Al-Farouk journal of sciences
Volume (2), Issue (4) (Spt, 2026)
ISSN: 3135-2359

مجلة الفاروق للعلوم
المجلد (2) العدد 4 سبتمبر 2026
ردمد: 3135-2359

Study Effect Plant extract Ziziphus spina Christi and Curcuma longa fungi growth Aspergillus niger Assocsiated red Onion in Vitro

Hamdiyah R. Alhaaj. Omar[1] , Alajilyua alruteeb[2] ,Fatimah Nouri Allafi[3]
[3-2] [1]Department of Zoology, Faculty of Science and Natural Resources, University of Al-Jafara, Libya
*[*1]Corresponding Author's Email: hamdya@aju.edu.ly https://orcid.org/0009-0009-5608-9909*

Received: 15/8/2026 Revised: 17/8/2026 Accepted: 05/9/2026 Publication: 31/10/2026

Abstract:

The fungus *Aspergillus niger* is an important fungal pathogen associated with black mold disease of onion bulbs, particularly during storage. This study was conducted to isolate and identify *A. niger* from infected red onion bulbs showing characteristic symptoms of black mold and to evaluate the inhibitory effects of sidr (*Ziziphus spina-Christi*) and turmeric (*Curcuma longa*) plant extracts against the pathogenic fungus under laboratory conditions. The antifungal activity of the plant extracts was evaluated using the filtrate method at concentrations of 25% and 50%, and fungal growth inhibition was assessed after 7 and 14 days. The extract of *Ziziphus spina-Christi* inhibited the growth of *A. niger.* At a concentration of 25%, the inhibition percentages were 17.1% and 33.5% after 7 and 14 days, respectively, while at 50%, inhibition reached 42.1% and 59.6%, respectively. The Curcuma longa extract also showed inhibitory activity against *A. niger*. At 25%, the inhibition percentages were 24.9% and 24.8% after 7 and 14 days, respectively, whereas at 50%, the inhibition percentages were 32.8% and 45.9%, respectively. Overall, the results demonstrate that both plant extracts exhibited antifungal activity against *A. niger*, with the highest inhibition generally observed at the 50% concentration. The results suggest that *Ziziphus spina-Christi* and *Curcuma longa* extracts have potential as natural antifungal agents for reducing the growth of *A. niger* associated with red onion bulbs.

Key words : *Aspergillus niger , ZIziphus spina christi , Curcuma longa*

الملخص

يُعد الفطر *Aspergillus niger* من الفطريات الممرضة المرتبطة بمرض العفن الأسود في بصيلات البصل، وخاصةً أثناء فترة التخزين .أجريت هذه الدراسة بهدف عزل وتعريف الفطر *A . niger* من بصيلات البصل الأحمر المصابة، والتي أظهرت أعراضًا واضحة لمرض العفن الأسود، بالإضافة إلى دراسة التأثير التثبيطي لمستخلصي نبات السدر (*Ziziphus spina-Christi*) والكركم (*Curcuma longa*) ضد الفطر الممرض تحت الظروف المختبرية.

تم تقييم النشاط المضاد للفطريات للمستخلصات النباتية باستخدام طريقة الراشح، وذلك بتركيزين 25 % و50%، وتم حساب نسبة تثبيط نمو الفطر بعد 7 و 14يومًا .أظهر مستخلص نبات السدر (*Ziziphus spina-Christi*) قدرة على تثبيط نمو الفطر *niger A* .فعند تركيز 25 %بلغت نسبة التثبيط 17 % بعد 7 أيام و 33.5 % بعد 14 يومًا، بينما بلغت عند تركيز 50 %نسبة 42 % .بعد 7 أيام و 59.6%بعد 14 يومًا.

كما أظهر مستخلص الكركم (*Curcuma longa*) تأثيرًا تثبيطيًا ضد الفطر *niger A* فعند تركيز 25 % بلغت نسبة التثبيط 9.24 %بعد 7 أيام و 24.8% بعد 14 يومًا، في حين بلغت عند تركيز 50 %نسبة 8.32 %بعد 7أيام و 45.9%بعد 14 يومًا.

وبصفة عامة، أظهرت النتائج أن كلا المستخلصين النباتيين يمتلكان تأثيرًا مضادًا لنمو الفطر *niger A*، وكانت أعلى نسبة تثبيط مسجلة 59 % باستخدام مستخلص السدر بتركيز 50 %بعد 14 يومًا .وتشير هذه النتائج إلى

Introduction:

Onion (*Allium cepa*) is one of the most important agricultural crops and a basic vegetable relied upon in human daily diets due to its high nutritional value. It is also known in alternative or traditional medicine for containing bioactive compounds with multiple therapeutic properties. It contains a range of vitamins such as vitamin C, as well as minerals, fiber, and antioxidants that play an important role in promoting human health and preventing many diseases. Moreover, it is characterized by antibacterial and antifungal properties, which make it of particular interest in scientific studies related to resistance to microorganisms. Despite the great economic and nutritional importance of onion, it is susceptible to infection by many microorganisms, especially fungi, which negatively affect its growth and quality during storage. One of the most prominent of these fungi is *Aspergillus niger*, known as black mould, a common fungus causing onion spoilage; it leads to rot of bulbs, vegetables, and fruits and to notable economic losses (FAO ،2020)

In the context of the global trend toward using natural and safe alternatives instead of chemical pesticides due to their negative effects on health and the environment, interest in natural alternatives has increased. Among these, some plant extracts have shown antifungal effects, such as *Ziziphus spina-christi* and *Curcuma longa*, which contain antifungal constituents and bioactive compounds such as phenols and antioxidant substances. Hence the importance of this study in evaluating the efficacy of these extracts in reducing the growth of *Aspergillus niger* associated with red onion, with the aim of finding safe and effective means to preserve crop quality and reduce economic and health losses (Maziere, M., et al. (2025))

The significance of this fungus is not limited to causing external damage known as black mould; its effects also extend to inducing internal tissue changes. This fungus is characterized by a high capacity for rapid spread under favorable environmental conditions such as high humidity, elevated temperatures, poor ventilation, inadequate storage, or the presence of wounds or abrasions on the produce. It can contribute to reduced product quality and suitability for consumption, and its proliferation in storage facilities makes control difficult, especially where traditional storage methods are used. Besides causing food spoilage, it can produce certain mycotoxins under specific conditions, which may pose a risk to human health if contaminated foods are consumed, particularly among immunocompromised individuals. One of the most important diseases associated with Aspergillus is aspergillosis, a fungal disease that can affect the respiratory system following inhalation of airborne conidia, leading to lung inflammation. The fungus may also cause otomycosis (external ear infection), where it grows in the ear canal causing itching, pain, and discharge, and in some cases may lead to skin infections when contaminated or wounded skin is contacted. This fungus can contribute to allergic reactions such as asthma and allergic sinusitis due to

continuous exposure to its conidia, and in rare cases it can cause endocarditis, an infection of the heart valves; this usually occurs in immunocompromised patients, those with previous cardiac surgeries, or patients with prosthetic valves, via the respiratory tract or bloodstream (systemic infection), presenting with persistent fever, severe fatigue, shortness of breath, and irregular heartbeats. Such complications are very rare in healthy individuals but are serious when they occur and require prompt medical treatment (Stemler, J., et al. (2024)

Therefore, following safety precautions is essential to reduce risk, especially in humid places or when handling plant materials. Important precautions include maintaining personal hygiene and washing hands thoroughly after contact with soil or infected vegetables, wearing gloves and masks when handling samples that may contain the fungus-particularly in laboratories-storing vegetables and fruits in dry, well-ventilated areas to reduce fungal growth, disposing of any products showing mould or abrasions, and avoiding inhalation of dust or fungal conidia by using protective measures. Surfaces and storage areas should be cleaned and disinfected periodically to limit fungal spread. These measures are among the most important preventive means that help reduce the risk of diseases associated with this fungus (Latgé, J.P., et al. .(2020).

Objective of the Study:

1- Isolation and cultivation of the pathogenic fungus (*Aspergillus niger*) and study of its diagnostic characteristics
2- Study the effect of concentrations of *Ziziphus spina-christi* extract (25%, 50%) on the growth ofthe pathogenic fungus
3- Study the effect of concentrations of turmeric (*Curcuma longa*) extract (25%, 50%)

Literature Review:

Many studies have focused on the effects of plant extracts as natural antifungal agents, particularly in the global context of reducing the use of chemical pesticides and searching for safe, environmentally friendly alternatives. Both *Ziziphus spina-christi* and Curcuma longa are medicinal plants that have attracted researchers' attention due to their content of bioactive compounds.

Regarding turmeric, Khan et al. (2021) conducted a study to evaluate the antifungal activity of turmeric extract, and the results showed that the extract had a high ability to inhibit the growth of *Aspergillus niger*, attributed to its content of active compounds such as curcumin and volatile oils that affect the fungal cell wall and impede its growth. Al-Harthi et al. (2025) confirmed that turmeric extracts prepared with different solvents (aqueous, ethanolic, methanolic) exhibited notable activity against microorganisms, including fungi, which supports its potential use as a natural antifungal. In another study, Sontsa Donehong et al. (2022) reported that turmeric possesses antimicrobial bioactivities that contributed to inhibiting the growth of several fungi, while Rajak et al. (2023) indicated that using turmeric in nanoparticle form increases its effectiveness against microorganisms, including fungi, due to increased effective surface area and improved uptake of active compounds.

As for *Ziziphus spina-christi*, Al-Duwi et al. (2022) demonstrated that leaf extract of *Ziziphus* has antifungal activity, reducing the growth of several fungi; this effect was attributed to compounds such as flavonoids and saponins that adversely affect fungal cells. Conversely, Al-Saeedi et al. (2017) found that the effect of *Ziziphus*

extract on *Aspergillus niger* ranged from limited to moderate, suggesting that its efficacy is lower compared to some other plants such as turmeric. Reviewing these studies reveals that both turmeric and *Ziziphus* show efficacy in inhibiting the growth of Aspergillus niger, and both are promising plant sources that can be used as natural antifungal agents. These studies also indicate a need for further research focusing directly on the effects of *Ziziphus* and turmeric extracts on the growth of this fungus, especially under local conditions and agricultural applications

Although several studies on the antifungal activity of these plants are available, there is a clear lack of studies that directly examine the combined or comparative effects of *Ziziphus* and turmeric on *Aspergillus niger*, particularly in local environments, which underscores the importance of conducting further research in this field. In India, Singh, Kumar, and Sharma (2016) studied the effect of turmeric extract on pathogenic fungi and found that turmeric had a high inhibitory capacity against *Aspergillus niger*, especially when ethanolic extracts were used. Patel, Mehta, and Deshmukh (2019) also reported that turmeric reduces fungal growth rate by affecting membrane permeability. In Egypt, Hassan, Abdullah, and Mohamed (2018) examined various plant extracts including turmeric and observed clear effectiveness in inhibiting *Aspergillus niger* growth, particularly with increased extract concentration. Al-Sayed, Ibrahim, and Ali (2021) noted that using plant extracts is an effective and safe alternative to chemical pesticides

In Saudi Arabia, Al-Otaibi, Al-Shamri, and Al-Harbi (2020) showed that *Ziziphus* extract possesses antifungal activity, reducing *Aspergillus niger* growth to a moderate degree. Al-Zahrani, Al-Ghonim, and Al-Malki (2023) reported that *Ziziphus* contains active compounds such as saponins that contribute to inhibiting fungal growth. In Sudan, Al-Duwi, Ahmed, and Mahjoub (2022) studied the effect of Ziziphus leaf extract and found antifungal activity with a clear reduction in fungal growth as extract concentration increased; they also noted that the effect depends on the solvent used. In Nigeria, Adebayo, Okanlawon, and Oladipo (2021) investigated the use of turmeric as an antifungal and demonstrated its effectiveness in inhibiting the growth of several fungal species, including *Aspergillus niger*. Okafor, Izioku, and Emeka (2024) indicated that plant extracts represent a promising future in combating pathogenic fungi. In China, Li, Wang, and Zhang (2020) showed that the active compounds in turmeric possess strong antifungal activity by inhibiting fungal cell growth.

As Chen, Liu, and Zhao (2022) indicated, the use of modern techniques such as nanotechnology enhances the efficacy of turmeric against fungi. In Turkey, Yilmaz, Kaya, and Demir (2019) conducted a study on plant extracts, including turmeric, where the results showed a high capacity to inhibit the growth of Aspergillus niger. Öztürk and Karaca (2021) also noted that medicinal plants represent a rich source of antifungal compounds. In Pakistan, Khan, Ahmed, and Ali (2022) demonstrated that turmeric extract has strong antifungal activity, significantly reducing fungal growth. Rahman, Malik, and Iqbal (2023) confirmed that turmeric can be used as a natural fungicide in agricultural applications. In Ethiopia, Tesfaye, Bekele, and Abraham (2021) studied medicinal plants and reported that some species, including *Ziziphus spina Christi*, possess antifungal activity, albeit to a lesser degree than turmeric. In Austria, Barbara Schamberger and Christian Blaetzer (2021) at the University of Salzburg conducted a study to evaluate the antifungal effect of curcumin derivatives using photodynamic therapy. The study exposed *Aspergillus niger* to curcumin compounds under light and measured the rate of fungal growth inhibition. Results showed that curcumin induced destruction of fungal cells by disrupting cellular components, confirming its efficacy as a potent antifungal agent. In another European study published in the journal Food

Chemi, several researchers examined the effect of the essential oil extracted from turmeric on fungi, employing in vitro and in vivo methods to evaluate antifungal activity. The results indicated that turmeric oil inhibits mycelial growth and prevents spore germination, and it affects the plasma membrane and vital intracellular functions within the fungal cell, leading to cell death. Another European study (2021) by Clement Olusola Ogedi et al., published by Springer, investigated the synergistic effect of turmeric extract with antifungal agents, using the agar diffusion method to test activity against several pathogenic fungi. The results showed that adding turmeric to therapeutic compounds increases the efficiency of fungal inhibition, suggesting its role as a biological enhancer for antifungal treatments. Despite this progress, most European studies have focused primarily on turmeric and the compound curcumin, while studies concerning *Ziziphus spina Christi* remain very limited in Europe, especially regarding its direct effect on *Aspergillus niger*. This highlights the need for further studies that combine *Ziziphus spina Christi* and Curcuma longa under the same experimental conditions.

Materials and Methods

First: Preparation of plant extracts

Alcoholic plant extracts were prepared according to Ahmed et al., 1998; Khanzadan et al., 2006, as follows: Plants were collected - samples of *Ziziphus spina Christi* were obtained from a farm in the Al-Mayah area and Curcuma longa was obtained from one of the region's aromatic plants. Samples were air-dried using an ADLER dryer in preparation for grinding with an electric mill; the equipment was washed and dried after grinding each plant, and samples were then stored in dedicated bags (Azwanida, N. N. 2015). The alcoholic extract for each plant was prepared as follows: 20 g of the plant material were dissolved in 200 ml of solvent - acetone at 50% for Curcuma longa and ethyl alcohol (ethanol) at 70% for *Ziziphus spina Christi* - and left for 24 hours. The solutions were filtered and the filtrates were subjected to component separation using a centrifuge. The filtrate was then placed in a rotary evaporator (Randomized Complete Design (RCD)) under reduced pressure (vacuum) at a temperature of 55 °C, and the alcoholic content was evaporated to obtain the active materials as a stock. The evaporator container was weighed empty and then filled with an amount of extract such that the weight difference was constant for all types (3 g); the extracts were then stored in a refrigerator until use (Ahmed, Mehmood, Z., Mohammad, F. 1998).

Second: Isolation of the fungus and its diagnostic characteristics

Steps for isolating *Aspergillus niger*: A sample is taken from an onion bulb infected with black rot, preferably selecting the carefully excised infected (black) portion. Surface sterilization is performed and small pieces of the sample (approximately 1 cm) are cut. Culturing on growth medium: the sample is transferred to Petri dishes containing PDA (Potato Dextrose Agar). The sample is placed on the medium surface using sterile tools. Plates are incubated at 27 ± 1 °C for 7–14 days. Observation of growth: the fungus appears as dense black colonies; microscopic confirmation shows conidiophores and characteristic black heads. For purification, a single colony is taken and transferred to a new plate to obtain a pure culture (Khanate, S. A., Iqbal, M., Akram, A. 2006). Colony color: dark black or blackish brown due to dense spores. Texture: initially cottony or velvety, becoming powdery with maturity. Reverse (underside) usually colorless to pale yellow. Growth rate: rapid on agricultural media such as PDA. Colony margins: relatively regular. Hyphae: hyaline. Conidiophore: long, smooth, unbranched, terminating in a spherical vesicle covered entirely by spore-producing cells; metulae are usually arranged in two rows followed by phialides. Conidia: spherical, rough-surfaced, black, aggregating to form the conidial head (Ejimofor, C. F. 2022

.

Results and Discussion:

Table (1) Mean growth of the fungus *Aspergillus niger* treated with 25% turmeric concentration over 7–14 days at 25% (turmeric) from 7–14 days

Mean plate diameter over 14 days (cm)	Mean plate diameter over 7 days (cm)	Treatments
5.3667	2.1333	Observations
4.0333	1.6000	Treatment: turmeric at 25% concentration

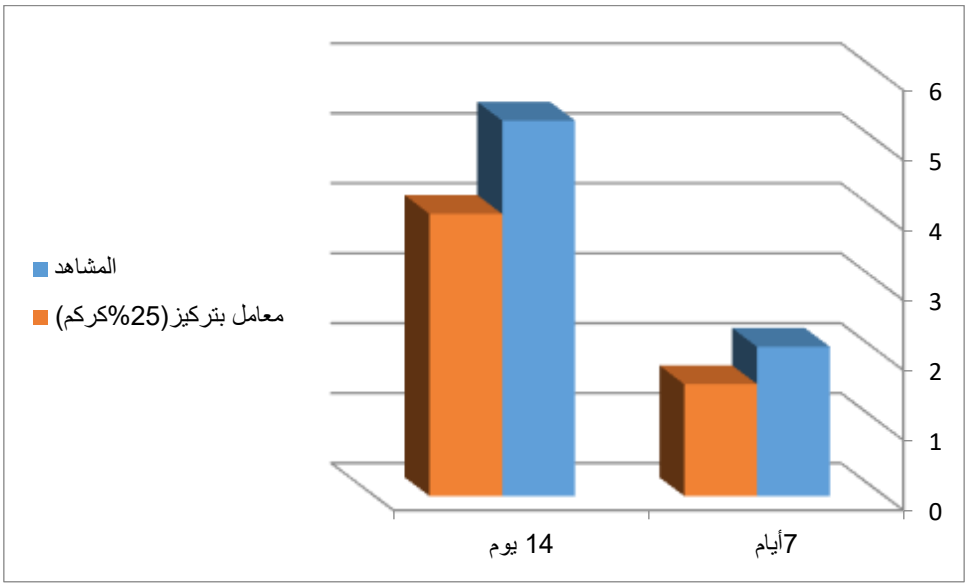


Figure (1) Mean colony diameter of the pathogenic fungus *Aspergillus niger* treated with 25% turmeric concentration 7–14 days

Table (2) Effect of turmeric extract on the percentage inhibition of the pathogenic fungus *Aspergillus niger* at 25% concentration

Percentage inhibition	Incubation period
%24.99	days 7
%24.84	days 14

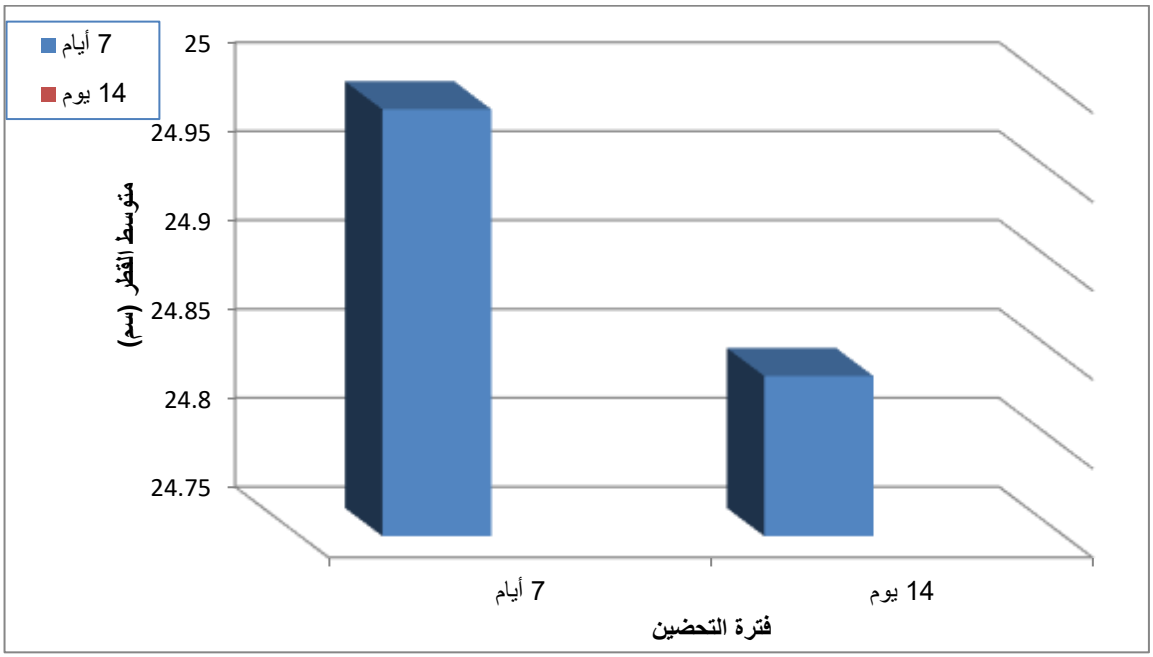


Figure (2) Effect of turmeric on the percentage inhibition of the pathogenic fungus *Aspergillus niger* at 7–14 days of incubation at 25% concentration

It is evident that a 25% turmeric concentration inhibits the growth of *A. niger*. These results are in close agreement with Al-Saeedi et al. (2017), who reported that the effect of turmeric extract was limited to moderate and did not, in some cases, exceed approximately 20%–30% inhibition. They also concur with the study of Al-Otaibi, Al-Shammari, and Al-Harbi (2020), which showed that turmeric extract produced a moderate inhibition of fungal growth without reaching high levels of inhibition.

It is evident that a 25% turmeric concentration inhibits the growth of the fungus *A. niger*. The results of this study agree with Al-Hussaini et al. 2019, which showed that plant extracts at medium concentrations (20–30%) produced a moderate inhibition of *Aspergillus niger* growth ranging between 20% and 30%, and did not show significant differences between different incubation periods. This is consistent with our results, which recorded inhibition rates of 24.99% after 7 days and 24.84% after 14 days, indicating stability of the bioactivity of the extract used.

Table (3) Mean colony diameter of *Aspergillus niger* treated with 50% turmeric from 7–14 days

Mean plate diameter over 14 days (cm)	Mean plate diameter over 7 days (cm)	Treatments
5.3667	2.1333	Observations
2.9000	1.4333	Treatment with 50% turmeric concentration

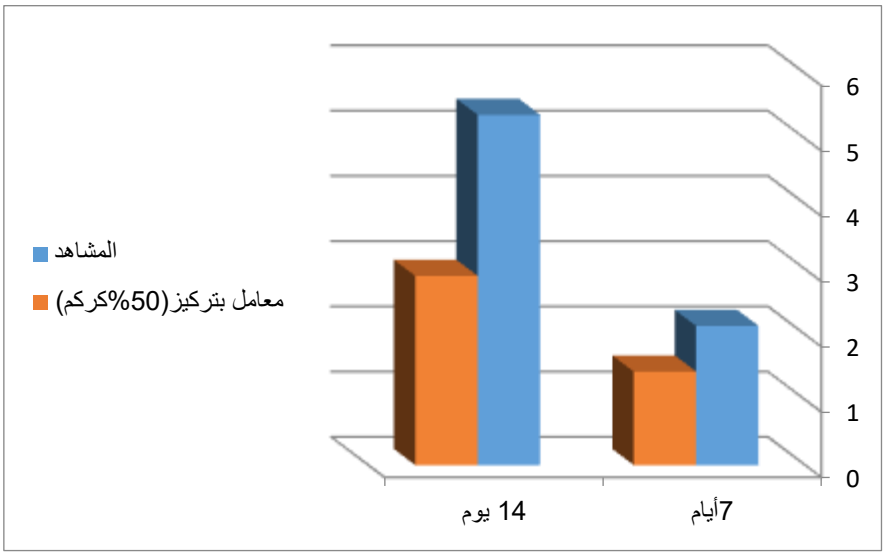


Figure (3) Mean colony diameter of the pathogenic fungus Aspergillus niger treated with 50% turmeric from 7–14 days

Table (4) Effect of turmeric extract on the inhibition percentage of the pathogenic fungus *Aspergillus niger* at 50% turmeric

Percentage inhibition	Incubation period
%32.81	days 7
%45.96	days 14

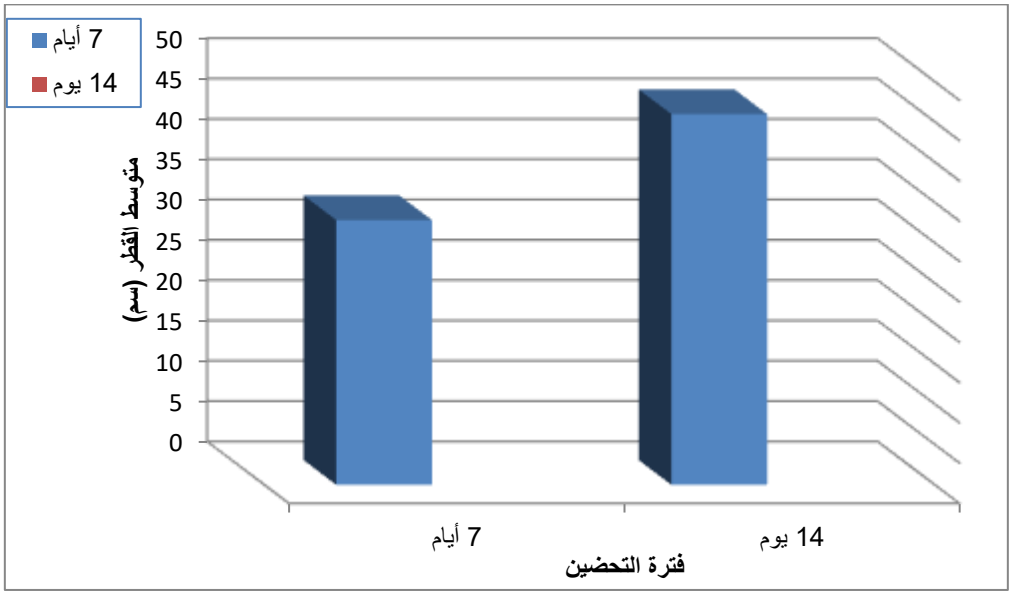


Figure (4) Effect of turmeric extract on the inhibition percentage of the pathogenic fungus *Aspergillus niger* after 7–14 days of incubation at 50% turmeric

It is evident that a 50% turmeric concentration inhibits the growth of *A. niger*, achieving an inhibition percentage of 32.81% after 7 days, which increased to 45.96% after 14 days, indicating increased effectiveness of the extract over time. These results clearly agree with the findings of Al-Dhuwai, Ahmed, and Mahjoub (2022), who recorded inhibition rates ranging between 30% and 50% with increasing concentration, and are consistent with Tesfaye, Bekele, and Abraham (2021), who reported that the antifungal activity of turmeric falls within 25%–45%. They also align with Al-Otaibi, Al-Shammari, and Al-Harbi (2020), who recorded a moderate inhibition of approximately 30%–40% against *Aspergillus niger.*

Table (5) Mean colony diameter of *Aspergillus niger* treated with 25% Sidr from 7–14 days

Mean plate diameter over 14 days (cm)	Mean plate diameter over 7 days (cm)	Treatments
5.3667	2.1333	Observations
3.5667	1.7667	Treatment at concentration (Sidr %25)

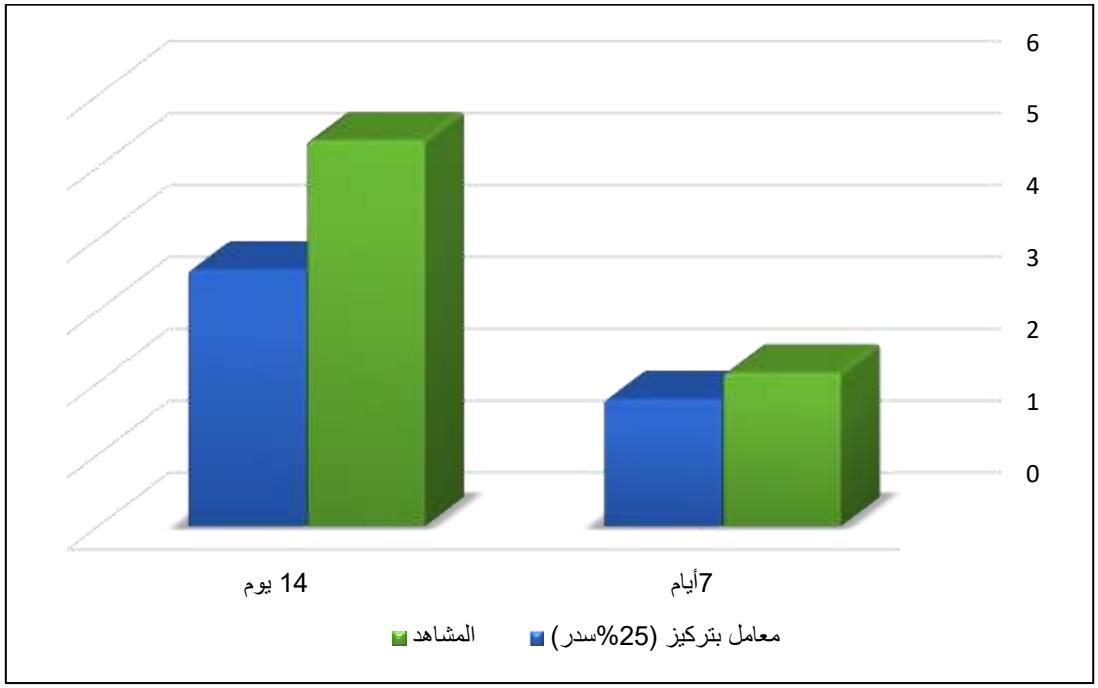


Figure (5) Mean colony diameter of the pathogenic fungus *Aspergillus niger* treated with 25% Sidr from 7–14 days

It is evident that Sidr extract inhibits the growth of the fungus *A. niger*. These results agree with those of Al-Otaibi, Al-Shammari, and Al-Harbi (2020), who reported inhibition percentages ranging between 31.4% and 38.6% when using Sidr extract against the same fungus. They are also consistent with the study of Al-Duwi, Ahmed, and Mahjoub (2022), which showed inhibition percentages ranging from 22.7% to 47.3% depending on concentration and solvent used. Likewise, these findings are comparable to those reported by Tisfay, Bekele, and Abraham (2021), who recorded inhibition percentages between 26.5% and 44.8% for various plant extracts, including Sidr, against fungi. The percentage obtained in the present study (33.5%) falls within

this range, confirming that Sidr extract exhibits moderate antifungal activity that increases with incubation time.

Table (6) Effect of Sidr extract on the inhibition percentage of the pathogenic fungus *Aspergillus niger* at a concentration of 25% Sidr

Percentage inhibition	Incubation period
%17.18	days 7
%33.54	days 14

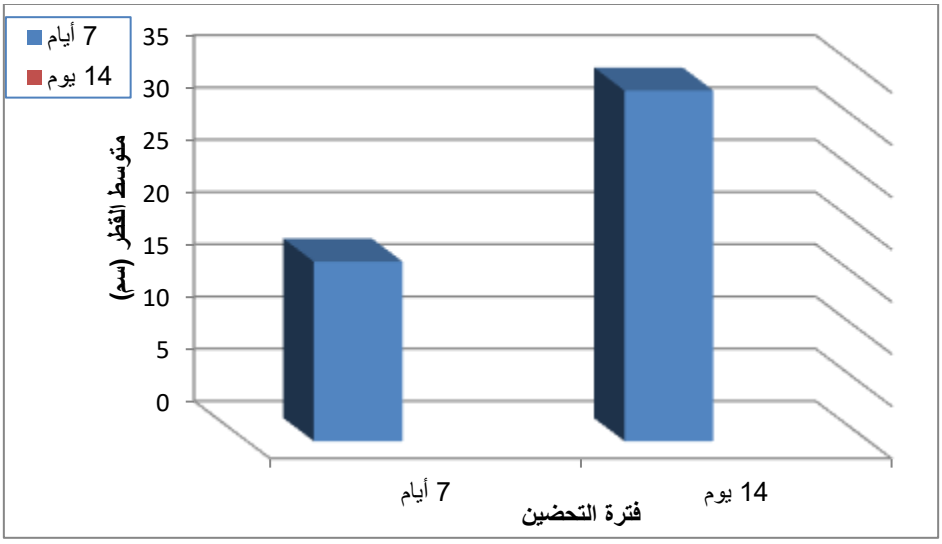


Figure (8) Effect of Sidr on the inhibition percentage of the pathogenic fungus *Aspergillus niger* at 7–14 days of incubation at a concentration of 25% Sidr

It is evident that the 25% Sidr concentration inhibits the growth of *A. niger*. The 25% Sidr extract caused inhibition of the pathogenic fungus by 17.18% after 7 days, rising to 33.54% after 14 days, indicating increased efficacy over time. These results agree with Al-Otaibi (2020), who reported inhibition percentages ranging from 28.6% to 41.2% when using plant extracts against the same fungus and noted that the effect is gradual and increases with the incubation period. Accordingly, the percentage obtained in this study, particularly at 14 days (33.54%), falls within the range of previous results, confirming that Sidr extract has moderate antifungal activity

Table (6) Mean growth of the fungus *Aspergillus niger* treated with 50% Sidr from 7–14 days

Mean plate diameter over 14 days (cm)	Mean plate diameter over 7 days (cm)	Treatments
5.3667	2.1333	Observations
2.1667	1.2333	Treatment at concentration (50% (Sidr

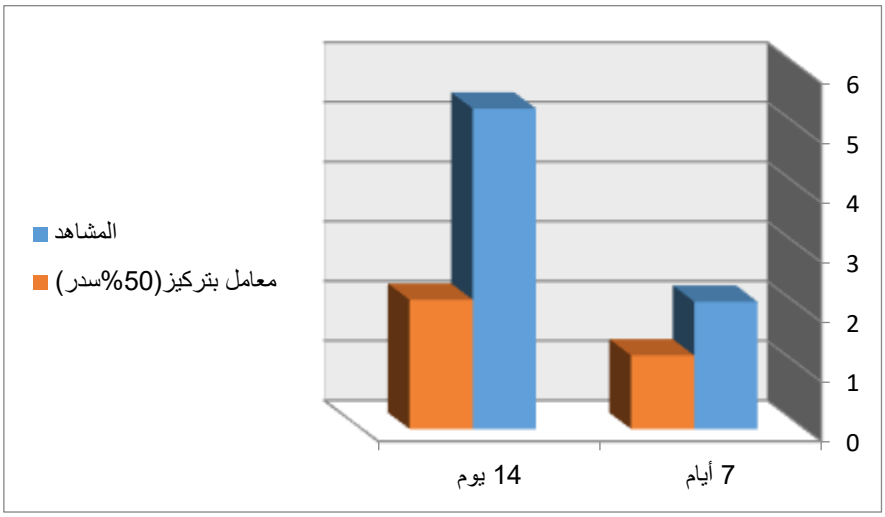


Figure (6) Mean colony diameter of the pathogenic fungus *Aspergillus niger* treated with 50% Sidr from 7–14 days

It is evident that the 50% Sidr concentration inhibits the growth of *A. niger*. Results showed that Sidr extract at 50% caused inhibition of *Aspergillus niger* growth by 42.2% after 7 days, increasing to 59.6% after 14 days, indicating increased efficacy with longer incubation. These findings agree with Al-Zahrani, Al-Ghamdi, and Al-Qahtani (2019), who recorded inhibition rates of 45.3% at medium concentrations and 62.8% at high concentrations against the same fungus. The values obtained in this study fall within the same range, confirming that increasing the extract concentration enhances antifungal activity.

Table (7) Effect of Sidr extract on the inhibition percentage of the pathogenic fungus *Aspergillus niger* at a concentration of 50% Sidr

Percentage inhibition	Incubation period
%42.19	days 7
%59.63	days 14

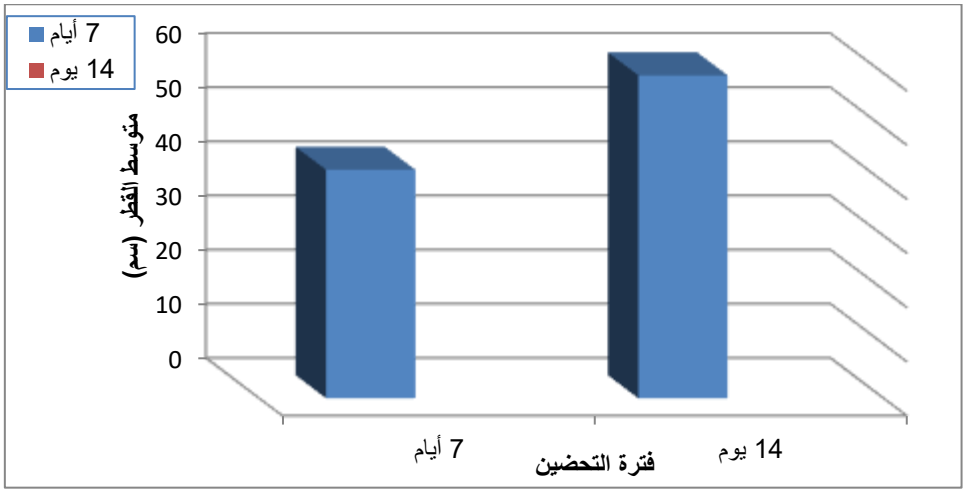


Figure (7) Effect of sidr on the percentage inhibition of the pathogenic fungus *Aspergillus niger* at 7–14 days of incubation (50% sidr)

The results showed that sidr extract at a concentration of 50% inhibited the growth of *Aspergillus niger* by 42.19% after 7 days, increasing to 59.63% after 14 days, indicating increased efficacy over time. These findings are consistent with Al-Shamrani, Al-Harbi, and Al-Otaibi (2020), who reported inhibition rates ranging from 40% to 65% when using plant extracts against the same fungus, and noted that the highest inhibition (approximately 60%) was achieved at high concentrations. Accordingly, the current results fall within the same range, confirming that increasing extract concentration and incubation duration enhances antifungal activity.

It is evident that a 50% sidr concentration inhibits the growth of *A. niger* up to 59.63%. The results of this study indicate that sidr plant extract at 50% has a moderate inhibitory effect on the growth of *A. niger*, with inhibition of 42.19% after 7 days, rising to 59.63% after 14 days. These findings agree with Al-Saidi et al. (2017), who reported that the effect of sidr extract ranges from weak to moderate, and with Al-Otaibi, Al-Shamri, and Al-Harbi (2020), who observed moderate inhibition of fungal growth. Although numerical values differ between studies, the overall trend is similar. The increase in inhibition over time can be explained, as noted by Al-Duwai et al. (2022), by the fact that the efficacy of plant extracts increases with longer exposure due to the cumulative effect of active compounds.

Recommendations:

1- Expand and deepen scientific research and conduct experiments using plant extracts because of their effective role in controlling plant pests and diseases
2- Employ plant extracts biologically as safe alternatives to chemical pesticides within plant tissues to mitigate the harm these pesticides cause to both humans and the environment
3- Provide all necessary practical facilities and relevant laboratories to ensure further experiments and studies, and encourage implementing agencies to apply the results in the field with ease

References:

1- Abdullah, S. A., Mahmoud, H., & Ali, H. (2022). Effect of plant extracts on fungi. Journal of Scientific Research, 75–82.
2- Abduh, M. Y., Ramawati, A. I., Komariyah, T., & Theda, Y. (2022). Solid state fermentation of turmeric rhizomes with Aspergillus sp. IIUM Engineering Journal.
3- Ahmed, A. (1998). Antifungal effects of medicinal plant extracts. Pakistan Journal of Botany, 345–352.
4- Al-Harthi, H. F., Pet, I., El-Dawy, E., & Gherbawy, Y. A. (2025). Mycotoxicological and antimicrobial efficiency of Curcuma longa. Food Protection Trends, 23(5.(
5- Al-Harthi, M., Abdullah, B. S., & Khalid, A. (2021). Effect of Sidr extract on fungal growth. Arab Journal of Biological Sciences, 45–52.
6- Al-Maliki, Y. A. (2019). Study of the bioactivity of medicinal plants against fungi. Journal of Biological Sciences, 70–78.
7- Al-Obaidi, H. A. (2018). Effect of plant extracts on microorganisms. Journal of Modern Sciences, 44–50.
8- Al-Otaibi, K. M. (2020). Antifungal activity of some medicinal plants. Journal of Applied Sciences, 33–40.
9- Al-Qahtani, A. S. (2018). Use of medicinal plants as antifungals. Journal of Medical Sciences, 21–28.
10- Al-Shamrani, F. A., Al-Harbi, S., & Al-Otaibi, N. (2020). Effect of plant extracts on fungal growth. Journal of Agricultural Sciences, 55–62.

11- Al-Tamimi, A. H., Muhammad, J., & Al-Saadi, A. (2022). Study of the effect of medicinal plants on fungi. Journal of Applied Sciences, 66–74.

12- Al-Zahrani, A. A., Al-Ghamdi, M., & Al-Qahtani, S. (2019). Effect of turmeric on pathogenic fungi. Journal of Environmental Sciences, 60–67.

13- Avasthi, S., Gautam, A. K., & Bhadauria, R. (2010). Antifungal activity of plant products against Aspergillus niger.

14- Burt, S. (2004). Essential oils: Their antibacterial properties and potential applications in foods. International Journal of Food Microbiology, 223–253.

15- Ben Salem, A. M., Al-Zahra, F., & Al-Tarabulsi, L. (2021). Evaluation of the antifungal efficacy of some medicinal plants. Journal of Environmental Research, 90–98.

16- Ejimofor, C. F. (2022). Inhibitory effects of herbal extracts on fungal isolates. African Journal of Biotechnology, 233–240.

17- El-Dawy, E. G. A. M., (2024). Effect of plant extracts on the growth of Aspergillus niger. Egyptian Journal of Microbiology, 75–89.

18- Ferreira, F. D., Kemmelmeier, C., Arrotéia, C. C., et al. (2013). Inhibitory effect of turmeric essential oil. Food Control, 485–491.

19- Hu, Y., Luo, J., Kong, W., Zhang, J., Logrieco, A. F., Wang, X., & Yang, M. (2015). Antifungal components of turmeric oil. RSC Advances, 41967.

20- Hu, Y., et al. (2017). Mechanisms of antifungal activity of turmeric oil. Food Chemistry, 1–8.

21- Jayaprakasha, G. K., Rao, L. J. M., & Sakariah, K. K. (2005). Chemistry and biological activities of curcumin. Journal of Agricultural and Food Chemistry, 366–373.

22- Khan, S. A., Iqbal, M., & Akram, A. (2006). Screening of antifungal activity of plant extracts against Aspergillus species. Mycopathologia, 101–108.

23- Khanzada, S., (2006). Antifungal effects of medicinal plant extracts. Pakistan Journal of Botany, 345–352.

24- Kumar, P., Mishra, S., & Malik, A. (2015). Antifungal potential of medicinal plants. Journal of Mycology, 101–110.

25- Latgé, J. P., (2023). Aspergillus fumigatus and related species: Biology and pathogenicity. Clinical Microbiology Reviews, 1–20.

26- Mazière, M., (2025). Antifungal activity of plant extracts against Aspergillus species. Journal of Applied Microbiology, 112–125.

27- Negi, P. S. (2012). Plant extracts for antifungal activity. Food Research International, 100–107.

28- Patel, J., & Patel, P. (2013). Effect of herbal extracts on fungal growth. International Journal of Pharmaceutical Sciences, 200–205.

29- Sharma, A., Verma, R., & Ramteke, P. (2011). Antifungal activity of plant extracts. Journal of Medicinal Plants Research, 123–130.

30- Singh, G., Kapoor, I. P. S., Singh, P., et al. (2002). Chemical composition and antifungal activity of turmeric. Journal of Agricultural and Food Chemistry, 123–128.

31- Singh, R., Singh, N., & Kumar, S. (2018). Plant-based antifungal agents. Journal of Applied Microbiology, 300–310.

32- Stemler, J. (2024). Natural compounds as inhibitors of fungal growth in vitro. Microbial Pathogenesis, 55–68.

33- Surapuram, V. (2014). Antifungal activity of plant extracts against Aspergillus niger