THE EFFECT OF HOT WATER DIP, WAXING AND FUNGICIDE TREATMENTS ON DISESASE SEVERITY OF PINEAPPLE (*Ananas comosus*)

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ABSTRAK

Tesis ini adalah untuk menentukan rawatan yang paling berkesan untuk mengawal penyakit lepas tuai bagi buah nanas. Rawatan yang digunakan adalah rawatan celupan air panas, pelilinan dan rawatan racun kulat. Setiap buah dianalisis dengan mata kasar untuk mengetahui pengaruh rawatan ke atas kemasakan buah. Tahap keparahan penyakit ditentukan dengan mata kasar dan juga dengan kewujudan koloni mikrob. Kewujudan kulat dan bacteria ditentukan dengan koloni yang dibentuk pada media PDA dan NA. Kesemua rawatan boleh mengawal penyakit lepas tuai bagi nanas. Rawatan tersebut hanya memberi kesan pada bahagian dalam nanas dan bukannya pada bahagian kulit luar. Pelilinan merupakan rawatan yang paling berkesan untuk mengawal penyakit lepas tuai bagi nanas jika dibandingkan dengan rawatan celupan air panas dan rawatan racun kulat. Pelilinan bukan sahaja mengawal penyakit, malah boleh melambatkan kemasakan buah nanas. Kajian berlanjutan perlulah dibuat pada masa hadapan terutamanya dalam rawatan pelilinan supaya dapat memenuhi keperluan pengguna.

ABSTRACT

There are many treatments that have been used for postharvest diseases control in pineapple. An appropriate research need to be done to choose most effective treatment among all the treatments. This study was done to determine the most effective treatment to control postharvest diseases of pineapple. Treatments used were hot water dip treatment, waxing and fungicide application. Fruits were visualized to get to know whether the treatments influence their ripeness. The severity of diseases was determined through visualization by naked eyes and also detection of the presence of microbial colony. The presence of fungus and bacteria was determined from the colony that formed on PDA and NA media. Waxing was the most effective treatment to control postharvest diseases in pineapple compared to hot water dip and fungicide treatments. All treatments were very effective on the inner part of the fruits only but not on the shell part. Waxing not only controlled the diseases but it helped to delay ripening. More research about the control of postharvest diseases of pineapple should be done especially on waxing to better understand how they could control postharvest disesases in pineapple.

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CHAPTER 1

INTRODUCTION

1.1 About Pineapple

The pineapple (*Ananas comosus* (L.) Merrill, family *Bromeliaceae*) was domesticated in tropical America, with south-eastern Brazil, Paraguay and northern Argentina being thought to be the place of origin. Ananas (2N=50) and its closely related genus *Pseudomonas* (2N=100) are distinguished from other *Bromeliaceae* by their fused syncarpous fruit. Differentiation among *Ananas* species could be due to ecological isolation rather than genetic divergence (Laison-Cabot, 1992).

The pineapple is produced throughout the frost-free tropics and subtropics from 33°N to 33°58'S latitude. Major producing countries are Hawaii, Mexico, Costa Rica, Brazil, Colombia, Honduras, the Dominican Republic, Malaysia, India, Congo, Kenya, China, Taiwan, Vietnam, Australia, the Philippines, Bangladesh, Thailand, Indonesia, South Africa, Zaire and the Ivory Coast. Major international fresh fruit exporters are the Philippines, Ivory Coast, Costa Rica and the Dominican Republic (Bartholomew and Malezieux, 1994).

Pineapple was brought to Malaysia and was established, with one or more varieties, before the end of the sixteenth century, and by then it was well known in the tropics of East Asia. The pineapple industry which is important in Malaysia today, was started in Singapore in about 1888 by a few Europeans who opened factories and after they were established, transferred them to the Chinese, who virtually control the industry today. At first the plants were grown between young rubber trees on estates; later sloping ground on hills was considered suitable. Then just before the last war, planting was started on a large scale on low-lying, peat soil. This was found to be the most satisfactory for the Malaysian climate, but these plants were almost entirely destroyed during the Japanese occupation (Betty *et al*., 1967). Today, however, in Malaysia, large cultivations are grown almost exclusively on deep, peat soils. In Malaysia, the latest figure show that the greatest amount of pineapple produced is in the state of the Johor (mostly in the west), and less in Selangor and Perak (Bartholomew *et al*., 2003).

Of the many pineapple varieties, 'Smooth Cayenne' is the major commercial variety. Other varieties are grown on a small scale 'Queen', 'Spanish', 'Pernambuco' and 'Mordilonus-Perolera-Maipure' are grown normally for local fresh fruit use. Varieties of the 'Queen' group are widely available in European markets. Selections of 'Smooth Cayenne' and other varieties have been made throughout the world, though they have not been well characterized. Though 'Smooth Cayenne' is the major variety worldwide, it has deficiencies as a fresh fruit. These deficiencies include high acidity, low ascorbic acid, poor flavor, and a susceptibility to translucency. Reevaluation of current germplasm is necessary to select varieties better suited for fresh fruit and for specialized market requirements (Paull, 1992).

Losses of fresh pineapple fruits after harvest may reach very high values depending on the species, harvest methods, length of storage, marketing conditions, etc. Losses are particularly high in many countries (almost 50%) and this is caused by mechanical damage, physiological disorders induced by high or low temperatures (chilling injury, flesh translucency, bruising, sunburn and malformations), an incorrect storage atmosphere and also by pests and diseases (Lim, 1985). Most of them are due to pathogen attacks and losses after harvest may reach 8–10% of the harvested crop. Postharvest pineapple diseases that begin prior to harvest may cause sporadic economic problems. So, many physical and chemical treatments are used for postharvest diseases control in pineapple (Mitra, 1997). This research was done to determine the most effective treatment to control postharvest diseases in pineapple.

1.2 Objective

The objective of this study was to determine the most effective treatment among hot water dip, waxing and fungicide treatments to control postharvest diseases of pineapple.

CHAPTER 2

LITERATURE REVIEW

2.1 Physiology of Pineapple

The pineapple is a xerophytic, succulent, herbaceous, perennial plant. The trough-shaped leaves are spirally arranged in a dense rosette pattern. The leaves are densely covered with large trichomes covering strips of stomata located in furrows. Stomatal density is low and the pore size is small. The single spike-like inflorescence carries variable numbers of flowers and is terminated with a vegetative shoot or crown. Pineapple, like most succulents, fixes 40 to 100% of its carbon in the dark via phosphoenolpyruvate carboxylase, storing the carbon as malic acid. The CO_2 is released from the malic acid in the light and is then fixed via conventional C_3 photosynthesis. This type of photosynthesis is referred to as Crassulacean Acid Metabolism (CAM) (Paull, 1992).

Natural inflorescence development is initiated by shortened day length and cool nights, but growth regulators (e.g. ethephon, 2-chloroethylphosponic acid) are used commercially to force flowering. Pollination is not required for fruit development in the self-incompatible commercial cultivars; the fruit develops parthenocarpically (Bartholomew and Malezieux, 1994).

2.2 Postharvest Storage of Pineapple

Pineapples are non-climacteric fruits and should be harvested when ready to eat. A minimum soluble solids content of 12% and a maximum acidity of 1% will assure minimum flavor acceptability by most consumers. Pineapple could be stored for almost 20 days when refrigerated at 10-13° C (50-55°F) for partially-ripe pineapples, 7-10°C (45-50°F) for ripe pineapples with RH 85-90%. Fruits harvested in early stage of ripening are stored at 7-10°C. Exposure of pineapples to temperatures below 7°C results in chilling injury. Controlled atmosphere storage (3-5% O_2 and 5-8% CO_2) delays senescence and reduces respiration. Maturity is indicated by change of shell color from green to yellow at the base of the fruit. Quality indices include uniformity of size and shape; firmness; freedom from decay; freedom from sunburn, sunscald, cracks, bruising, internal breakdown, endogenous brown spot, gummosis, and insect damage. Quality also indicated by tops (crown leaves); green color, medium length, and straightness. Other quality indices are range of soluble solids 11-18%; titratable acidity (mainly citric acid with 0.5-1.6%); and ascorbic acid with 20-65 mg/100g fresh weight which depending on cultivar and ripeness stage. Rates of respiration production in pineapple;

Temperature	7°C (45°F)	10°C(50°F)	13°C(55°F)	15°C(59°F)
ml CO_2/kg·hr	2-4	3-5	5-8	8-10

To calculate heat production, ml CO_2/kg·hr is multiplied by 440 to get Btu/ton/day or by 122 to get kcal/metric ton/day. Rates of ethylene production is less than 0.2 μlC_2H_4/kg·hr at 20° (68°F). Exposure of pineapples to ethylene may result in slightly faster degreening (loss of chlorophyll) without influencing internal quality. Pineapples must be picked when ripe because they do not continue to ripen after harvest. Controlled Atmospheres (CA) is in 3-5% O_2 and 5-8% CO_2. Benefits of CA include delayed senescence and reduced respiration rate. Postharvest life potential: 2-4 weeks in air and 4-6 weeks in CA 10°C (50°F), depending on cultivar and ripeness stage. Exposure to O_2 levels below 2% and/or CO_2 levels above 10% should be avoided because of the potential for development of off-flavors (Kader, 1992).

2.3 Microorganisms Causing Postharvest Diseases in Commodities.

Many bacteria and fungi can cause the postharvest disease. However, it is well established that the major postharvest losses of fruit and vegetables are caused by species of the fungi *Alternaria*, *Botrytis*, *Botryosphaeria*, *Coletotrichum*, *Diplopoda*, *Monolinia*, *Penicillium*, *Phomopsis*, *Rhizopus* and *Sclerotinia* and of the bacteria *Erwinia* and *Pseudomonas*. Most of the organisms are weak pathogens in that they can only invade damaged produce. A few such as *Colletotrichum* are able to penetrate the skin of healthy produce. Often the relationship between the host (fruit or vegetable) and the pathogen is reasonably specific. For example, *Penicillium digitatum* rots only citrus and *P.expansum* rots apples and pears, but not citrus. Complete loss of the commodity occurs when one or a few pathogens invade and break down the tissues. This initial attack is rapidly followed by a broad spectrum of weak pathogens that magnify the damage caused by the primary pathogens. The appearance of many commodities may be marred by surface lesions caused by pathogenic organisms, without the internal tissues being affected (Armstrong, 1994).

2.4 Postharvest Pathology of Pineapple

Most pests and disease of pineapple are universally distributed, as vegetative germplasm has been transported around the world since 1800s. The 'Smooth Cayenne' cultivar is relatively resistant to most pineapple diseases. Disease is generally sporadic in occurrence, particularly in Hawaii (Paull, 1992).

Black rot was the most common problem reported in markets, affecting 70% of the inspected shipments. Severity in affected shipments varied from 11 to 50% rot. Historically, only black rot is of sufficient economic importance and occurrence to warrant control practices. This disease begins following harvest and occurs in fresh pineapple markets throughout the world. Other fruit diseases such as fruitlet core rot, interfruitlet corking, pink disease and marbling disease are universally distributed and occasionally can be important. Brown rot or fruitlet core rot occurred in only 7% of the inspected fruit. Saprophytes growing on the broken end of the peduncle (*Penicillium* sp.) and the fruit surface are not pathogenic but are unsightly and therefore a marketing problem (Cappellini *et al*, 1988).

2.4.1 Black Rot

Black rot, also called *Thielaviopsis* fruit rot, water blister, soft rot or water rot, is a universal fresh fruit problem characterized by a soft watery rot. Black rot is caused by the fungus *Chalara paradoxa* (De Seynes) Sacc. (syn. *Thielaviopsis paradoxa* (De Seyn.). Hohn (telemorph *Ceratocytis paradoxa* (Dade) C. Moreau). The severity of the problem is dependent on the degree of bruising or wounding during harvesting and packing, the level of inoculum on the fruit and storage temperature during transportation and marketing. Susceptibility varies with the cultivar, 'Red Spanish' types being more resistant than 'Smooth Cayenne'. The high correlation between moisture (rainfall duration) prior to harvest and disease following harvest has resulted in the name 'water rot'. Infection occurs between 8 and 12 hours after wounding. Black rot does not occur in the field unless the fruit is overripe or injured (Rohrbach, 1983).

As a wound parasite, *Chalara paradoxa* rot usually starts at the point of detachment of the fruit. Disease tissue turns dark in the later stages of the disease because of the dark-colored mycelium and the chlamydospores. Optimal conditions for hyphal growth are pH 6.0 and 25° C. Fungal growth can occur from 21 to 32 ° C. The fungus is widespread in the tropics on the pineapple, coconut and other palms, sugarcane, cacao and banana. Strain with light-and dark-coloured mycelia have been reported from sugarcane and pineapple (Rohrbach and Schmitt, 1994).

2.4.2 Endogenous Brown Rot

The most economically important physiological disease of the pineapple fruit, endogenous brown rot, also known as internal browning, is usually a postharvest disorder even though it may occur under field conditions. The first symptom of endogenous brown rot is the appearance of a small translucent spot in the flesh of the fruit, close to the central cylinder, approximately 2 cm below the base of the crown. The affected area enlarges, and only a narrow band of the flesh between the peel and the rotted tissue remains healthy. Despite the internal alterations no symptoms are observed externally and the infected fruit looks healthy. Endogenous brown rot occurs when the fruit is removed from the low temperature of storage and shipping conditions to room temperature during commercialization. Besides the alternation effect of the temperature, fruits with low levels of ascorbic acid are more susceptible to the endogenous brown rot (Rohrbach and Phillips, 1990).

2.4.3 Fruitlet Core Rot

Fruitlet core rot (FCR), black spot, fruitlet brown rot and eye rot are all terms used to describe the brown to black color of the central part of an individual fruitlet. Epidemic levels are rare in the major commercial pineapple-growing areas. This disease could become more important if some of the more susceptible low-acid cultivars are grown commercially for niche fresh fruit markets. This disease is caused by a complex involving the fungi *Penicillium funiculosum* Thom, *Fusarium moniliforme* Sheldon var. *subglutinas*

Wollenw. & Reink., and the round yeast *Candida guillermondi*, the pineapple fruit mite, *steneotarsonemus ananas* Tryon, and pineapple red mite *dolichotetranychus floridanus* Banks. Three strains of *P. funiculosum* have been associated with the complex. Little is known about the species of yeast and bacteria isolated from infected fruit. Septa between locules become brown in color with a grey water soaked centre. The infected fruitlets, and frequently lead to misshapen fruit. The degree to which these symptoms develop appears to depend on the time of infection, the pathogens, or mixture of pathogens present, the cultivar and the environmental conditions (Rohrbach and Schmitt, 1994).

2.4.4 Rotting

Rotting caused by the cottony wood-louse is one of the most widely spread and harmful disease in pineapple culture mainly for the cultivar "Smooth Cayenne". A quick expansion occurs from the initial infestation point. As soon as symptoms appear the insects invade healthy plants. Roots stop growing, then collapse and rot, causing plant fading. The plague starts at the tips of the leaves, which develop a yellow-red color. The actual cause of the disease appears to be a virus, but nobody has proven it yet. The yellow spot has been associated with a transmitted virus (Rohrbach, 1983).

2.4.5 Pink Disease

Pink disease is a bacterial infection of the pineapple fruit, characterized by the development of a brown color in the flesh resulting from the processing of fruits infected by *Acetobacter aceti, Erwinia herbicola* and *Gluconobacter oxydans.* The bacteria are brought by insects to the open flowers and under favorable conditions they infect the ovary and reach the flesh of the fruit (Hine, 1976).

2.4.6 Yeast Fermentation

Pineapples are not sterile inside, and contain many non-growing viable yeast and bacteria. In damaged and overripe fruit and in fruit with inter-fruitlet cracking already present, yeasts start growing and dividing or new yeasts invade. This growth leads to fermentation, with bubbles of gas and juice escaping through cracks in the skin. The skin turns brown and leathery and the fruits become spongy with bright yellow flesh (Paull, 1992).

2.5 The Infection Process

Many fungi that cause considerable disease are unable to penetrate the intact skin of produce, but readily invade via any break in the skin. The damage is often microscopic but is sufficient for pathogens present on the crop and the packing house to gain access to the produce. In addition, the cut stem is a frequent point of entry for microorganisms, and stem-end rots are important forms of postharvest wastage of the fruit. Postharvest infection can also occur through direct penetration of the skin (Wills *et al*., 1998).

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