PHILIPPINE SCIENCE HIGH SCHOOL WESTERN VISAYAS
Doña Lawa-an H. Lopez Campus
Iloilo City

EFFECT OF TEMPERATURE ON THE SHELF LIFE, WEIGHT LOSS, AND SUSCEPTIBILITY TO ANTHRACNOSE AND DIPLODIA STEM-END ROT OF NEWLY HARVESTED MANGOES

A Research Paper Presented to the

Faculty of the Philippine Science High School Western Visayas

Iloilo City

In Partial Fulfillment
of the Requirements

In Technology Research II

by

Jeorge H. Gregori
Ron Albert R. Tumasis
Leandre R. Yeban

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APPROVAL SHEET

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Jeorge H. Gregori
Ron Albert R. Tumasis
Leandre R. Yeban

Approved by the Research Committee:

MR. MARVIN L. CADORNIGARA, Adviser/ Chairperson

MS. JOSEPHINE H. CORDERO

MRS. MYRNA B. LIBUTAQUE

MRS. VIRNA JANE NAVARRO

January 2002

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Doña Lawa-an H. Lopez Campus
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Iloilo City

And most of all, God Almighty for without him, we would be lost.

Long live TAU 2002!

JEORGE H. GREGORI

RON ALBERT R. TUMASIS

LEANDRE R. YEBAN

January 2002

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Doña Lawa-an H. Lopez Campus
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Abstract

This study in a completely randomized design aimed to determine the effect of temperature on the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes. It also determined the significant differences in the effect of hot-water treatment (55°C), cold-water treatment (4°C) and ice treatment (0°C) on the shelf life, weight loss and susceptibility to these fungal infections. It is hypothesized that there is no significant difference in the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes in the different temperature treatments. This study employed the mean and standard deviations as descriptive statistical tests, while the One-Way Analysis of Variance (ANOVA) was employed as inferential statistical test. The Scheffe Test was used as a post-hoc multiple comparison test.

Results showed that the hot water treatment was the most effective treatment in terms of the shelf life of the newly harvested mangoes, followed by the non-treatment, and cold water treatment. Since there were no significant differences in the shelf life of the mangoes in the hot water, cold water treatment and the non-treatment groups, they were as effective as each other.) Ice water treatment was the least effective. In terms of the weight loss of the newly harvested mangoes, the cold water treatment was the most effective, followed by the ice and hot water treatments. Although the cold water treatment proved to be the most effective, the hot water treatment and the ice treatment procedures were as effective as well. Non-treatment of temperature was the least effective. In terms of susceptibility to anthracnose and diplodia stem end rot of newly harvested mangoes, the hot water treatment and the cold water treatments prevented the development of infection after 10 days. The ice treatment allowed the development of anthracnose and diplodia stem end rot (both 1%-25%) after 10 days while the non treatment of temperature allowed the development of anthracnose (76%-100%) and diplodia stem end rot (26%-50%) after 10 days. The hot water, cold water, and ice treatment are more effective in delaying the development of anthracnose and diplodia stem end rot than non treatment.

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EFFECT OF TEMPERATURE ON THE SHELF LIFE, WEIGHT LOSS AND SUSCEPTIBILITY TO ANTHRACNOSE AND DIPLODIA STEM-END ROT OF NEWLY HARVESTED MANGOES

Chapter 1

Introduction to the Study

Background to the study

Mango (*Mangifera indica Linn.*) is a fruit crop that has great market value. People have come up with various ideas to utilize the product that will eventually make mango production system more productive, profitable and sustainable.

Farmers from different plantations devoted solely to mangoes have the benefit of exporting mangoes and earn a big amount of profit. Although mangoes are grown all over the country, the principal producing areas are those with continuous dry periods of at least four months (Golez and Bignayan, 1993).

The Philippines is one of the leading in exporting of fresh mangoes almost exclusively to Hong Kong and Japan. Advances in the technology of mango production, particularly fruit fly control and flower induction, have contributed considerably in increasing yields to levels that permitted increase exportation not only to the said places but also to other countries (Golez and Bignayan, 1993).

Mango is one commercial crop, which receives a tremendous amount of pesticides during flower and fruit development. Over the past decades, mango has become increasingly dependent on chemicals or conventional approaches to pest control. These include calendar spraying (about 8-10 times during flower and fruit development), and the use of different mixtures of toxic chemicals. These practices create economic, environmental and health problems in the countryside.

Western Visayas has large number of hectarage to mango, in fact the region is considered as one of the major mango producing regions in the country. On yield it has the highest quantities of fruit produced as compared to other regions (Golez and Bignayan).

One major hindrance to the organization of mango producers is the small number of mango growers. Mangoes are grown on the backyard basis all over the country. Support services cannot be given to small growers. Furthermore, the majority of mango growers have little incentive to improve their cultural practices owing to their relatively small investment in the crop.

Diseases are responsible for the losses and poor quality of mango production. Anthracnose occurs in all mango-producing areas in the country. Considered the most serious fungal disease of mangoes, it attacks the different parts of the tree but the major damage occurs during flowering up to fruit setting and then again after harvest. The disease is most serious during wet seasons.

Diplodia stem-end rot is the second most serious disease. It is prevalent during transport and storage. Violet lesions impended on fruits, which become light brown and finally turn black is the initial symptom of the disease. Usually the most affected is the fruit basal where the pedicel is attached. However the fungus may also attack any part of the fruit damaged during wet seasons.

The major purpose of processing mangoes is to preserve them against chemical and microbiological deterioration. The high temperature, high humidity, and intense sunlight during the harvest seasons accelerate the metabolic processes in fresh fruits; this makes them susceptible to microbial attack.

Hot Water Treatment (HWT) is recommended to minimize the infection from Anthracnose and Diplodia stem-end rot. This consist of dipping the fruits for 10 minutes in water at 52°C to 55° C followed by cooling in running water and air drying. For effective results, fruits should be subjected to HWT immediately after harvest since this procedure not only minimizes the development of the disease, but also removes the latex of the fruit sap.

Finding the positive effect of HWT to newly harvested mangoes in terms of shelf life, weight loss, and resistance to infections, this study will also consider the effect of other temperature levels. The independent variables for this study would be temperature treatment, i.e., hot water treatment, cold water treatment, and ice treatment, on newly harvested mangoes. The dependent variables would be the shelf life, weight loss and susceptibility to Anthracnose and Diplodia stem-end rot of newly harvested mangoes.

The relationship of the dependent and the independent variable is shown in Figure 1.

Statement of the Problem and the Hypothesis

This study aims to determine the effect of temperature on the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes.

Specifically, it will answer the following questions:

1. What is the effect of (a) hot water treatment, (b) cold water treatment, and (c) ice treatment on the (1) shelf life, and (2) weight loss of newly harvested mangoes?

2. What is the effect of (a) hot water treatment, (b) cold water treatment, and (c) ice treatment on the susceptibility to (1) anthracnose (2) diplodia stem-end rot of newly harvested mangoes?

3. Is there a significant difference in the (a) shelf life and (b) weight loss of newly harvested mangoes when treated with (1) hot water, (2) cold water, (3) ice, and (4) not treated at all?

4. Is there a significant difference in the susceptibility to (a) anthracnose and (b) diplodia stem-end rot of newly harvested mangoes when treated with (1) hot water, (2) cold water, (3) ice, and (4) not treated at all?

Based on the problems presented it is hypothesized that:

1. there is no significant difference in (a) shelf life, and (b) weight loss of newly harvested mangoes when treated with (1) hot water, (2) cold water, (3) ice, and (4) not treated at all.

2. there is no significant difference in the susceptibility to (a) anthracnose and (b) diplodia stem-end rot of newly harvested mangoes when treated with (1) hot water, (2) cold water, (3) ice, and (4) not treated at all.

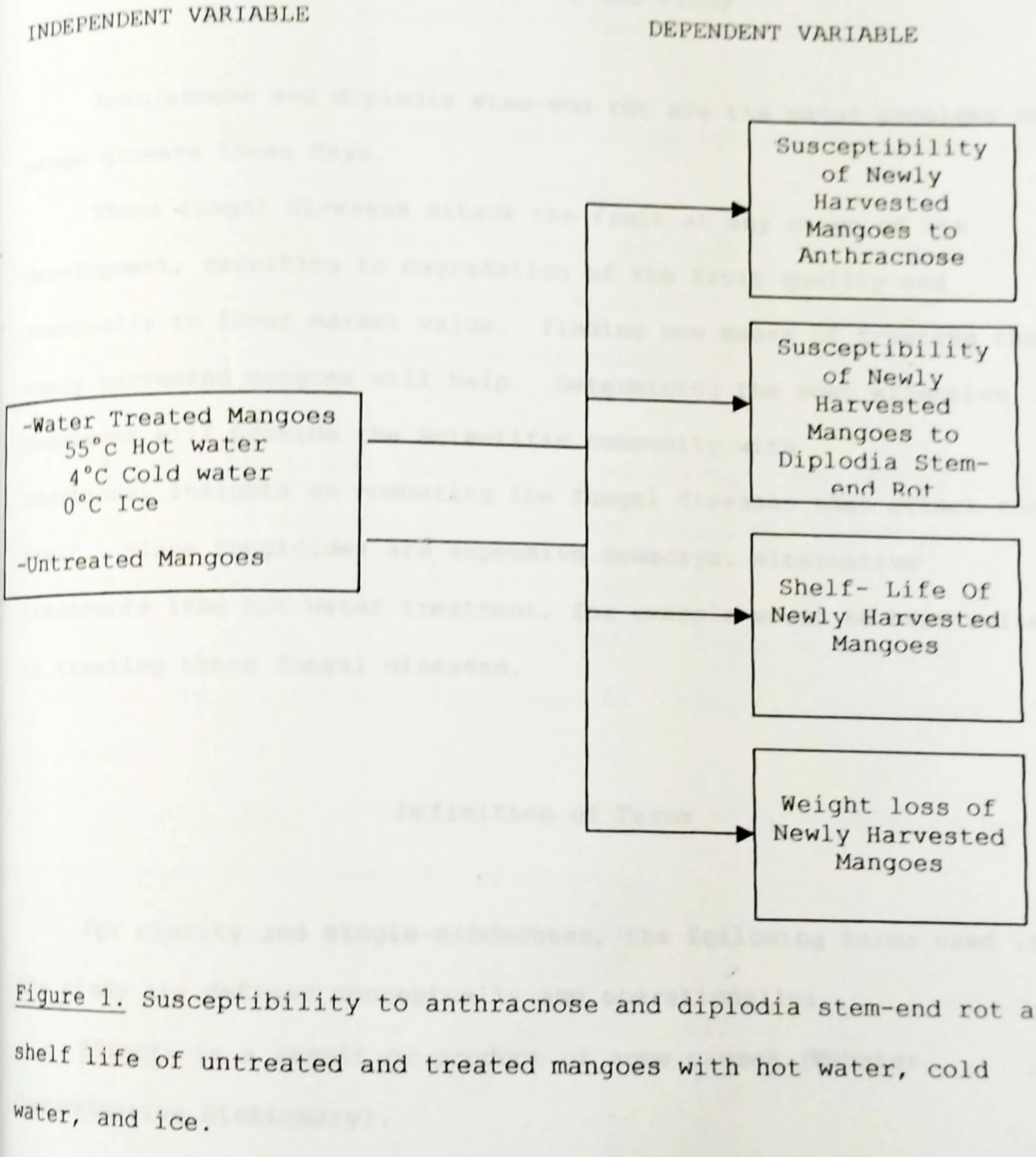

Figure 1. Susceptibility to anthracnose and diplodia stem-end rot and shelf life of untreated and treated mangoes with hot water, cold water, and ice.

Significance of the Study

Anthracnose and diplodia stem-end rot are the major problems of mango growers these days.

These fungal diseases attack the fruit at any stage of its development, resulting to degradation of the fruit quality and eventually to lower market value. Finding new means of treating the newly harvested mangoes will help. Determining the most effective treatment will provide the scientific community with additional insights on combating the fungal diseases that attack the fruit. Since fungicides are expensive nowadays, alternative treatments like hot water treatment, for example would be best suited in treating these fungal diseases.

Definition of Terms

For clarity and single-mindedness, the following terms used in the study are defined conceptually and operationally:

Effect- is a result or product of some causes (Webster Comprehensive Dictionary).

In this study, the term "effect" refers to the ability of the different temperature treatments to preserve the newly harvested mangoes from rotting or diseases.

Temperature- is the measurement of the hotness or coldness of a body (Webster Comprehensive Dictionary).

In this study, the term "temperature" refers to the temperature levels of the independent variable, i.e., 55°C for hot water treatment, 4°C for the cold water treatment and 0°C for the ice treatment.

Shelf life- is the time span in which fruits are still consumable after harvesting from the tree. In this stage, the fruits are free from disease (Webster Comprehensive Dictionary).

In this study, the term "shelf life", refers to the length of time that the mangoes turn from green to completely yellow upon ripening.

[Weight] loss- is the act or state of losing; failure to keep weight (Webster Comprehensive Dictionary).

In this study, the term "weight loss", which is one of the dependent variables, is determined by subtracting the final weight of the mango after the treatment period from the initial weight of the newly harvested mangoes.

Susceptibility- is the capability of being influenced, acted on, or determined (Webster Comprehensive Dictionary).

In this study, the term "susceptibility", which is one of the independent variables, refers to the length of days the newly harvested mangoes shows signs of anthracnose and diplodia stem-end rot infestations.

Anthracnose- is a plant disease of warm, humid areas that infects a variety of plants from trees to grass (Webster Comprehensive Dictionary).

In this study, the term "anthracnose" refers to the disease characterized by sharply defined discolored spots on the shell of mango fruit.

Diplodia Stem-end Rot- is a violet lesion impended on fruits, which become light brown and finally turn black is the initial symptom of the disease. Usually the most affected is the fruit basal where the pedicel is attached (Webster Comprehensive Dictionary).

In this study, the term "diplodia stem-end rot" refers to the disease characterized by violet lesions on the pedicel of mango fruit.

Mango *(Mangifera indica)*- is a member of the cashew family (Anacardiaceae), one of the most important and widely cultivated fruits of the tropical world, considered indigenous to Eastern Asia, Myanmar (Burma) and Eastern State of India (Webster Comprehensive Dictionary).

In this study, the term "mangoes" refers to the test subjects where the treatment is applied.

Hot water treatment- the process of treating materials in hot water (Webster Comprehensive Dictionary, 1995).

In this study, the term "hot water treatment" refers to one of the treatments of the independent variable, specifically, 55°C hot water, to which the newly harvested mangoes is immersed for ten minutes.

Cold [water treatment]- is a temperature reading ranging from 1°C to 19°C (Webster Comprehensive Dictionary).

In this study, the term "cold water treatment" refers to one of the treatments of the independent variable, specifically, 4°C cold water, to which the newly harvested mangoes is immersed for ten minutes.

Ice [water treatment]- is a temperature reading, which is equal to 0°C, or lower (Webster Comprehensive Dictionary).

In this study, the term "ice water treatment" refers to one of the treatments of the independent variable, specifically, 0°C ice, to which the newly harvested mangoes is immersed for ten minutes.

Scope and Delimitation of the Study

The problem is to find new means of improving ripening, delaying weight loss, and preventing fungal diseases in newly harvested mangoes from Guimaras as test specimens. The mangoes were subjected to hot-water treatment (55°C), cold-water treatment (4°C), and ice (0°C).

This study was also limited to the determination of susceptibility of anthracnose and diplodia stem-end rot of newly harvested mangoes. Data were gathered in terms of length of days, for susceptibility and shelf life, and grams for weight loss. The experiment took place at the Philippine Science High School Western-Visayas Campus last June 2001.

Chapter 2

Review of Related Literature

This chapter consists of seven topics, namely, (1) Mango, (2) Anthracnose, (3) Control of Anthracnose, (4), Diplodia Stem-end Rot, (5) Control of Diplodia Stem-end Rot, (6) Scab, and (7) Hot Water Treatment,

Mango

Mango is prone to attack of insect pests and diseases in all stages of its development. Hardly any plant part (roots, trunks, branches, leaves) is immune and yield is considerably reduced when damage is done during flowering and fruiting stages.

Pest problems that maybe encountered during the early induction of mango usually in September and November, and also in late flower induction in January to March. Without an effective pest management program, few, if any, quality fruits can be produced.

A good control program should include not only measures to destroy pests, but also sound cultural practices that will encourage vigorous growth of the tree to withstand pressure from pest attack.

The success of any controlled program, however, depends on a comprehensive knowledge of the pest, particularly its life history and behavior, distribution, movement and seasonal abundance. Anthracnose, on the other hand, becomes an important disease problem during the wet season.

At present, insecticide is the most widely used control measure against insect pests; and fungicide, against, diseases.

However, some inefficacies and drawbacks have already been reported in the field. To obtain good results, therefore, the recommended dose has to be followed, proper application must be observed, and chemical spray must be directed to the vulnerable stage of insect and disease development.

For an appropriate and long-term effect, judicious use of pesticides should be complemented with other control measures such as cultural, biological, and proper tree management.

Anthracnose

Anthracnose is the most popular and destructive disease in mango industry. It occurs in all mango-growing areas and tends to be more serious in mango orchards that are poorly managed. This disease is caused by a wet-loving fungal organism (*Colletotrichum* *gloeosporioides*). The fungus attacks mango leaves and branch terminals during flushing and also in inflorescence and fruits during flowering and fruit development. The disease is a usual problem during wet seasons or in places where is a prolonged rainfall.

Control of Anthracnose

Apply fungicides to prevent or reduce yield loss due to flower and fruit infections. Chemicals such as maneb, propineb, zineb, chlorothalonil, captan, benomyl, and copper fungicides are effective when used singly, in combination, or in sequential spray.

Incorporate liquid fertilizer into the fungicidal mixture. It is advantageous since it allows rapid nutrient absorption and utilization, correct deficiency symptoms, and improves the tree vigor.

Maintain field sanitation. Collect and burn fallen fruits and tree trashes to reduce sources of inoculum.
Control weeds and other undergrowth beneath the tree so as to reduce humidity, increase in ventilation, and discourage the growth of fungus.

Fruit bagging with materials saturated with fungicide reduces fruit infection. Use drip irrigation instead of the overhead since the latter can easily spread the fungal spore.

Diplodia Stem-end Rot

A fungus [*Lasiodiplodia theobromae* (*Diplodia natalensis*)] causes diplodia stem-end rot and is becoming quite a post-harvest problem causing about 5% post-harvest losses under current production practices. The disease can be easily recognized by the external symptoms that normally appear as a purplish discoloration at the base of the peduncle of ripening fruits. The basal portion turns light brown and finally turns black. As the lesion enlarges, the affected pulp becomes soft and watery and produces an unpleasant odor. The presence of black purplish-like pyncidia of varying shapes and sizes is the unmistakable sign of the disease.

Control of Diplodia Stem-end Rot

The primary sources of inoculum, such as dead twigs, pedicels, and leaves, were removed and burned. About 0.5-cm pedicel at harvest was retained since higher incidence of the disease occurs on fruits without pedicel.

Pre-harvest sprays of fungicides against also reduce stem-rot incidence.

The use of banana leaves as packing materials is avoided. These often harbor the inoculum, which spreads easily to the fruit.

Scab

A fungus [Sphaceloma mangifera (Elsinoe mangifera) that normally affects the appearance of the fruits causes scab. In young fruits, infection appears as a grayish brown spot with a dark irregular margin. As the infected fruit develops, the spots enlarge and the surfaces of the mangoes becomes covered with cracks or fissured corky tissues. The spots are usually skin-deep, but the unsightly appearance of the scabish fruits not only renders the fruits less attractive to buyers but also lowers their market value.

Hot Water Treatment

In the bureau of Plant Industry (BPI in Bergonia and Diloy, 1974), experiment showed that the water treatment could free ripe fruits without impairing their quality. Soaking newly harvested mangoes into heated water at 52°C to 55°C for 5 to 10 minutes does this. Ten minutes of heating is especially recommended for more serious infections.

After treatment, the heated fruits should be exposed in a well-ventilated room or immersed in tap water for 2 hours to cool them down to normal temperature before keeping them in closed container to avoid heat injury.

According to previous studies, 55°C is the best temperature to be used for hot-water treatment (Dideles, Sonalan, Tionko, 1999).

Chapter 3

Research Design and Methodology

This study aimed to determine the effect of temperature on the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes.

Specifically, it determined the effect of hot water, cold water and ice treatments on the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes. It determined further if there is a significant difference in the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes when treated with hot water, cold water, and ice and when they are not treated at all.

Based on the problems presented it is hypothesized that there is no significant difference in shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes when treated with hot water, cold water, and ice, and when they are not treated at all.

The Research Design

The pre-test post-test control group in a completely randomized design was employed in achieving the aim of this study.

Twenty mangoes were randomly assigned to any of the four treatment groups, each group receiving five mangoes. The initial weight of the mangoes was determined prior to treatment.

Mangoes in Group 1 were immersed in 55°C hot water for ten minutes, while mangoes in treatment Group 2 were immersed in 4°C cold water for ten minutes. The mangoes in Group 3 were embedded in ice cubes, also for ten minutes. The remaining five mangoes in Group 4 served as the control.

After treatments, the mangoes were stored for ten days. Everyday, the mangoes were checked for signs of anthracnose and diplodia stem-end rot. The sign of rotting and weight loss were also observed until the tenth day.

Materials and Equipment

The subjects of the study were twenty newly harvested carabao mangoes from the National Mango Research and Development Center in Guimaras. Four trays were used as containers for the four different treatment groups. A cauldron was used for the hot water treatment. Styrofoam coolers were used for the cold-water and ice treatments. A thermometer was used to monitor the temperature of the systems. Crushed ice were used for the ice treatment. A weighing scale was used to measure the daily weight of the mangoes to determine weight loss.

Methodology

Preparation of test organisms

Newly harvested mangoes were gathered from Guimaras. They were placed in a box and transported to Philippine Science High School Research Laboratory. They were transported with care to prevent any handling defects that could affect the results of the study.

Twenty mangoes were randomly selected from a cavan of newly harvested mangoes. They were divided into four treatment groups; each group had five mangoes.

The first group for hot water treatment was identified as Treatment 1 Group, and the five mangoes were tagged as R1.1, R1.2, R1.3, R1.4, and R1.5.

The second group for cold water treatment was identified as Treatment 2 Group, and the mangoes were labeled as R2.1, R2.2, R2.3, R2.4, and R2.5.

The third group for ice treatment was named as Treatment 3, and the mangoes were labeled as R3.1, R3.2, R3.3, R3.4, and R3.5.

The fourth and the untreated group was identified as Treatment 4 Group, and the mangoes were labeled as R4.1, R4.2, R4.3, R4.4, and R4.5.

Determination of the initial weights of the mangoes

Each mango in every treatment group was weighed using a top loading electronic weighing scale. The mean weights for all the treatment groups were determined and recorded.

Temperature Treatment of the Mangoes

Sufficient amount of hot water was placed in a large cauldron. The cauldron was placed on top of a hot plate and heated until the water temperature reached 55°C. The mangoes from the Treatment Group 1 were immersed in hot water for 10 minutes (Sonalan, et.al., 1999) and rinsed with distilled water for the fruits to cool down.

Cold water obtained from a refrigerator set at 4°C was placed in a cooler to be able to maintain the water's temperature. Mangoes from Treatment Group 2 were immersed in the cold water for 10 minutes, afterwards they were set aside for storing.

Crushed ice was placed in a cooler and mangoes from Treatment Group 3 were carefully embedded for 10 minutes, afterwards they were set aside for storing.

The mangoes from Treatment Group 4 did not receive any of the temperature treatments, but were just set aside for storing.

Gathering of data

After ten days, weight loss was determined for each treatment group by subtracting the mean final weights of the mango after the treatment period from the mean initial weights of the newly harvested mangoes.

Shelf life was determined by counting the number of days it took the mangoes to turn from green to yellow.

The following rating scale was used in determining the color changes in the mangoes:

1	All green
2	85% green - 15% yellow
3	75% green - 25% yellow
4	65% green - 35% yellow
5	50% green - 50% yellow
6	45% green - 55% yellow
7	35% green - 65% yellow
8	25% green - 75% yellow
9	15% green - 85% yellow
10	All yellow

In determining the shelf life status of the mangoes, the following rating scale was used:

0 - 1.0	All green
1.1 - 2.0	85% green - 15% yellow
2.1 - 3.0	75% green - 25% yellow
3.1 - 4.0	65% green - 35% yellow
4.1 - 5.0	50% green - 50% yellow
5.1 - 6.0	45% green - 55% yellow
6.1 - 7.0	35% green - 65% yellow
7.1 - 8.0	25% green - 75% yellow
8.1 - 9.0	15% green - 85% yellow
9.1 - 10.0	All yellow

Susceptibility of newly harvested mangoes to anthracnose and diplodia stem-end rot was determined by noting the appearance of sharply defined discolored spots on the shell of the mango fruit and violet lesions on the pedicel of mango fruits, respectively.

The following rating scale was used in determining the degree of anthracnose and diplodia stem end rot infection of the mangoes:

1	No infection
2	1% - 25% infection
3	26% - 50% infection
4	51% - 75% infection
5	76% - 100% infection

In determining the susceptibility status of the mangoes against anthracnose and diplodia stem end rot infection, the following rating scale was used:

0 - 1.0	Not infected
1.1 - 2.0	1% - 25% infected
2.1 - 3.0	26% - 50% infected
3.1 - 4.0	51% - 75% infected
4.1 - 5.0	75% - 100% infected

Statistical Testing

Certain statistical tools were used in testing the data for analysis of this study.

The mean and standard deviation were used as descriptive statistical tools.

The One-Way Analysis of Variance (ANOVA), set at 0.05 alpha level of significance, was used as inferential statistical tool.

The Scheffe test, also set at 0.05 alpha level of significance was used as post hoc multiple comparison test.

Mean

The mean was used to express the average number of days for the testing of the shelf life and susceptibility to anthracnose and diplodia stem-end rot of the mangoes in the different treatments. It was also be used to express the average of the initial and final weights and weight loss of the mangoes in all treatment groups.

Standard Deviation

The standard deviation measured the variability of each value, i.e, the weight and the number of days for the shelf life and susceptibility testing, from their respective means.

One-Way Analysis of Variance (ANOVA)

The One-Way ANOVA, set at 0.05 alpha level of significance, determined the significance of the difference in the weight loss, shelf life and susceptibility to anthracnose and diplodia stem-end rot among the experimental and control treatments.

Scheffe Test

The Scheffe test, also set at 0.05 alpha level of significance, was used as post hoc multiple comparison test whenever the One-Way ANOVA test showed significance of difference.

Chapter 4

Results

This study aimed to determine the effect of temperature on the weight loss, shelf life, and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes.

Specifically, it determined the effect of hot water, cold water and ice treatments on the weight loss, shelf life, and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes. It determined further the significance in the differences in the weight loss, shelf life, and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes when treated with hot water, cold water, and ice, and when they are not treated at all.

Based on the problems presented, it was hypothesized that there is no significant difference in the weight loss, shelf life, and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes when treated with hot water, cold water, and ice, and when they are not treated at all.

Effect of hot water, cold water and ice on the shelf life of newly harvested mangoes

The average length of time the mangoes treated with hot water to turn from green to yellow was 8 days after treatment.

The average length of time the mangoes treated with cold water to turn from green to yellow was 10 days after treatment.

The average length of time the mangoes treated with ice to turn from green to yellow was beyond 10 days after treatment. On the 10^{th} day, the mangoes were only 85% yellow.

The average length of time the untreated mangoes to turn from green to yellow was 9 days after treatment.

Table 1 shows the data.

In terms of shelf life, the hot water treatment was the more effective treatment as it caused ripening for only 8 days. The ice water treatment was the least effective.

Effect of hot water, cold water and ice on the weight loss of newly harvested mangoes

After 10 days, the average weight loss of mangoes treated with hot water was 48.1000 grams.

Table 1

Means of shelf-life ratings of newly harvested mangoes treated with hot water, cold water and ice

Treatment	Means									
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
Hot water	1.0	1.8	3.4	4.4	6.6	7.6	8.4	9.4*	10.0	10.0
Cold water	1.0	1.0	1.6	2.4	3.4	4.8	5.8	7.0	7.0	9.4*
Ice	1.0	1.0	1.2	2.2	3.0	4.6	5.6	6.0	7.2	8.6
Untreated	1.0	1.0	2.2	3.2	4.6	5.8	6.8	8.2	9.6*	10.0

*all yellow

The average weight loss of mangoes treated with cold water was 42.6000 grams and the average weight loss of mangoes treated with ice water was 43.16000 grams.

The average weight loss for untreated mangoes was 51.24000 grams. Table 2 shows the data.

In terms of weight loss, the cold water treatment was the most effective as it caused the least loss in weight (42.6000 grams) followed by the ice treatment (43.1600 grams).

Table 2

Means of weight loss of mangoes treated with hot water, cold water and ice after 10 days

Treatment	N	Means of Weight Loss	Standard deviation
Hot water	5	48.1000 grams	17.9414
Cold water	5	42.6000 grams	3.2164
Ice	5	43.1600 grams	7.4989
Untreated	5	51.2400 grams	7.6891

The hot water treated and the untreated mangoes had a high weight loss, i.e., 48.1000 grams and 51.2400 grams, respectively.

The effects of cold water and ice were evident as they have freshwater potentials.

Effect of hot water, cold water and ice on the susceptibility to anthracnose of the newly harvested mangoes

After 10 days, mangoes treated with hot water and cold water showed no anthracnose infection. Those treated with ice showed 1%-25% infection while those untreated mangoes showed 76%-100% infections. Table 3 shows the data.

In terms of improving the susceptibility to anthracnose infection, the hot water treatment and cold water treatments proved to be effective as they prevented the development of infection among the mangoes even after 10 days.

The ice treatment helped a little, as it delayed the development of infection. The mangoes showed 1%-25% infection after 10 days.

Effect of hot water, cold water and ice on the susceptibility to diplodia stem-end rot of newly harvested mangoes

After 10 days, mangoes treated with hot water and cold water showed no diplodia stem-end rot infection. Those treated with ice showed 1%-25% infection and those untreated showed 26%-50% infection.

Table 4 shows the data.

Table 3

Means of susceptibility ratings to anthracnose of newly harvested mangoes treated with hot water, cold water and ice

Treatment	Means										Description
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	
Hot water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Not infected
Cold water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Not infected
Ice	1.0	1.0	1.0	1.0	1.2	1.4	1.6	1.6	1.6	1.6	1-25% infected
Untreated	1.0	1.0	1.4	1.6	2.2	2.8	2.8	3.4	3.8	4.0	76-100% infected

Table 4

Means of susceptibility ratings to diplodia stem-end rot of newly harvested mangoes treated with hot water, cold water and ice

Treatment	Means										Description
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	
Hot water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Not infected
Cold water	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	Not infected
Ice	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.4	1-25% infected
Untreated	1.0	1.0	1.0	1.6	1.6	1.6	2.0	2.0	2.0	2.2	26-50% infected

In terms of improving the susceptibility to diplodia stem-end rot infection, the hot water treatment and cold water treatments proved to be effective as they prevented the development of infection among the mangoes.

Significant difference in the shelf life, weight loss, and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes treated with hot water, cold water, and ice.

The One-Way ANOVA showed that there were no significant difference in the weight loss of newly harvested mangoes when treated with hot water, cold water and ice, when they were not treated at all, as reflected by $F(19) = .531$, $p > .05$.

In terms of weight loss, although the cold water treatment proved to be the most effective (42.000 grams), there were no significant difference as compared with hot water (48.000 grams) and ice (43.1600 grams) and the mangoes that are untreated (51.2400 grams).

Table 5 shows the data.

On the other hand, the One Way ANOVA showed significant difference in terms of shelf life and susceptibility to anthracnose and diplodia stem-end rot infections among newly harvested mangoes treated with hot water, cold water, and ice and those that are not treated at all, as reflected by $F(19) = .000$, $p < .05$; $F(19) = .000$, $p < .05$; and $F(19) = .000$, $p < .05$, respectively.

Table 5

One Way ANOVA of the significant differences in the shelf life, weight loss, and susceptibility to anthracnose and diplodia stem-end rot infections (Significance difference exists when the significance level is equal to or less than 0.05.)

Dependent Variable		Sums of Square	df	Mean Square	F	Significance
Weight loss	Between groups	255.953	3	85.318		
	Within groups	1790.384	16	111.899	.762	.531
	Total	2046.337	19			
Shelf life	Between groups	6.600	3	2.200		
	Within groups	2.400	16	0.150	14.667	.000
	Total	9.000	19			
Susceptibility to anthracnose Infections	Between groups	25.350	3	8.450		
	Within groups	7.200	16	0.450	18.778	.000
	Total	32.550	19			
Susceptibility to Diplodia stem-end rot infections	Between groups	4.800	3	1.600		
	Within groups	2.000	16	0.125	12.800	.000
	Total	6.800	19			

Table 5 shows the data.

In terms of shelf life, the effect of hot water, cold water and ice, and non-treatment upon the newly harvested mangoes differed significantly.

The Scheffe test as a post hoc multiple comparison test showed that significant differences existed between hot water treatment (ripening at 8^{th} day) and ice treatment (ripening beyond 10^{th} day). A significant difference also exist between cold water (ripening at 10^{th} day) and ice (ripening beyond 10^{th} day) as well as between ice treatment (ripening beyond 10^{th} day) and non-treatment (ripening at 9^{th} day).

Table 6 shows the data.

It shows therefore that in order to speed up ripening, the newly harvested mangoes should be exposed to higher temperature or even room temperature.

In terms of susceptibility to anthracnose infection, the Scheffe test showed that there were significant difference in the degree of anthracnose infection between hot water treated mangoes (not infected) and untreated mangoes (76%-100% infected). The same difference existed between the cold treated mangoes (not infected) and the untreated mangoes (76%-100% infected) and between the ice treated mangoes (1%-25% infected) and the untreated mangoes (76%-100% infected).

Table 6

Scheffe test of One Way in Table 5 (Significant difference exists when the significance level is equal to or less than 0.05.)

Dependent Variable	Mean Difference	Standard error	Significance
SHELF-LIFE			
Hot water vs. Cold water	.6000	.245	.155
Hot water vs. Ice	1.400*	.245	.000
Hot water vs. Untreated	.000	.245	1.000
Cold water vs. Ice	.8000*	.245	.038
Cold water vs. Untreated	-.6000	.245	.155
Ice vs. Untreated	-1.4000*	.245	.000
SUSCEPTIBILITY TO ANTHRACNOSE INFECTION			
Hot water vs. Cold water	-.6000	.424	.585
Hot water vs. Ice	-1.000	.424	.178
Hot water vs. Untreated	-3.0000*	.424	.000
Cold water vs. Ice	-.40000	.424	.828
Cold water vs. Untreated	-2.4000*	.424	.000
Ice vs. Untreated	-2.0000*	.424	.002
SUSCEPTIBILITY TO DIPLODIA STEM-END ROT INFECTION			
Hot water vs. Cold water	.0000	.224	1.000
Hot water vs. Ice	-.4000	.224	.391
Hot water vs. Untreated	-1.2000*	.224	.001
Cold water vs. Ice	-.4000	.224	.391
Cold water vs. Untreated	-1.2000*	.224	.001
Ice vs. Untreated	-.8000	.224	.022

* Significant at 0.05 alpha level

Table 6 shows the data.

The results indicated that hot water and the cold water treatments are more effective in preventing the development of anthracnose infection than when the mangoes are not treated at all.

Despite the 1%-25% anthracnose infection among mangoes treated with ice, such treatment was still more effective than when the mangoes are not treated at all.

The same results and implications hold true with the effectiveness of hot water, cold water and ice as compared with when the mangoes are not treated at all.

Chapter 5

Summary, Conclusions and Recommendations

This study aimed to determine the effect of temperature on the shelf life, weight loss and susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes.

Specifically, it answered the following questions:

1. What is the effect of (a) hot water treatment, (b) cold water treatment, and (c) ice treatment on the (1) shelf life, and (2) weight loss of newly harvested mangoes?

2. What is the effect of (a) hot water treatment, (b) cold water treatment, and (c) ice treatment on the susceptibility to (1) anthracnose (2) diplodia stem-end rot of newly harvested mangoes?

3. Is there a significant difference in the (a) shelf life and (b) weight loss of newly harvested mangoes when treated with (1) hot water, (2) cold water, (3) ice, and (4) not treated at all?

Summary

Based on the results of the study, the following are the findings of the study.

1.1 The hot water treatment caused the most rapid ripening of the mangoes in just 8 days. Non-treatment of mangoes caused the ripening in 9 days and the cold water treatment caused the least ripening of the mangoes beyond 10 days.

In terms of shelf life of the mangoes, the hot water treatment was the most effective.

1.2 The cold water treatment caused the least loss of the weight of the mangoes after 10 days, followed by ice treatment. The hot treatment and the non-treatment procedure caused the greater and the greatest loss of weight of the mangoes after 10 days respectively.

In terms of weight loss of the mangoes, the cold water treatment was the most effective.

2.1 The hot water and cold water treatments prevented the development of anthracnose infections after 10 days. The ice treatment allowed the development of 1%-25% infection while the non-treatment procedure allowed the development of 76%-100% infection after 10 days.

In terms of susceptibility to anthracnose infection of the mangoes, the hot water and cold water treatments were the most effective.

2.2 The hot water and cold water treatments prevented the development of diplodia stem-end rot infections after 10 days. The ice treatment allowed the development of 1%-25% infection while the non-treatment procedure allowed the development of 26%-50% infection after 10 days.

In terms of susceptibility to diplodia stem-end rot infection of the mangoes, the hot water and cold water treatments were the most effective.

3.a. There was a significant difference in the shelf life of mangoes when treated with hot water, cold water, and ice treatments, and when not treated at all. The significant difference lies between ice treatment and hot water treatment, ice treatment and cold water treatment, and ice treatment and non-treatment.

In terms of shelf life, the hot water, cold water, and non-treatment were as effective as each other in achieving mango ripening. Only ice treatment was not as effective.

3.b. There was a significant difference in the susceptibility of mangoes to anthracnose infection when treated with hot water, cold water, and ice treatment, and when not treated at all.

Although the cold water treatment caused the least loss of weight of the mangoes, all other treatments were as effective.

4.a. There was a significant difference in the susceptibility of mangoes to anthracnose infection when treated with hot water, cold water, and ice treatment, and when no treated at all.

The hot water, cold water, and ice treatment do not differ significantly among themselves in terms of susceptibility to anthracnose infection. Each treatment however, differs significantly with the non-treatment procedure. Hot water, cold water, and ice treatment are more effective for mangoes than when the mangoes are not treated at all.

Although hot water and cold water are both more effective than ice treatment, they show no significant difference after all.

4.b. There was a significant difference in the susceptibility of mangoes to diplodia stem -end rot infection. When treated with hot water, cold water, and ice treatment, and when not treated at all.

The hot water, cold water, and ice treatment do not differ significantly among themselves in terms of susceptibility to anthracnose infection. Each treatment however, differs significantly with the non-treatment procedure. Hot water, cold water, and ice treatment are more effective for mangoes than when the mangoes are not treated at all.

Although hot water and cold water are both more effective than ice treatment, they show no significant difference after all.

Conclusions

In terms of the shelf life of the newly harvested mangoes, the hot water treatment was the most effective, followed by the non-treatment, and the cold water treatment. Since there were no significant differences in the shelf life of hot water, cold water treatment and the non-treatment groups, they were as effective as each other. Ice water treatment was the least effective.

In terms of the weight loss of newly harvested mangoes, the cold water treatment was the most effective, followed by ice and hot water treatments. Non-treatment of temperature was the least effective.

In terms of susceptibility to anthracnose and diplodia stem end rot of newly harvested mangoes, the hot water treatment and cold water treatments prevented the development of infection after 10 days. The ice treatment allowed the development of anthracnose and diplodia stem end rot (both 1%-25%) after 10 days while the non-treatment of temperature allowed the development of anthracnose (76%-100%) and diplodia stem end rot (26%-50%) after 10 days.

The hot water, cold water, and ice treatment are more effective in delaying the development of anthracnose and diplodia stem-end rot of mangoes than when the mangoes are not treated at all.

Recommendations

In terms of shelf life, the hot water treatment is the most effective. Mango growers, who want to purchase their mango in the market in a short period of time, should expose their newly harvested mangoes with hot water treatment to speed up the ripening process.

The cold water treatment is advisable for mango farmers that would like to preserve their newly harvested mangoes for a longer period of time.

In terms of weight loss, the cold water treatment is the most effective. For farmers who want to decrease the weight loss of their mangoes, it is advisable that mangoes will be exposed to cold water treatment for less weight loss.

In terms of the susceptibility to anthracnose and diplodia stem-end rot of newly harvested mangoes, the hot water treatment proved to be the effective for it prevented fungal infection to the mangoes. Farmers who want their mangoes to be purchased at a higher price, newly harvested mangoes should be subjected hot water treatment to prevent fungal infection.

We recommend that further studies will be implemented on other mango species and other temperature treatment. Also, we would also like to recommend that experiments should also be done with tap water.

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