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The Effect of Temperature and Relative Humidity on Pawpaw Fruit Rot in South-Western Nigeria

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Abstract: Fungi found associated with fruit rot of pawpaw *(Carica papaya L.)* in South-western Nigeria includes *Rhizopus nigricans*, *Aspergilus niger*, *Fusarium moniliforme*, *Curvularia lunata* and *Collectotrichum capsicis.* All were pathogenic on the test pawpaw fruits varieties (Isolo, JS[22] and Homestead) in this study. The most pathogenic being *C. lunata* followed by *R. nigricans,* while the least rot was induced by *C. capsicis*. Results reveal that optimum temperature for maximum rot, range from 30-35°C, while fruits stored above or below this temperature showed blemishes. The relative humidity for maximum rot in this research range from 60-80%. Pawpaw fruits stored well at relative humidity below 40%. Hence, 30-35°C temperature and 35-40% relative humidities are recommended for the control of these common pawpaw fruit rot pathogens.

Key word: Isolo variety · homestead variety · JS[22] variety

INTRODUCTION

Pawpaw fruits *(Carica papaya L.)* is one of the most nutritional and cheapest fruits grown and consumed in Nigeria. The fruit is widely consumed as it is grown all the year round. However in the average, fruits are increasingly becoming popular in the Nigerian diet, but the production of these crops remain low and inadequate [1]. Pawpaw fruits are beset with problems of field and storage rot. Gutpa and Pathak [2] identified 22 different fungi in post harvest decay of pawpaw fruits. Raymond [3] and Ishaku [4] estimated the post harvest losses of tropical fruits to the extent of 25% of the production in Nigeria. The relative inadequacy in the pawpaw fruit production with the increasing popularity of the fruits thus emphasizing the need for investigating the problem facing the fruit production, the causes as well as the means of fruit production that will commensurate with demand [1].

Most of the pawpaw fruit consumed in South-western Nigeria are grown in the wild and are harvested into large open basket or fibre bags by the local farmers. The baskets/fibre bags are often piled on top of one another during transportation, fruits arrived at their destination bruised and squeezed. Bruised fruits readily become colonized by propagules of the pathogens from the already rotted fruits.

Fruit rots incited by fungi have been reported to cause heavy losses of many fruits both in the field and during storage [5]. This study aimed at isolating and identifying fruit rot inducing pathogens and the effect of temperature and relative humidity on the pathogenicity of the isolates. Bearing in mind that any measure taken to select a suitable temperature and relative humidity for fruit storage in order to control fruits rot will definitely have positive effect on the overall economic returns and fruit utilization.

MATERIALS AND METHODS

Isolation of associated fungi: Decaying pawpaw fruit samples collected from different locations, were brought in clean polythene bags to the laboratory, swabbed in 70% ethanol for 2 min, washed with several changes of sterile distilled water and blotted dry with sterile filter papers.

Lesions were aseptically excised from the fruit, plated on the sterile Potato Dextrose Agar (PDA) in 9 cm Petri-plates and incubated at 30±1°C for 3 days. Pure culture obtained from emerging mycelia colonies were

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maintained on PDA slants in McCartney bottles and later identified by morphological examination. This was further sent to the advanced pathology laboratory of the International Institute of Tropical Agriculture (IITA) Ibadan Nigeria for confirmation.

Pathogenicity: Pathogenicity test was carried out (using two techniques) on three different pawpaw fruits varieties; Isolo, JS[22] and Homestead collected from the National Institute of Horticultural Research and Training (NIHORT), Ibadan.

First technique involved an incision made with sterile scapel on each of the fruits and a mycelia piece of the isolated fungi was put while the second technique involved the boring of a hole into each of the surface sterilize fruits with a 5 mm-cork borer. A 3 mm mycelia disk each of the isolated fungi was put in the hole and the core of tissue was replaced and sealed with vaseline petroleum jelly.

The control experiment involved fungal mycelia pieces placed on unwounded fruits surface. The inoculated fruits were arranged in batches of five, for each of the isolated fungi in clean polythene bags each replicated three times moistened with wet balls of absorbent cotton wool to create a micro humidity chamber and incubated at 30 + 1°C for 7 days. Transverse section of each fruit was cut tangentially along plane of inoculation and converted to rot indices. The indexes included 1 = 1-4 mm diameter rot, 2 = 5-9 mm, 3 = 10-14 mm, 4 = 15-19 mm, 5 = 20-24 mm diameter.

Effect of temperature on rot development: Inoculated fruits were arranged in moistened polythene bags (5 fruit inoculated with each fungus) and incubated at 15, 25, 35, 45 and 55°C for 7 days. Tissue rot was determined as extent of rot from point of inoculation and converted to arbitrary rot indices as described above.

Effect of relative humidity on rot development: A similar procedure to that described above was employed except that fruits were incubated in a desicator at 20, 40, 60, 80 and 100% R. H. The extent of rot was determined as described above.

Effect of storage temperature and relative humidity on the appearance, firmness and feet of the fruits: This was scored for in this study over a period of 7 days. Storage was at these given temperature (15, 25, 35, 45 and 55°C and relative humidity (20, 40, 60, 80 and 100%). For appearance, the following qualities were scored.

0 = No symptom, fruit very smooth and very firm
1 = 1/5 total surface area of fruit rough but firm
2 = 2/5 total surface of fruit rough and slightly depressed
3 = 3/5 total surface of fruit rough and slightly depressed
4 = 4/5 total surface of fruit rough and easily depressed
5 = total surface of fruit very rough and fruit depressed with slightest pressure

Smoothness and freshness was measured by considering the presence and absence of blemishes and wrinkleness on the fruit skin while the firmness of the fruit were felt with hand. Appearance and firmness are some of the qualities readily used by fruit buyers to determine the marketability of fruit.

RESULTS

Five different fruit fungi were found associated with rotten pawpaw fruits obtained from the 20 locations of study in the South-western part of Nigeria. These fungi include *Fusarium moniliforme Sheldom*, *Aspergillus niger*, *kita*, *Curvularia lunata*, *Tandam* and *Bilgrami*, *Rhizopus nigricans*, *Enrenberg* and *Collectotrichum capsicis*. Bult and Bisby.

Aspergillus niger, *F. moniliforme and R. nigricans* were found to be the most frequently occurring pathogens associated with the rot of pawpaw fruits varieties in this study. The result in Table 1a shows that *C. lunata* induced the most severe rot on pawpaw fruit followed by *F. moniliforme* and *R. nigricans.*

All the fungi isolates showed higher rot indexes for ripe pawpaw fruits. The optimum temperature for maximum fruit rot was 35°C for all the test fungi. While Maximum rot index of 4 was recorded for the ripe pawpaw fruits, 2 were recorded for the unripe pawpaw fruit (Table 1a and b).

The relative humidity for maximum rot development recorded ranged between 60-80% for all the fungi isolates. Analysis of variance showed that there was no significant difference between the amount of fruit decay caused by the different fungi ($p>0.05$). At R.H. 50-60% the rot development on fruit was slower while below 40% R.H. pawpaw fruit stored well. Total degradation of fruits occurred at relative humidity above 80% (Table 2).

Effect of temperature and relative humidity on the appearance and firmness of the fruits: Results showed that each of the three test pawpaw fruits varieties scored

Table 1a: Effect of temperature on rot development pawpaw fruit on the tree (Ripe)

	15°C			25°C			35°C			45°C			55°C		
Isolates	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3
A. Niger	0	0	0	1	0	0	2	3	3	1	1	1	0	0	0
R. Nigricans	1	0	0	0	1	1	3	3	4	0	1	0	0	1	0
F. Moniliforme	0	0	0	0	0	0	3	4	3	1	2	1	1	0	0
C. Lunata	0	0	0	1	0	0	4	4	3	1	1	0	0	0	0
C. Capsici	0	0	0	0	0	0	3	3	3	1	1	0	0	0	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1b: Effect of temperature on rot development of pawpaw fruits on the tree (Unripe)

	15°C			25°C			35°C			45°C			55°C		
Isolates	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3
A. Niger	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0
R. Nigricans	0	0	0	0	1	0	2	2	2	0	0	0	0	0	0
F. Moniliforme	0	0	0	0	0	0	2	1	1	1	1	1	0	0	0
C. Lunata	0	0	0	0	0	1	2	2	2	2	2	2	0	0	0
C. Capsici	0	0	0	0	0	0	2	1	1	1	2	1	0	0	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

V1 = Isolo variety, V2 = Homestead variety, V3 = JS^{22} variety

Indice: 0 = no symptom, 1 = 1-4 cm diameter, 2 = 5-9 cm diameter, 3 = 10-14 cm diameter, 4 = 15-19 cm diameter, 5 = 20 cm-> diameter

Table 2: Effect of Relative Humidity (RH) on the rot development of the test isolate on the three pawpaw (Ripe)

	20Rh			40 Rh			60 Rh			80 Rh			100 Rh	
Isolates	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2	V3	V1	V2
A. Niger	0	0	1	1	1	0	2	3	3	4	4	4	1	0
R. Nigricans	0	0	0	1	1	1	3	3	3	4	4	5	1	0
F. Moniliforme	1	0	0	1	0	1	3	3	3	4	5	4	1	0
C. Lunata	1	0	0	1	1	1	2	3	3	4	5	5	2	0
C. Capsici	0	0	0	1	0	1	1	1	1	2	2	3	1	0
Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0

V1 = Isolo variety, V2 = Homestead variety, V3 = JS^{22} variety

Indices: 0 = no symptom, 1 = 1-4 cm diameter, 2 = 5-9 cm diameter, 3 = 10-14 cm diameter, 4 = 15-19 cm diameter, 5 = 20 cm-> diameter

highest for appearance and firmness at temperature 15°C. At 0°C the fruits shriveled while at temperature 35-45°C blemishes were observed on the fruits surfaces. Relative humidity of 60-80% did not favour the desire fruit qualities while at R.H above 80% total degradation of the test fruit was observed. Desired appearance and firmness of the pawpaw fruit was maintained at the relative humidity of 20-40%.

DISCUSSION AND CONCLUSIONS

Major fungi associated with the rot of pawpaw fruit as revealed in this study includes *R. nigricans*, *Curvularia lunata*, *F. moniliforme*, *A. niger* and *Collectorichum capsicis*, respectively.

Pathogenicity test revealed that the fungi isolates were capable of inducing rot on pawpaw fruits at different stages of maturity; ripe and unripe, wounded and unwounded, if the prevailing conditions are favourable. *Fusarium moniliforme* and *R. nigricans* occurred more frequently in the rot of pawpaw fruits followed by *A. niger* *Curvularia lunata* was the most pathogenic of all the five test pathogens.

Wardlaw and Leonard [6] associated extensive injury on fruit to bad storage and loose packing. During harvest, long poles are used to dislodge fruits from tall pawpaw trees. These fruits often land on stones, pebbles or wood stump when they fall on the ground. Also during packing, fruits are placed on top of one another thereby fruits on top pressing on the lower ones in the baskets. It is most likely that wounds inflicted during these processes serve as source of entrance for micro-organisms. This study showed that wounded fruits rotted faster than the unwounded ones. This is in line with the report of Oludemokun [5] and Olunloyo [7] which associated injury with rapid rot of Kolanut.

Unripe pawpaw fruit recorded low pathogenic activities for all the fungi isolates. This might be due to the fact that the sugar content of unripe fruits is generally low [8] and the enzyme that converts polysaccharide into

monosaccharide (such as amylase) may not be produced in large quantity in such fruits since such enzymes exist more where sugar content is high.

The study revealed that pathogenic activities of the fungi isolates were low in Isolo pawpaw fruit variety (both ripe and unripe). It could be that the sugar content of this fruit variety is lower compare to the other two varieties JS[22] and Homestead, respectively, or that the Isolo pawpaw fruit variety, has some additional substance that inhibits or suppresses the fungi activities. Hence, variety Isolo exhibited the most resistant quality to infection by the fungi (Table 1a and b).

Temperature and relative humidity are important components of the environment, which affect the life of fruits and vegetables especially the rate of respiration in microorganisms. Results obtained from this study on the effect of temperature on fruit rot development showed that the fungi isolates with the exception of *R. nigricans* and *F. moniliforme* caused no rot at 0-25°C, while optimum temperature for fruit rotten ranged between 30 and 35°C [3]. This may be due to the fact that low temperature generally reduces respiration of the decaying microorganisms and other enzymatic reactions, which can cause deterioration. Nightingale and Ramsy [9] found that fungi grow best at 30°C in the USA. The present findings confirms the earlier reports of Butler [10], Can and Alvarex [11] and Carmichael [12], which stated that maximum rot by fungi will be caused between 30-38°C.

The importance of relative humidity is more emphasized in preserving the freshness of the fruits quality rather than the decay, caused by micro-organisms. Relative humidity 60-80% supported to equal extent the rot caused by the different micro-organisms, while relative humidity below 40% tends to favour the storage of pawpaw fruit. Fruits got affected by chilling injury, at 0-10°C since the fruit tissue tends to lose its firmness after storage at these temperatures.

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