



Identification of Postharvest Diseases of Citrus Fruits in Kabul City

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Abstract

Citrus fruits are economically important horticultural crops, but their postharvest quality and market value are often reduced by fungal diseases. This study was conducted in Kabul city to identify the major postharvest diseases affecting citrus fruits. Samples were collected from markets, storage facilities, fruit carts, and retail fruit shops, and disease identification was carried out through symptom observation and laboratory diagnosis. The findings showed that citrus fruits are affected by several important fungal diseases after harvest, resulting in considerable quantitative and qualitative losses. The diseases identified in this study included brown rot, anthracnose, Fusarium dry rot, gray mold rot, blue mold rot, sour rot, green mold, and melanose. These diseases significantly reduce fruit quality, shelf life, and marketability. The study highlights the importance of accurate disease identification and improved postharvest handling and management practices to reduce losses and maintain the quality of citrus fruits in local markets.

Keywords: Citrus fruits, Postharvest diseases, Fungal pathogens, Postharvest losses, Kabul city

مطالعه و شناسایی امراض بعد از برداشت میوه‌های سیتروس در شهر کابل

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خلاصه

میوه‌های سیتروس از بارزترین محصولات زراعتی در کشور ما به شمار می‌آیند. با این حال، این میوه‌ها به انواع مختلفی از امراض حساس بوده که خسارات قابل توجهی به دهاقین وارد کرده و تأثیر منفی بر اقتصاد ملی دارند. با توجه به اهمیت سیتروس‌ها، تحقیقی درباره بیماری‌های پس از برداشت این میوه‌ها انجام شد. نمونه‌ها از بازارها، ذخیره‌خانه‌ها، کراچی‌های میوه‌فروشی و دوکان‌های مختلف جمع‌آوری شدند. هدف اصلی این مطالعه، شناسایی و بررسی این امراض با استفاده از منابع علمی، اطلس‌ها، کلیدهای شناسایی، کتاب‌های مرجع، منابع اینترنتی و همچنین از طریق مشاهده و تشخیص در لابراتوار حفاظه نباتات پوهنځی زراعت بود. در مرحله اولیه شناسایی مرض، علائم و نشانه‌های قابل مشاهده شامل انواع پوپنک‌ها، اشکال مختلف پوسیدگی میوه و دیگر علائم بارز مشاهده شد. تحقیقات ما نشان داد که سیتروس‌ها پس از برداشت توسط امراض قارچی مختلفی مصاب می‌شوند که باعث خسارات اقتصادی چشمگیری می‌گردد. در پایان مطالعه، چندین مرض از جمله پوسیدگی نضواری، قرغنه، پوسیدگی خشک فیوزاریمی، پوسیدگی پوپنک خاکستری، پوسیدگی پوپنک آبی، پوسیدگی ترش، پوپنک سبز و آبی و میلانوز شناسایی شدند.

کلمات کلیدی: میوه‌های سیتروس، امراض بعد از برداشت حاصل، انواع پوپنک‌ها، ضایعات بعد از رفع حاصل، شهر کابل

Introduction

Citrus is an evergreen shrub or small tree grown in tropical, subtropical, and temperate regions. Citrus fruits include oranges, mandarins, tangerines, limes, grapefruits, lemons, and citrons (Singh, 1976; Lado et al., 2018). They are a valuable source of phytochemicals beneficial to the human body, such as vitamin C, B vitamins (Oyetade et al., 2012), potassium, phosphorus, and other elements. Additionally, various active compounds extracted from citrus fruits are used in the treatment of heart diseases and hypertension, and they also possess anticancer, anti-inflammatory, antiviral, antibacterial, and antifungal properties (Amita et al., 2013; Ma et al., 2020). Citrus juice contains enzymes considered a natural aid for obesity control and includes a range of proteins that help burn body fat (Abobatta, 2019).

Citrus fruits are non-climacteric, meaning they differ from climacteric fruits (e.g., apples, pears, melons, tomatoes) by not exhibiting a ripening-associated increase in respiration or ethylene production. They generally have a longer shelf life compared to other tropical fruits; however, if not properly handled and stored, they can become unsuitable for marketing. The perishability of fruits is generally proportional to their respiration rate, and the energy released as heat affects postharvest technology, such as refrigeration and ventilation requirements.

Transpiration is a physical process characterized by the evaporation of water from fruit tissues, leading to deterioration due to the loss of appearance (wilting and shriveling), texture (softening), and nutritional quality (Ladaniya, 2008 and 2010). The transpiration rate is influenced by rind injuries, the maturity stage, and environmental factors such as temperature, relative humidity, and air movement. The application of surface coatings and the manipulation of the storage environment (e.g., low temperatures, high relative humidity levels, and controlled air circulation) help manage this process. Diseases, physiological disorders, fruit senescence, and physical damage are the major causes of postharvest losses. Postharvest citrus decay is the most severe cause of wastage and quality deterioration, rendering fresh fruit unsuitable for consumption and consequently causing significant economic losses. These losses can reach up to 30% of total production and as high as 50% in less developed countries. Physiological disorders and fruit senescence are often caused by inadequate storage temperatures, high rates of respiration and transpiration, and the stress associated with harvesting and postharvest handling. Rind injuries and impact bruising are major contributors to fruit deterioration, as they accelerate water loss, increase respiration and ethylene production rates, and promote pathogen development (Droby et al., 2008).

The susceptibility of citrus fruits to pathogenic attacks, both in pre- and postharvest environments, has emerged as a significant concern. Approximately one-quarter of the total citrus yield is estimated to face severe challenges from fungal pathogens during postharvest storage. The magnitude and severity of fruit loss are influenced by various factors, including genotype, cultivar, geographical location, fruit age, climatic conditions, and potential injuries sustained during harvesting and postharvest transportation. Additionally, the limited effectiveness of fungicides applied during pre- or postharvest storage further exacerbates the issue. However, wound infections and injuries incurred during harvesting, handling, and transportation remain the primary factors contributing to decay in citrus fruits. These conditions also promote the growth of fungal and bacterial pathogens (Solanki et al., 2024).

To maintain the quality of citrus fruits, proper methods of harvesting, handling, hygiene, sanitation, storage, and refrigeration are essential. Decay levels often reach between 20% and 40%, causing economic losses in terms of production, harvesting, packaging, marketing, transportation costs, and also reducing consumer trust (Eckert, 1986; Brown and Eckert 1986). Postharvest losses occur from the initial harvesting stage to final distribution and consumption. The causes include physical damage during handling and transport, physiological decay, water loss, and pathogen infections, all of which ultimately decrease trade and distribution value (Ali et al., 2022; Moradinezhad and Ranjbar., 2023). Several factors contribute to the development of diseases in citrus fruits (Sdiri et al., 2014): relative

humidity, rainfall, temperature, tree condition, fruit maturity stage, fruit type, and postharvest operations such as harvesting, handling, and packaging (Eckert, 1989). Green mold, caused by the fungal pathogen *Penicillium digitatum*, produces olive-green masses on the fruit. Infection occurs through wounds and is stimulated by nutrients, leading the fruit to become soft and watery until the entire surface is covered and decayed (Eckert, 1989). The objective of this study was to identify and analyze postharvest diseases of citrus fruits using scientific literature, atlases, identification keys, reference books, internet resources, as well as through observation and diagnosis conducted in the Plant Protection Laboratory of the Faculty of Agriculture.

Post-harvest fungal pathogens of citrus fruits

Fungal pathogens are considered the main cause of citrus diseases, severely affecting postharvest management. Preharvest infections include brown rot (*Phytophthora* spp.), Alternaria rot (*Alternaria* spp.), stem-end rot (*Diplodia natalensis* Pole-Evans, *Phomopsis citri* Fawcett), grey mould (*Botrytis cinerea* Pers.), and anthracnose (*Colletotrichum gloeosporioides* Penz.). Postharvest infections include green mold (*Penicillium digitatum* Sacc.), blue mold (*P. italicum* Weh.), and sour rot (*Geotrichum candidum* Link). Green and blue molds are the most common and serious diseases, causing significant economic losses during fruit storage and marketing. *P. digitatum* and *P. italicum* particularly attack blood oranges, and infection occurs only through rind wounds, where nutrients are available to stimulate spore germination. The incidence of other pathogens is generally low but can become a serious problem in warm, wet years (Smilanick, 2006; Sharma et al., 2009).

Fusarium dry rot, caused by *Fusarium maniforme*, infects citrus fruits during storage. Symptoms on the surface of infected fruit include rough or dry rot, light or dark brown discoloration, and sunken areas. Under moist conditions, white, gray, or pink mycelia may appear on the fruit surface, depending on the *Fusarium* species (Timmer et al., 2003).

Gray mold (*Botrytis cinerea*), according to a recent review, ranked second on the world's Top 10 fungal plant pathogens list based on scientific and economic importance (Dean et al., 2012). *B. cinerea* is a significant postharvest pathogen due to the favorable conditions present throughout the postharvest handling chain, including injuries, high humidity, senescing plant tissue, and high sugar content. Major postharvest losses caused by *B. cinerea* occur in a wide range of fresh fruits.

Blue mold, caused by *Penicillium italicum*, also infects citrus through injuries. It initially resembles green mold but can be distinguished by narrow white bands surrounding the lesion. Blue mold is more common in fruits stored in cold storage during summer and spreads easily in packed cartons (Eckert, 1989). Sour rot, caused by *Geotrichum citri-aurantii*, affects all citrus varieties, especially those stored for extended periods. It infects fruit through cracks, particularly in mature fruit under high humidity. Symptoms begin as water-soaked lesions that turn from light yellow to dark, producing a sour odor and attracting flies, which further spread the fungus (Eckert, 1989). Anthracnose, caused by *Colletotrichum gloeosporioides*, grows on dead wood in trees. It produces spores that are carried by water to immature fruits, where they form infectious structures (appressoria) and cause rot (Eckert, 1989). Brown rot, caused by *Phytophthora* species, occurs both pre- and post-harvest. The pathogen remains in the soil and splashes onto hanging fruit during rain, leading to infection (Ali et al., 2022; Kalatippi et al., 2024).

A study in Pakistan found that most lemon losses were due to *Aspergillus* black mold, which causes shriveling and brown spots, leading to premature fruit drop (Liaquat et al. 2016). Citrus black spot is a serious disease affecting all lemon varieties, especially in coastal areas. It affects leaves and branches, turning the fruit gray or darker (Barkley, 1988). Gray mold, caused by *Botrytis cinerea*, infects citrus even during the flowering stage under cool and moist conditions. It lives on decaying matter and is spread by wind, water, and insects (Barkley, 1988). Black spot, caused by *Guignardia citricarpa*, severely affects oranges in semi-tropical, humid regions (Barkley, 1988). Black mold rot,

caused by *Aspergillus niger*, infects lemons under relatively high temperatures, especially after weakening. It produces soft, sunken spots and large, fermented-smelling lesions with characteristic signs (Barkley, 1988).

Problem statement

With the increasing prevalence of diseases and growing concerns regarding the quality and quantity of citrus fruits, studying and identifying these issues has become important. The objective is to gather reliable information about citrus fruit diseases in the mentioned locations, particularly to understand their impact on the decline in the market value of citrus fruits. Recognizing these diseases is considered essential for improving both the quality and quantity of citrus fruits.

Importance of the Research

Considering the nutritional value of this fruit and the need to maintain its health and production, it is essential to study and identify its post-harvest diseases. This will allow for the development and application of possible control methods for farmers and stakeholders involved in the production of these products.

Objective

1. To identify the common diseases affecting citrus fruits after harvest.
2. To investigate the factors contributing to the development of diseases during transit, handling, packaging, and storage.

Research Questions

1. Which diseases are responsible for infecting citrus fruits after harvest?
2. To what extent do these diseases affect the quantity and quality of citrus fruits?
3. Do these diseases reduce the market value of citrus fruits?

Materials and Methods

Study site and collection of infected fruit samples

Kabul city is located in the central part of Afghanistan. The diseased samples of different citrus fruits were collected from the markets of this site. The disease-infected fruits were picked up from markets, fruit cars or transits, fruit shops, and storage places.

Sample collection, isolation and identification of fungal pathogens

The disease-infected fruits were collected in polythene bags and brought to the laboratory. The symptoms of the disease were carefully observed and recorded. Fungal pathogens were isolated from the diseased parts of the fruits. The infected tissues were cultured on PDA media in Petri dishes. After full growth of the mycelium and reproductive structures, the samples were stained with cotton blue and mounted in lactophenol on clean glass microscope slides. Temporary slide preparations were observed under a compound microscope. Identification of the fungal pathogens was based on somatic structures, fruiting bodies, and asexual and sexual reproductive structures. Identification keys were used to assist in the identification of the fungal pathogens.

Result and discussion

In the present investigation, a survey of postharvest diseased citrus fruits was carried out. The infected citrus fruits were screened for the fungal infection and symptoms developed thereof (Table 1). The symptoms of different diseases and their causal organism were recorded as follows:

Table-1: Common postharvest diseases of citrus fruits

S. N	NAME OF THE DISEASE	CAUSAL ORGANISM
1	Brown rot	<i>Phytophthora citricola</i>
2	Anthraxnose	<i>Glomerella cingulata</i>
3	Fusarium dry rot	<i>Fusarium moniliforme</i>
4	Grey mold rot	<i>Botrytis cinerea</i>
5	Blue mold rot	<i>Penicillium italicum</i>
6	Sour rot	<i>Geotrichum candidum</i>
7	Green mold	<i>Penicillium digetatum</i>
8	Melanoses	<i>Diaporthe citri</i>

Brown rot: The first symptom is a greyish-brown spot which, even after enlargement, tends to remain firm and leathery. Infected fruits give off a characteristic pungent odor. Under humid conditions, a fine white spore-bearing mold develops on the peel and spreads by contact to neighboring fruit (Plate-1). This finding is correlated with findings of Smilanick J.L., 2006.

Anthraxnose: Fruits may be disfigured by 'tearstain' patterns on the peel, or they may undergo severe rotting, with the formation of dark sunken lesions (Plate-2). Humid conditions encourage the development of spore masses, which are at first salmon-pink and later brown. Our finding is the same as the finding of Eckert (1989).

Fusarium rot: Lesions are generally dark brown, leathery, and sunken, sometimes becoming soft and water-soaked in the center (Plate-3). Under humid conditions, a white or pinkish mold form on the surface. Internally, there may be a purplish or reddish-brown discoloration of the flesh. Our findings are similar to those of Timmer et al (2003).

Gray mold rot: Rot may occur at the stem end or on the sides of the fruit. Initially, the affected areas are light, but over time they darken and soften. A nest-like fungal structure develops (Plate 4). Further infections may occur via wounds sustained during harvesting and handling. Substantial rotting occurs even in refrigerated storage, and decay spreads from fruit to fruit. Our findings correlate with those of Dean et al. (2012).

Blue and Green mold rot: In both diseases, the earliest symptom is a soft, water-soaked area on the peel of the fruit, which soon becomes covered with white mold. Colored spores form at the center of the lesion; in green mold rot, there is usually a broad band of white beyond the sporing area (Plate 5), whereas in blue mold rot, the white margin is generally not more than about 2 mm wide (Plate 6). The two fungi frequently appear together; during short-term transport and storage, green mold usually predominates because it grows more rapidly at moderate temperatures. Our findings are consistent with those of Eckert (1989).

Sour rot: The first symptom is a water-soaked spot where the affected tissue is extremely soft but not discolored (Plate 7). The surface of the lesion becomes covered with slimy, off-white spores, and the fruit tissue beneath breaks down into a sour-smelling watery mass, which is very attractive to fruit flies. Our finding is consistent with Smilanick (2006).

Melanoses: Small, raised, reddish-brown to black pustules are present on the peel, making it rough to the touch. The individual spots are approximately 1 mm across and may be randomly distributed or form a 'tearstain' pattern (Plate 8). When lesions are very numerous, they coalesce, forming brown, crusted areas on the fruit surface.

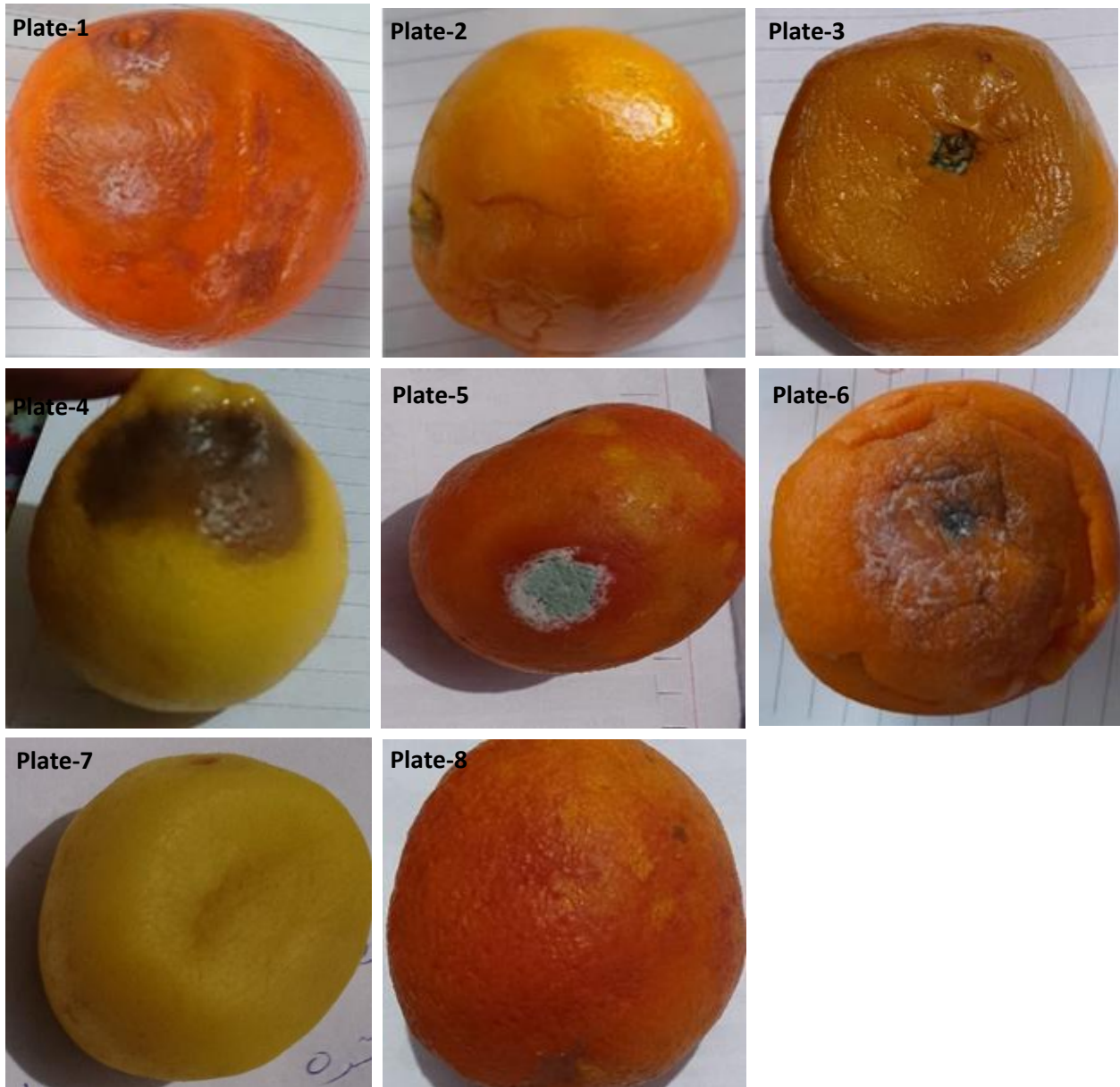


Fig-1: Identified postharvest diseases of Citrus fruits in the markets of Kabul city: Plates: 1 (Brown rot); 2 (Anthrachnose); 3 (Fusarium rot); 4 (Gray mold rot); 5 & 6 (Blue and Green mold rot); 7 (Sour rot); 8 (Melanoses).

Conclusions

Citrus fruits are cultivated worldwide due to their positive health benefits, especially their bioactive substances, vitamin C, and phenolic compounds. The perishability of these fruits is generally caused by improper temperature and relative humidity, which lead to increased respiration rates, physiological disorders, and fungal infections. To optimize temperature and relative humidity during cold storage and transportation of citrus fruits, both experimental and theoretical methods are employed, including numerical methods such as computational fluid dynamics. Fungal pathogens severely affect the postharvest life of citrus fruits, particularly when they are stored for extended periods or shipped over long distances.

Based on the current knowledge of citrus postharvest handling and in order to extend the shelf life of fruits, the following future challenges can be identified: reducing mechanical damage during handling and packing operations; researching new alternative methods for fruit treatment to reduce the

use of chemical compounds; and optimizing both cold storage rooms and refrigerated containers for citrus shipping.

According to our research conducted in Kabul city, it appears that several diseases attack citrus fruits after harvest at different times and under varying conditions, infecting them and reducing both their yield and quality. Although we studied and identified several diseases, such as blue mold rot, gray mold rot, Fusarium dry rot, and others, this work is not sufficient. There is still a need for further research to identify the pathogens causing postharvest diseases in citrus fruits.

Recommendations

Air and soil contain numerous microscopic organisms, some of which are beneficial while others are harmful. Some harmful organisms are responsible for post-harvest diseases of citrus fruits, causing major losses to farmers and the national economy. The research conducted in markets and Kabul city mainly focused on the post-harvest diseases of citrus fruits, which have been explained in detail in earlier sections.

To prevent and control these diseases, the following recommendations are advised for farmers and those involved in the fruit sector:

- Maintain proper hygiene.
- Collect and pack fruit with care.
- Avoid any physical damage or injury to the fruit.
- Use standard cold storage facilities and warehouses.
- Plant resistant varieties.
- Regulate fertilizer application and irrigation.
- Use appropriate chemical treatments, such as sanitizers (chlorine solutions) and fungicides like imazalil (IMZ), thiabendazole (TBZ), and sodium-orthophenylphenate (SOPP) for fruit surface treatment. Additionally, several low-risk fungicides classified as minimal risk to human and environmental health—such as trifloxystrobin, azoxystrobin, fludioxonil, cyprodinil, and pyrimethanil—have been proposed.

These measures are crucial for reducing post-harvest diseases in citrus fruits and for obtaining healthy, high-quality, and satisfactory yields. Preventive actions must be strictly implemented, with careful attention to hygiene practices, proper collection, suitable packaging, fruit cooling, and other key considerations.

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