INFLUENCE OF WOOD SPECIES ON MOIST SAW-DUST STORAGE OF FRESH TOMATOES

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Summary

The effect of using moist saw-dust from three different wood species for the storage of fresh tomatoes (*Lycopersicum esculentum*) was studied. The three wood species were *Triplochiton scleroxylon*, *Terminalia ivorensis* and *Chlorophora excelsa*. Tomato at three ripening stages, matured-green, breaker and light-red were used in the study. The water uptake capacities of the saw-dust of *Terminalia ivorensis* and *Chlorophora excelsa* were found to be comparable and better than the saw-dust of *Triplochiton scleroxylon*. This trend did not influence the rates of physiological loss in weight. The rates of physiological loss in weight of the tomatoes at all the three ripening stages were significantly ($P < 0.05$) higer in the moist saw-dust of *Chlorophora excelsa* than in the moist saw-dust of the other wood species. Colour development of matured-green and breaker tomato fruits stored in moist saw-dust of *Terminalia ivorensis* was slower as compared to the rest. High bacterial and mould counts were found on fruits stored in the saw-dust of *Chlorophora excelsa*.

Key Words: Tomatoes, saw-dust, wood species, water vapour pressure deficit, physiological loss in weight.

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Introduction

The tomato fruit, *Lycopersicum esculentum*, features prominently in the diets of tropical dishes. Significant post-harvest losses do occur mainly because of poor harvesting methods, delays in transportation and lack of techniques to store the fruits on the farm in most tropical countries (Akinbolu *et al.*, 1991). From the farm-gate, during transportation to the marketing centres, there is usually a time lapse of two to seven days before eventual sale (Johnson & Adjei, 1990). The prevailing high ambient temperature and humidity conditions favour its rapid deterioration. This makes on-farm short-term storage of fresh tomatoes problematic. One simple technique, however, found suitable for on-farm short-term storage of tomatoes in the tropics is the use of moist saw-dust (Nuyda & Bautista, 1981). This technique extends the shelf-life of fresh tomato fruits by exerting a cooling effect around the fruits by evaporative cooling. The respiratory heat from the fruit is used as latent heat to vaporise water in the saw-dust. As a result a cooling effect is created around the fruit. The rate of respiration of the fruit is decreased, and hence, the shelf-life of the fruit is increased. The extent of evaporative cooling of a produce depends on the water vapour pressure deficit of the immediate environment, the area of exposed surface to the ambient air as well as the nature of the surface (Burton, 1972). Storage in saw-dust in areas with low relative humidity and high temperature favour evaporative cooling (Nuyda & Bautista, 1981).

The saw-dust storage technique makes use of saw-dust collected from wood-millers. The saw-dust can be from any commercial wood species used in the wood industry. In Ghana, three popular wood species extensively used are *Triplochiton scleroxylon, Terminalia ivorensis* and *Chlorophora excelsa.* These are locally referred to as *"wawa","emire"* and *"odum"*, respectively (Addae *et al.*, 1989).

The saw-dust from these different wood species may differ in water uptake capability and retention. This is because slight differences in the chemical composition of the different wood species are likely to influence the wood-water relationship in the moist saw-dust (Browning, 1975). The water uptake capability and retention by saw-dust will depend on the forces of adhesion and cohesion between the chemical constituents of the wood particles and water molecules (Hillel, 1980). Nuyda & Baustista (1981) showed that fine saw-dust retained water better than coarse saw-dust and, therefore, was preferable for use in saw-dust storage of fresh tomatoes. However, the influence of different wood species on the ability of saw-dust to adsorb and retain water has not been reported. This factor is likely to influence the ability of the saw-dust to exert a cooling effect discussed earlier, serve as harbourage for micro-organisms likely to affect the stored tomatoes and thus the overall efficiency of using moist saw-dust for storage of tomatoes. This study therefore aimed at investigating the effect of using moist saw-dust from three popular Ghanaian wood species – *Triplochiton sceroxylon*, *Terminalia ivorensis and Chlorophora excelsa* - on the short-term storage of fresh tomato (*Heinz* var. 1407).

Materials and Methods

2.1 Collection of Saw-dust

Freshly milled saw-dust was collected from the main wood-milling centre in Accra, popularly referred to as " Timber Market". Two 10 kg bags full of saw-dust of each of the three different wood species were collected. Each lot of saw-dust was cleaned by first sieving through a medium-sized raffia basket and removing any debris from it. It was sieved again through a Laboratory Test Sieve (Endecotts Ltd) with aperture 6×10^{-4} m. This was to ensure that the dust particles, from the different wood species, were of uniform size.

Boiled water was poured onto the saw-dust and spread out on a thin metal tray and allowed to oven-dry at 40 °C for 2 days. The dried, clean saw-dust was collected back into appropriately labelled, sterile polyethylene bags.

2.2 Determination of Water Saturation Capacity of the Saw-dust

About 50 g of saw-dust of each wood species was suspended in 1000 ml water held in a 5 litre flask and allowed to stand for 24 h. The flasks, containing the saw-dust were left in a room in which the average temperature was 30 ± 1 °C and RH 75 ± 3 %. The wet saw-dust was then filtered through a 24 cm diameter filter paper (Whatman) for 1 h.

The amount of water absorbed by the saw-dust during the 24 h period was determined gravimetrically by drying a weighed sample of the moist saw-dust to constant weight at 103 °C for 24 h; using the dry saw-dust as a control. The amount of water absorbed by the saw-dust was therefore expressed as a percentage dry weight of the saw-dust.

2.3 Tests on the Stored Tomatoes

Tomato fruits (*Heinz* var. 1407) grown under irrigation by the Weija Irrigation Company, Accra, were carefully harvested early in the morning and conveyed to the laboratories of the Food Research Institute, Accra, on the same day.

The fruits were sorted and randomly placed in small truncated raffia baskets containing the different types of saw-dust which had been moistened according to the results of the water uptake.

Distilled water was used for wetting the saw-dust. Each treatment was in triplicate. Three stages of ripeness; matured-green, breaker and light-red were picked according to the formula by Nuyda & Bautista (1981). Tomato stored in baskets without saw-dust served as control. The fruits were stored for 15 days under the same conditions and in the same room as used for the test on the water uptake by the saw-dust.

2.3.1 Physiological Loss in Weight

A Mettler pan top balance (model PJ1600) was used to follow changes in the physiological loss in weight (PLW) of five fruits purposely marked from each treatment. The total weight loss over the storage period was calculated. This value was divided by the storage days to give the mean relative daily rates of physiological loss in weight.

2.3.2 Colour Development

These were carried out on the five purposely marked tomato fruits used in the PLW test. A quantitative descriptive analysis method (Agillon, 1984) was used. Colour development, expressed as the Average Colour Score (ACS) was assessed using a hedonic scale 1= green to 9 = table red.

2.3.3 Firmness to touch

This was assessed using the scale: 1 = not firm, 2 = moderately firm and 3 = very firm, using a panel of five.

2.3.4 Microbiological examination

2.3.4.1 Total Aerobic Bacteria Count (Pour Plate Technique)

From 5 tomato fruits aseptically picked from each batch of moist saw-dust, 10 g tomato was weighed into sterile stomacher bags. 90 ml of saline peptone solution was added and macerated. Serial dilutions of 10^{-1} to 10^{-8} were prepared. 1 ml of each dilution was pipetted into sterile petri dishes. This was overlaid with Plate Count Agar (PCA) cooled to 45 °C, thoroughly mixing the contents by rotating the plates in a clockwise and anticlockwise direction. The plates were then incubated at 30 °C for 72 h.

2.3.4.2 Enterobacteriaceae (Coliforms)

1 ml portions of 10^{-1} dilution of the tomato juice were pipetted into 5 ml portions of sterile MacConkey broth in test tubes. These were then incubated at 37 °C for 12 h. The test tubes were then examined for coliform organisms by the production of acid and gas.

2.3.4.3 Pathogenic micro-organisms

i. *Staphylococcus spp.*: A 5 g sample of tomato was aseptically weighed and placed in cooked meat medium and incubated at 37 °C for 12 h. The sample was aseptically sub-cultured onto Mannitol salt agar and incubated at 37 °C for 72 h.

ii. *Salmonella spp.*: 25 g of the macerated tomato juice was placed into Selenite broth and incubated at 37 °C for 18 h. It was then sub-cultured onto Bismuth Sulphite agar and incubated at 37 °C for 72 h.

iii. *Mould and yeast count*: Employing the Pour Plate Technique, 1 ml portions of the 10^{-1} dilution of the tomato suspension were pipetted into duplicate sterile petri dishes. These were pour-plated with Malt Extract Agar, mixed and incubated at 25 °C for 5 days. Characteristic colonies that appeared were counted. Fungal identification was according to the morphology and cultural characteristics.

Results and Discussion

The saw-dust of *Triplochiton scleroxylon* absorbed and retained water much better than that of the other two wood species. However, the rate of water evaporation from the different saw-dust did not differ significantly ($P> 0.01$) from each other (Table 1). It is difficult to suggest any special reasons for this except that *Triplochiton scleroxylon* is known to contain more starch than the other two wood species (Irvine, 1961). Moist saw-dust of *Triplochiton scleroxylon* was therefore likely to give a better water vapour pressure deficit which would enable it to remove more heat from the tomato than moist saw-dust of the other two wood species (Burton, 1972). In Table 2, the higher rate of the PLW of the tomato stored in the saw-dust of *Chlorophora excelsa* must have been influenced by its inability to be saturated with as much water as the saw-dust of *Triplochiton scleroxylon*. The physiological loss in weight (PLW) is an indication of the rate of respiration of fruits. Respiration leads to the break-down of the tissues in the fruits (Willis *et al.*,1981). In this moist saw-dust storage technique, the rate of respiration decreases with increase in the level of cooling (Nyuda & Baustita, 1981). The more the evaporative cooling the more the reduction in the rate of respiration. Fig. 1 shows that though the initial reduction in temperature from 30 to 27 °C up to the sixth day of storage was almost the same for tomatoes stored in all three types of saw-dust, the temperature build up after the ninth day was faster in the saw-dust of *Cholophora excelsa* than for the other wood species.

The light-red tomato showed the fastest rate in physiological loss in weight because tomato is a climacteric fruit. This is because respiration is much faster at the light-red ripening stage than at the earlier ripening stages (Willis *et al.*, 1981). An increase in respiration resulted in an increased loss of water from the fruit, which was reflected in high loss of weight.

The rates of colour development of matured green and breaker tomatoes stored in moist saw-dust of *Terminalia ivorensis* were found to be slower as compared to tomatoes stored in the other saw-dust (Fig. 2 and 3). In Fig. 3, the tomato fruits (breaker) stored in the saw-dust of *Terminalia ivorensis* and *Triplochiton scleroxylon* became table red in colour after 12 days, whilst the fruits stored in the saw dust of *Cholophora excelsa* took only 9 days to achieve the table red ripening stage. These results appear to be consistent with those obtained for the physiological loss in weight (Table 2). Results of the colour development in light-red tomato did not show any particular trend.

Table 1 Water saturation capacities of saw dust of different wood species

Type of wood species	Water Absorbed (% dry basis)	Water Lost after 3 days (% dry basis) at	
		58 % RH	75 % RH
Chlorophora excelsa	67.8 (± 1.8)	5.7 (± 0.3)	2.7 (± 0.1)
Triplochiton scleroxylon	77.9 (± 2.6)	6.3 (± 0.5)	3.4 (± 0.2)
Terminalia ivorensis	68.6 (± 2.1)	5.4 (± 0.2)	3.2 (± 0.1)

Each value is from 3 replicate determinations. Value in ( ) is the standard deviation.

Table 2 Rates of Physiological Loss in Weight (PLW) expressed as a percentage of initial weight of tomato fruits stored in moist saw-dust for three wood species

Ripening Stage of Tomato Fruit	Rates of Physiological Loss in Weight (%/day)			
	Chlorophora excelsa	*Triplochiton scleroxylon*	*Terminalia ivorensis*	Control
Matured-Green	0.22 b	0.17a	0.15 a	0.23 b
Breaker	0.28 c	0.22 b	0.21 b	0.33 d
Light-red	0.27 c	0.27 b	0.24 b	0.37 e

Each value represents the mean obtained from 3 replicate treatments; each replicate consisting of 5 fruits

Values in the same row followed by the same letter did not differ significantly ($P < 0.05$)

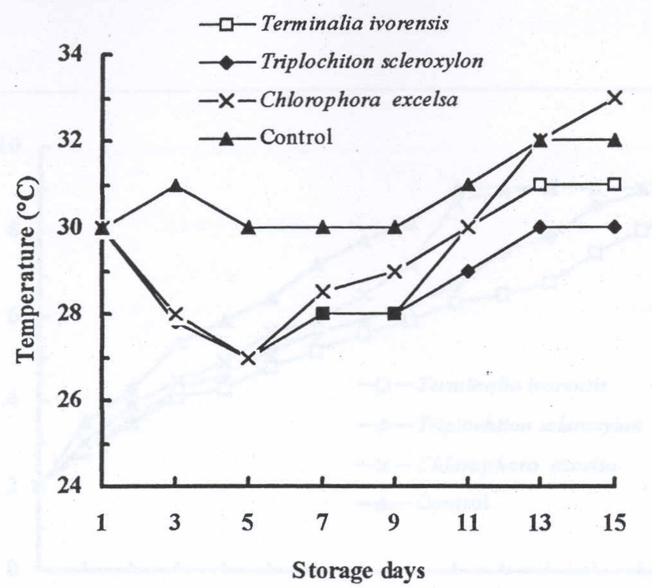

Fig. 1 Mean temperature around tomato fruits (matured green) stored in moist saw-dust media of three wood species

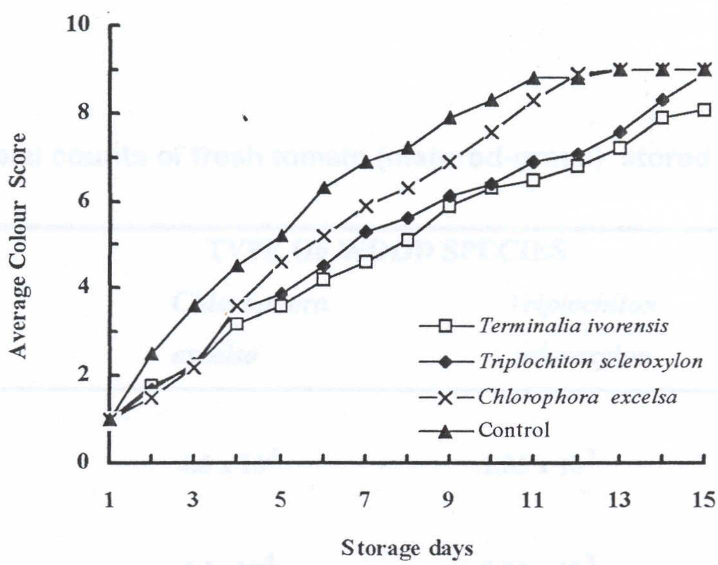

Fig. 2 Trends in colour development of tomato fruits (matured-green) stored in moist saw-dust media of three wood species

(Colour scored from 1 = green to 9 = table red)

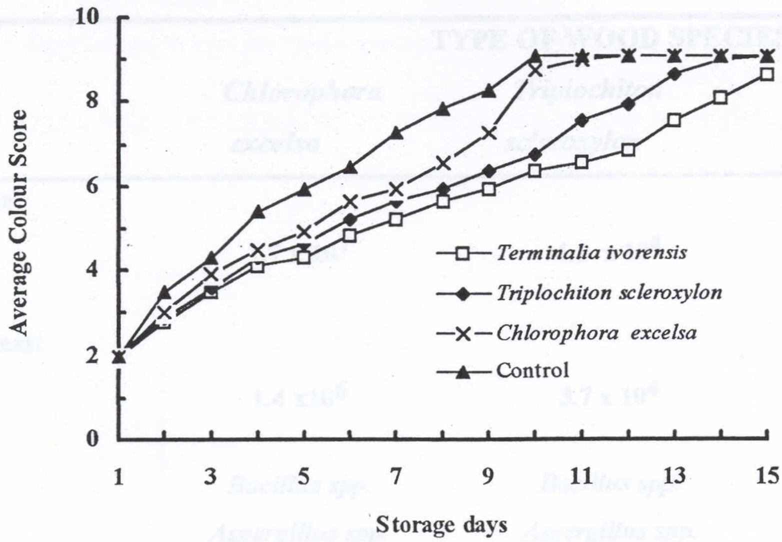

Fig. 3 Trends in colour development of tomato fruits (breaker) stored in moist saw-dust media of three wood species.

(Colour scored from 1 = green to 9 = table red)

Table 3 Microbial counts of fresh tomato (matured-green) stored in moist saw-dust

	TYPE OF WOOD SPECIES		
	Chlorophora excelsa	*Triplochiton scleroxylon*	*Terminalia ivorensis*
Total Bacterial Count /g	**4.6×10^4**	**1.35×10^3**	**1.99×10^3**
Mould and Yeast Count /g	**1.1×10^4**	**7.53×10^3**	**4.9×10^2**
Culture	***Bacillus spp.***	***Bacillus spp.***	
Coliforms (0.1 g)	**Not present**	**Not present**	**Not present**

Table 4 Microbial counts of fresh tomato (breaker) stored in moist saw-dust

	TYPE OF WOOD SPECIES		
	Chlorophora excelsa	***Triplochiton scleroxylon***	***Terminalia ivorensis***
Total Bacterial Count /g	**1.7×10^7**	**4.1×10^4**	**9.33×10^3**
Mould and Yeast Count /g	**1.4×10^6**	**3.7×10^4**	**1.2×10^4**
Culture	***Bacillus spp.*** ***Aspergillus spp.*** ***Penicillium*** ***Rhizopus*** ***Mucor***	***Bacillus spp.*** ***Aspergillus spp.*** ***Penicillium*** ***Rhizopus*** ***Mucor***	--
Coliforms (0.1 g)	**Not present**	**Not present**	**Not present**

Firmness of the fruits is an important quality criterion since it determines how well the fruit can withstand transportation from the farm-gate to the marketing centres. It also serves as an indicator of the internal breakdown during ripening. This explains why the decrease in firmness (Fig. 4) correlates very well with the increase in change of green to red colour of the matured-green tomatoes stored in the saw-dust of all three wood species (Fig. 2).

Bacteria and mould counts of tomato fruits sampled directly from the farm before storage in the saw-dust were high. After storage in the saw-dust of *Chlorophora excelsa, Triplochiton scleroxylon* and *Terminalia ivorensis*, it was observed that the increase in bacteria and mould counts on fruits stored in *Terminalia ivorensis* were less than those kept in the other wood species (Tables 3 to 5). This is possibly due to the presence of some fungicidal and bactericidal agents in the composition of the *Terminalia ivorensis* which inhibited further growth of the micro-organisms. Freshly cut timber logs are usually given prophylactic treatment, using a mixture of borates and flourides, to prevent sapstain (Ampong, 1991). In addition logs are treated with fungicides such as methlene-bis-thiocyanate. For the *Triplochiton scleroxylon*, the presence of a very high concentration of micro-organisms can be attributed to the higher

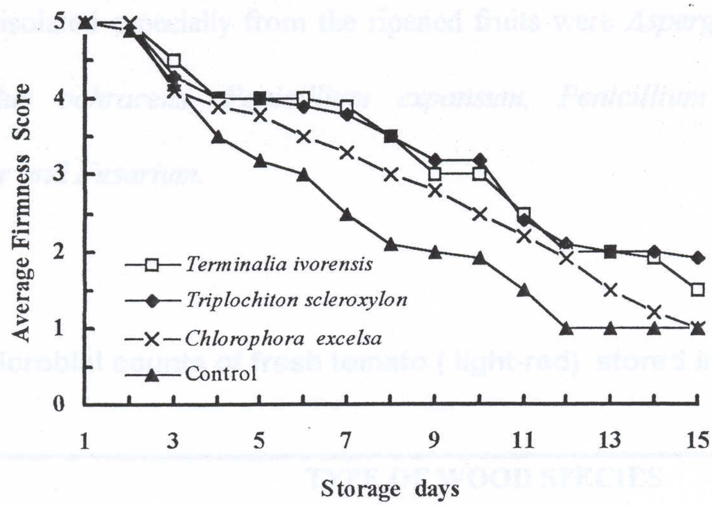

Fig. 4 Trends in firmness of tomato fruits (matured green) stored in moist saw-dust media of three wood species

(Firmness scored from 1 = very soft to 5 = very firm)

proportion of starch in the wood as compared to the other wood species (Irvine, 1961). Starch is a very good carbohydrate substrate for fungi (Christensen & Kaufmann, 1979). The higher concentration of micro-organisms found on fruits of the light-red colour ripening stage as compared to those on the matured-green fruits may be attributed to the fact that the former fruits being in their advanced stage of maturity contained abundant substrates for the growth and proliferation of these micro-organisms. The composition of the fruits may have influenced the kinds and even the numbers of micro-organism. In the ripened state, the skin may have been bruised or pierced during handling on the farm (Akinbolu *et al.*, 1991) and this created easy access for the infestation of micro-organisms. The matured-green fruits showed less spoilage. This may have been due to the thick waxy outer covering of the skin of the tomato fruit which protected the fruit from early microbial invasion. The thick cover also served to minimise moisture loss from the fruit and this reduced fungal attack.

Bacillus spp. and yeast cells were found to be predominant in all the samples stored. Other micro-organisms isolated especially from the ripened fruits were *Aspergillus niger, Aspergillus flavus, Aspergillus ochraceus, Penicillium expansum, Penicillium digitatum, Rhizopus, Alternaria, Mucor and Fusarium.*

Table 5 Microbial counts of fresh tomato (light-red) stored in moist saw-dust

	TYPE OF WOOD SPECIES		
	Chlorophora excelsa	***Triplochiton scleroxylon***	***Terminalia ivorensis***
Total Bacterial Count /g	**1.0×10^{10}**	**1.1×10^{5}**	**2.0×10^{5}**
Mould and Yeast Count /g	**1.4×10^{7}**	**1.1×10^{5}**	**1.9×10^{5}**
Culture	***Bacillus spp.*** ***Aspergillus spp.*** ***Penicillium*** ***Rhizopus*** ***Mucor*** ***Alternaria***	***Bacillus spp.*** ***Aspergillus spp.*** ***Penicillium*** ***Rhizopus*** ***Mucor*** ***Fusarium***	***Bacillus spp.*** ***Aspergillus spp.*** ***Penicillium*** ***Mucor***
Coliforms (0.1 g)	**Not present**	**Present**	**Present**

Conclusions

This study indicated that moist saw-dust of *Terminalia ivorensis* and *Triplochiton scleroxylon* were better able to maintain the keeping qualities of fresh tomatoes, especially if harvested at the matured-green ripening stage, than moist saw-dust of *Chlorophora excelsa*. Tomato stored in moist saw-dust of *Chlorophora excelsa* tended to be more pathologically damaged than tomato stored in moist saw-dust of the other two wood species.

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