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Exploration of Fungal Pathogens Associated with Post Harvest Diseases of Guava in Prayagraj, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Guava (*Psidium guajava* L.) is a climacteric fruit belonging to the family Myrtaceae. Guava's perishability makes it vulnerable to various diseases from root to crown, with fungal pathogens being a major cause of significant loss of production during storage and transit. An experiment was conducted to identify the fungal pathogens causing post-harvest diseases. Total 70 diseased guava samples (5 fruits from each location) were collected from various fruit markets in Prayagraj, U.P. These samples were then taken to the laboratory of the Department of Plant Pathology at the Naini Agricultural Institute, SHUATS, Prayagraj for the purpose of isolation and identification of the pathogens. The study revealed the presence of ten fungal pathogens responsible for post-harvest diseases *viz*., *Pestalotia psidii* (37.14%), *Curvularia* sp. (15.71%), *Alternaria* sp. (11.42%), *Penicillium* sp. (8.57%), *Colletotrichum* sp. (7.14%), *Fusarium* sp. (7.14%), *Aspergillus* sp. (5.71%), *Rhizopus* sp. (2.85%), *Rhizoctonia* sp. (2.85%), and *Verticillium* sp. (2.58%).

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Keywords: Alternaria sp.; Curvularia sp.; fungal pathogens; Guava; Prayagraj; post-harvest diseases; Pestalotia psidii; Penicillium sp.

1. INTRODUCTION

Guava (*Psidium guajava* L.) is a notable fruit in tropical and subtropical areas, known for its delicious taste and rich nutritional content [1]. In India, it holds the fourth position in terms of importance, coming after mango, banana, and citrus fruits in both production and consumption. The country dedicates approximately 315,000 hectares to guava cultivation, resulting in a production of 45.16 million metric tons. Uttar Pradesh stands as the top guava producer in India, with Madhya Pradesh and Bihar also playing key roles in cultivation. In Uttar Pradesh alone, guava is grown on 29,000 hectares, yielding 9.83 million metric tons. The Prayagraj district is especially famous for its high-quality guavas, recognized both nationally and internationally [2]. Due to its perishable nature, guava is vulnerable to a range of diseases that affect all parts of the plant, including the fruit, especially under varying climatic conditions. It is susceptible to bacterial, fungal, algal, and nematode infections, as well as occasional physiological disorders, which can result in postharvest diseases [3]. Postharvest diseases account for an estimated 40% loss of produce, with fungal pathogens responsible for over 30% of the damage during storage and transit. Key fungal pathogens are *Alternaria* sp., *Aspergillus niger*, *Penicillium* sp., *Pestalotia psidii*, *Rhizopus stolonifer*, and *Colletotrichum gloeosporioides* [4]. The high sugar and nutrient content of guava, combined with its low pH, makes it particularly vulnerable to fungal decay [5]. This investigation will help to understand the microbial diversity affecting post-harvest quality of guava. It is crucial because identifying the types of fungi enables the development of control methods. Beyond contributing to scientific knowledge, it is also important for farmers and fruit traders, as it raises awareness about the causes of damage to their products. Additionally, identifying these pathogens is vital for human health, as it helps prevent the consumption of contaminated fruits.

2. MATERIALS AND METHODS

To carry out the experiment, a total of 70 (5 samples from each fruit market) diseased guava samples were gathered from various fruit markets in Prayagraj, U.P. during October, 2023 to February, 2024. The samples were promptly transported to the Department of Plant Pathology at the Naini Agricultural Institute, SHUATS, in Prayagraj, Uttar Pradesh, India. Small sections, 2-3 mm in size, were taken from both healthy and diseased parts of the fruits. These sections were surface-sterilized by soaking them in a 1% sodium hypochlorite solution for 30 seconds, then dipped in ethyl alcohol, and finally rinsed three times with sterile distilled water. The sterilized fragments were initially laid on blotting paper and then transferred to a solidified potato dextrose agar (PDA) medium under sterile conditions. The plates with the inoculated fragments were incubated at room temperature (27±1°C) in an inverted position. Fungal growth was observed, and colonies that emerged from the tissue fragments were transferred to PDA medium slants for further culturing and examination [6]. The isolated fungal pathogens were examined under a compound microscope to identify their characteristic morphological features. To verify the fungal identity, observations of conidia, conidiophores, and colony morphology were compared with descriptions in standard references such as Gilman [7] Barnett and Hunter [8] and Nelson et al. [9]. The frequency of each isolated pathogens were calculated by following the formula given by Singh [10].

> Frequency % = No. of fruits infected with certain pathogen / Total No. of fruits brought from market

3. RESULTS AND DISCUSSION

There were 10 fungal pathogens isolated and identified as those were associated with post-harvest decay of guava. The details about the isolated pathogens are mentioned in Table 3.

The occurrence of various diseases affecting guava in different fruit markets is outlined below:

In Naini, three fungal pathogens were identified: *Pestalotia psidii* (60%), *Penicillium* sp. (20%), and *Aspergillus* sp. (20%). At Khan Chauraha, *P. psidii* and *Colletotrichum* sp. had the highest prevalence (40%), while *Rhizopus* sp. was at 20%. In Rambag, *P. psidii* was the most frequent (40%), followed by *Fusarium* sp., *Aspergillus* sp., and *Penicillium* sp. each at 20%. Civil Lines saw *P. psidii* and *Curvularia* sp. as the most common (40%). In Chaka, *P. psidii* was the predominant pathogen (60%). In Mehewa West, *Curvularia* sp. was most prevalent (40%), followed by *Alternaria*

sp., *Colletotrichum* sp., and *P. psidii* each at 20%. In Teliarganj, *Alternaria* sp. had the highest frequency (40%). In Karchana, *Curvularia* sp. was the most frequent, followed by *Rhizoctonia* sp., *Fusarium* sp., and *P. psidii*. Other areas like Chungi, Khusroobagh, Katra, Medical Chauraha, Gaughat, and Meja had *P. psidii* as the dominant pathogen with a frequency ranging from 20-40%.

Table 1. Incidence of fungal pathogens associated with post-harvest diseases of guava in fruit markets of Prayagraj

Place of collection	Isolated pathogens	No. of samples	Frequency (%)
Naini	*Pestalotia psidii*	3	60
	Penicillium sp.	1	20
	Aspergillus sp.	1	20
Khan Chauraha	*Pestalotia psidii*	2	40
	Colletotrichum sp.	2	40
	Rhizopus sp.	1	20
Rambag	*Pestalotia psidii*	2	40
	Fusarium sp.	1	20
	Aspergillus sp.	1	20
	Penicillium sp.	1	20
Civil Lines	*Pestalotia psidii*	2	40
	Curvularia sp.	2	40
	Aspergillus sp.	1	20
Chaka	*Pestalotia psidii*	3	60
	Colletotrichum sp.	1	20
	Curvularia sp.	1	20
Chungi	*Pestalotia psidii*	2	40
	Alternaria sp.	2	40
	Curvularia sp.	1	20
Khusroobagh	*Pestalotia psidii*	2	40
	Fusarium sp.	1	20
	Alternaria sp.	1	20
	Colletotrichum sp.	1	20
Mehewa West	*Curvularia* sp.	2	40
	Alternaria sp.	1	20
	Colletotrichum sp.	1	20
	Pestalotia psidii	1	20
Katra	*Pestalotia psidii*	2	40
	Aspergillus sp.	1	20
	Penicillium sp.	1	20
	Rhizopus sp.	1	20
Medical Chauraha	*Pestalotia psidii*	2	40
	Penicillium sp.	2	40
	Alternaria sp.	1	20
Gaughat	*Curvularia* sp.	1	20
	Alternaria sp.	1	20
	Pestalotia psidii	1	20
	Fusarium sp.	1	20
	Rhizoctonia sp.	1	20
Teliarganj	*Alternaria* sp.	2	40
	Fusarium sp.	1	20
	Verticillium sp.	1	20
	Pestalotia psidii	1	20
Karchana	*Curvularia* sp.	2	40
	Rhizoctonia sp.	1	20
	Fusarium sp.	1	20
	Pestalotia psidii	1	20

Place of collection	Isolated pathogens	No. of samples	Frequency (%)
Meja	*Curvularia* sp.	2	40
	Pestalotia psidii	2	40
	Penicillium sp.	1	20

**Five diseased guava fruit samples were collected from each location*

Table 2. Overall incidence of pathogens associated with post-harvest diseases of guava in Prayagraj

Sl. No.	Pathogens	No of samples	Frequency (%)
1	*Pestalotia psidii*	26	37.14
2	*Curvularia* sp.	11	15.71
3	*Alternaria* sp.	8	11.42
4	*Penicillium* sp.	6	8.57
5	*Colletotrichum* sp.	5	7.14
6	*Fusarium* sp.	5	7.14
7	*Aspergillius* sp.	4	5.71
8	*Rhizopus* sp.	2	2.85
9	*Rhizoctonia* sp.	2	2.85
10	*Verticillium* sp.	1	1.42

**Total number of diseased guava fruit samples were 70*

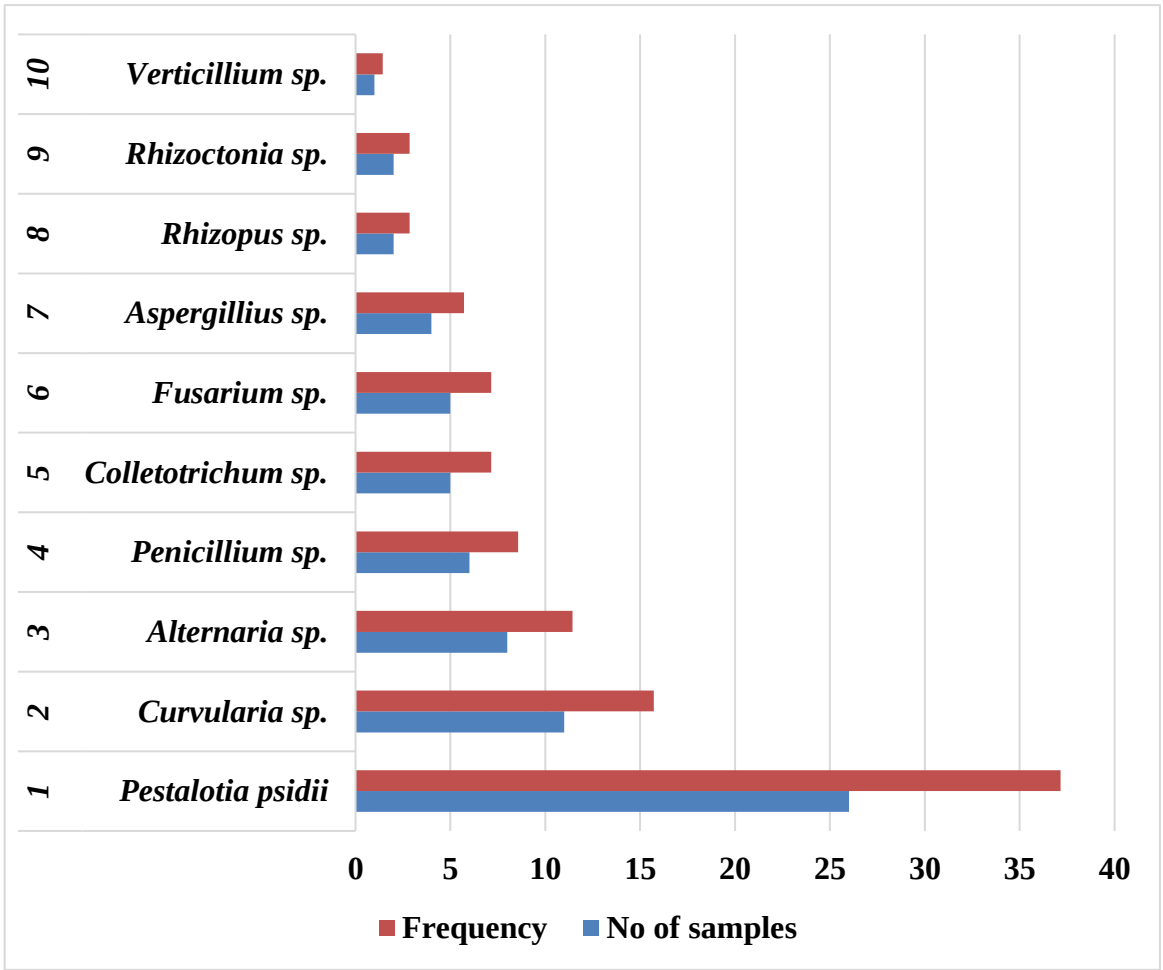

Fig. 1. Frequency of different pathogens associated with post-harvest decay of guava

Table 3. List of fungal pathogens frequently associated with post-harvest diseases in guava

S. No.	Disease name	Causal organism	Symptoms	Morphological characteristics of pathogen
1.	Fruit canker Plate 1. (i-iii)	*Pestalotia psidii*	Reddish-brown necroticspots appear, enlarge, penetrate the pulp, and form a sunken center.	Acervuli are dark, cushion-shaped structures below the epidermis with short conidiophores. The multicellularconidia have dark bodies and hyaline apical appendages [11].
2.	Fruit spotPlate 1. (iv-vi)	*Curvularia* sp.	A circular honey-yellow spotgrows, turns brown, and its edges blend with the surrounding healthy tissue.	Conidiophores are brown, simple, andbear spores at their tips. The dark conidia have lighter end cells, usually3-5 cells, are fusiform, often curved, with one enlarged central cell [11]
3.	Fruit spotPlate 1. (Vii-ix)	*Alternaria* sp.	Blackish to brown, parched spots on the fruit's surfacepenetrate the inner pulp as the condition progresses.	Colonies grow quickly with a glassy appearance and black conidia specks. Conidia, produced in long, branched chains, are cylindrical and muriform, narrowing towards the apex with a rounded basal cell [11]
4.	Penicillium rot Plate 1. (x-xii)	*Penicillium* sp.	The infected fruit turnsbrown, watery, and breaks easily. In severe cases, mold covers the fruit.	Conidiophores arise singly or in synnemata, branched near the apex, ending in phialides. Conidia are 1-celled, hyaline or brightly colored, globose or ovoid, arranged in basipetal chains [12].
5.	Anthracnose Plate 1. (xiii-xv)	*Colletotrichum* sp.	Dark necrotic lesionsdevelop and, in humid conditions, are overlaid with pinkish spore masses. These lesions merge, forming extensive necrotic areas that affect the fruit's flesh.	The colony ranges from white to grey.Conidia are oblong, forming asalmon-colored spore mass. Acervuli are disc-shaped or cushion-shaped, salmon to grey, with a waxy texture and dark spines among simple, unbranched conidiophores [11]
6.	Fruit rot Plate 1. (xvi-xviii)	*Fusarium* sp.	Impacted fruits remain small,hard, and stony with dark brown spots that enlarge, merge, and turn blackish- brown.	The mycelium forms dense masseswith a pinkish hue in culture. Conidiaare hyaline, varying in colors like purple or yellow, with two types: Macroconidia are curved like canoes, and microconidia are single-celled, ovoid or oblong [11]
7.	Aspergillus- rot Plate 1. (xix-xxi)	*Aspergillus* sp.	The water-soaked spotexpands, turns brown, and depresses at the center. Blackconidial heads emerge on the surface as the condition advances.	The branched mycelium developsthick-walled foot cells that form a single, globose conidiophore with brown sterigmata. This structure, along with vesicles and conidia, creates the characteristic black head of the fungus [13]

S. No.	Disease name	Causal organism	Symptoms	Morphological characteristics of pathogen
8.	Soft watery rot Plate 1. (xxii-xxiv)	*Rhizopus* sp.	As water-soaked lesions advance, they become slightly sunken, turn brown, and develop mycelial strandson the surface.	*Rhizopus* fungi grow rapidly with a cottony texture. They have a coenocytic, branched mycelium comprising stolons, rhizoids for anchorage, and sporangiophores forspore production [14].
9.	Fruit rot Plate 1. (xxv-xxvii)	*Rhizoctonia* sp.	Small dark brown flecks enlarge, coalesce, and become blackish-brown blotches.	Asexual fruiting bodies and spores absent. Sclerotia small, brown orblack, varied shapes. Mycelium's brown hyphae elongated, septa branching from primary hyphae [11]
10.	Fruit rotPlate 1. (xxviii- xxx)	*Verticillium* sp.	Affected fruits become smaller. Uneven ripening, brown discoloration nearstem end. Rot starts inside, abnormal development.	Transparent vegetative mycelium withsepta. Conidia ovoid or ellipsoid, single-celled, produced on phialides arranged in whorls around conidiophores [15].

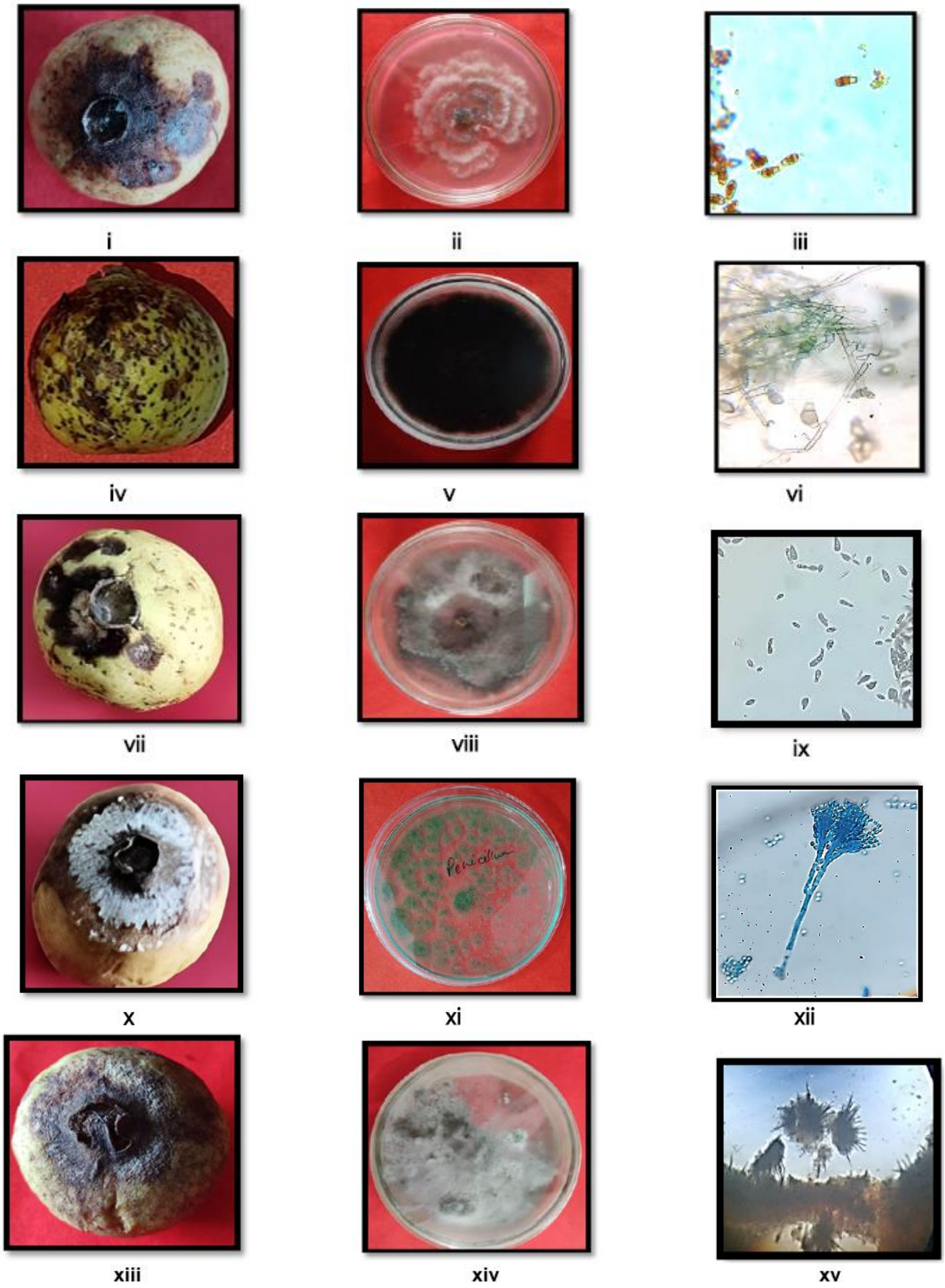

Plate 1. (i-xv) Fungal pathogens isolated from guava fruits (40x)

Overall, in Prayagraj, the average incidence of post-harvest fungal pathogens in guava was highest for *P. psidii* (37.14%), followed by *Curvularia* sp. (15.71%), *Alternaria* sp. (11.42%), Penicillium sp. (8.57%), Colletotrichum sp. and Fusarium sp. (7.14%), *Aspergillus* sp. (5.71%), and *Rhizopus* sp. and *Rhizoctonia* sp. (2.85%). The least common was *Verticillium* sp. (1.42%).

The incidence of guava fruit rot in Prayagraj appears to have been influenced by various factors, including the presence and concentration of microbial components on the fruit surface, the physiological state of the fruit, ambient temperature, and relative humidity [16]. Among the pathogens identified, *Pestalotia psidii* had the highest incidence, recorded at 37.14%. This finding aligns with the research conducted by Srivastava and Lal [17] who reported similar results. Additionally, Rao et al. [18] observed that *P. psidii* was the most frequently isolated pathogen, responsible for 36.45% of the cases of guava fruit rot. These studies collectively highlight the significant impact of *P. psidii* on guava fruit rot and the insights gained from this research can be effectively applied to establish proper post-harvest practices, thereby enhancing the guava fruit's shelf-life.

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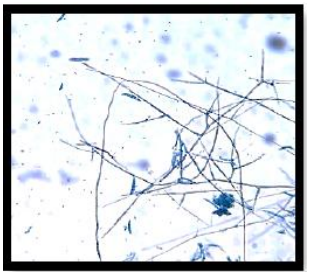

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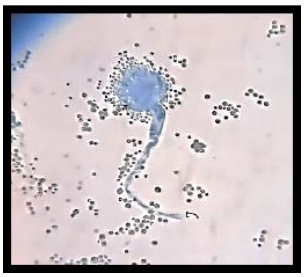

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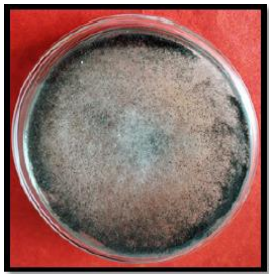

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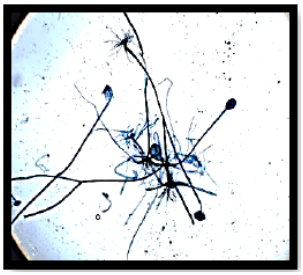

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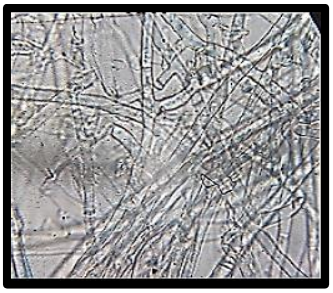

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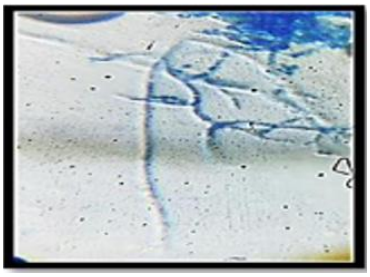

xxviii **xxix** **xxx**

Plate 2. (xvi-xxx) Fungal pathogens isolated from guava fruits (40x)

4. CONCLUSION

The study highlights the widespread occurrence of fungal pathogens in guava across different markets in Prayagraj, with *Pestalotia psidii* emerging as the most prevalent and damaging pathogen. The findings corroborate previous research, underscoring the significant impact of *P. psidii* on guava fruit rot. The study also emphasizes that the incidence of guava fruit rot is influenced by various factors, including microbial presence, the physiological state of the fruit, ambient temperature, and relative humidity. Understanding the prevalence and impact of these pathogens is crucial for developing effective post-harvest management strategies. Implementing such strategies can significantly enhance the shelf-life of guava, reduce post-harvest losses, and improve the overall quality and marketability of the fruit. These insights are not only valuable for scientific research but also for farmers and traders, who can benefit from awareness and control measures to mitigate the effects of these pathogens on guava production and storage.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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