

Research Paper



Isolation and identification of wheat seed fungi and effect of microwave on fungi loads in salah al-din governorate in iraq

Maha Saud Khalaf^{1*}, Hawazin Ahmed Abid², Rafea Zaidan Mukhlif Alsugmiany³

^{1*2,3}Department of Biology, College of Science, Tikrit University, Iraq.

Article Info

Article History:

Received: 18 April 2023

Revised: 26 June 2023

Accepted: 04 July 2023

Published: 19 August 2023

Keywords:

Wheat

Seeds

Fungi

Microwave

Fungal



ABSTRACT

This study was conducted to determine the seed borne fungi of wheat cultivars in the seed production stores companies in Salah AL-Din Governorate, Iraq, 2021, and then evaluate the efficiency of Microwaves to kill or eliminate the fungal pathogens of wheat. The results of the study indicate that all samples of wheat seeds were contaminated with fungi in different percentage. 318 isolates of fungi were isolated from the studied wheat seed samples. They were identified culturally and microscopically according to approved taxonomic keys. The fungus *A. flavus* appeared with a percentage of 100 %, as it was present in all samples of the studied wheat seeds, as well as the species of *A. niger*. Then the species of *Alternaria* (*A. alternata*, *A. tenuissima*, *A. saponaria*) and the species of *Aspergillus* (*A. flavus*, *A. fumigatus*, *A. terreus*, *A. niger*), *Rhizopus oryzae*, *Rhizoctonia solani*, *Penicillium* spp, *Aureobasidium pullulans*, *Phoma* spp, *Curvularia lunata*, *Stemphylium* spp, and *Mucor* spp appeared with different percentages. an investigation into the effect of microwaves on fungal pathogens of wheat varieties was undertaken. This was achieved by microwaving seeds at 0, 10, 20, 30 and 40 Seconds. Agar plate tests were used to assess pathogen loads. Pathogen levels were steadily reduced at all treatment times and by 30 S treatment. All pathogens were consistently destroyed. In comparison, at 40 S the levels of saprophytic fungi were increased because it is thermotolerant. The use of microwave radiation was a valuable tool for crop improvement, it was rapid, economic, efficient and safe to eradicating the pathogens.

Corresponding Author:

Maha Saud Khalaf

Department of Biology, College of Science, Tikrit University, Iraq.

Email: maha.s.khalaf4410@st.tu.edu.iq

Copyright © 2023 The Author(s). This is an open access article distributed under the Creative Commons Attribution License, (<http://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1. INTRODUCTION

Improving and maintaining crop yields of wheat grain is severely important in feeding world population that's continually growing [1], [2]. As it is thought high density cultivation of crops may have encourages growth of fungi, and the natural defense mechanisms may have reduced because use of agrochemicals. It has been proven that the microwave has to be effective for use in seed drying methods [3], as it has benefits of being developed technology that is safe, reliable and cheap [2]. Microwave are a part of electromagnetic radiation spectrum, frequencies ranging from (300 MHZ to 300 GHZ), and wavelengths between (1m-1mm) according to countries and regions, includes five frequencies with exclusive frequency for home applications (2450 MHZ), besides they have been works through absorption at the molecular level. [4]. The microwave are one of the new technologies for seed treatment [5], [6] Triticum aestivum L. return to family Poaceae and it is one of the most important strategic crops for human food security and an important source of fodder due to its high nutritional value [7]. The wheat crop is considered one of the main cultivated grains in Iraq followed by barley *Hordeum vulgare* L [8]. Its cultivation is concentrated in China, Canada, European Union, Australia, Russia, Pakistan, India, United states, Turkey and Ukraine accounting for over 80%of the total production [9]. It is considered as an excellent health building food, rich in protein 9.2-11.3, dietary fibers 1.8-1.9%, B-group vitamins, moisture content 8.4-9.8%, and a blend of minerals like Zn, Cu, Fe, and Mg [10]. Wheat also enters the food and industry sectors it is consumed in the form of confectionary products, bread, biscuits, noodles, ethanol, cosmetics, and seitan or vital wheat gluten (Cappelli et al.,2020) [11]. The volume of Iraq's production of the wheat crop during the winter season of 2021 was amounted to 4 million and 234 thousand tons, according to (CSO, Iraq). Various seed characteristics such as germination, nutritional value, moisture content and discoloration are influenced by a number of biotic and abiotic factors during seed storage. The stored seeds are more prone to be attacked by the fungi making them unacceptable as food and feed [12]. Wheat seeds are susceptible to attack by different types of fungi at harvest and during storage, the first type of fungi represented by field fungi and it is a group of fungi that alter the composition and quality of seeds before harvesting [13]. These damages can be detected through routine evaluations or periodic examinations, in general field fungi cannot appear in storage if the grain has been stored in suitable temperature and moisture contents [14]. As for a second type which is represented by storage fungi, they are those fungi that cause damage to grain during storage, and usually do not occur at a critical level prior to harvest [15], The fungal flora of stored grains is mostly composed of wide spread mold species of genera *Rhizopus* spp, *Mucor* spp, *Fusarium* spp, *Cladosporium* spp, *Alternaria* spp, *Aspergillus* spp and *Penicillium* spp [16]. These genera are usually found in grain stored in the form of spores, in accurate quantities during transportation and storage and could survive for several years [17], it affects grain yield as some of them cause rotting roots of wheat especially fungi *Fusarium culmarum*, *Bipolaris sorokiniana*, *Rhizoctonia solani* [18].

2. METHODOLOGY

Sample Collection: The studied wheat grain samples were collected from the storages of the seed production companies in Salah-al-Deen Governorate, Iraq, for three regions Baiji, Samarra, and Sherqat for the (2020 -2021) Agricultural season, which includes eight samples distributed into six varieties (Ibaa, Adenah, Boro, Baiji, Diglah, Cham 6 Samarra, Cham 6 Sherqat, and Alafia). samples were collected in September ,2021 and the samples were taken according to the rules and regulations of the International Organization for Examination of Seeds (ISTA .2018) [19] and placed in Polyethylene bags and sealed with holes for ventilation to avoid the death of embryos, then they were transferred to the laboratory and placed in refrigerator at a temperature 4°C until the tests are carried out [20].

2.1 Microwave Treatment

Microwave treatment were carried out using an 800 W, LG microwave, at 2450 MHZ. For each treatment, 204 seeds were randomly taken and placed in a 90 mm diameter glass petri dishes that was

placed in the centre of microwave on the rotating plate. Heating at full power was applied for 0,10,20,30 and 40 S respectively [2].

2.2 Agar Plate Tests

To assess both background and seed infection levels, agar plate tests were undertaken. These were based on Science and Advice for Scottish Agriculture (SASA) guidelines, which adhere to the official seed health testing methods of the International Seed Testing Association (ISTA). 200 seeds were sterilized in 1% (v/v) sodium hypochlorite solution for 1 min followed by three washes in deionized water. Seeds were aseptically transferred to Potato Dextrose Agar (PDA) (Potato extract 4.0 g/l; Glucose 20 g/l; Agar 15 g/l) with streptomycin (30 µg/ml agar) in 90 mm diameter Petri dishes. Five seeds were placed on each plate. Plates were sealed with parafilm and incubated for seven days at 25°C [21]. After four days, the growth of the fungi was monitored and the fungi were visually identified. Followed by purification of the fungi isolates on the food medium (PDA). Seeds with no fungal growth were also recorded.

2.3 Conditions for Keeping Isolates

The different isolates of the fungi that were isolated from the seeds of the wheat samples after their cultivation on the medium of potato dextrose agar PDA were kept in an oblique from inside the Slants test tubes in the incubator and kept in the refrigerator at a temperature of 4°C.

2.4 Microscopy of Fungal Cultures and their Identification

After the growth of the fungal cultures isolated from wheat seeds from the Varieties under study, they were examined microscopically by taking part of the fungal growth with a sterile inoculation needle and placing it on a glass slide containing a drop of solution lactophenol, and the sample was then spread out in a droplet of loading the slide cover was placed and examined microscopically; or by using Scotch No.800 transparent tape by taking 4 cm of the tape, so that, the adhesive side was facing the surface of the mycelium and attached with great care and caution, where it is placed. The tape was between the thumb and forefinger, after the fungal growth stick on the tape, it was lifted gently remove from the plate and put on a slide containing a drop of lactophenol-aniline blue and then examined microscopically [22], to identify spinning characteristics mycelium and spores, according to the approved taxonomic keys [23], [24], [25], [26].

2.5 Purification of Fungi by Single Spore Method

The studied fungi were purified by the single spore technique by mixing a sample of 0.5 cm in diameter from the fungal colony with 10 ml sterile distilled water. The dilution was continued until the number of spores ranged between (1-10 spore microscopic field) at power 10 X, after which 0.5 ml of the spore suspension and spread on the surface of a plate containing a medium consisting of 2% agar and water. The dishes inoculated with the fungi were incubated in the incubator at 25 ± 2°C for 48 hours, after that fungal colonies resulting from the growth of the single spore were transferred to a new PDA medium by means of a sterile inoculation needle [27].

2.6 Calculate the Percentage of Fungal Appearance%

The percentage of fungal appearance was calculated as follows:
Percentage of appearance = the number of fungus appeared in the samples / the total number of samples [27].

2.7 Statistical Analysis

Statistical analysis was done using Statistical Analysis System version 9.3 (SAS). Complete Randomized Design (CRD) by use Duncan multiple level test [28]. P values of 0.05 were considered significant [29]. Results, represented an average of three replicates per treatment.

3. RESULTS AND DISSCUSION

3.1 Isolation and Identification of Fungi

318 isolates of different fungi were isolated from grain samples of wheat varieties, results of the current study indicated in the Table 2 the presence of 15 fungal species, which belongs to 9 genera of fungi associated with grain samples, which were collected from grain stores in Salah al-Din Governorate, which were exposed to human consumption and animal. These species were diagnosed after conducting a surface sterilization that affects the fungi carried out on the surface of the seeds and leads to a reduction in their presence for getting rid of contamination by using sterilized sodium hypochlorite, wich effect was limited to fungi carried out on the outer cover of seeds and does not affect fungi that infected seeds from inside or that affects the embryo of the seed, this was consistent with [30], [21]. The seeds of various crops were susceptible to invasion of pathogens during the stages of plant development, before and after harvested period by a wide range of fungal flora, seeds that carry out pathogen, that's became as primary source of infection and that's had been an important role in pathogenicity of pathogens. As fungal flora present on Seeds or within their may lead to longer seed dormancy period and reduced germination and percentages of surviving seedlings [31], [32], [33].

3.2 The Incidence of Fungi

The Table 1 indicates the rates of appearance of fungi isolates in different wheat cultivars. Highest percentage of occurrence was recorded for two species *A. flavus* and *A. niger* with percentage of 100 % for each as, then percentage occurrence of 75% was recorded for each of fungal species *Alternaria tenuissima* and *Rhizopus oryzae*, followed by the fungal species *Alternaria alternata*, *Aspergillus fumigatus* and *Penicillium* spp, then species of *Aureobasidium pullulans*, *Aspergillus terrus* and *Phoma* spp were recorded with an incidence of 37.5% to each as, respectively, then species of *Stemphylium* spp recorded an incidence of 25 %, then species of *Alternaria saponaria*, *Curvularia lunata* and *Mucor* spp were recorded with the lowest incidence Which amounted to 12.5 % for each of them, respectively.

Table 1. The Percentage of Appearance of Fungi Isolates in all Wheat Cultivars

No.	Isolates	Appearance %	No.	Isolates	Appearance %
1	<i>Alternaria alternata</i>	50 %	9	<i>Curvularia lunata</i>	12.5 %
2	<i>Alternaria tenuissima</i>	75 %	10	<i>Mucor</i> spp.	12.5 %
3	<i>Alternaria saponaria</i>	12.5 %	11	<i>Penicillium</i>	50 %
4	<i>Aureobasidium pullulans</i>	37.5 %	12	<i>Phoma</i> spp.	37.5 %
5	<i>Aspergillus flavus</i>	100 %	13	<i>Rhizoctonia solani</i>	50 %
6	<i>Aspergillus fumigatus</i>	50 %	14	<i>Rhizopus oryzae</i>	75 %
7	<i>Aspergillus niger</i>	100 %	15	<i>Stemphylium</i> spp.	25 %
8	<i>Aspergillus terrus</i>	37.5%			

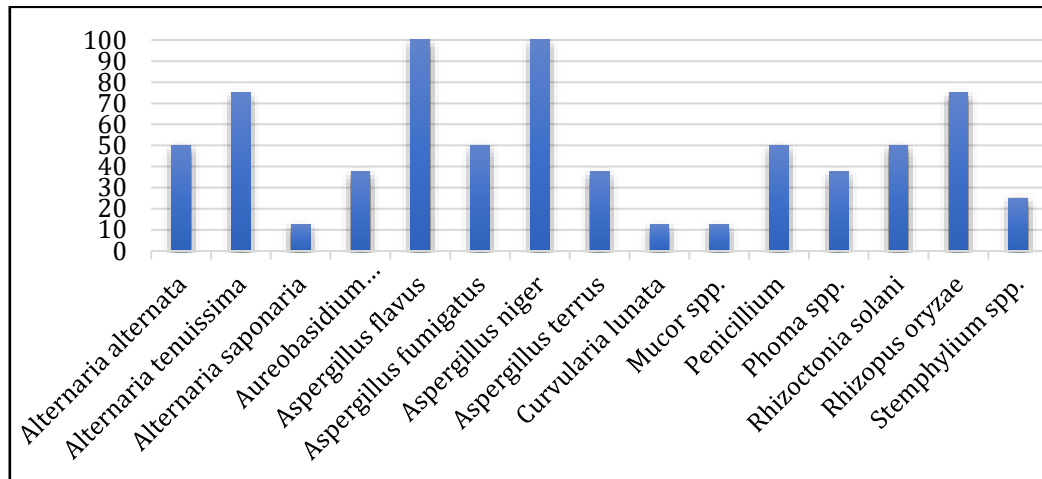


Figure 1. The Percentage of Appearance of Fungi

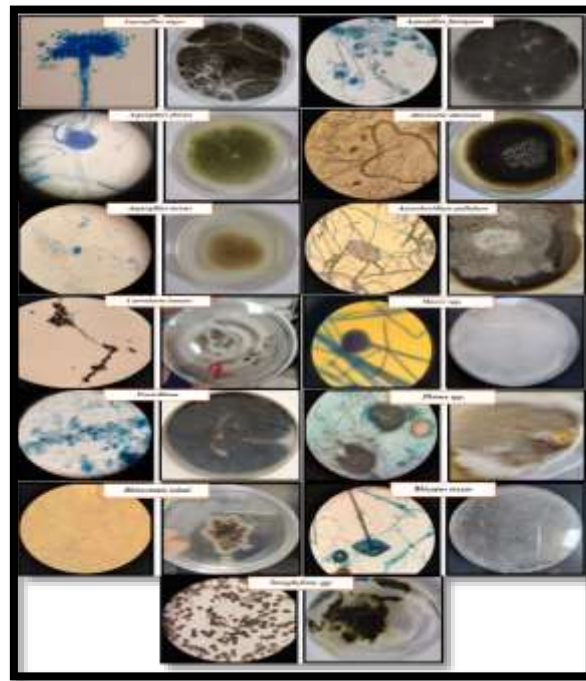


Figure 2. Culture and Microscope Picture for Fungi Isolate, Culture Picture Using Single Spore Technique and Microscope Picture with Scotch Tape Technique Solates in all Wheat Cultivars Effect of Microwave on Contamination Load

The levels of fungal loads reported as 0 S microwave exposure the majority of fungal groups were of the species *Aspergillus* and *Penicillium*, which could be active at moisture contents about (65-90 %) and that's were agreements with a study concluded that wheat seeds in Bulgaria were infected with a group of fungi belongs to the genera *Alternaria*, *Aspergillus*, *Mucor*, *Fusarium*, *Rhizopus* and *Penicillium*. [34], [35], [36]. At 10 S recorded that emergence of pathogenic fungi and their dominance over saprophytic fungi species may be due to the secondary metabolic compounds that inhibitory to other fungal species, as it were used in biotechnology. At 20 S results indicate that some of fungal species that were recorded in the treatments 0, 10 S did not appear, as well as decreases in appearance of pathogenic fungi like *penicillium* spp. Exposure of seeds to microwave radiation for 30S led to eliminated of pathogenic fungi and these results were agreements with [2], [37] as they concluded that 30 S showed decrease in fungal infection. The decrease in pathogenic fungi may be due to thermal damage from microwave ovens, which change the

nature of fungal proteins, leading to cell death and loss of vitality [38]. Because of, microwave radiation kills fungi that carried out by seeds through heat and desiccation [2]. The spores form was more resistant to microwaves radiation than the mycelium of pathogens which were easily eradicated [39], [37]. At 40 S the saprophytic fungi were continued to appear and this may be due to the higher tolerance of their to microwaves, especially the species of *Aspergillus*. *Fumigatus* as it was thermotolerant and grows at a temperatures up to 55° [40], as well as the species *A. niger* that was tolerant and resistant to high temperatures, then followed by *A.flavus* in appearance at high temperatures and *Rhizopus oryzae*. That grows at 40°C [41]. The decrease in pathogenic fungi such as *Alternaria* spp, *Rhizoctonia solani* [42]. may be facilitated the growth of saprophytic fungi to be present at higher rates [43]. Thus, the microwave oven is a promising tool, as it was eliminated pathogenic fungi at higher temperatures [44], and it had been proven that its use can reduce the invasion of microorganisms in wet soil [45], [46].



Figure 3. The Effect of Microwaves on the Fungi Associated with the Seeds of the Eight Wheat Varieties at the Thermal Coefficient (0) Seconds

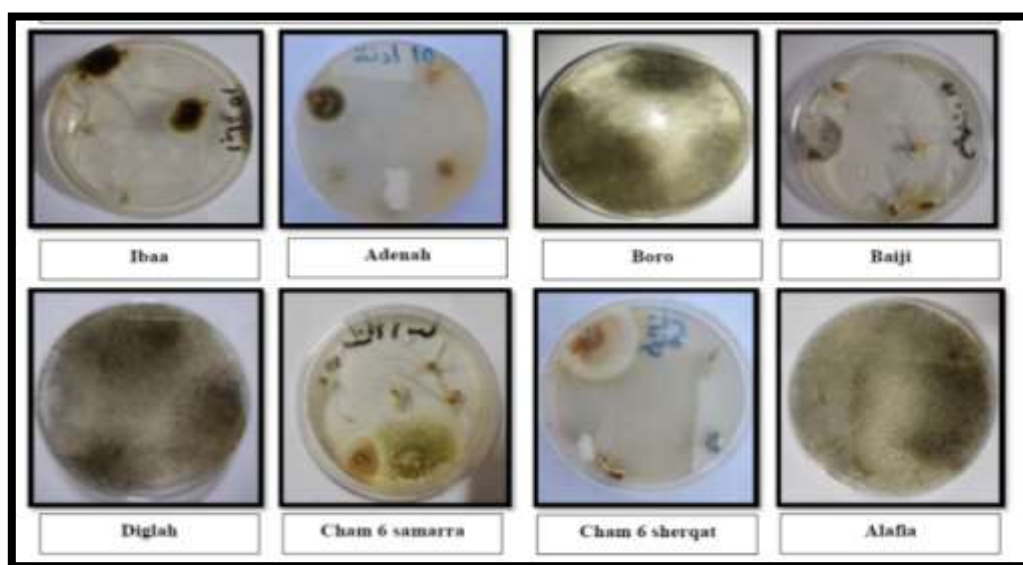


Figure 4. The Effect of Microwaves on the Fungi Associated with the Seeds of the Eight Wheat Varieties at the Thermal Coefficient (10) Seconds

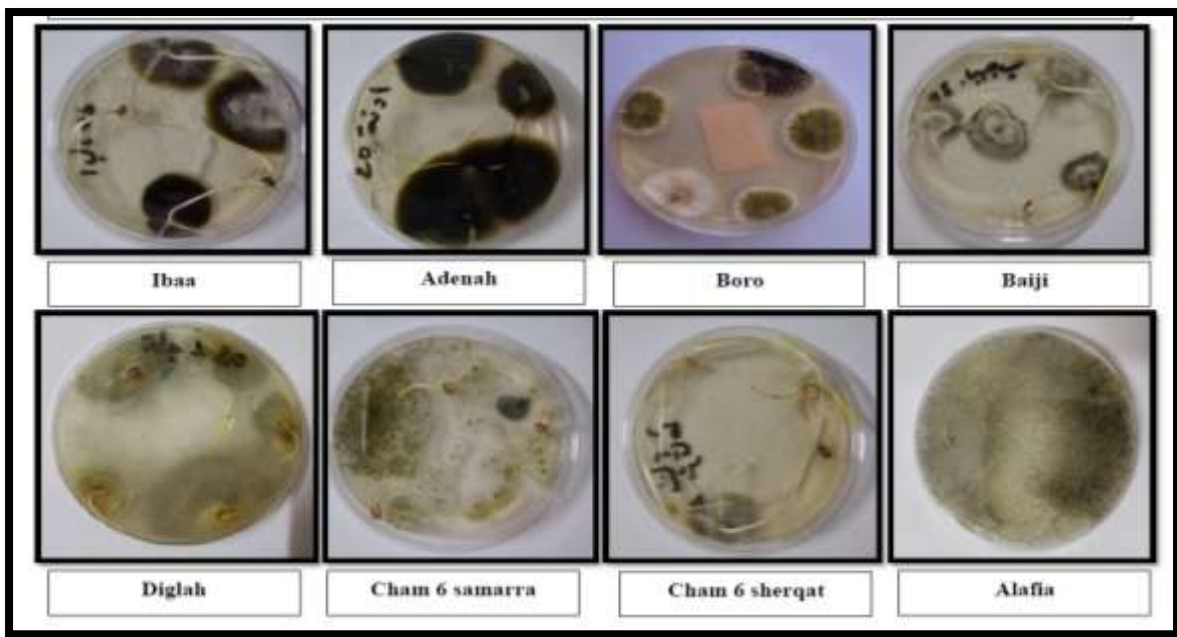


Figure 5. The Effect of Microwaves on the Fungi Associated with the Seeds of the Eight Wheat Varieties at the Thermal Coefficient (20) Seconds

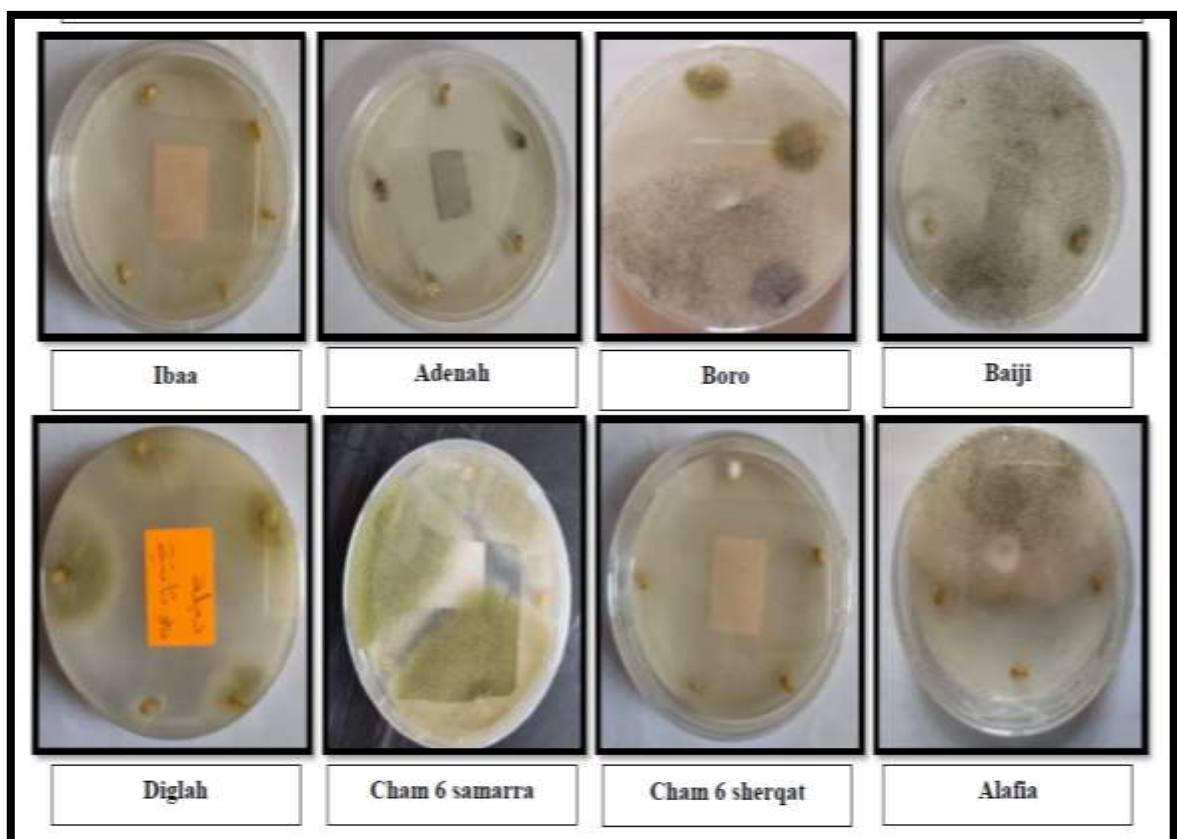


Figure 6. The Effect of Microwaves on the Fungi Associated with the Seeds of the Eight Wheat Varieties at the Thermal Coefficient (30) Seconds

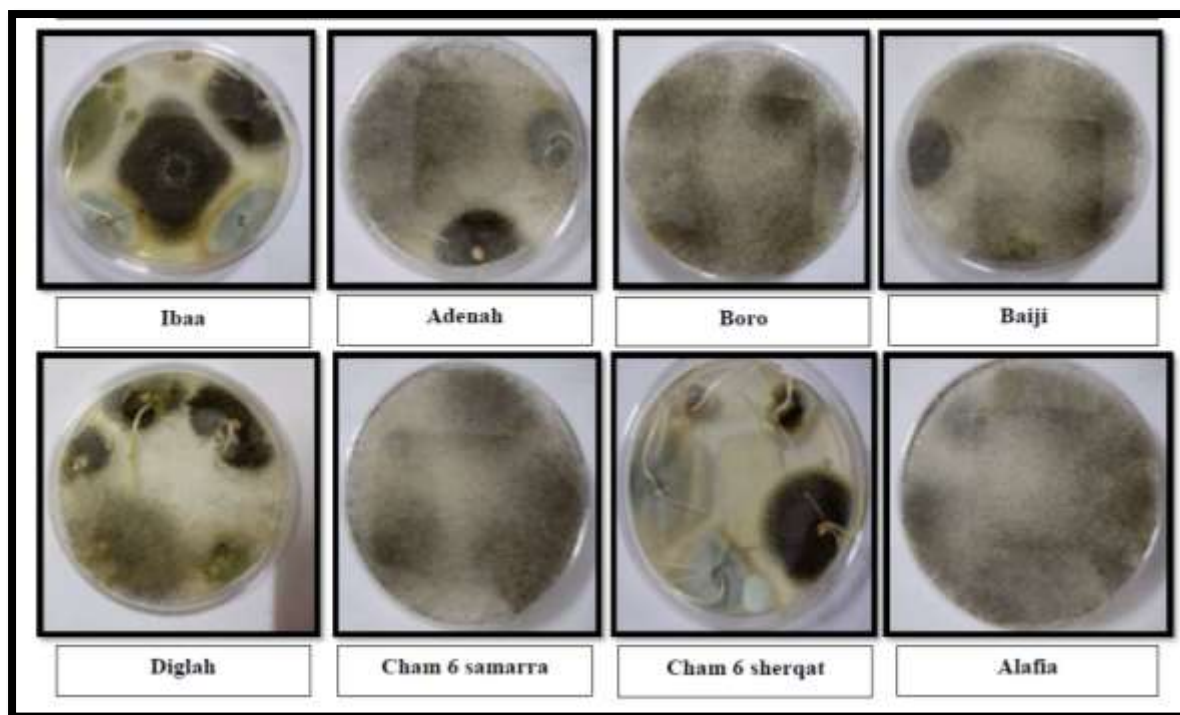


Figure 7. The Effect of Microwaves on the Fungi Associated with the Seeds of the Eight Wheat Varieties at the Thermal Coefficient (40) Seconds

Table 2. Fungal Frequency Percentage Relative to Microwave Exposure Time for All Wheat Cultivars Means with the Same Letter Are Not Significantly Different

No.	Fungi Isolates	The Percentage Frequency of Fungi in Relation to the Time of Exposure to the Microwave				
		0 S	10 S	20 S	30 S	40 S
1	Alternaria alternata	6.553 I J K L	15.833 F G	9.052 I	0 R	0 R
2	Alternaria tenuissima	7.636 I J K	13.303 G H	22.792 D E	0 R	0 R
3	Alternaria saponaria	2.083 P Q R	0 R	0 R	0 R	0 R
4	Aureobasidium pullulans	6.826 I J K L	5.972 J K L M N	1.637 P Q R	0 R	0 R
5	Aspergillus flavus	20.895 E	18.243 F	26.621 C	40.173 B	13.213 G H
6	Aspergillus fumigatus	0 R	0 R	0 R	0 R	26.458 C
7	Aspergillus niger	25.470 C	18.025 F	12.450 H	24.503 C D	44.616 A
8	Aspergillus terreus	0 R	8.819 I	1.389 P Q R	0 R	0 R
9	Curvularia lunata	1.116 Q R	0 R	0 R	0 R	0 R
10	Mucor spp.	0 R	2.718 O P Q R	1.983 P Q R	0 R	1.637 P Q R

11	Penicillium spp.	3.627 M N O P Q	6.250 I J K L M	3.264 N O P Q	0 R	0 R
12	Phoma spp.	4.990 K L M N O	0 R	0 R	3.646 M N O P Q	0 R
13	Rhizoctonia solani	5.552 J K L M N	6.667 I J K L	7.242 I J K	1.042 Q R	0 R
14	Rhizopus oryzae	14.721 G H	4.166 L M N O P	5.406 J K L M N O	5.635 J K L M N	14.071 G H
15	Stemphylium spp.	1.116 Q R	0 R	8.159 I J	0 R	0 R

4. CONCLUSION

The studied wheat seeds samples, in Salah AL-Din, Governorate, were all contaminated with fungi, the fungal species *Aspergillus flavus* and *A.niger* were the most frequently occurring species. The results showed possibility of recorded a specific time period to eliminate pathogenic fungi and it was 30 seconds. The saprophytic fungi cannot be removed by microwaving, because, these species were thermotolerant, so we could support this physical treatment with a chemical treatments to get the best results and could kills all fungal loads in stored seed wheats.

Acknowledgments

The authors have no specific acknowledgments to make for this research.

Funding Information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Maha Saud Khalaf	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	
Hawazin Ahmed Abid		✓		✓		✓		✓	✓			✓		✓
Rafea Zaidan Mukhlif Alsugmiany	✓	✓		✓	✓		✓			✓		✓	✓	

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Informed Consent

All participants were informed about the purpose of the study, and their voluntary consent was obtained prior to data collection.

Ethical Approval

The study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and approved by the relevant institutional authorities.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES




- [1] Satorre, E.H., Slafer, G.A., 1999. Wheat: Ecology and Physiology of Yield Determination. Food products press, An Imprint of The Haworth press, Inc
- [2] G. G. Oliver, M. J. Knok, J. M. Mchugh, and N. D. Fountaine, 'Effects of microwaves on fungal pathogens of wheat seed', Crop protection, vol. 50, pp. 12-16, 2013. doi.org/10.1016/j.cropro.2013.03.009
- [3] R. A. Wesley, D. W. Lyons, T. H. Garner, and W. E. Garner, 'Some effect of microwave drying on cottonseed', Journal of Microwave power, vol. 94, pp. 329-340, 1974.
- [4] Pakhomov. A.G., Y. Akyel, O.N. Pakhomova, B.E. Stuck, M.R Murphy, 1998. Current State and implications of research on biological effects of millimeter. Bioelectromagnetics, 19 (7) : 393-413
- [5] Adhikari, B., Pangomm, K., Veerana, M., Mitra, S., & Park, G. (2020). Plant Disease Control by Non-Thermal Atmospheric-Pressure Plasma. *Frontiers in Plant Science*, 11(77). Doi: 10. 3389 /fpls. 2020.00077 doi.org/10.3389/fpls.2020.00077
- [6] Saeedeh Taheri / Development and evaluation of a non-chemical method with microwave source for disinfection of legumes / School of Agriculture and Food, Faculty of Veterinary and Agricultural sciences, The University of Melbourne / May 2020
- [7] P. R. Shewry, 'Wheat', *J. Exp. Bot.*, vol. 60, no. 6, pp. 1537-1553, 2009. doi.org/10.1093/jxb/erp058
- [8] Soppe R, Saleh R. 2012. R. Report B2, 1 Historical Agricultural Production Data in Iraq. Iraq Salinity Project. The International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon.
- [9] Senapati N and Semenov M a (2019) Assessing yield gap in high productive countries by designing wheat ideotypes. *Scientific Reports* 9 (1), 1-12.
- [10] Johansson E, Branlard G, Cuniberti M, Flagella Z, Husken A, Nurit E, Peña RJ, Sissons M, Vazquez D, 2020. Genotypic and environmental effects on wheat technological and nutritional quality. In: *Wheat Quality For Improving Processing and Human Health*. Springer, Cham. pp. 171-204
- [11] Cappelli, A.; Oliva, N. and Cini, E. (2020). Stone milling versus roller milling: A systematic review of the effects on wheat flour quality, dough rheology, and bread characteristics. *Trends in Food Science and Technology*, 97: 147-155
- [12] Chattha, S.H.; Hasfalina, C.M.; Mirani, B.N.; Mahadi, M.R. and Lee, T.S. (2016) . Food grain losses associated with indigenous storage methods and development of storage facilities for food security. *International Food Research Journal*
- [13] V. Chelladurai, D. Jayas, and N. White, 'Thermal imaging for detecting fungal infection in stored wheat', *Journal of Stored Products Research*, vol. 46, no. 3, pp. 174-179, 2010. doi.org/10.1016/j.jspr.2010.04.002
- [14] C. M. Christensen and H. Kaufmann, 'Deterioration of stored grains by fungi', *Annual Review of Phytopathology*, vol. 3, no. 1, pp. 69-84, 1965. doi.org/10.1146/annurev.py.03.090165.000441
- [15] Muir, W., & White, N. (2000). Microorganisms in stored grain. Manitoba: Grain Preservation Biosystems, 1-17.
- [16] Mathew, S. (2010). An evaluation on grain quality under post-harvest storage in selected indian wheat varieties. *International Journal of Pharmaceutical Sciences and Research*. 1(11): 174-177.
- [17] Ulzaijargal, E.; Gorgo, Y.P. and Skorochood, I.O (2019). Detection of seedborne mycoflora in wheat. *International Journal of Innovative Science and Research Technology*, 4 (10): 532
- [18] S. Al-Rashdi, Biological control of root rot and wheat smut in soil not plowed. Iraq, 2011.
- [19] ISTA (2018). *International Rules for Seed Testing Association*, Vol. 2018, Full Issue i-19-8-(284). Online ISSN 2310-3655

- [20] A. S. Maryam, 'Isolation and Identification of Fungi from Cereal Grains in Libya', *International Journal of Photochemistry and Photobiology*, vol. 1, no. 1, pp. 9-12, 2017.
- [21] Fandohan P, B Gonovonfin B, Hell K, Marasas W F and Wing field M (2005) Natural occurrence of fusarium in stored maize in Benin West Africa. *Int. J. Food Microbiol.* 99, 173-183.
- [22] Al-Khalil, Abdullah bin Saleh bin Hassan (2011) the practical basis of fungi. Book. King Saud University. Riyadh. Third edition
- [23] Ellis, M. B. (1971). *Dematiaceous Hyphomycetes. Common wealth* doi.org/10.1079/9780851986180.0000 Mycological institute, Kew, Surrey, England.
- [24] K. U. Domesch, W. Gams, and A. Traute-Heidi, 'Compendium of Soil Fungi', *Compendium of Soil Fungi*, vol. 1, 1980.
- [25] Nelson, P. E.; Toussoun, T. A. and Marasas, W. F. O. (1983). *Fusarium species, an illustrated manual for identification*, The Pennsylvania state university press, University park. 73:1457-146.
- [26] Pitt J I and Hocking a D (2007) *Fungi and food spoilage*. Academic Press, Sydney, Australia.
- [27] Mohammed Hamza Abass, Qusai Hattab Madhi and Abdunabi Abdul Ameer Matrood. 2021. Identity and prevalence of wheat damping-off fungal pathogens in different fields of Basrah and Maysan provinces. *Bulletin of the National Research Centre*. <https://doi.org/10.1186/s42269-021-00506-0>. doi.org/10.1186/s42269-021-00506-0
- [28] Duncan, D.B., 1995. Multiple range and Multiple F test. *Journal of Biometrics*. 11:1-42.
- [29] K. Mahmoud and A.-A. M. Khalfallah, Eds, *Design and analysis of agricultural experiments*. Dar Al-Kutub Foundation for Printing and Publishing. 2000.
- [30] A. R. Sarhan, 'Fungi associated with stored grains in the silos of Al-Qadisiyah Governorate', *Al-Qadisiyah Journal*, vol. 24, 1995.
- [31] A.-A. Saadoun, 'the use of alfalfa root powder and sodium hypochlorite as lternatives to the use of chemical pesticides to control fungus associated with wheat seeds before planting', *Al-Qadisiyah Journal*, 2005.
- [32] G. M. Christensen and L. C. Lopezf, 'Pathology of stored seeds', *Proc. International seed testing association*, vol. 28, pp. 701-711, 1963.
- [33] H. Dhakar and R. S. Ratnoo, 'Isolation of seed borne myco flora of wheat *Triticum aestivum* L. em. The ll. Seed samples', *Journal of Pharmacognosy and Phytochemistry*, vol. 7, no. 4, pp. 162-166, 2018.
- [34] Borrisova, L.; Tacheva, T. and Bajkushev, R. (2000). *Amycotoxicological survey on wheat from two grain producing regions in Bulgaria*, *Vet. Med.* 6: 29-31
- [35] B. Muhammad and Z. Hamid, 'Isolation and identification of fungi associated with wheat grains an Y. Ahmed and A. Hadeel, *Isolation And Identification Of Fungi Carried In Wheat Seeds In Seed Production Companies In Nineveh Governorate, Iraq And The Study Of Varieties' Sensitivity To Some Fungi*. 2021.
- [36] Y. Ahmed and A. Hadeel, *Isolation And Identification Of Fungi Carried In Wheat Seeds In Seed Production Companies In Nineveh Governorate, Iraq And The Study Of Varieties' Sensitivity To Some Fungi*. 2021.
- [37] Martinez Solis, J., Nieves Flores, A. and Pena Ortega M.G., (2014) "Physiological Seed Quality and Fungi Incidence in Wheat (*Triticum aestivum* L.) Seeds Treated with Microwave Radiation", Athens: ATINER'S Conference Paper Series, No: AGR2014-1234.
- [38] R. M. Daniel, M. Dines, and H. H. Petach, 'The denaturation and degradation of stable enzymes at high temperatures', *Biochemistry Journal*, vol. 317, pp. 1-11, 1996. doi.org/10.1042/bj3170001
- [39] Cavalante, M.J.B. and J.J. Muchovej. 1993. Microwave irradiation of seeds and selected fungal spores. *Seed Sci. & Techn.*, 21: 247-253.
- [40] D. Ellis, S. Davis, H. Alexiou, and R. Handke, Robyn Bartley / *Descriptions Of Medical Fungi / Mycology Unit Women's And Children's Hospital*. .
- [41] Ferris, R. S. 1984. Effects of microwave oven treatment on microorganisms in soil. doi.org/10.1094/Phyto-74-121
- [42] Allison, D.Frisen (2014). *Microwave Radiation as an Alternative control for seed-borne-Diseases in Dry Bean*.

- [43] Brandt, k., Molgaard, J.P 2001.Organic agriculture does it enhance or reduce the nutritional value of plant foods? Journal of the Science of Food and Agriculture 81,924-931.
- [44] E. Barkat, Fungi Associated With Stored Wheat Grain in Australia: Isolation, Identification and. Alexandria, Egypt, 2016.
- [45] N. Shad, R. Ejaz, and A. Jamal, Iqra Haider Khan and Arshad Javaid .2019 Isolation and identification of seed associated fungi of .
- [46] Thomas J. Walsh, Randall T. Hayden Davise H. Larone / Larone's. (2018). Medically Important Fungi / A Guide To Identification / 6TH Edition

How to Cite Maha Saud Khalaf, Hawazin Ahmed Abid, Rafea Zaidan Mukhlif Alsugmiany. (2023). Isolation and identification of wheat seed fungi and effect of microwave on fungi loads in salah al-din governorate in iraq. International Journal of Agriculture and Animal Production (IJAAP), 3(2), 42-53. <https://doi.org/10.55529/ijaap.34.40.53>

BIOGRAPHIES OF AUTHORS

	<p>Maha Saud Khalaf, is a distinguished scientist and academic researcher affiliated with the Department of Biology, College of Science at Tikrit University, Iraq. With a strong foundation in biological sciences, she is actively engaged in advancing scientific research and education in Iraq. Her scholarly contributions to the field of biology reflect her dedication to academic excellence and scientific inquiry. As a faculty member at Tikrit University, one of Iraq's prominent higher education institutions, Maha demonstrates remarkable commitment to fostering scientific knowledge and inspiring the next generation of biologists within the Iraqi academic community. Email: maha.s.khalaf4410@st.tu.edu.iq</p>
	<p>Hawazin Ahmed Abid, is a driven and accomplished researcher specializing in biological sciences, associated with the Department of Biology, College of Science at Tikrit University, Iraq. Her academic journey reflects a profound dedication to scientific exploration and discovery, contributing meaningfully to the growing body of biological research in Iraq. With a strong analytical mindset and research-oriented approach, she actively participates in advancing scientific understanding within her discipline. Hawazin's work at Tikrit University underscores her passion for biology and her commitment to elevating the standards of scientific education and research in the Iraqi academic landscape.</p>
	<p>Rafea Zaidan Mukhlif Alsugmiany, is a dedicated and accomplished biological scientist and researcher based at the Department of Biology, College of Science, Tikrit University, Iraq. Renowned for his rigorous approach to scientific research, he has made notable contributions to the field of biological sciences within Iraq's academic community. His scholarly endeavors at Tikrit University reflect a steadfast commitment to uncovering new frontiers in biological research and fostering a culture of scientific excellence. Rafea's work exemplifies the resilience and intellectual vigor of Iraqi researchers striving to advance science and contribute to global biological knowledge despite challenging circumstances.</p>