



## **Control of Peduncular Rot in Post-harvest Mango Fruits with Hydrotherapy and Refrigeration**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors GNR, EPRA and JGF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VNC, SSL, EMS and JASF managed the analyses of the study. Authors JLXLC, LARL and ASA managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The objective of this study was to evaluate the effect of hydrotherapy associated with refrigeration on the control of peduncular rot in mango fruits (*Mangifera indica*) of the Tommy Atkins variety. For this, an experiment was set up in the phytopathology laboratory of the Agrarian Sciences Center of the Federal University of Alagoas - UFAL - Delza Gitaí Campus - Rio Largo - AL, from June to December 2018. Mango fruits, previously inoculated with *L. theobromae* ( $10^6$  con.mL<sup>-1</sup>), were immersed in warm water at temperatures of 40, 45, 50 and 55°C for 1, 5 and 10 minutes and then placed under refrigeration for 5 days, then evaluated for disease severity. The results show that hydrotherapy associated with refrigeration is able to control peduncular rot in mango fruits. The temperatures of 50, 55 and 60°C in the time of 9 minutes of fruit immersion showed 100% control

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of the disease, in the time of 1 minute only the temperature of 60°C presented control superior to 90% of the disease, the temperatures of 45 , 50 and 55 presented control of 74.6, 76.2 and 89%, respectively. In the time of 5 minutes, the temperatures of 55 and 60°C were the best with control superior to 90% of the disease. In all immersion times, the equation that best fit the data was the 3rd degree polynomial. The temperature of 40°C, in all evaluated times, was the only one that presented control of the disease inferior to 20%.

**Keywords:** *Alternative control; hydrotherapy; Lasiodiplodia theobromae; Mangifera indica; peduncle rot.*

## 1. INTRODUCTION

The mango tree (*Mangifera indica L.*), introduced in Brazil by the Portuguese in the 16th century, was planted in Rio de Janeiro, from where it spread throughout the country [1]. According to [2], this fruit is subject to loss of quality, influenced by several post-harvest factors, among which are diseases caused by phytopathogens, which may develop after harvesting, especially in the ripening phase, when not receives the necessary care and has not undergone phytosanitary treatment. The pathogenic rot caused by *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl, occurring in all the producing regions of the world, stands out among post-harvest diseases of the mango, for damage caused, in the order of 40 to 50% when the fruit peduncle is infected [3]. The source of the pathogen's inoculum is produced in rotted fruit on the tree or on the ground. Once the plant is infected, the fungus can remain in the vascular tissues for years until the tissue dies. Spreading occurs through winds, pruning instruments and penetration into the plant occur through natural openings or wounds, and the infection can occur in the fruits, in the field and in the harvest phase [4]. Most of the time, the fruit is already infected from the field where the etiological agent (*L. theobromae* (*Botryodiplodia theobromae* (Pat.)) Remains in the quiescent fruit until the appearance of favorable conditions for its development [5]. The peduncular rot in mango culture develops in post-harvest in a period of three to 12 days, in fruits stored at room temperature. However, once the process has started rotting occurs in all fruits within two to three days [6]. Among the recommendations for controlling the disease are preventive sprays of fungicides. However, the forms of control are increasingly evolving. In addition to this, population thinking that seeks not only a healthier consumption of food but also the maintenance of the environment, has required less aggressive and economically viable methods to combat diseases, among which the

use of various forms of energy [7]. The use of thermotherapy and refrigeration are alternative methods, widely used to control post-harvest rot, and are capable of eradicating or weakening the pathogen [8]. The objective of this study was to verify the efficiency of physical control in the management of peduncular rot (*L. theobromae*) in Tommy Atikns mangoes through the use of hydrotherapy and refrigeration.

## 2. MATERIALS AND METHODS

The experiment was conducted at the phytopathology laboratory of the Agrarian Sciences Center of the Federal University of Alagoas - CECA / UFAL - Campus Delza Gitaí - Rio Largo - AL, from June to December 2018.

Mango fruits at the E1 maturation stage were obtained from the Agricultural Sciences Center of UFAL and after harvesting, only those fruits that had no disease caused by phytopathogens were selected.

The fruits were then disinfected with 1% sodium hypochlorite for 10 minutes and washed in running water and dried at room temperature, after which they were submitted to hydrothermal treatment, using a CT 245 water bath, immersing the fruits in water heated at 40, 45, 50, 55 and 60°C for 1, 5 and 10 minutes (Fig. 1), 24 hours after inoculation of the fruits with the *Lasiodiplodia theobromae* ( $10^6$  con.mL<sup>-1</sup>) inoculum suspension, cultivated in BDA (potato-dextrose-agar) culture medium, aiming to evaluate the curative effect of hydrotherapy on peduncular rot in mango fruits.

After receiving the treatments, the fruits were placed on refrigeration at 20°C for 5 days in a BOD incubator model CE-300, when they were evaluated, in relation to the severity of the disease.

For the evaluation of severity, a diagrammatic scale adapted from [9], was used to quantify the

severity of anthracnose in passion fruit, Fig. 2. Severity data were transformed into disease control by the formula  $C = (100\% - \text{severity})$  since that control is the inverse of severity.

The experimental design was completely randomized with 15 treatments, in a factorial

scheme 5 x 3, represented by the 5 temperatures and 3 times of immersion of the fruits in heated water. For statistical evaluation, the Sisvar ver 5.6 computer program was used, the data were submitted to analysis of variance and the means submitted to regression analysis.



Fig. 1. Mango fruits in a water bath, 24 hours after inoculation, at a predetermined temperature

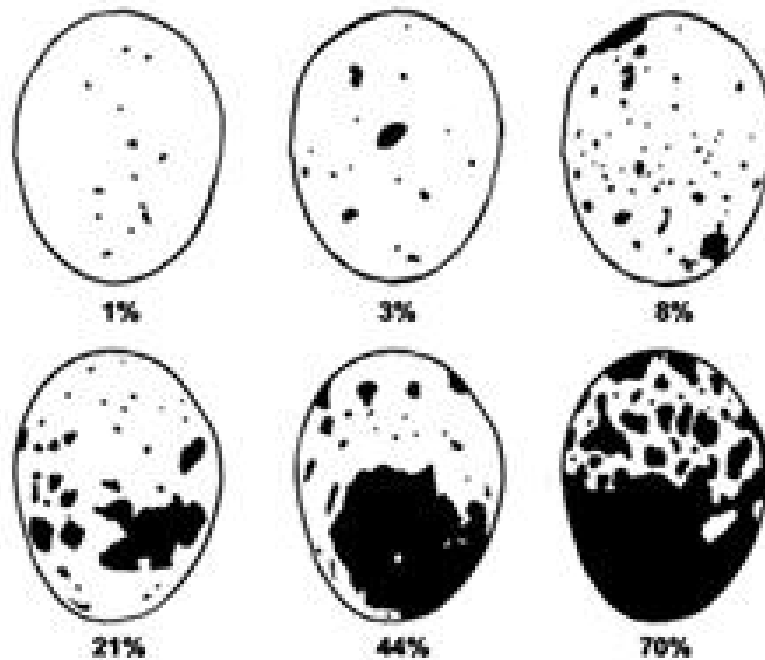


Fig. 2. The scale of notes used in the experiment for disease severity

### 3. RESULTS AND DISCUSSION

According to the test F (Table 1), there was a significant difference in the 1% probability level in the interaction between the studied factors (temperature and time), indicating that the percentage of peduncular rot control depends on the temperature and the immersion time of fruits in heated water.

There was a significant difference at the 1% probability level for the cubic regression at 1, 5 and 9 minutes immersion times, indicating that the 3rd degree equation explains the control of peduncular rot caused by *L. theobromae* in fruits of mango, Tommy Atkins cultivar, in post-harvest.

The coefficient of variation was 3.28%, indicating an excellent experimental precision.

The temperatures of 45, 50, 55 and 60°C were unfolded within each immersion time (1, 5 and 9 minutes), and the discussions are below.

At the time of 1 minute (Fig. 3), the maximum control point of the disease was 90.2%, corresponding to the temperature of 60°C, temperatures of 45, 50 and 55°C presented a control of 74.4, 76.6 and 89% respectively. The temperature of 40°C presented control less than 20%, showing to be inefficient in the control of the disease.

When the temperature increases, an increase in control occurs and consequently a reduction in the incidence of the disease. When the temperature increases, an increase in control occurs and consequently a reduction in the incidence of the disease. The increase in temperature to 60°C provided a 76.8% increase in disease control when compared to the temperature of 40°C, whereas in the 45, 50 and

55°C temperatures, the increases in the control were 61, 62.8 and 75.6%. Although there was significant control, there was no 100% control of the disease.

The R<sup>2</sup> value explains 96.94% of the increase in disease control as a function of the temperature increase determined by the 3rd degree equation.

In the 5-minute immersion time of the fruits (Fig. 4), the maximum control was also obtained with the temperature of 60°C with 95% control, followed by 91.8, 81.6 and 75.6% for temperatures of 55, 50 and 45°C respectively, with increase in disease control when temperature is increased, but a 100% control of disease was not obtained in the 5 minute immersion time.

As temperature increased, there was an increase in disease control of 58.6, 71.6, 74.8 and 78% for temperatures of 45, 50, 55 and 60°C, respectively, when compared with the temperature of 40°C.

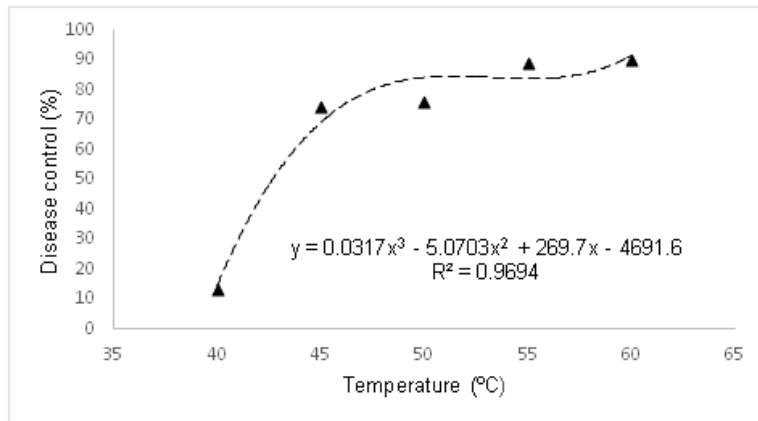
The R<sup>2</sup> value explains 99.77% of the increase in disease control as a function of the temperature increase determined by the 3rd degree equation.

Immersion of the fruits in warm water for 9 minutes at temperatures of 50, 55 and 60 ° C followed by refrigeration at 20°C showed 100% control of pedicle rot in the mango caused by *L. theobromae* (Fig. 5). the temperature of 45°C showed control of 81.6% and the temperature of 40°C showed control of 19.4%, indicating that the latter is inefficient to denature the reproductive structures of the pathogen.

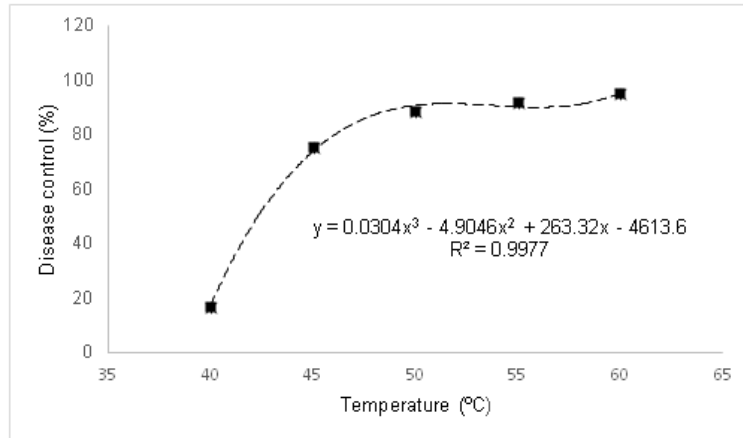
The increases in disease control were 62.2% at 45°C and 80.6% at 50.55 and 60°C when compared to the temperature at 40°C.

**Table 1. Variance analysis (ANOVA) showing significant results**

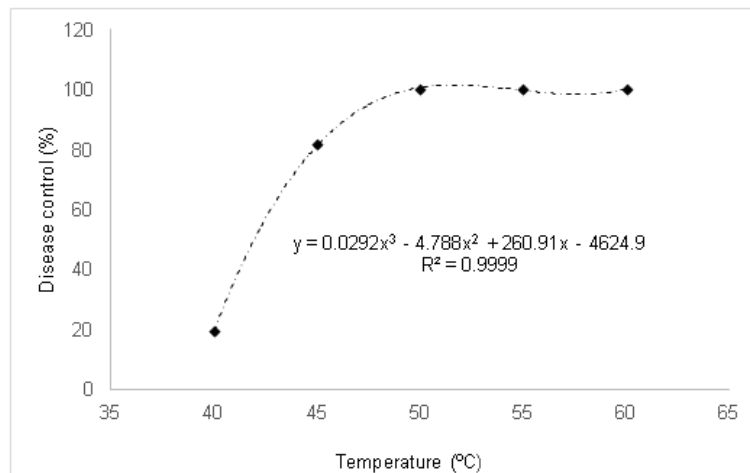
FV	GL	SQ	QM	Fc	Pr>Fc
Temperature	4	6.476885	1.619221	2747.548	0.0000
Time	2	0.169523	0.084761	143.826	0.0000
Temperature*time	8	0.053531	0.006691	11.354	0.0000
Error	60	0.035360	0.000589		
Total corrected	74	6.735299			
CV (%) =	3.28				
Overall average:	0.7401333		Number of observations:	75	



**Fig. 3. Effect of hydrotherapy and refrigeration on the control of peduncular rot in mango fruits after immersion in warm water for 1 minute**



**Fig. 4. Effect of hydrotherapy and refrigeration on the control of peduncular rot in mango fruits after immersion in warm water for 5 minutes**



**Fig. 5. Effect of hydrotherapy and refrigeration on the control of peduncular rot in mango fruits after immersion in warm water for 9 minutes**

The R<sup>2</sup> value explains 99.99% of the increase in disease control as a function of the temperature increase determined by the 3rd degree equation.

Some researchers state that hydrotherapy has not demonstrated efficiency in the control of fungi when used alone: [10] observed this in post-harvest diseases of papaya culture; in the banana, [11] found that heat treatment alone was not efficient in the control of post-harvest anthracnose of banana 'Prata anã' and [12], evaluating the effect of hydrotherapy on the severity of peduncular rot (*L. theobromae*) in fruits mango cv Tommy Atkins, with temperatures of 53, 55 and 57°C for 4 and 5 minutes, found no efficiency in controlling this disease. In a way, these observations reinforce the results found in this study, since hydrotherapy associated with refrigeration was used. It was observed that the temperatures of 50, 55 and 60°C for 9 minutes associated with fruit refrigeration, showed efficiency in reducing the severity of peduncular rot in cv. Tommy Atkins.

Other studies corroborate the results found in this research: [13] obtained the control of anthracnose (*C. gloeosporioides*) in post-harvest mango cv Espada (94%), using hydrotherapy (53 ° C for 5 minutes), thus like [14] who obtained control of *C. gloeosporioides* in post-harvest passion fruit (85%), using the same method of inoculation by [13].

The thermotherapy or hydrotherapy has as a prerogative that the treatment cannot affect the physical-chemical properties of the fruits. In this work, the exposure of Tommy Atkins mango fruits at temperatures of 55°C for 5 and 9 minutes did not affect the physicochemical properties of these fruits, which presented consistency, colour and flavour unchanged. Similar results were observed by [15], who verified that 5 minutes at 55°C, used to reduce the severity of the anthracnose in mango, did not affect the physical-chemical properties of the fruits.

In this work the direct effect of hydrotherapy and refrigeration on peduncular rot in mango fruits was demonstrated, evidencing the importance and efficiency of this method in the control of post-harvest disease of fruits.

#### 4. CONCLUSION

The thermotherapy associated with refrigeration is able to control the peduncular rot in mango

fruits caused by *Lasiodiplodia theobromae*. The immersion of the fruits in heated water at temperatures of 50, 55 and 60°C for 9 minutes promotes 100% control of the disease.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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