility in water is limited. It contains a lactone ring in its chemical structure and does not decompose, and is resistant to high temperatures such as boiling and pasteurization (Melvin, 2012).

As reported by "USDA-Economic Research Service, 18.9 billion pounds of fruits and vegetables are lost annually due to spoilage by fungi such as *Alternaria*, *Aspergillus*, *Fusarium*, *Mucor*, *Rhizopus*, and *Penicillium* etc. Ingestion of food contaminated with fungi may contribute to the formation of many health-related concerns, such as mycoses, which can vary from moderate to life-threatening clinical diseases, notably in immune compromised people. (Barth et al. 2009).

The mycotoxins that receive the most significant concern from scientists are aflatoxin B1 and M1, cyclopiazonic acid, ochratoxin A, patulin, T-2 toxin, deoxynivalenol, zearalenone, ergot alkaloids, and macrocyclic trichothecenes, due to their health and economic effects. For instance, aflatoxin B1 is classified as the most potent hepatocarcinogen and mutagen (Magnussen and Parsi, 2013; Tola and Kebede, 2016). Therefore, researchers from different fields work together towards understanding the fungal secondary metabolites in terms of their regulation, function, and applications, and evaluate their toxicity (Karwehl and Stadler, 2016 & Grove et al. 1952).

This study investigates the fungal contamination of dried fruits sold in Ajdabiya, with a particular focus on products displayed openly. Given the health risks associated with aflatoxin exposure, the research aims to detect fungal presence and assess aflatoxin contamination in these dried fruits using available resources.

Materials and methods

Study area: This study was conducted in the local markets of Ajdabiya, a city situated along the northern coastal road at 30.7575° N, 20.2230° E. Located 13 km from the seashore, Ajdabiya is the largest urban center in the region. It lies 870 km east of Tripoli and 160 km south of Benghazi, making it a significant hub within the area.

Sampling: Twenty-nine samples of dried fruits—including yellow raisins, black raisins, dried figs, and dried apricots—were randomly collected from various local shops in Ajdabiya at different time intervals between July 2024 and October 2024. Each sample was placed in sterile, vacuum-packed plastic bags, which were properly labeled, sealed, and immediately transported to the laboratory for further analysis. The samples were stored in a cool environment at 3–5°C for a maximum of three days. Prior to examination, the dried fruits were surface-sterilized using 2% sodium hypochlorite for two minutes, then diluted with distilled water three times to achieve a 1% concentration. Finally, they were rinsed in 100 mL of distilled water and left to dry. Total sample of dried fruits (150g) for each type.

Place of study: This study was conducted in the laboratories of the Higher Institute of Medical Sciences and Technology, Ajdabiya.

Source of Culture media: Potato Dextrose Agar (PDA): Manufacture: Linofilchem S.r.l. Via scozia, zona industriale 64026 Roseto degli Abruzzi (TE) Italy. Sabouraud Dextrose Agar (SDA): Manufacture: Linofilchem S.r.l. Via scozia, zona industriale 64026 Roseto degli Abruzzi (TE) Italy.

Preparation of media: 42 g of PDA Medium and 65 g of SDA medium were Suspend in one liter of distilled water, autoclaved at 121° C for 15 minutes and poured into petri dishes or tubes for slants.

Fungi cultivation and isolation: Petri dishes containing suitable nutrient media, such as Potato Dextrose Agar (PDA) and Sabouraud Dextrose Agar (SDA), were prepared for fungal growth. The dried fruits were cut into large pieces, and surface-sterilized by immersion in 1% sodium hypochlorite for three minutes, followed by three consecutive washes with distilled water. The samples were then dried using absorbent paper and placed on filter papers until completely dry. Once dried, the samples were placed inside the prepared Petri dishes, which were then covered and incubated at 25–27°C (±2°C) for 5–7 days, allowing for fungal growth. After fungal growth was established, a portion of the fungal colonies was transferred to fresh nutrient media to obtain pure isolates. These were then incubated again at 25–27°C for 5–7 days to facilitate further testing. Chemical analyses, including the Ammonium Hydroxide Vapor Test and Lateral Flow Strip Test, were then performed to assess fungal characteristics.

Identification of isolated fungi: The isolated fungal genera are identified by: Macroscopic Characteristics; based on morphological and cultural characteristics (Color, pigmentation and reverse of the colony), and Microscopic Characteristics in which, the mycelium type is a key taxonomic feature for fungal species identification, as noted by Ainsworth (1976), Samson et al. (2010, 2014), Visagie et al. (2014), and Pitt & Hocking (2009). To examine fungal structures microscopically, the wet mount technique was employed. A drop of lactophenol cotton blue (LPCB) was placed on a clean, grease-free slide. Using a sterile fungal needle, a small portion of fungal growth was carefully transferred into the LPCB drop. A cover slip was then placed over the sample, and the slide was examined under a microscope at 10x and 40x magnification, following the method described by Pitt & Hocking (1997). Developing fungal isolates were purified and maintained on slanted Potato Dextrose Agar (PDA) medium for further study. Species identifications will be according to the keys and descriptions provided by (Pitt & Hocking, 2009; Carughi, 2015 and Samson et al. 2007).

Frequency percentage %: The isolation frequency of genera from samples was calculated by the following formula.

$$\text{Isolation frequency \%} = \frac{\text{Number of colonies on which fungus appeared}}{\text{Total number of colonies}} \times 100$$

Statistical Analysis:

The fungal isolation frequencies were statistically analyzed using one-way analysis of variance (ANOVA), followed by Tukey's Honest Significant Difference (HSD) test to compare the mean differences at a significance level of $p < 0.05$. All statistical analyses were conducted according to the method described by Zar (2010).

Detection of Aflatoxin producing fungi: Aflatoxin producing strains of *Aspergillus* spp. can be detected by two methods i.e., cultural methods and analytical methods;

a) The Ammonium Hydroxide Vapor Test, introduced by Saito & Machida (1999), is a rapid and sensitive method for distinguishing aflatoxin-producing and non-producing strains of *Aspergillus flavus* and *Aspergillus parasiticus*. In this method, a single fungal colony was inoculated at the center of a Potato Dextrose Agar (PDA) plate and allowed to grow. The Petri dish was then inverted, and 1–2 drops of concentrated ammonium hydroxide were added to the inside of the lid. A plum-red color change on the reverse side of the colony indicated an aflatoxin-producing strain, while the absence of color change confirmed a non-producing strain (Abbas et al., 2004).

b) Analytical methods; Lateral Flow strip (LFIA): The Lateral Flow Strip Assay (LFIA) is a rapid immunochromatographic technology that integrates chromatography with

immunoassay, gaining significant attention in recent years. This method commonly utilizes nanoparticles, particularly gold nanoparticles (AuNPs), as detector reagents. A lateral flow strip consists of three membrane pads—an absorbent pad, conjugate-release pad, and sample pad—along with a nitrocellulose (NC) membrane. When a test buffer containing analytes is introduced at the absorbent pad, capillary action transports it through the strip. Upon reaching the Au conjugate-release pad, the gold-labeled antibodies (Au-labeled Abs) specifically bind to the analytes. As the complex migrates along the NC membrane, it interacts with immobilized antigens (Ag), generating a signal. The test result interpretation is as follows:

- If the analyte is present, the complex continues migrating and binds to the secondary antibodies at the control line, with no red signal appearing on the test line.
- If the analyte is absent, some Au-labeled Abs bind to the immobilized antigen (aflatoxin-protein conjugate) at the test line, while the remaining Au-labeled Abs bind to the control antibodies, resulting in a visible red signal (Li et al., 2009).

Total Aflatoxins Test: The Total Aflatoxins Test consists of three main steps: sample preparation, operation procedures, and result interpretation.

a) Sample Preparation: A 1 ± 0.05 g portion of the crushed sample was weighed into a 15 mL centrifuge tube. 3 mL of sample extraction buffer was added, and the mixture was shaken vigorously by hand or using a vortex mixer for 3 minutes. The sample was then centrifuged at 4,000 r/min at room temperature for 10 minutes. The clear upper liquid layer was carefully collected for testing.

b) Operation Procedures: 200 μ L of the test sample was added to the micro-wells and mixed thoroughly by pipetting five times until no visible solid particles remained. The mixture was incubated at room temperature (20–25°C) for 3 minutes. A test dipstick was inserted into the micro-well, ensuring that the "MAX" end was fully submerged in the solution. The dipstick remained in the micro-well for 5–8 minutes, after which the result was read. Results obtained outside this timeframe were considered invalid.

c) Test Result Interpretation:

- Negative Result: The T line appears darker than or the same color as the C line, indicating that no total aflatoxins were detected or their concentration was below the detection limit.
- Positive Result: The T line appears significantly lighter than the C line or is completely absent, indicating that the total aflatoxin concentration is at or above the detection limit.
- Invalid Result: If the C line does not appear wine red, the test is invalid due to expired test strips, improper handling, or a malfunction in the test procedure.

Results

Identification of isolated fungi: The identification of the isolated fungal genera was carried out based on macro- and microscopic characteristics. This process involved analyzing morphological and cultural traits, including colony color, pigmentation, and reverse colony appearance. The classification was further supported by specialized references in fungal taxonomy, leading to the identification of the following fungal genera: *Aspergillus niger* it was appeared on (Dried Yellow raisins , Dried Black raisins , Dry Fig and Dried apricot samples , as in Fig. 1 (a,b,c,g,) and Fig. 2 (a,b,c,d,e,l). *Aspergillus flavus* was appeared in Dried Yellow raisins , dried Black raisins , dry Fig and dried apricot samples , as in Fig. 1 (a,b,c,) and Fig. 2 (c,d,e,f,g,j,). *Yeasts(Saccharomyces bayanus)* appeared in Dried Yellow raisins , Dried Black raisins , Dry Fig and Dried apricot samples , as in Fig. 1 (b,c,d,f,h) and Fig. 2 (b,d,l). *Yeasts (Saccharomyces cerevisiae)* appeared in Dried Yellow raisins only as in Fig. 1 (g) and Fig. 2

(f). *Rhizopus sp* appeared in Dried Black raisins and Dry Fig samples. As in Fig.1 (d) and Fig. 2 (h). *Cladosporium cladosporioides* appeared in Dried Black raisins and Dry Fig samples as in Fig. 1 (e) and Fig. 2 (k). *Glomus sp*. it only appeared in Dried Black raisin samples, as in Fig. 1 (h) and Fig. 2 (j).

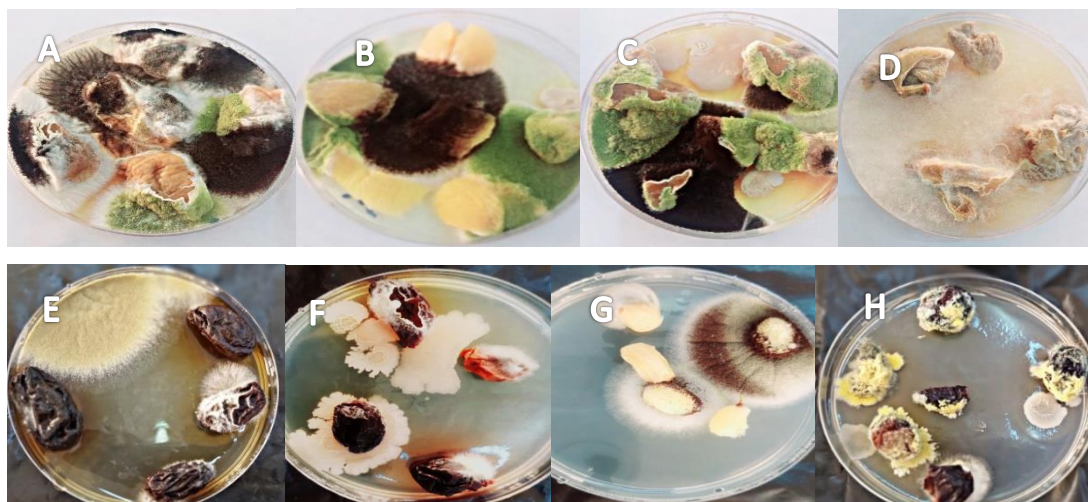


Figure (1) shows (A,B,C,G) *Aspergillus niger* , (B,C,D,F,H) *Saccharomyces bayanus*, (G) *S. cerevisiae*, (A,B,C) *Aspergillus flavus* , (D) *Rhizopus sp*, (E) *Cladosporium cladosporioides*) and (H) *Glomus sp*, growth on culture media.

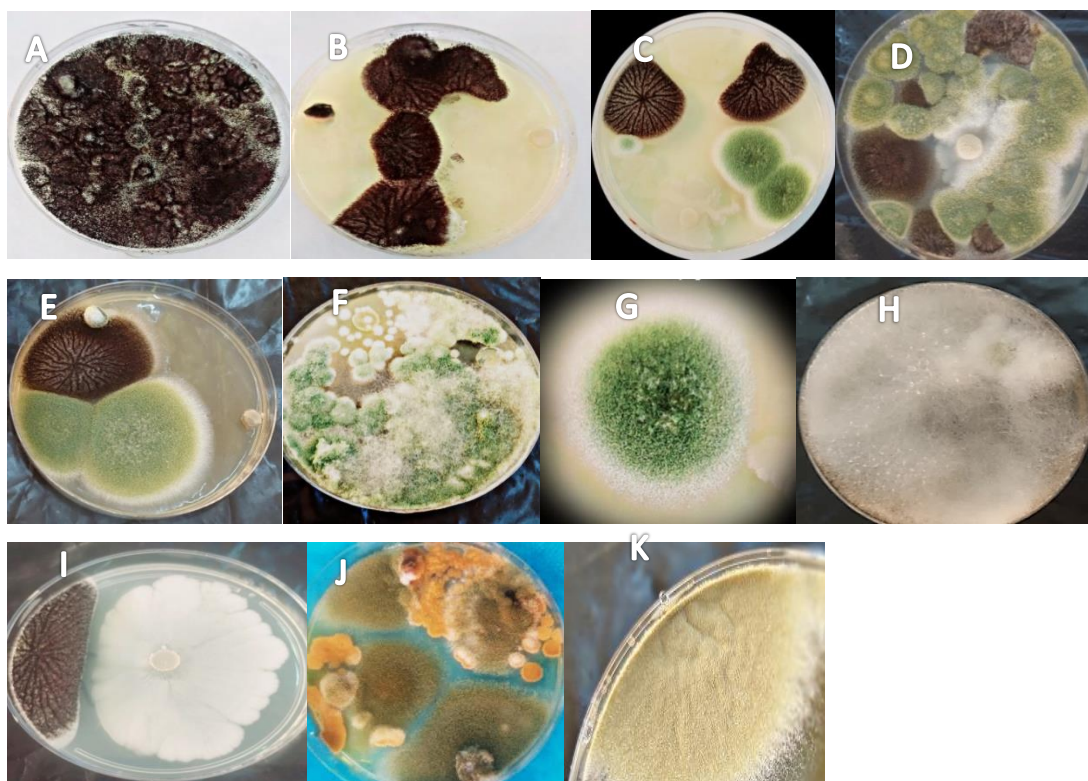


Figure (2) Pure isolation of Colons of *Aspergillus niger* as in (a,b,d,e,i), *Saccharomyces bayanus* as in (b,d,i) and *S. cerevisiae* as in (F) *Aspergillus flavus* as in (c,d,e,f,g,j) , *Rhizopus sp* as in (h), *Cladosporium cladosporioides* as in (k) and *Glomus sp* as in (j) grown on SDA at 30°C for 7 days

Isolation frequency:

The table (1) presents the frequency (means) of different fungal genera detected in selected dried foods, specifically yellow raisins, black raisins, dry figs, and apricots. The statistical significance of differences among the frequencies was determined:

Aspergillus niger: The highest frequency was observed in dry figs (45), which is significantly higher than in yellow raisins (33.63) and apricots (28.04). No significant difference was found between black raisins (34) and yellow raisins (33.63).

Aspergillus flavus: The highest occurrence was in apricots (53.37), which is significantly higher than in black raisins (26.65) and yellow raisins (45.75). Yellow raisins and dry figs (32.76) showed no significant difference. Black raisins (26.65) had an intermediate frequency, with partial overlap in statistical significance between apricots and dry figs.

***Saccharomyces bayanus* (*S. bayanus*)**: The highest frequency was recorded in black raisins (30.82), which is significantly higher than dry figs (21.06) and apricots (24.95). Yellow raisins (19.58) had the lowest frequency and were significantly different from black raisins but not from dry figs.

***Saccharomyces cerevisiae* (*S. cerevisiae*)**: This fungus was only detected in yellow raisins (13.73c) and absent in all other dried foods.

***Rhizopus* sp**: Present only in black raisins and dry figs at similar frequencies (11.17 and 10.96), indicating no significant difference between these two dried foods.

Cladosporium cladosporioides: Found in black raisins and dry figs with identical frequencies (11.17 and 10.96), showing no significant difference.

***Glomus* sp**: Detected only in black raisins at a frequency of 23.77, indicating no direct comparison with other dried foods. These findings indicate that different dried foods harbor distinct fungal populations, with significant variations in their occurrence.

Table (1). Fungal Frequency of detected fungi in the selected dried foods

Fungal genera	Frequency (means) of dried foods			
	Yellow raisins	Black raisins	Dry fig	Apricot
<i>Aspergillus niger</i>	33.63 ^b	34 ^a	45 ^a	28.04 ^b
<i>Aspergillus flavus</i>	45.75 ^a	26.65 ^{ab}	32.76 ^b	53.37 ^a
<i>S. bayanus</i>	19.58 ^c	30.82 ^a	21.06 ^c	24.95 ^b
<i>S. cerevisiae</i>	13.73 ^c	-	-	-
<i>Rhizopus</i> sp.	-	11.17 ^c	10.96 ^d	-
<i>Cladosporium cladosporioides</i>	-	11.17 ^c	10.96 ^d	-
<i>Glomus</i> sp.	-	23.77 ^b	-	-

Values followed by same letters in the same column within frequency mean don't differ significantly according to Tukey HSD test at $\alpha=0.05$.

Detection of Aflatoxins

Two tests were conducted to detect aflatoxin-producing strains in all dried samples: **Ammonium Hydroxide Vapor Test** for identifying aflatoxin-producing fungal strains by observing color changes in fungal colonies. A positive reaction indicates that the fungi can produce aflatoxins, and **Lateral Flow Immunoassay (LFIA)** test for detecting total aflatoxin residues; this **rapid immunological test** detects total aflatoxin residues in dried fruit samples. A negative result suggests either the absence of aflatoxins or levels below the detection limit.

The Ammonia Test results (Table 2) showed that dried figs and dried apricots had 100% positive results, indicating a high prevalence of aflatoxin-producing fungi. Yellow raisins (62.5%) and black raisins (50%) also showed positive ammonia test results, but at lower percentages compared to dried figs and apricots. Despite the high percentage of positive ammonia tests, all samples tested negative in the LFIA test, suggesting: Aflatoxin levels might be below the LFIA detection limit, or the detected fungal strains might not be actively producing aflatoxins or the drying and storage conditions could have influenced aflatoxin production.

Table (2): Aflatoxin detection results in dried food samples

Sample type	Ammonium Hydroxide test (positive %)	(LFIA) Test (positive %)
Yellow Raisins	(5/8) 62.5%	0%
Black raisins	(4/8) 50%	0%
Dry fig	(8/8) 100%	0%
Dried Apricot	(5/5) 100%	0%

Discussion

The results of this study highlight the significant presence of fungal contamination in dried fruits sold in Ajdabiya, with *Aspergillus* spp., *Saccharomyces* spp., and *Rhizopus* spp. being the most commonly isolated genera. Among these, *Aspergillus flavus* and *Aspergillus niger* are of particular concern due to their ability to produce mycotoxins, especially aflatoxins. The high prevalence of these fungi, especially in dried figs and apricots, underscores the importance of monitoring and controlling fungal contamination in food products. Comparing these findings with previous studies, the results align with recent research conducted by Tola & Kebede (2016), which highlighted the high prevalence of aflatoxigenic *Aspergillus* species in dried fruits and nuts, particularly in markets where storage conditions were suboptimal. Similarly, a study by Alshannaq & Yu (2017) reported that *Aspergillus flavus* was the dominant species in dried fruits from Middle Eastern markets, emphasizing the role of temperature and humidity in fungal proliferation. Our results further support these conclusions, demonstrating a strong correlation between storage conditions and fungal contamination.

However, this study diverges from findings reported by Janik et al. (2020), who observed significantly higher aflatoxin contamination levels in dried fruits from markets with poor regulatory enforcement. In contrast, while the Ammonium Hydroxide Vapor Test confirmed the presence of aflatoxin-producing fungi in our study, the LFIA test did not detect aflatoxin residues in any of the samples. This suggests that while fungal contamination is present, actual toxin production may be influenced by environmental factors, storage duration, or competitive microbial interactions that suppress aflatoxin synthesis. Moreover, research by Masood et al. (2015) found that dried figs and apricots were particularly susceptible to fungal growth due to their higher moisture-retaining properties, a finding that closely matches our results, where dried figs and apricots had the highest rates of fungal contamination. These similarities reinforce the importance of targeted interventions for these specific dried fruit types.

The detection of aflatoxin-producing fungi through the Ammonium Hydroxide Vapor Test showed high positivity rates, particularly in dried figs and apricots (100%). However, the LFIA test for total aflatoxin residues yielded negative results across all samples. This discrepancy suggests that while aflatoxin-producing fungi are present, the actual toxin levels may be below the detection limit or not actively produced under current storage and processing conditions. Factors such as moisture content, temperature, and oxygen availability play crucial roles in mycotoxin production, and variations in these conditions may influence toxin synthesis. These results are consistent with recent findings by Saleh et al. (2022) and Yousef et al. (2023), who emphasized the critical role of storage conditions in controlling fungal growth and aflatoxin contamination in dried fruits."

Furthermore, the findings align with previous research emphasizing the risks associated with fungal contamination in stored food products. *Aspergillus flavus* is well-documented as a major producer of aflatoxins, which are highly carcinogenic and pose significant health risks. The absence of detectable aflatoxin levels in the LFIA test does not eliminate the possibility of contamination, as mycotoxin production can be sporadic and influenced by environmental conditions.

These results emphasize the need for strict food safety regulations and proper storage practices to minimize fungal growth and mycotoxin contamination. Regular monitoring of dried fruit products, along with improved drying and storage conditions, can help mitigate the risks associated with fungal contamination. Future studies should focus on long-term surveillance, environmental factors affecting mycotoxin production, and the implementation of more sensitive analytical techniques to confirm toxin presence. Future research should focus on evaluating seasonal variations in fungal contamination, as well as exploring natural antifungal treatments to enhance the safety of dried fruit products

Conclusion

This study provides valuable insights into the fungal contamination of dried fruits sold in Ajdabiya, highlighting the presence of several fungal genera, particularly *Aspergillus flavus* and *Aspergillus niger*, which are known for their potential to produce aflatoxins. The high prevalence of these fungi, especially in dried figs and apricots, raises concerns regarding food safety and public health. Although the Ammonium Hydroxide Vapor Test indicated the presence of aflatoxin-producing fungi in a significant proportion of samples, the LFIA test did not detect aflatoxin residues, suggesting that toxin levels may be below the detection threshold or that environmental conditions were not conducive to toxin production. These findings emphasize the importance of continuous monitoring, improved storage conditions, and stringent food safety regulations to mitigate fungal contamination and mycotoxin risks.

Recommendations

Based on the findings of this study, the following recommendations are proposed to minimize fungal contamination and mycotoxin risks in dried fruits:

1. **Improved Storage Conditions:** Maintain optimal storage conditions by controlling temperature and humidity to prevent fungal growth and aflatoxin production. Store dried fruits in airtight containers to reduce exposure to oxygen and moisture.
2. **Regular Monitoring and Testing:** Implement routine fungal contamination and mycotoxin screening using sensitive analytical methods. Use advanced detection techniques, such as high-performance liquid chromatography (HPLC) or ELISA, for accurate aflatoxin quantification.
3. **Good Manufacturing Practices (GMP) and Hygiene Control:** Ensure proper handling, packaging, and transportation of dried fruits to minimize contamination. Educate vendors and food processors on hygiene practices and fungal contamination risks.
4. **Public Awareness and Consumer Education:** Raise awareness among consumers about the risks of consuming mold-contaminated dried fruits. Encourage the purchase of properly packaged and certified dried fruits from reputable sources.
5. **Regulatory Measures and Quality Standards:** Establish stricter regulations on fungal contamination and mycotoxin limits in dried fruits. Enforce compliance with international food safety standards to ensure product quality and consumer protection.
6. **Further Research:** Conduct long-term studies on environmental factors affecting mycotoxin production. Explore natural antifungal treatments and preservation methods to reduce fungal contamination.

Ethics:

The authors declare that they have no conflicts of interest in this article. The data are original and from experiments conducted by the Authors of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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