**International Journal of Botany Studies**
**ISSN: 2455-541X; Impact Factor: RJIF 5.12**
**Received: 24-11-2020; Accepted: 11-12-2020: Published: 22-12-2020**
**www.botanyjournals.com**
**Volume 5; Issue 6; 2020; Page No. 694-697**

# Spoilage of fruits and vegetables due to fungal infection and its post-harvest control: A review

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**Abstract**
Fruits and vegetables are essential sources of health due to presence of fiber, vitamins and antioxidant compounds in them. Fungi are mainly responsible for spoilage of fruits and vegetables. Many changes occur in composition of antioxidant compounds during post-harvest spoilage. Some fruits and vegetable will be studied, which can be collected from crop land of Gujarat. Poor handling practices and storage are responsible for fungal infection or spoilage. Some technics are there for prevention of post-harvest spoilage control.

**Keywords:** post-harvest, fungi, spoilage, prevention, fruits and vegetables

## Introduction
Mycology (A stream of fungal study) is the study of the microorganisms (fungi) that inhabit, create, or contaminate food. The main purpose of the maximum spoilage due to fungal infection is caused in fruits and vegetables, some of the fruits and vegetable species are undertaken for present study. Food borne pathogens are the leading causes of sickness and death of people in undeveloped countries, killing approximately 1.8 million people per year. In developed countries, food borne pathogens are responsible for many cases of infectious gastrointestinal diseases each year, costing billions of dollars in medical care and lost productivity, Jaspreet Kaur Multhani, 2013 [1]. The consumption of the fungicide replacement and complaint of the public regarding the harm full effect of the fungicides to the human health there has to be the alternative way of reducing the fungicides or should be no more use of fungicide, Siddarth *et.al*, 2015 [2].

## Fungal identification
Pour plate and serial dilution methods were commonly used for fungi inoculation and lacto-phenol cotton blue used for identification, Oza K and Mankad A, 2015 [3]. Identification based on morphological as well as reproductive structure, studied with the help of literature available, Gilman, 1957 [4]; Summerell *et.al*, 2003 [5].

The *Lycopersicon esculentum M*. (tomato) is an important crop across the world, originated in Western South America. Because of the importance of tomato as all food varieties, it has been bred to improve productivity, fruit quality, and resistance to biotic and a biotic stress, Kimura and Sinha, 2008 [6], Barkai and Fauchs 1980 [7] and Hassan 1996 [8] have reported that several fungi are pathogenic under storage conditions, but *Alternaria* is main decay causing organism of post-harvest fruits while responsible for black rot lesions on tomato fruits. Many studies have been carried out with respect to, severity, losses, occurrence, causal organisms, pathogenecity and disease control with fungicides, A. H. Wani, 2011 [9]. Mohamed S Massoud, 2013 [10] reported that *Aspergillus* is the high incidence as highest fungal genera and represented by three species namely; *A. flavus var colamnaris, A. niger* and *A. ochraceus*. The genus *Aspergillus* was recovered from *Allium cepa, Solanum lycopersicum, S. tuberosum, Citrus lemon, Cucurnis sativus* and *Cucrbite pepo, A. flavus var colamnaris* was isolated from 5 fruits and vegetables, *A. niger* was recovered from *Solanum lycopersicum* only, whereas *Aspergillus ochraceus* was isolated from *Solanum lycopersicum* and *Cucurnis sativus* only. Iniekong P. Udoh, 2015 [11], reported that a total of 2140 (71.3%) positive fungi isolates are recorded in their work some are *L. esculentus* 410 (19.2%), *E. guineensis* 415 (19.4%), *I. batatas* 200 (9.3%), *S. tuberosum*, 380 (17.8%), *M. sapientum* 120 (5.6%), *D. carota* 110 (5.1%), *M. paradisiaca* 115 (5.4%), *C. papaya* 78 (3.6%), *P. americana* 67 (3.1%), *C. lanatus* 110 (5.1%) and *C. chinense* 135 (6.3%). ). Identification was done using photomicrographs of fungi in books and journals, Dimphna, Nneka Ezikanyi, 2016 [12].

Seven fungal species are reported by Akinro, 2015 [13] that are *Aspergillus sp., Rhizopus sp., Candida sp., Fusarium sp., Phytophthora sp.* and *Mucor sp*. Which were isolated from a total of twelve fruits, *Aspergillus flavus* was isolated from pawpaw (*Carica papaya)* and pineapple *(Ananas comosus*), while *Aspergillus niger* was isolated from orange *(Citrus sinensis), Rhizopus sp.* was obtained from pawpaw *(Carica papaya)* and Tomato *(Lycopersicon esculentum) Candida sp* was isolated from orange (*Citrus sinensis)* and tomato *(Lycopersicon esculentum)* while *Fusarium sp.* and *Mucor sp*. were isolated from tomato (*Lycopersicon esculentum*) and *Phytophthora sp.* from pineapple *(Ananas comosus).* Researcher shows the frequency of occurrence of fungi in the various fruits. *Aspergillus niger* had the highest occurrence in pineapple, watermelon, oranges, pawpaw, and tomatoes with a frequency of 38%.which is followed by *Fusarium avenaceum* i.e.31% in fruits such as pineapple, watermelon, oranges, pawpaw, and tomatoes while *Penicillium digitatum* and *R. stolonifer* had the least frequency of 4% each with tomato; and orange and tomato, respectively. Some other fungal species were identified as yeast (*Saccharomyces* species) (10%), *F. solani* (8%) and

*Aspergillus flavus* (5%) Samuel Mailafia *et.al*, 2017 [14]. Kalipati variety of sapota fruit showed the predominance of filamentous Aspergillus minisclerotigenes and Lasiodiplodia theobromae Oza K *et.al*, 2020 [15]. Mycological analysis shows, a wide range of filamentous fungal species belonging to the genera *Aspergillus*, *Penicillium* and *Fusarium* contaminating food commodities with varying colony forming units (Cfu) this indicated that Cocoa and cocoa- based powder beverages were contaminated mainly with a wide range of *Aspergillus* species dominated by the prevalence of *Aspergillus flavus* (82.4%), *Aspergillus fumigatus* (76.5%), *Aspergillus niger* (82.4%), *Aspergillus parasiticus* (54.6%) and *Aspergillus ochraceus* (52.9%) with lesser incidences of *Penicillium* and *Fusarium* species, Mary Augustina Egbuta *el.al*,2015 [16]. *A.niger i*s a fungus commonly found on grapes, apples and tomatoes, Junghare *et.al*. 2015 [17].

Many researchers confirmed that Post-harvest spoilage of banana fruits has been reported from different regions of the world due to infection caused by fungi. Contamination refers to any change in the condition of food in which the food becomes less acceptable, or even toxic, these changes may be accompanied by alterations in taste, smell, appearance or texture. Agricultural crops are infected from various types of microorganism; the process of infection in the case at fungal invasion follows the development of fungal penetrating structure. Division of fungal mycelium creates colony and Colonization of fungi is a critical phase in the microbial spoilage of post harvested fruits. The colonization process involves the ability of the fungi to establish itself without the host, Snowdon, A.L., 1988 [18].

**Antifungal activities**

Antifungal activities of crude extracts (buffer extract and acid extract) and their respective dilutions from medicinal plants belonging to seven plant families were studied against *Alternaria sp*. On the 29 extracts evaluated, 31%, from nine plants, exhibited *in vitro* antifungal activity, with inhibition values of over 90% Paola Díaz Dellavalle *et.al*, 2011 [19]. K D Mwambete 2009 [20] observes that fruit extracts showed higher antimicrobial activity than leaf extract. Extracts of *M. charantia* demonstrated antimicrobial activity of test microorganisms except on *Proteus mirabilis* and *Cryptococcus neoformans* Broekaert *et al*., 1990 [21]. Measured Antifungal activity by a quantitative micro Spectro photometric assay. Absorbance was evaluated at 595 nm in an ELISA plate reader. After 48 h of incubation at 27 °C, growth was recorded by measuring absorbance. All assays for antifungal activity were carried out at least in triplicate. Growth inhibition Broekaert *et al*., 1990 [21]. was calculated based on the equation $[(\Delta C - \Delta T) / \Delta C] \times 100$, where $\Delta C$ is the corrected absorbance of the control microculture at 595 nm and $\Delta T$ is the corrected absorbance of the test microculture Paola Díaz Dellavalle *et.al*, 2011 [19]. On the other tested samples obtained from plant species, 3 species showed antifungal activity only against *C. paradoxa*, 16 species showed antifungal activity only against *F. guttiforme*, 24 species showed antifungal activity against both fungi and 14 species did not exhibit antifungal activity against the tested fungi Maria Diana Cerqueira Sales *et.al*, 2016 [22]. Many medicinal plant exhibits antifangal activity against *Alternaria sp*. They have some effective bioactive compounds for growth inhibition of the fungi. These species showed antifungal activity at low concentrations. These are close to the commercial fungicide used as a positive control Dellavalle *et.al*, 2011 [19].

Highest mycelial growth inhibition was directly proportional to the concentration increase of neem and Karanja oils. Neem concentration corresponding to 100 µg a.i. mL-1 with 1/3 Karanja oil was the most effective in reduction of mycelial growth, with 63% inhibition. Among the vegetable extracts, fruits of long pepper were the most promising for reducing mycelial growth, with 43% inhibition Núcleo de Pesquisas em Fitopatologia, 2012 [23]. *Arachis hypogaea* oil had an antifungal activity also inhibited the germination of fungal spores. Oil having more antifungal potential as compare to others against *Aspergillus sp*. Oza K *et.al*, 2018 [24]. Essential oils could be used as a potential source of sustainable ecofriendly botanical fungicides, after successful completion of wide range trials. Oregano oil and rosemary result in the utilization of natural plants or their oils and extracts in post-harvest disease control. *In vivo* experiments, oregano essential oil showed enhancement in the shelf life of cold stored tomatoes by reducing postharvest diseases caused by fungi. Further studies are required to determine the active components of oregano essential oil and rosemary extract that are responsible for the antifungal property and the potential use of fumigation in cold storage or for active packing Ibrahim FAA and Ebady NA, 2014 [25].

**Post-harvest treatment**

Fruits have their great fungal diversity. These fungi grow fruits showing their impact on human health and businessman with reference to post harvest losses Archana Jungharea, 2015 [17]. To enhance longer shelf life and greater income papaya fruit can be reduced, their degree of post-harvest spoilage. There are various post-harvest treatments to control decay in papaya fruit, these include hot water treatment Chan, 1983 [26] and higher temperature forced air treatment on the breeding of resistant variety of papaya. However, one satisfactory measure against papaya spoilage is through hygiene, quarantine, treatment procedures and vector control Awoite TM, 2013 [27].

Heat treatment has been considered as eco-friendly methods of deterioration control, either alone or in combination with other methods. The three most frequently used methods are hot water immersion, forced-hot air treatment and vapor heat treatment. Hot water immersion has been classically used for fungal control and vapor heat treatment was used specifically for insect control, while forcing-hot air treatments used for both fungal and insect management Chun-to-Wu, 2010 [28].

Several physical and chemical treatments have been evaluated for controlling post-harvest diseases. The physical treatment includes heat therapy, low temperature storage and radiation, and chemical treatment includes the use of chemical agents like antibiotics, growth regulators, fungicides, oils, chemicals and vapors emitting compounds. The results have emphasized that efforts should be made to adopt an improved packaging system, cushioning material and cold storage facilities at the retail level Rinkey Pallavi *et.al*, 2016 [29]. Some other technics can be used for improving post-harvest quality like temperature management, control water loss, atmosphere modification, treatments to reduce ethylene damage Chun-ta-wu, 2010 [28]. Poor handling practices in the food supply chain, storage conditions, distribution, marketing practices and

transportation could also be as a result of contamination of fruits and vegetables by fungi Efiuvwevwere, B.J.O., 2000 [30]. Researchers used an illustrated reference book for identification of Microbial spoilage agents of tomato and assorted fruits and vegetables (Port Harcourt). To avoid long term exposure to spoilage, fruits and vegetables are advised to be eaten fresh or cooked. Also, the high moisture content of fruits and vegetables will be a serious limiting factor in their preservation. Finally, the farmers transport their fruits into bags for the marketers and consumers should take necessary precautions in preventing contamination and try to create an environment that would discourage the growth or multiplication of microorganisms Akinro *et.al*, 2015 [31]. The biggest issue in Kashmir's tomato attacked by varieties of pathogens; predominant being the fungal fruit rots Taskeen-un-Nisa *et.al*, 2011 [32]. The fungal rot was reported in India and these fungal roots are responsible for causing serious production problems and become a menace for successful cultivation of tomatoes in the valley. Thomas, 1944 [33].

## Conclusion

Symptoms of spoilage by fungal growth keep fruits and vegetables with a furry growth and become pulpy to produce bad smells. Spoilage due to mold and yeasts produces souring taste, due to growth of mold and rotting of fruit and vegetables. These are harmful to humans. Maximum experiments have been carried out with respect to occurrence, causal organisms, severity, losses, pathogenicity and disease control with fungicides. This review may help the future research scholars to devise a concrete strategy for evaluating different pathological aspects and prevention of the post-harvest fungal diseases of fruit and vegetables.

## Reference


1. Jaspreet Kaur Multhani. Isolation and Identification of Fungi from Spoiled food samples and testing their Antibiotic efficacy, Helix. 2013; 4:361-364.
2. Siddarth. Challenges in postharvest management of fungal diseases INS fruits and vegetables – A review, 2015.
3. Kalpa Oza. Archana Mankad. Fungal Diversity in Gujarat University Campus in Different Seasons, International Journal of Science and Research (IJSR). 2015; 6:7.
4. Gilman Joseph. A manual of soil fungi. 1957; 84(2):183.
5. Summerell BA, Sallah B, Leslie JE. A utilitarian approach to Fusarium identification. Plant Disease. 2003; 87:117-128.
6. Kimura S, Sinha N. Tomato (Solanum lycopersicum): A model fruit bearing crop. CSH Protoc, 2008, 105.
7. Barkai GR, Fauchs Y. Research on post-harvest diseases of tomato. A survey of the organisms causing rot-of stored tomato fruits. Preliminary-report,-volcani-centre,-Bet-Dagan. 1980; 782:1-12.
8. Hassan HAH. Alternaria my cotoxins in Black rot lesion of tomato fruits: Conditions and regulations of their productions. Acta Immunolgica Hungarica. 1996; 43:125-133.
9. Taskeen-un-Nisa, Wani AH, Bhat MY, Pala SA, Mir RA, *In vitro* inhibitory effect of fungicides and botanicals on mycelia growth and spore germination of Fusarium oxysporum. J Biopest. 2011; 4:53-56.
10. Mohamed S Massoud. Survey of Fungal Diseases of Some Vegetables and Fruits in Aswan, EGYPT, IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS) e-ISSN: 2278-3008, p-ISSN: 2319-767. 2013; 6(3):39-42.
11. Iniekong P, Udoh, Clara I, Eleazar, Bryan O, Ogeneh, *et al.* Studies on Fungi Responsible for the Spoilage/Deterioration of Some Edible Fruits and Vegetables, Advances in Microbiology. 2015; 5:285-290.
12. Dimphna Nneka Ezikanyi. Isolation and Identification of Fungi Associated with Postharvest Decay of Lycopersicum esculentum M. sold in Abakaliki, Nigeria, IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS). 2016; 9(7):87-89. e- ISSN: 2319-2380, p-ISSN: 2319-2372.
13. Akinro EB, Adetuberu IA, Efunwole OO, Olakunle TP. Isolation and Identification of Fungal Species Associated With the Spoilage of Some Selected Edible Fruits in Iree Town Of Boripe Local Government, Osun State, Nigeria, Journal of Research in Pharmaceutical Science. 2: 7- 07-10. ISSN (Online), 2015, 2347-2995.
14. Samuel Mailafia, God'spower Richard Okoh, Hamza Olatunde K. Olabode, Ramatu Osanupin. Isolation and identification of fungi associated with spoilt fruits vended in Gwagwalada market, Abuja, Nigeria, Veterinary World, EISSN, 2231-0916.
15. Oza K, Jain BK, Maitreya B. Isolation and identification of fungi from Kalipati variety of Sapota fruits. International Journal of Botany Studies. 2020; 5:264-66.
16. Mary Augustina Egbuta, Mulunda Mwanza, Patrick Berka Njobeh, Judith Zanele Phoku, Cynthia Adaku Chilaka, Micheal Francis Dutton, *et al* Isolation of Filamentous Fungi Species Contaminating Some Nigerian, 2015.
17. Archana Jungharea, Nasareb PN, Mousmi Bhowl. Fungal Diversity in Fruits and their Impact on Human Health and Businessman with Reference to Losses, Online International Interdisciplinary Research Journal, 5, ISSN 2249-9598, 2015.
18. Chan HT. Handbook of Tropical Foods. Marcel Dekker New York, 1983, 469-488.
19. Snowdon AL. A review of the nature and causes of post-harvest deterioration in fruits and vegetables, with special references to those in International Trade. Biodeterioration. 1988; 7:585-602.
20. Paola Díaz Dellavalle. Anti-fungal activity of medicinal plant extracts against Phyto Pathogenic fungus alternaria spp., Chilean journal of agricultural research, 2011, 71(2).
21. Mwambete KD. The *in vitro* antimicrobial activity of fruit and leaf crude extracts of Momordica charantia: A Tanzania medicinal plant, Afr Health Sci. 2009; 9(1):34-39.
22. Broekaert WF, Terras FRG, Cammue BPA, Vanderleyden J. An automated quantitative assay for fungal growth inhibition. FEMS Microbiology Letters. 1990; 69:55-60.
23. Maria Diana Cerqueira Sales. Anti-fungal activity of plant extracts with potential to control plant pathogens in pineapple, Asian Pacific Journal of Tropical Biomedicine. 2016; 6(1):26-31.

24. Núcleo de Pesquisas em Fitopatologia. Antifungal activity of vegetable oils and extracts against Sclerotinia Sclerotiorum, Bioscience. 2012; 28(1):48-57 ref.32.
25. Oza K, Jain BK, Maitreya B. Inhibitory Effect of Antifungal Activity of Ground Nut Oil Agent's Fungi, International Association of Biologicals and computational Digest iABCD. 2018; 2:106-111.
26. Ibrahim FAA, Ebady NA. Evaluation of Antifungal Activity of Some Plant Extracts and their Applicability in Extending the Shelf Life of Stored Tomato Fruits. J Food Process Technol. 2014; 5:340.
27. Awoite TM, Olorunfemi MF, Ajani AO, Oyelakin MO. Studies on Fungi Associated With Post Harvest Spoilage of Pawpaw Carica PAPAYA Fruit, IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS). 2013; 4(6):01-04. ISSN 2278-3008.
28. Chun-Ta-Wu. An overview of postharvest biologyand technology of fruits and vegetables, AARDO workshop on technology on reducing postharvest losses and maintaining quality of fruits and vegetables, 2010, 2-11.
29. Rinkey Pallavi, Thakur Uma, Dongarwar Nitin, Post-harvest fungal diseases of fruits and vegetables in Nagpur, Int. J. of Life Sciences, Special Issue A2, 2014.
30. Efiuvwevwere BJO. Microbial spoilage agents of tomato and assorted fruits and vegetable, an illustrated references book, 2000, 1-39.
31. Akinro EB. Adetuberu IA, Efunwole OO, Olakunle TP. Isolation and Identification of Fungal Species Associated With the Spoilage of Some Selected Edible Fruits in Iree Town Of Boripe Local Government, Osun State, Nigeria, Journal of Research in Pharmaceutical Science. 2: 7- 07-10. ISSN (Online). 2015, 2347-2995.
32. Taskeen-Un-Nisa, Wani AH, Bhat MY, Pala SA, Mir RA, *In vitro* inhibitory effect of fungicides and botanicals on mycelia growth and spore germination of Fusarium oxysporum. J Biopest. 2011; 4:53-56.
33. Thomas HR. Freckle spotting of tomato fruits. Phytopathology. 1944; 34:341-343.