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STUDIES ON POSTHARVEST DISEASES OF VEGETABLES AND FRUITS OF THREE MARKETS IN WARANGAL TOWN, TELANGANA STATE, INDIA

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Vegetable and Fruit (VF) production is an emerging horticulture sub-sector in India even though, almost one-third of the produced VF is lost before reaching the plate. VF postharvest losses in India range from 40 to 70%, depending on a crop. Lack of postharvest management skills and techniques such as temperature control to maintain the cold chain, value addition, and packaging have caused several economic and food security setbacks among them are high levels of poverty, hidden hunger and malnutrition.

Post-harvest deterioration of Potato (*Solanum tuberosum*) Tomato (*Lycopersicon esculentum Mill*), Carrot (*Daucus carota*) Cauliflower *(Brassica oleracea)*. Cabbage (*Brassica oleracea L* var *botrytis*). Pineapple (*Ananas comosus*), Papaya (*Carica papaya*) Grapes (Vitis vinifera) Lemon (Citrus lemon) and from three selected markets in Warangal District, was studied. Both healthy and diseased samples were collected from the selected markets. Nine fungal species : *Alternaria* Species, *Aspergillus flavus, Aspergillus niger, Curvularia, Fusarium, Mucor, Penicillium, Phytophthora* and *Rhozopus* species were found associated with deteriorating Vegetable &Fruits (VF) of *S. tuberosum, L. esculentum, D. carota, B. oleracea, Brassica oleracea L* var *botrytis, A. comosus, C. papaya, V. vinifera and C. lemon.* All isolated fungi were pathogenic to the different fruits when pathogenicity tests were carried out.

Keywords: *Solanum tuberosum, Lycopersicon esculentum* Mill*, Daucus carota, Brassica oleracea. Brassica oleracea* L Var *botrytis*. *Ananas comosus, Carica papaya, Vitis vinifera, Citrus lemon*, Post-harvest deterioration, Fungal species.

Post-harvest technology (PHT), most popularly known as post-harvest handling, is a series of methods and techniques used in the preservation of agricultural commodities after harvest. It is a science applied to agricultural commodities for preservation, conservation, quality control and enhancement, processing, packaging, storage, distribution, marketing, and utilization to meet the food and nutritional requirements of consumers concerning their needs.

Harvested fruits and vegetables require extensive and advance post-harvest processing to minimize both qualitative and quantitative losses after harvesting. Every year, nearly 40% of harvested fruits and vegetables are wasted due to improper handling, storage, packaging, and transportation.

As a means to counter this, post-harvest technology or PHT provides trusted methods in the preservation of fruits and vegetables since they are often transported at a perishable state. These methods are used to maintain the quality of fruits and vegetables by strategically enhancing the environment related to the product's preservation, processing, packaging, storage, and distribution.

Fruits are known to have commercial and nutritional importance. They play a vital role in human nutrition by supplying some necessary nutritional substances such as vitamins and essential minerals in the human daily diet that can help to keep good and normal health. Fruits are widely consumed. One of the factors that impact negatively on the economic value of fruits is that they have a short shelf-life. This is a result of many factors, prominent among which is the activity of pathogens. It has been reported (Droby 2006, Zhu 2006) that about 20-25% of the harvested fruits are lost via the activities of pathogens during the post-harvest chain.

Fruits and vegetables are exposed to contamination by microbes through contact with soil, dust, and water and by handling at

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harvest or during postharvest processing. This makes them to harbor a wide range of microorganisms including plant and human athogens (Eni *et al*. 2010). Differences in microbial profiles of diverse fruits and vegetable results could be due to varying factors including resident microflora in the soil, application of non-resident microflora through animal manures, sewage or irrigation water, transportation and handling by individual retailers (Ofor *et al*. 2009).

After banana and citrus, Pineapple (*Ananas comosus,* family Bromeliaceae*)* is ranked the third most important tropical fruit in the world. India is fourth on the list of world pineapple producers with about 800,000 tonnes produced per annum. *Ananas comosus* is a rich source of Vitamin C as well as other vitamins and fibre. The fruit is also used as a raw material in confectionery industries. It also has various medicinal values (Amao *et al*. 2011).

1. Potato (*Solanum tuberosum*) is of the family Solanaceae. It is a staple crop in 130 countries worldwide, ranking fourth in production after rice, maize, and wheat (Calvo *et al*. 2010), India is the fourth biggest producer in Asia. The tuber is the most important part of the Irish potato plant and it is an excellent source of carbohydrates, protein, and vitamins (Ducreaux *et al.* 2005). In India, *S. tuberosum* is responsible for more than half of the total carbohydrate requirements of the populace in areas where it is grown and consumed as a staple food (Omafuvbe and Enyioha 2011).

2. Tomato (Lycopersicon esculentum Mill. Syn. Solanum Lycopersicon) is a widely grown fruit the world over (Agrios 2005). It is native to South America (Nonneoke 1989), but was introduced into West Africa by Portuguese traders and freed slaves from the West Indies (Tindall 1988). Tomato is rich in vitamins (John *et al.* 2010, Bugel 2003), minerals and lycopene, an excellent antioxidant (Osemwegie *et al.* 2010) that helps to reduce the risk of prostate and breast cancer (Giovannucci 1999). Global production is about 89.8 million metric tonnes from an area of about 3,170.000 ha (Samuel *et al*, 2011). India is fourth-largest producer of tomato in Asia (Erinle 1989) where a total area of one million hectares is used for tomato cultivation every year (Anon 1989, Bodunde *et al*.1993).

3. Carrot (*Daucus carota)* belongs to the family Apiaceae. It is a root vegetable usually orange in color, though purple, red, white and a yellow variety exists. It has a crisp texture when fresh (Salmond 1994). The most commonly eaten part of a carrot is the taproot. The leaves are not ingested in most of the cultures because it is mildly toxic but it is edible (Lantz 1977). *D. carota* is very rich in vitamin C as well as carotene (Favel 1998). Despite all the benefits derived from carrots, a large percentage is lost annually to post-harvest deterioration caused by pathogens (Mahale *et al.* 2008*)*.

4. Cauliflower is one of several vegetables in the species *Brassica oleracea* which is in the family Brassicaceae. It is an annual plant that reproduces by seed. Typically, only the head is eaten – the edible white flesh sometimes called "curd" (with a similar appearance to cheese curd). It is a cool-season crop; it is more exacting in its climatic requirements than most other crops in this family. The plant is extremely sensitive to unfavorable conditions, such as unusually hot weather, drought or too low temperature, which often result in the formation of premature curds. It is monogenic species whose genomic constitution is C and chromosome number is n=9 belongs to Cruciferae family (Thamburaj and Singh 2001). The variety attains acceptance when the farmers get a genetically pure seed of high standard. For the purpose, each cultivar should be properly defined with suitable descriptors, to maintain its identity during seed production through field inspection and certification. In

India, Protection of Plant Varieties and Farmer's Right Act, 2001 (PPV and FRA, 2001) envisages the registration and protection of new and notified/extant plant varieties based on the criteria of Distinctness, Uniformity, and Stability (DUS) of morphological characteristics and increasing attention is being paid towards comprehensive plant genetic recourses.

5. Cabbage (*Brassica oleracea* L Var *botrytis*.). is an important vegetable crop species that includes fully cross-fertile cultivars or form groups with widely differing morphological characteristics (cabbage, broccoli, cauliflower, collards, Brussel sprouts, kohlrabi, and kale). historical evidence indicates that modern head cabbage cultivars are descended from wild non-heading brassicas originating from the eastern Mediterranean and Asia Minor (Dickson and Wallace 1986). It is commonly accepted that the origin of cabbage is the north European countries and the Baltic Sea coast (Monteiro and Lunn 1998), and the Mediterranean region (Vural *et al.* 2000). Zhukovsky considered that the origin of the white head cabbage was the Van region in Anatolia and that the greatest cabbages of the world were grown in this region (Bayraktar 1976, Günay 1984).

6. Cabbage is vegetables that are grown all over the world, although cabbage is cultivated to a much greater extent. Both belong to the species *Brassica oleracea* L., a species of the Brassicaceae (Cruciferae) family comprising several crops known under the generic name of cole crops. Some types of kale are grown for fodder. Modern classifications of the family Brassicaceae are based on a review by Schultz (1936) who reduced the number of tribes from 19 to 15; nowadays the number of tribes commonly accepted is 13. A problem arises when trying to determine the number of genera included in the family. Hickey and King (1997) indicate 390 genera, Paterson *et. al.* (2000) 360, and the USDA (2006) 107. The position of the family in the general classification of the kingdom of plants is as follows (USDA 2006).

7. Pineapple (*Ananas comosus*) is one of the commercially important fruit crops of India. Total annual world production is estimated at 14.6 million tonnes of fruits. India is the fifth-largest producer of pineapple with an annual output of about 1.2 million tonnes. Other leading producers are Thailand, the Philippines, Brazil, China, India, Mexico, Indonesia, Colombia, and the USA.

8. Grapes, (Genus *Vitis*), any member of the grape genus, *Vitis* (family Vitaceae), with about 60 species native to the north temperate zone, including varieties that may be eaten as table fruit, dried to produce raisins or crushed to make grape juice or wine. *Vitis vinifera,* the species most commonly used in winemaking, was successfully cultivated in the Old World for thousands of years and was eventually brought to California.

9. Citrus fruits, which belong to the genus Citrus of the family Rutaceae, are of various forms and sizes (from round to oblong), It also contains important nutritional elements for health. Citrus is a good source of vitamin C (ascorbic acid), phenolic compound, flavonoid, folic acid, potassium, pectin and antioxidant properties (Chiba *et al.* 2003; Samraj an Rajamurgugan 2017). As humans cannot synthesize and store ascorbic acid, their daily requirements depend on fresh fruits. and vegetables. Citrus fruit production in Indonesia reaches 2 million tons each year while its consumption in 2018 totaled almost 2.76 to 2.45 million tons. Commonly, it was planted in the highland and lowland (Direktorat Jenderal Holtikultura 2015).

Different fungal species have been reported to be associated with the post harvested deterioration of these fruits and vegetables in

different locations. This study was carried out to investigate and document the fungi responsible for the spoilage of some fruits and vegetables from three selected markets in Warangal District Telangana State, India.

MATERIALS AND METHODS

Survey and Sample Collection : Three markets in Warangal District Telangana State: Kazipet, Hanamkonda, and Warangal markets were surveyed. Diseased and healthy Vegetables and Fruits of Potato (*Solanum tuberosum)* Tomato (*Lycopersicon esculentum* Mill), Carrot (*Daucus carota*) Cauliflower (*brassica oleracea*). Cabbage (*Brassica oleracea* L var botrytis). Pineapple (*Ananas comosus*), Pawpaw (*Carica papaya*) Grapes (*Vitis vinifera*) Lemon (*Citrus lemon*). were collected. All infected vegetables and fruits were inspected for rotted areas and were stored in clean polyethylene bags. The healthy samples were also stored separately. All the samples were brought to the Department of Botany Laboratory at Kakatiya University, Warangal, Telangana State India for further analysis.

Isolation of Associated Fungi: The diseased samples were the first surface sterilized by washing under running tap water to remove dirt such as sand. A flamed blade was used to cut partly diseased and partly healthy portions of the sample, the cut portions were then surface sterilized using 70% alcohol after which they were rinsed in successive changes of sterile distilled water. They were then inoculated on Potato Dextrose Agar (PDA). This was done for all the samples from the three markets, the plates were incubated at 28^0C±2. Fungal growth was observed daily. After six days of incubation, a small portion of mycelium from each fungal colony was transferred aseptically into fresh plates containing the medium used. The fungi were purified by repeated sub-culturing.

Preparation of Potato Dextrose Agar

1. Suspend 39 grams in 1000 ml distilled water. Heat to boiling to dissolve the medium completely.
2. Sterilize by autoclaving at 15 lbs pressure (121°C) for 15 minutes. Mix well before dispensing.
3. In specific work, when pH 3.5 is required, the medium should be acidified with sterile 10% tartaric acid.
4. The amount of acid required for 100 ml. of the sterile, cooling medium is approximately 1ml.
5. Do not heat the medium after addition of the acid Molds will grow as filamentous colonies of various colors.

Identification of isolated organisms: Using sterile inoculating needle, minute portion of each organism was aseptically taken and teased at the center of a clean microscopic slides containing drop of lactophenol cotton-blue stain, covered with cover slips and observed under the microscope. Identification was made with reference to standard textbooks such as Domsch *et al.* (1980).

RESULTS

Alternaria, Aspergillus sp., Penicillium sp., Mucor, Rhizopus sp, and *Phytophthora* sp. were isolated from Potato, Tomato, Carrot, Cauliflower, Cabbage, Pineapple, Pawpaw, Grapes, Lemon, and pineapple imported from Warangal town Markets respectively. (Table-1) show the distribution as per the markets, the organisms isolated.

Six Species of *Alternaria*, *Aspergillus flavus, Aspergillus niger, Mucor, Phytophthora* and *Rhozopus* were isolated from infected tuber of Potato. Six species of *Alternaria, Aspergillus flavus, Aspergillus niger, Fusarium, Phytophthora* and *Rhozopus* were isolated from diseased fruit of tomato. Seven species of

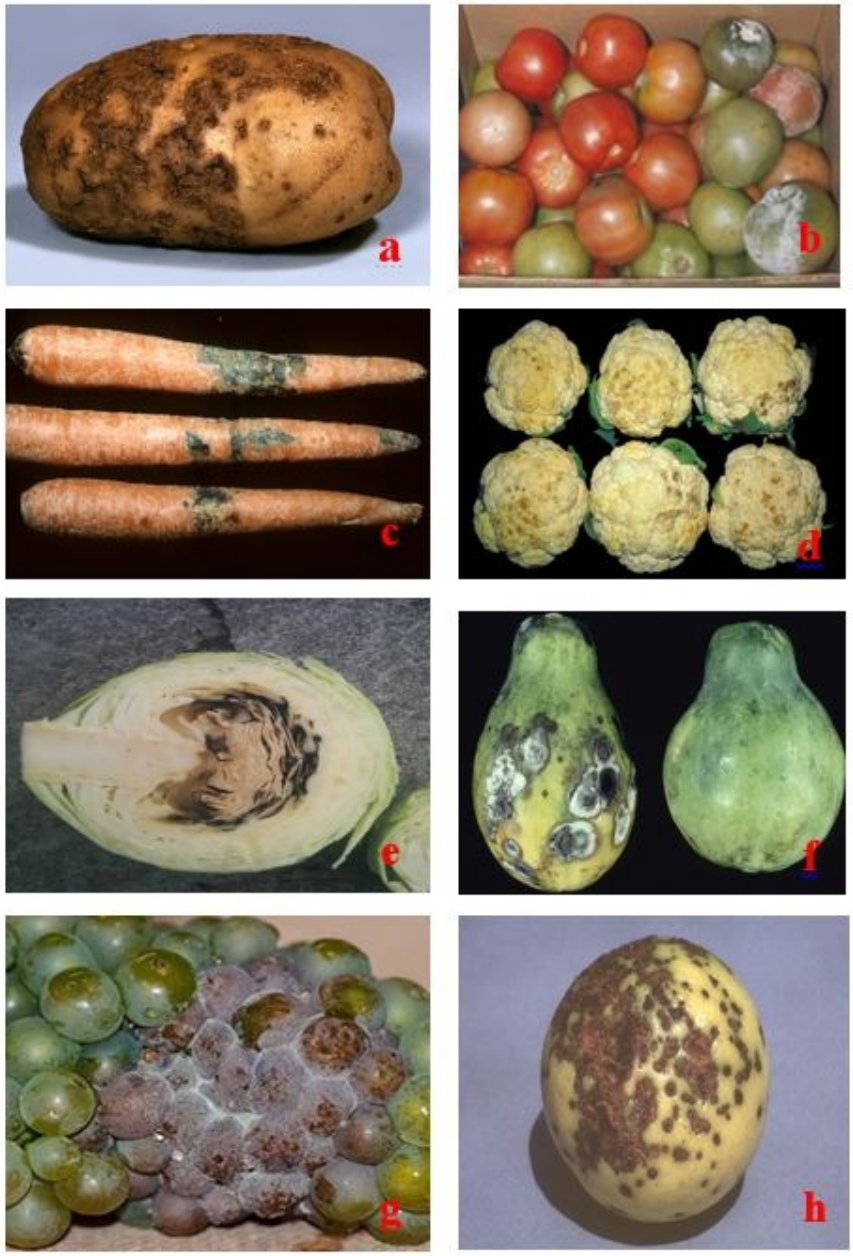

Figure- 1. a- h Collected infected vegetables and fruits of three markets in Warangal town

Alternaria, *Aspergillus, Fusarium, Mucor*, *Penicillium, Phytophthora* and *Rhozopus* yet to be identified organisms from the pathogenicity test of *D. carrote*, four fungal species of *Alternaria*, *Fusarium*, *Phytophthora* and *Rhozopus* were isolated from fungal infected vegetables of Cauliflower and cabbage (Table-1).

Six fungal species were isolated from fruit of *A.comosus* they are *Alternaria*, *Aspergillus niger, Curvularia, Mucor, Phytophthora* and *Rhozopus.* Highest fungal species identified from *Citrus lemon,* lowest fungal species were isolated from the fruit of papaya and only one fungal pathogen isolated from the fruit of *Vitis vinifera.* (Fig- 1 &2) .

All the organisms were found to initiate diseases symptoms as found on the diseased Vegetables and fruits were isolated from samples collected from Warangal market:

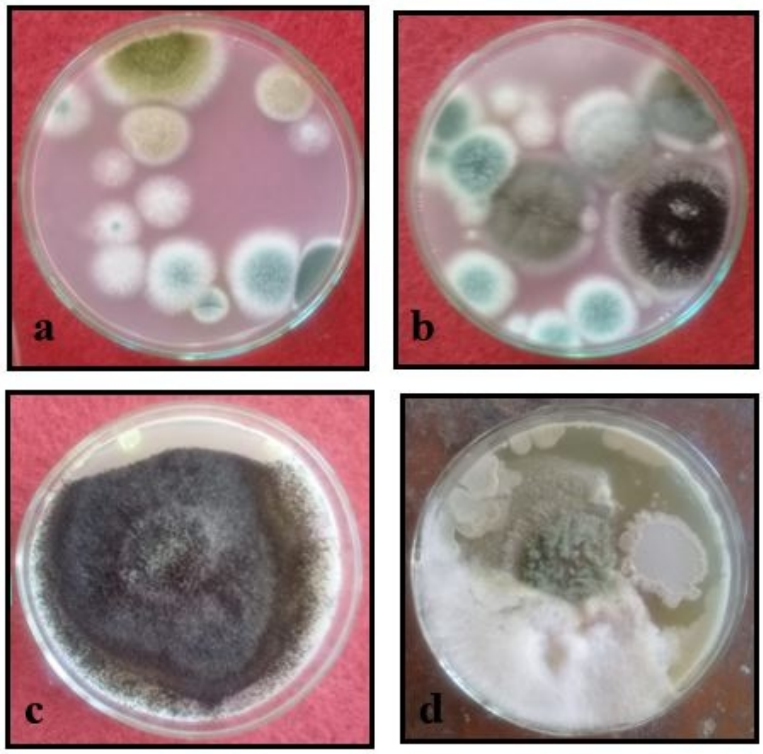

Figure- 2. Inoculation of infected surface of Vegetables and Fruits in Potato Dextrose Agar medium after five weeks of culture **a)** *Alternaria* Spp, *Aspergillus flavus, Aspergillus niger, Mucor Rhozopus* **b)** *Penicillium* spp and *Aspergillus flavus, Aspergillus niger,* ***c*****)** *Mucor* and *Rhozopus* Sp **d)** *Curvularia, Mucor, Phytophthora* and *Rhozopus*

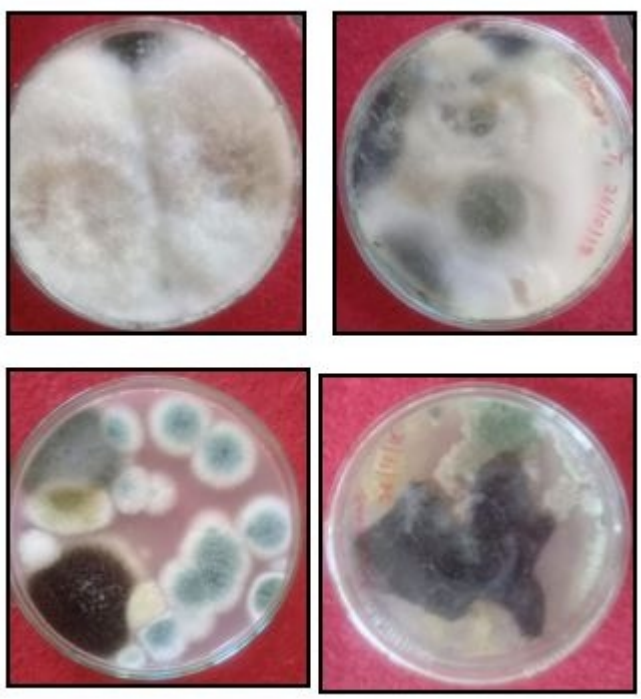

Figure- 3. Growth of Various species of fungus cultures on PDA plates inoculated from infected surface vegetable and fruits after eight weeks

Mucor sp., *Rhizopus* sp. and *Alternaria* sp. from Hanamkonda and Kazipet markets; The result of the pathogenicity test revealed that all the fungi originally isolated from diseased carrots induce similar disease symptoms when inoculated on healthy carrots.

DISCUSSION

Fruits and vegetables are susceptible to pathogenic attack due to their low pH, high moisture content and nutrient composition. These make them rot and unfit for consumption due to the production of mycotoxins (Stinson *et al.* 1981, Philips 1984). Fungi have been documented to penetrate host tissue through natural openings such as lenticels, stomata and through the unbroken epidermis by means of appressorium or germ tube. For an organism to cause infection, it must have the ability to breakdown the natural defense mechanisms of the host.

In this investigation, *Aspergillus flavus, Aspergillus niger* sp. were isolated from the pusa ruby varieties of *L. esculentum* and *Solanum tuberosum* tubers are of high economic significance and are considered as one of the world's most important food crops. Many fungal diseases have been affecting its production but the most challenging are the post-harvest diseases. Booth (1974) reported that this loss was as a result of physical, physiological or pathological factors or a combination of the three factors and in this research, the diseased Potato tubers collected has mechanical injuries due to physical factors. In the works of Abiodun and Olamide (2007), *Rhizopus oryzae* was among the organisms implicated for causing rot in *S. tuberosum* tuber. In this study, *Aspergillus niger, Aspergillus flavus* and *Rhizopus* sp. were isolated from *S. tuberosum*. This observation is consistent with a previous work (Amadioha and Adisa 1993) that reported these organisms among others that were responsible for tuber rot in potato.

In this investigation, the fungi associated with the spoilage of *Carica papaya* are as reported by Gupta and Pathak (1986). Some of the pawpaw fruits found in these markets have been perched by birds and destroyed by insects which reduced the quality of fruit and also creating openings for pathogen entry. During the course of this study, after 3-5days, total rotting of the fruit occurs and as spot develops, some became sunken which turns to brown or black and oozes out a foul odor and milky latex. One of the diseased papayas (from Warangal market) was characterized by water-soaked spot which is caused by *Fusarium accuminatum* has also been reported by Pathak (1976) and Barkai-Golan (1981).

Pathogenicity test result revealed *Rhizopus*, *Aspergillus* and *Phytophthora* were the most virulent on *S. tuberosum* and *Ananas comosus* while *Mucor* sp. Was the most virulent on *Daucus carota* and *Carica papaya*. The occurrence of organisms at the different markets showed *Rhizopus* sp. and *Mucor* sp. have the highest frequency followed by *Aspergillus niger.* Different organisms have been isolated from carrot diseases ranging from *Phytophthora* sp. (McElroy *et al.* 1971), *Thielaviopsis basicola* (Punja and Gaya 1993), *Fusarium* sp. (Piling and Cox 1999), *Alternaria* sp. The variations in the isolates obtained from different researchers may be connected to the fact that different varieties of carrots may be used as well as different experimental procedures (Mildenhil 1975). Difference in the location of sample collection can also be accountable for this. The market value of fruits and vegetables are reduced as a result of pathogen infestation. Their presence in these foods products also constitute health risks.

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