Effect of salt solution on the mycelial growth of orange fruit spoilage fungi in passive evaporative cooling structures

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Abstract: A study was carried out on the effect of salt solution on mycelial growth of fruit spoilage fungi in passive evaporative cooling structures. Three sets of four different types of passive evaporative cooling structures made of two different materials, clay and aluminium were constructed. One set consists of four separate cooling chambers. Two cooling chambers were made with aluminium container (cylindrical and square shapes) and the other two were made of clay container (cylindrical and square). These four containers were separately inserted inside a bigger clay pot inter- spaced with clay soil of 5 cm (to form tin-in-pot, pot-in-pot, tin-in-wall and wall-in wall) with the outside structure wrapped with jute sack. The other two sets followed the same pattern with interspacing of 7 cm and 10 cm respectively. The set with 7 cm interspace served as the control in which the interspace soil and the jute sacks were constantly wetted at intervals of 2 to 4 h depending on the rate of evaporation with water at room temperature. The other two sets (5 cm and 10 cm interspaced soil) were constantly wetted with salt solution (table salt (Nacl)) at the same interval to keep the soil in moist condition. In addition, the control has no fans and the inner cooling chambers were not lined with polyethylene nylon, while the other two sets have fans and their inner cooling chambers lined with polyethylene nylon. Freshly harvested oranges were used for the experiment, and the temperature, relatively humid and decayed were monitored daily, while the fungal counts were determined at interval of three days for a period of three weeks. The oranges kept inside the 7 cm soil interspace recorded higher values of fungi count compared to those stored inside 5 cm soil interspace throughout the storage period.

The total fungi count values for the oranges stored inside 7 cm soil interspace were 7.6×10 CFU g^{-1}, 8.5×10 CFU g^{-1}, 8.6×10 CFU g^{-1}, 9.2×10 CFU g^{-1}, 9.2×10 CFU g^{-1}, 9.0×10 CFU g^{-1}, and 8.8×10 CFU g^{-1}. The total fungi count values for the oranges stored inside 10 cm soil interspace were 8.2×10 CFU g^{-1}, 7.8×10 CFU g^{-1}, 10.0×10 CFU g^{-1}, 9.2×10 CFU g^{-1}, 9.0×10 CFU g^{-1}, 9.2×10 CFU g^{-1}, and 8.4×10 CFU g^{-1}, while those inside 5 cm interspace were 7.4×10 CFU g^{-1}, 7.5×10 CFU g^{-1}, 8.5×10 CFU g^{-1}, 9.2×10 CFU g^{-1}, 8.7×10 CFU g^{-1}, 8.4×10 CFU g^{-1}, and 8.6×10 CFU g^{-1}. From the results, higher values of fungi counts were recorded on the 5th, 15th and 21st day of storage in oranges stored in 7 cm soil interspace structure, as well as on the 1st, 8th, and18th day of storage in oranges stored in 10 cm soil interspace structure. However, the three soil interspaces have the same number of fungi count on the 11th day of storage.

Keywords: fungi, sodium chloride, solution, oranges, mycelial, soil

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1 Introduction

Post harvest diseases affect a wide variety of crops particularly in developing countries who lack sophisticated post harvest storage facilities (Jeffries and Jeger, 1990). One of the restricted factors that influence the fruits economic value is the relatively short shelf-life period caused by pathogens attack. Infection by fungi and bacteria may occur during the growing season, at harvest time, during handling, storage, transport and marketing, or even after purchase by the consumer (Dennis, 1983).

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It is estimated that about 20%-25% of the harvested fruits are decayed by pathogens during post-harvest handling even in developed countries (Droby, 2006; Zhu, 2006). Specific causes of post harvest losses of fruits and vegetables may be classified as parasitic, non-parasitic, or physical (Cappellini and Ceponis, 1984). The parasitic causes are of microbiological origin that begin as latent infections before harvest or occur at or after harvest during storage. Fungi are more commonly found attacking fruit and bacteria are more common as post harvest pathogens of vegetables. Post harvest diseases of vegetables are caused by microscopic fungi and bacteria (Snowdon, 1992; Howard *et al*., 1994). The presence of many biological agents in the storage environment is due to dampness and inadequate ventilation. Excess moisture in storage structures leads to growth of microbes, such as mould, fungi and bacteria, which subsequently emit spores, cells, fragments and volatile organic compounds into the air. Sanitation is of great concern to produce handlers, not only to protect produce against post harvest diseases, but also to protect consumers from foodborne illnesses. *E. coli* 0157:H7, *Salmonella*, *Chryptosporidium*, *Hepatitis*, and *Cyclospera* are among the disease-causing organisms that have been transferred via fresh fruits and vegetables (Suslow, 1997; Melnick, 1998).

The most common pathogens causing rots in vegetables and fruits are fungi such as *Alternaria, Botrytis, Diplodia, Monilinia, Phomopsis, Rhizopus, Pencillium, Fusarium*,etc (Chandy, 2000).

Preservation usually involves prevention of the growth of bacteria, yeasts, fungi and other microorganisms. Since these microorganisms are the main cause of food spoilage, food preservation depends on rendering conditions unfavourable to their growth (David, 1994). Peach and orange had been studied for fungal decay in storage (Sinha, 1946).

The fungicidal activity of copper sulfate was first recognized by Prevost (1807). Even today, copper fungicides are used widely in many countries. The copper fungicides have been used for the protection of many vegetables, fruits and flowering plants for many plant diseases. Copper sulphate is a naturally occurring inorganic salt, also known as basic copper sulphate, blue stone and blue vitrol. It is used to control a variety of bacterial and fungal diseases of fruits, nuts, vegetables and field crops (Nene and Thapliyal, 1996).

Copper chloride is also known as a toxic substance having potential to kill pests. It is sparingly soluble in water and is effective to kill or inhibit the growth of fungi and microbes (Hartley and Kidd, 1983).

Hallos and Cooney (1981) have reported that heavy metals are generally toxic to microorganisms, especially if these metals are present at high concentrations (Gadd and Griffth, 1978; Wood and Wang, 1985; Ehrlich, 1986).

Chlorine readily kills microorganisms suspended in dump tanks and flumes if the amount of available chlorine is adequate. The level of salt concentration of 15%-20% in every 100 g salt solution is normally selected so that it will be toxic to the parasite like fungi, bacteria, worms, reptiles, etc., and makes life unbearable for them (Lee, 2004).

Sodium chloride is a colourless and odourless gas and also soluble in water. It also has biological used to control microorganisms. Sodium chloride has desiccant property and when applied in excess to any plant (including weed), it draws out the moisture from them and causes them to die. It is one of the oldest herbicides. Therefore, table salt has a natural antibiotic and antifungal effect, but not harmful to humans when consumed in moderate quantities (Chia, 2003; Lavan *et al.*, 1982)

This paper focuses on the effect of salt solution on the growth of fruit spoilage fungi in passive evaporative cooling structures.

2 Materials and methods

The experiment was carried out in Minna, Niger state, Nigeria and the samples of oranges were sourced from Bosso Market. The fresh oranges were stored inside the three sets of four different types of passive evaporative cooling structures for a period of 21 days. Thirty samples of fresh oranges were stored in each structure.

3 Microbial analysis

The total fungal plate counts were determined using

the methods of Collins et al., (2004). The pulp or mesocarps of samples were cut aseptically using sterile forceps and Scalpel. Five grams aseptically weighed into conical flasks containing 50 mL peptone water. The contents were transferred into a sterile mortar and homogenized into a watery paste. Aliquots (0.1 mL) of diluted homogenate were then plated. Fungal counts were conducted using malt extract agar. Plates were incubated at room temperature 28 ± 2^{o}C for 3-5 days. Microbial counts of the samples were reported as CFU g^{-1}.

4 Preparation of salt solution

About 15,000 parts/millions (ppm) solution of sodium chloride (NaCl) was prepared by dissolving 225 g of Nacl in 15 L of water at room temperature and 450 g of NaCl in 30 L of water at room temperature for keeping the four structures in moist condition in the 5 cm and 10 cm soil inter-space respectively. The four structures in the 7 cm soil inter space were kept in moist condition using 20 L of water.

5 Results and discussion

The result of this study based on the fungal analysis of stored oranges in each structure is presented in Table 1.

Table 1 shows that higher values of total fungi counts were obtained in the 7 cm soil interspace structures compared with the oranges stored in the 5 cm soil interspace structures throughout the storage period, due to the absence of salt solution as wetting media to control the growth of fungi. From the results, higher values of total fungi counts were also recorded on the 5th, 15th and 21st day of storage in oranges stored in 7 cm soil interspace structures. The result obtained in 5 cm soil interspace was attributed to the application of salts of sodium (NaCl), showing that decrease in fungi growth may be due to toxic nature of these compound on cellular metabolism of the fungi as suggested by Alexopoulos *et al.* (1996). The higher values of total fungi count in the 7 cm soil interspace structures may be attributed to the growth of weeds in and around the structures (Figure 1) which serves as hidden space for the fungi. The application of table salt is capable of making life uncomfortable for the growth of weeds (David, 1994; Chia, 2003; Armerego, 2003; Lavan *et al*, 1982). *Fusarium spp.* was the most common fungi in citrus fruits (Tournas and Katsoudas, 2005).

Table 1 Fungal count analysis (CFU g^{-1}) of stored onges inside different storage structures

Storage period	Storage structures	Soil Interspace		
		5 cm	7 cm	10 cm
1	Tin-in-pot	2.1 × 10	1.8 × 10	2.1 × 10
	Pot-in-pot	1.7 × 10	1.6 × 10	2.1 × 10
	Tin-in-wall	1.6 × 10	2.1 × 10	2.2 × 10
	Wall-in-wall	2.0 × 10	2.1 × 10	1.8 × 10
	Total	7.4 × 10	7.6 × 10	8.2 ×10
5	Tin-in-pot	1.6 × 10	2.0 × 10	2.0 × 10
	Pot-in-pot	1.8 × 10	2.1 × 10	1.6 × 10
	Tin-in-wall	2.1 × 10	2.3× 10	2.1 × 10
	Wall-in-wall	2.0 × 10	2.1 × 10	2.1 × 10
	Total	7.5 × 10	8.5 × 10	7.8 × 10
8	Tin-in-pot	1.8 × 10	2.2 × 10	2.4 × 10
	Pot-in-pot	2.5 × 10	1.8 × 10	2.4 × 10
	Tin-in-wall	2.4 × 10	2.6 × 10	2.8 × 10
	Wall-in-wall	1.8 × 10	2.0 × 10	2.4 × 10
	Total	8.5 × 10	8.6 × 10	10 × 10
11	Tin-in-pot	2.4 × 10	2.4 × 10	2.6 × 10
	Pot-in-pot	2.2 × 10	2.0 × 10	2.0 × 10
	Tin-in-wall	2.4 × 10	2.6 × 10	2.4 × 10
	Wall-in-wall	2.2 × 10	2.2 × 10	2.2 × 10
	Total	9.2 × 10	9.2 × 10	9.2 × 10
15	Tin-in-pot	1.8 × 10	2.0 × 10	2.2 × 10
	Pot-in-pot	2.7 × 10	2.6 × 10	2.2 × 10
	Tin-in-wall	2.2 × 10	2.4 × 10	2.6 × 10
	Wall-in-wall	2.0 × 10	2.2 × 10	2.0 × 10
	Total	8.7 × 10	9.2 × 10	9.0 × 10
18	Tin-in-pot	2.2 × 10	2.4 × 10	2.4 × 10
	Pot-in-pot	1.8 × 10	2.2 × 10	2.0 × 10
	Tin-in-wall	1.8 × 10	2.0 × 10	2.2 × 10
	Wall-in-wall	2.6 × 10	2.4 × 10	2.6 × 10
	Total	8.4 × 10	9.0 × 10	9.2 × 10
21	Tin-in-pot	1.8 × 10	2.0 × 10	2.2 × 10
	Pot-in-pot	2.4 × 10	2.4 × 10	2.2 × 10
	Tin-in-wall	2.6 × 10	2.4 × 10	2.2 × 10
	Wall-in-wall	1.8 × 10	2.0 × 10	1.8 × 10
	Total	8.6 × 10	8.8 × 10	8.4 × 10

The higher values of total fungi counts recorded on the 1st, 8th and 18th day of storage in oranges stored in 10 cm soil interspace structures may be due to soil cracking that allows rapid transportation of water to the subsoil (Kissel et al., 1994; Harris et al., 1994; Bronswijk et al., 1995). This action of soil cracking gives room for

fungi to settle around the remaining part of the soil interspace not affected by cracking, as greater percentage of salt solution must have found their ways into the cracks (Figure 2).

Figure 1 Growth of weeds in and around the structures

Figure 2 Effect of cracking on soil interspace

6 Conclusion

This paper focusesed on the effect of salt solution on mycelia growth of fruit spoilage fungi in passive evaporative cooling structures. Also on a global application, this study focused on food safety which is an important aspect of food engineering by the introduction of salt solution as wetting media. It was observed that salt solution affects the growth of fungi on orange fruits by drastically reducing their population. It is recommended that the wetting of the jute sack and soil interspace should be done with salt solution at 15,000 ppm instead of water at room temperature so as to reduce the growth of fungi on fruits.

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