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A COMPARATIVE STUDY ON THE ANTIFUNGAL EFFECTS OF TAMARIND (*Tamarindus indica*) AND GARLIC (*Allium sativum*) EXTRACTS ON BANANA ANTHRACNOSE.

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ABSTRACT This study was conducted to investigate and compare the antifungal activity of tamarind and garlic extracts against anthracnose in bananas. Using the 100mg:1L ratio, extracts of the plants were prepared as T_1 – tamarind and T_2 – garlic while T_3 – commercial pesticide, and T_0- no treatment served as the controls. After inoculation with *Colletotrichum* sp. spores, five (5) banana samples were dipped in all the treatments and were observed for nine (9) days. Statistics revealed that VQR, Firmness, DDI, degree of shriveling, aroma, off-odor, incidence of disease, marketability, color index, off-flavor, sweetness are significantly different. T_2 was found to be the best treatment, even better than T_3 and much better than T_1. For the peel quality and pulp quality ratings, T_2 was comparable to T_3 in terms of off-odor and color index, while the rest of the parameters showed that T_2 was still the best treatment. After the nine days of treatment, the anthracnose which started to develop on the third day was least in T_2 next in T_3 and T_1 while T_0 showed the highest incidence of the disease. Generally, for all the tests used, the samples treated with T_2 were the best, followed by T_3 and T_1. Likewise, T_2 had the best quality banana samples. Based on these results, it can be concluded that the treatment with garlic (T_2) is better than the treatment with tamarind (T_1) in preventing anthracnose in bananas. Moreover, T_2 was found to be comparable or even better than the commercial fungicide (T_3). In terms of cost and a negative effect on the environment, these plant extracts may be used by farmers as substitute to commercial fungicides in the natural prevention of the postharvest diseases of bananas. However, it is recommended that a study on the specific concentrations of garlic and tamarind which are best for treating the disease be made as well as considering naturally occurring diseases of bananas.

Keywords: antifungal activity, anthracnose, postharvest disease, parameters

INTRODUCTION

Being rich in natural resources, the Philippines has fertile and arable lands, diverse flora and fauna, extensive coastlines, and rich mineral deposits. The country's primary source of livelihood is its fertile land characterized with rich, wide plains suitable for farming particularly in the Cagayan Valley, Central Luzon, South western Bicol, Panay, Negros, Davao, Cotabato, Agusan and Bukidnon. The country's six major crops are rice, corn, sugarcane, coconut, abaca and tobacco. Except for rice and corn, all these products are exported, along with bananas and pineapples.

As a tropical country, the Philippines grows an abundant variety of fruit crops primarily for local consumption and export market. Banana is considered as the most important fruit crop in the country. Eaten raw, either alone or cut in slices with sugar and cream, or wine and orange juice, bananas can be roasted, fried or boiled, and are made into fritters, preserves and marmalades. Its extract is used in the manufacture of catsup, vinegar, and wine. The unripe fruit is powdered and chipped. Due to the high demand for export, the government and other agencies are working together to sustain the production of this important crop.

Banana production contributes significantly to the national income in terms of volume of production and export earnings (Calderon & Rola, 2003). The earnings depend on the quality of the bananas being exported. The quality of the bananas is determined by size (length of fingers and thickness), evenness of ripening, absence of blemishes and defects and the arrangement of the clusters. However, the quality of the banana to be exported might be affected due to several postharvest diseases such as crown-rot and anthracnose (*Colletotrichum musae)* (De Bellaire and Mourichon, 1997).

Characteristics of Banana - The Host

Bananas are herbaceous plants native to tropical Southeast Asia. Banana plants produce the seedless banana fruit, valued worldwide for its sweet taste, sticky texture and high vitamin content. Despite their tree-like appearance, banana plants are scientifically classified as herbs. belonging to Order Zingiberales, or flowering plants,Family Musaceae and Genus *Musa* (Wishhart,2010).

The *pseudostem* is the main or upright growth of the plant, which for some species can obtain a height of up to 2–8 m, with leaves of up to 3.5 m in length. Its fruit grows in hanging clusters, with up to 20 fruit to a tier (called a *hand*), and 3-20 tiers to a bunch, and averages 125 g, of which approximately 75% is water and 25% dry matter content. Each individual fruit or banana or 'finger' has a protective outer layer (a peel or skin) with a fleshy edible inner portion. Typically the fruit has numerous strings which run between the skin and the edible portion of the banana, and which are commonly removed individually after the skin is removed. Bananas are a valuable source of Vitamin A, Vitamin B6, Vitamin C, and potassium.

Characteristics of Anthracnose – The Pathogen

The serious problems that decrease the quality of export bananas (*Musa* AAA Cavendish) are wound anthracnose and early ripening of fruit caused by the fungus *Colletotrichum musae* (De Bellaire & Mourichon, 1997; Chillet, 2006). Anthracnose spreads from the floral parts and senescent bracts to contaminate fruit in plantations. The spores that reach the fruit surface in runoff rainwater on the banana bunch quickly germinate and form melanized appressoria. As quiescent structures of the pathogen, appressoria germinate during fruit maturation and form infection hyphae colonizing the peel and then penetrating into the fruit pulp. When wounded, rot in the fruit develops long before the fruit ripens, and lesions expand quickly. Anthracnose can trigger early fruit ripening, sometimes seriously damaging fruit when it develops during container transport.

Anthracnose disease attacks all plant parts at any growth stage. The symptoms are most visible on leaves and ripe fruits. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown, or black spots. The spots can expand and merge to cover the whole affected area. The color of the infected part darkens as it ages. The disease can also produce cankers on petioles and on stems that causes severe defoliation and rotting of fruits and roots. Infected fruit has small, water-soaked, sunken, circular spots that may increase in size up to 1.2 cm in diameter. As it ages, the center of an older spot becomes blackish and emits gelatinous pink spore masses.

On green banana fruit, the peel has dark-brown to black diamond-shaped lesions about 8 x 3 cm in size. The lesions are sunken with pale margins. Orange fungal fruiting bodies are found growing on the lesions. On yellowing fruit, brown spots initially appear that later become sunken and covered with orange spore masses. A tip rot may develop and can rot the entire fruit but the pulp is usually not affected unless the fruit is overripe. (OISAT,2010).

To prevent the disease which is uncontrollable and hard to manage, farmers use the hot water treatment which is done within 24 hours of harvest by dipping the fruit for 5 minutes at 52^0C. However, lowering the temperature of the hot water will reduce the effectivity of the treatment. Moreover, the treatment needs more time and manpower. On the other hand, use of agrochemicals and pesticides and intensive production methods in plantations poses damage to the environment. Hence, the study utilized two plants, tamarind and garlic for their antifungal properties without harming the environment.

Nelson (2008) reported that these pathogens are found wherever bananas are grown but are more prevalent in high-rainfall areas, and especially where growers do not follow good field and packinghouse sanitation practices. He also said that premature ripening of affected fruits may occur after infection. The following are general conditions favoring postharvest banana disease symptom development:

- Poor disease management and cultural practices in banana fields for fungal diseases of leaves and fruits (no de-trashing, poor weed control, mats not regularly pruned to thin out plant population density, and poor soil fertility management).
- High rainfall and high relative humidity.
- Poor sanitation in banana fruit packinghouses (facilities not kept clean and orderly).

- Poor fruit packinghouse practices (bananas not washed and dried, dirty de-handing knives, dull knives or ragged cuts during de-handing of banana hands from stalks).
- Not enclosing banana bunches on plants in fields with perforated polyethylene sleeves.
- Fruits are not refrigerated after harvest and before ripening (56°F after packing and during shipping is appropriate).
- Fruits are not harvested on time (fruit bunches should be harvested green when the fingers are about three-fourths the caliper size of their maximum diameter).

from a single, central trunk as the tree matures and is often pruned to optimize tree density and ease of fruit harvest. At night, the leaflets close up. It has red and yellow elongated flowers which are 2.5 cm wide (one inch) five-petalled borne in small racemes, yellow with orange or red streaks. Buds are pink as the sepals and are lost when the flower blooms. The fruit, sometimes called a pod, 12 to 15 cm (3 to 6 inches) in length with a hard, brown shell, has a fleshy, juicy, acidulous pulp. It is mature when the flesh is coloured brown or reddish-brown. Molsby (2005) reported that tamarind can be used to prevent fungal diseases of plants. When extracted with benzene, an odorless liquid called "tamarindienal" was found to be its antifungal agent (Imbabi et al., 1992).

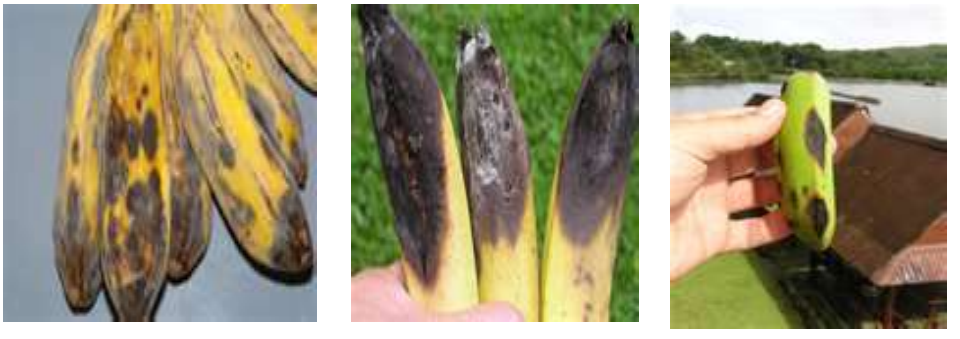

Figure 1. Anthracnose: Symptoms occur as peel blemishes, as black or brown, sunken spots of various sizes on fruits that may bear masses of salmon-colored acervuli with their associated conidia. Spots may have triangular-shaped or angular edges. The pathogen may cause symptoms on green fruit and may also enter the crowns after fruits are severed from stalks.

Related Studies on Tamarind and Garlic – The Antimicrobial Agents

The tamarind is a medium-growth, long-lived bushy tree which attains a maximum crown height of 12.1 to 18.3 metres (40 to 60 feet). The crown has an irregular vase-shaped outline of dense foliage. The tree grows well in full sun in clay, loam, sandy, and acidic soil types, with a high drought and aerosol salt resistance. Its leaves are bright green in colour, elliptical ovular, arrangement is alternate, of the pinnately compound type, with pinnate venation and less than 5 cm (2 inches) in length. Its branches droop

Belonging to Family Fabaceae, the genus, *Tamarindus* is monotypic (having only a single species). It can be eaten fresh or can be prepared as jam or candies. Its juice is a sweet-sour beverage made by infusing *Tamarindus indica* dried pulp. It has been used for treatment of inflammations, fevers, and alcohol intoxication since ancient times. Tamarind drink is rich in calcium and has cathartic, astringent, refrigerant, and antiseptic effects (Nassereddin and Yamani, 2005). Moreover, the tamarind has been used extensively in the laboratory for biosorption of aqueous chromium (Agarwal et a al.,2006), functional and nutritional properties of kernel protein (Bhattacharya et al., 1994), effect on in vitro rumen fermentation (Bhatta,2001), antioxidant activity and phenolic content (Yean-Yean Soong and Barlow, 2004) and anti–

*Escherichia coli a*gents and their effects on bacterial cell aggregation (Voravuthikunchal and Linsuwan, 2006).

Studies on the antifungal property of tamarind have also been recorded. As early as the 1970's, Ray and Majumdar (1973) studied on the antifungal and antibacterial activities of some Indian plants which included tamarind. Among the plants they tested, 30 showed antibacterial activity while 20 of these exhibited antifungal action as well. They noted that the ripe fruit of tamarind showed activity against all the organisms they tested, namely, bacteria, yeast and fungi. Similarly, the fruits have been reported to have anti-fungal and anti-bacterial properties (Guerin and Reveillere, 1984; Bibitha et al., 2002; Metwali, 2003; John et al., 2004). When extracted with benzene and digested with petrol, Imbabi (1992) observed that the fruit yielded 0.67% a brown, odorless liquid named "tamarindienal" which was identified as 5-hydroxy 2-oxo-hexa-3,5-dienal. This liquid is a potent fungicidal agent to cultures of *Aspergillus niger* and *Candida albicans* which also has antibacterial activity to cultures of *Salmonella*, *Bacillus subtilis*, *Staphylacoccus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. The molluscicidal activity of the extract of tamarind fruit pulp was observed in *Bulinus trancatus* snail which was due to the presence of 33 saponins in the fruit (Imbabi and Abu-Al-Futuh, 1992).

There are also related studies about the important properties of tamarind. Through bioassay-guided studies, the allelopathic performance of the bark and seed of the tree was evaluated by Parvez *et al.* (2004) using seven common agronomic crops (asparagus,cucumber, lettuce, radish, sesame, tomato and welsh onion) and seven weed species (barnyard grass, Chinese milk vetch, perennial ryegrass, phacelia, timothy grass, white clover and wild ginger), under laboratory conditions. Results revealed the inhibitory and excitatory effects of the bark and seed of the tamarind tree. Moreover, Parvez *et al.* (2004) tested for the allelophatic competence of the tamarind root and leaf. Results indicated that the growth of both radical and hypocotyls was strongly inhibited under both conditions. Also, accelerated root exudation observed with an increase in the age of tamarind seedlings caused a high magnitude of growth inhibition of the plant. The observations revealed that the tamarind root exudates and tamarind leaf have allelochemical competence (Parvez *et al*.,2003).

Garlic (*Allium sativum*) is a member of the Lily family, which contains over 6,000 species including well-known edible plants such as onion, chives, leek, and shallot. It has been found to be medicinal as ancient Egyptians, Greeks, Chinese, Indians and Romans all advocated its therapeutic value in the treatment of ailments ranging from eye disorders, sore throats and headaches to old age. It was even know as an aphrodisiac. It was also used in the First and Second World War both as an oral medicine to treat battleground infections and as a wound dressing. Garlic is also very effective in treating lung disorders, i.e. coughs, bronchitis, pneumonia, etc.

Garlic is a bulbous member of the onion family. It is grown in herb and vegetable gardens for its segmented bulbs, which are commonly used in cooking. Foliage consists of aromatic, linear, flattened, grass-like green leaves. A central scape topped by an umbel of pinkish-white flowers rises from each clump of leaves to 18" tall in summer. Garlic is widely used around the world for its pungent flavor as a seasoning or condiment. It is a fundamental component in many or most dishes of various regions and its flavour varies in intensity and aroma with the different cooking methods. It is often paired with onion, tomato, or ginger. The garlic bulb consists of a tightly packed cluster of multiple cloves. Both the head and the cloves are surrounded by thin, papery skin that is unpalatable. Otherwise, the whole plant is edible. The mild-flavored leaves and immature flower stems can be cooked and are relished in many cuisines. The cloves have a sharp, pungent, even hot taste when raw but develop a mild, sweet flavor when cooked. Fresh, raw garlic contains a large amount of sulphur-containing compounds that show potent antifungal properties. Allicin, one of the beneficial sulphur-containing compounds, is derived from the amino acid known as cysteine (Green, 2010).

Over the years studies have shown that fresh garlic juice inhibits the growth of *Staphylococcus* (wound infection), *Brucella* (brucellosis), *Salmonella* (typ hoid) and several other bacteria. The action was comparable *in vitro* (in the laboratory) with that of several antibiotics including penicillin, streptomycin, chloramphenicol, tetracycline and erythromycin. The antibacterial and antifungal activities of garlic come from allicin and ajoene, respectively. Allicin is also responsible for the characteristic odor of garlic.

Garlic is an immune modulator. Researchers used mice implanted with transitional

carcinoma (cancer) and introduced garlic extract both systemically (into the whole body) and into the actual tumors. They found that the tumors were reused and/or eliminated and that the degree of beneficial effect corresponded with the dosage level and length of garlic treatment. In humans, garlic has been shown to enhance the activity of natural killer (NK) cells, cells that act as part of the immune defense system that can also destroy some types of tumor cells. Another component of garlic - diallyl suphide - has been used to inactivate carcinogens in animal studies and to suppress the growth of tumors. Garlic can stimulate the production of glutathione, an amino acid which is known to be a very potent antioxidant and detoxifier and the smooth muscle relaxant - adenosine - also found in the herb, will lower blood pressure.

Garlic contains significant amounts of vitamins A, C, B_1, iron, copper, zinc, calcium and sulphur and a rich source of organically-bound selenium and germanium. Nutritionally, selenium is known to aid in detoxifying heavy metals and this may explain why garlic has been shown to be effective in countering lead, mercury, cadmium and arsenic poisoning. Garlic has been found to have a free-radical scavenging activity, probably because of the oxidation potential of many of its free sulphur compounds. Also from the selenium, zinc and glutathione found in garlic are known to enhance the concentration of certain antioxidant enzymes.

Many studies show the evidence on the usefulness of garlic as an antimicrobial agent due to its volatile organic compounds mainly consisting of linear chain aldehydes, allyl sulfides and disulfides. Pai and Platt (1995) studied the efficacy of garlic extracts against *Aspergillus, the fungi that cause otitis* which is an infection of the eardrum using aqueous garlic extract (AGE) and concentrated garlic oil (CGO). When compared with commercial garlic supplements and pharmaceutical prescriptions used *in-vitro*, the two agents showed similar or better inhibitory effects. Another fungi, *Candida spp*. were used to test the effectivity of garlic. Fresh garlic extract (FGE) demonstrated *in vitro* its antimicrobial activity against *Candida albicans* biofilms better than the traditional antifungal agents which was attributed to the action of allicin (Shuford, 2005). A related study by TsingHua (2003) has been investigated on the use of garlic oil injection against *C. albicans*. Results showed that the garlic injection retarded the growth of the fungi. Another study by Laughlin et al. (2003) investigated on the antifungal properties of vinegar and garlic combinations on one strain of *Candida albicans* using two commercially available vinegar products and one commercially available garlic product. To assess the ability of *Candida albicans* to grow in the presence of red wine vinegar (rwv), white distilled vinegar(wdv) or garlic either alone or in combination, minimum inhibitory concentrations were assessed and growth kinetic assays were conducted. Results of this study suggest that vinegar in combination with garlic has both fungistatic and fungicidal properties and could potentially be for the treatment of candidiasis.

Along with other herbs and spices, water soluble garlic extracts showed inhibitory effects on two fungi, *Aspergillus niger* and *Aspergillus flavus (Yin and Cheng, 1998). Similarly, Kim, et al (2004) found out that the* essential oils of garlic and onion and their constituent sulfides with three or more sulfur atoms were potent inhibitors of yeast growth. In their experiment with cherry tomatoes, Holt and Gomez (1994) evaluated the inhibitory effects of garlic on the growth of pathogenic molds in plants. Based on their findings, aqueous and ethanolic extracts of garlic were inhibitory in vitro to a wide range of molds previously isolated from contaminated tomatoes. A study by Bianchi et.al (1997) was made of the effects of garlic on the development of mycelium in four (4) species of fungi. Using a suspension of micronized garlic powder, mycelia development of the fungi was strongly inhibited at the maximum concentration of the aqueous extract tested (100 ml/liter) and transmission and scanning electron microscopy revealed cytomorphological alterations of the hyphae treated with garlic.

The use of natural products for the control of fungal diseases in plants is considered an interesting alternative to synthetic fungicides due to their lower negative impact on the environment.

Proven for the antifungal properties of tamarind and garlic on mango disease, their effectivity on banana anthracnose was evaluated. Specifically, the study was conducted to compare the effectivity of the two plant species as fungicide. Results of the study may be used as an alternative treatment among growers of banana in order to increase the production of this important crop thereby helping improve the country's economy.

As the pathogens (fungi) interact with the host plant (banana), by parasitizing it, the two plant species tested for their antifungal properties, were used as antimicrobial agents.

METHODOLOGY

Gathering of the Banana Samples

Twenty (20) semi-ripe bananas were obtained and labeled 1- 20. Before the inoculation with *Colletotrichum sp*. spores, the samples were disinfected first with a solution of xonrox for five (5) minutes. This was done to ensure that the samples would not contain any contaminants that might interfere with the results of the study. The samples were then placed in a tray and were covered with plastic. The inoculation was set aside for 24 hours at room temperature.

Preparation and Application of the Treatment

One hundred grams each of unpeeled and unwashed tamarind and cloves of garlic were prepared and blended in 1000mL of water to collect the extracts.

After the inoculation, five (5) banana samples were dipped each in T_1 (tamarind extract), T_2 (garlic extract) and T_3 (commercial fungicide) for five (5) minutes. T_4 (commercial fungicide) and T_0 served as the controls.

Effects of the Treatment

The effects of T_1,T_2 and T_3 were determined and compared based on Visual Quality Rating (VQR), Disease Development Index (DDI), Peel Color Index (PCI), Firmness and Weight loss. All the samples were initially weighed. Data were collected until the last day (9^{th}) of the experimentation.

Sensory evaluation test in terms of pulp quality and peel quality was also done to compare and analyze the external appearance of banana.

The results were subjected to Kruskal-Walis test to find out the significant differences among the different treatments used.

RESULTS AND DISCUSSION

VQR, DISEASE DEVELOPMENT, FIRMNESS, WEIGTH LOSS,

Visual Quality Rating (VQR) is the rating from 1-10 (10 as the highest) based on the outside quality of the total outlook of the fruit. Peel Color Index (PCI) is used to determine the color of the fruit. The index is from 1-6 with 1 as full green, 2 as tinge of yellow, 3 as mere green than yellow, 4 as more yellow than green, 5 as tinge of green and 6 as full yellow. Disease Development Index (DDI) measures the incidence of anthracnose that ranges from 0-5 (0-no disease; 1-5% of the fruit was infected; 2-10% of the fruit was infected; 3-25% of the fruit was infected; 4-50% of the fruit was infected and 5-75% or more of the fruit was infected). Hand feel was used to determine firmness ranging from 1 – 4 (1-firm; 2-yielding; 3-moderately soft and 4-soft). The weight loss was computed during the duration of the experiment.

For the first set of criteria, statistical test revealed that the three (3) treatments, T_1 (tamarind extract), T_2 (garlic extract) and T_3 (commercial insecticide) are not significantly different in terms of the PCI and weight loss. This means that all the treatments are significantly different in terms of VQR, Firmness and DDI (Table 1).

For the ranking of VQR, Firmness and DDI, T_2 is consistent as the best treatment followed by T_3 and T_1 (Table 2). As expected, the samples without any treatment ranked last.

Table 1. KW Values for VQR, Firmness, DDI

Parameter	KW
VQR	13.87**
Firmness	13.73**
DDI	12.13**

***Significantly different at 1% and 5%*

Table 2. Summary of Ranking for VQR, Firmness, DDI

Treatment	VQR	Firmness	DDI
T1	5.5	13	13.5
T2	18..5	3.5	5
T3	10.5	8.5	10
T_0 (Without Treatment)	3.5	17.5	16.5

Best Treatment:

(For VQR, best is highest; for firmness, best are the lowest ranks)

PEEL QUALITY

Five (5) people made a sensory evaluation on Peel Quality of the bananas based on color uniformity, color density, degree of shriveling, aroma, incidence of disease, off-odor and marketability.

Of the parameters observed, color uniformity and color density were found to be not significantly different among the treatments. However, the other parameters - degree of shriveling, aroma, off-odor, incidence of disease and marketability are significantly different in all the treatments (Table 3).

Table 3. KW Values for Peel Quality

Parameter	KW
Degree of Shriveling	16.38**
Aroma	13.46**
Off-Odor	21.44**
Incidence of Disease	10.54*
Marketability	8.46*

*Significantly different at 1%
**Significantly different at 1% and 5%

Anthracnose developed on the third day of the experiment (Fig. 2). T_0, with no treatment showed more anthracnose developed in the fruit which made the decaying very fast. Nelson (2008) reported that anthracnose survives readily on dead and dying plant tissues. The symptoms of the disease that occurred were as black peel blemishes and sunken spots of various sizes on fruits. The spots bore masses of the fungi with their associated conidia (the spores) in the lesions.

Fig. 2. Development of Anthracnose in the Bananas Without Treatment

The highest degree of shriveling was observed in T_2 followed by T_3 and T_1. The best aroma was observed in T_2 followed both by T_1 and T_3. For off-odor, T_1 and T_0 have the highest rank followed both by T_2 and T_3. The incidence of disease was expectedly high in T_o followed by T_1 and T_3 while the least incidence was observed in T_2 (Table 4).

Table 4. Summary of Ranking for Peel Quality

Treatment	Degree of Shriveling	Aroma	Off-Odor	ID	Marketability
T_1	13.5	13	15	11	11
T_2	3.5	16.5	6.5	4	19
T_3	6	13	6.5	7	11
T_0 (No Treatment)	16.5	8	15	15.5	1.5

As far as the physical appearance is concerned, marketability is related to incidence of disease. Figure 3 shows the incidence of anthracnose in the three (3) treatments and in T_o (no treatment).

As the physical appearance of the samples after treatment is shown (Fig. 3), the banana samples treated with garlic (T_2) and with the fungicide (T_3) show comparable results in terms of marketability. However, as indicated in Table 4, T_2 is still better than T_3.

PULP QUALITY

The same number of people made a sensory evaluation on the samples based on color intensity, off-odor, sweetness, characteristic of taste, texture and off-flavor (Table 5).

Statistics shows that the characteristic of taste and off-flavor were found to be not significantly different among the three (3) treatments while color intensity, off-odor, sweetness and texture were significantly different.

Figure 3. Comparison of the Condition of the Banana Samples After Application of T_1, T_2 and T_3. T_4 is also shown.

Table 5. KW Values for Pulp Quality

Parameter	**KW**
Color Intensity	19.36**
Off- Odor	28.67**
Sweetness	10.99*
Texture	14.73**

*Significant at 1%
**Significant at 1% and 5%

Table 6. Summary of Ranking for Pulp Quality

Treatment	Color Intensity	Off-Odor	Sweetness	Texture
T_1	16	5.5	8	11.5
T_2	11.5	5.5	14.5	16
T_3	11.5	13.5	8	12.5
T_0	3.5	16.5	5	2.5

For the color intensity, T_1 has the highest rank followed both by T_2 and T_3. With no treatment, off-odor was obviously observed in T_0. The samples in T_0 smelled foul because the samples got rotten very fast. With T_3 as the fungicide, it ranked second while T_1 and T_2 both ranked the last. T_2 was the sweetest followed both by T_1 and T_3. The best texture was observed in T_2 followed by T_3 and then by T_1 (Table 6).

For all the parameters evaluated, T_2 was almost consistent as the best treatment. Tested by Sotto (1998) for mango anthracnose, the garlic extract was proven to be effective for postharvest diseases. The results also indicate that T_2 was found to be even better than T_3. This finds support to the study made by Tedeshi, et.al (2007) who compared local garlic ecotype (Voghiera) extracts with commercial fungicides, mancozeb and iprodione against 14 pathogenic fungi. The study revealed that spray-dried preparations were more effective against the pathogen, *F. avenaceum*.

Figures 4 – 6 show the patterns of the effect of the different parameters used in evaluating the bananas.

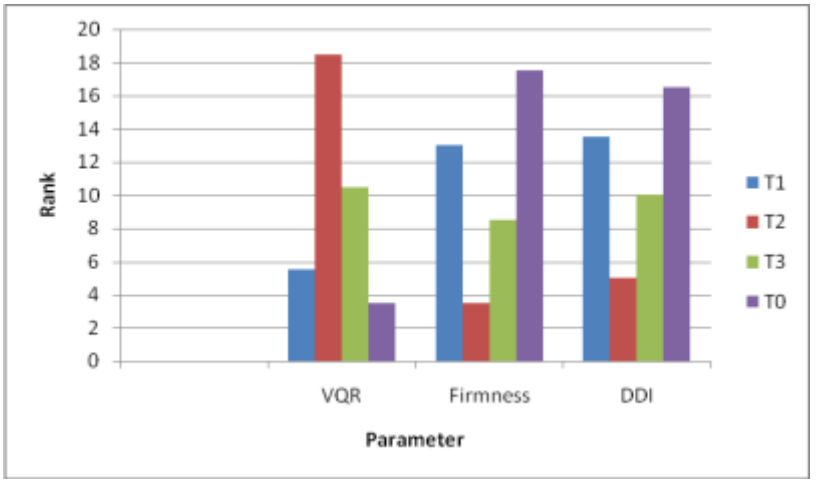

Figure 4. Ranking of the Parameters

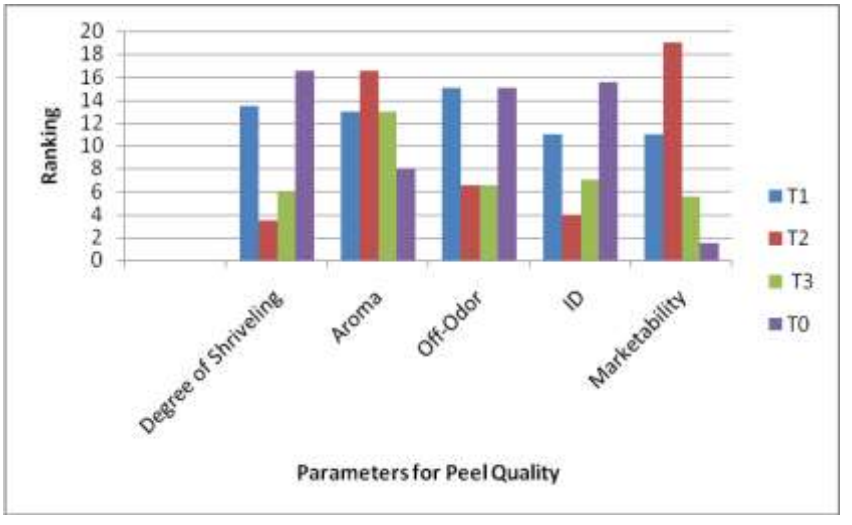

Figure 5. Peel Quality Ranking

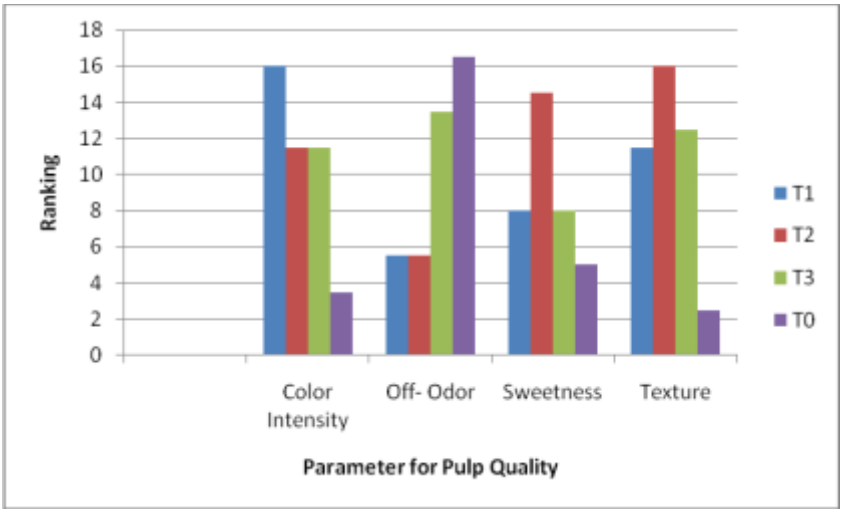

Figure 6. Pulp Quality Ranking

CONCLUSION

The extracts of tamarind and garlic were investigated and compared for their antifungal activity against the postharvest fungal disease on bananas. The extracts were obtained by preparing 100g of the samples blended in 1L of water. Three treatments were prepared, namely, T_1 – Tamarind extract, T_2 – Garlic extract, T_3 – Commercial fungicide. T_0 (no treatment) served as the controls along with T_3. After inoculation with Colletotrichum sp. spores, five (5) samples were dipped in the treatments and were observed for nine (9) days which is within the shelf life of bananas.

Kruskal- Wallis test revealed significant differences on VQR, firmness, DDI, degree of shriveling, aroma, off-odor, incidence of disease, marketability, color index, off-flavor, sweetness among the treatments in the study. For the first set of criteria (VQR, Firmness and DDI), T_2 was the best treatment, much better than T_1. For the sensory evaluation involving peel quality and pulp quality ratings, T_2 was comparable to T_3 and still much better than T_1. For the over-all evaluation, T_2 was the best treatment, followed by T_3 and T_1. By observation of the over-all appearance after the experimentation, T_2 had the best quality banana samples.

These results indicate T_2 is the better treatment than T_1 in preventing the postharvest disease in bananas. Moreover, in almost all of the parameters tested, T_2 was comparable or even better than T_3.

RECOMMENDATIONS

As tamarind and garlic extracts were evaluated and compared to prevent anthrachnose in banana, the following recommendations may be done to improve the study:

1. Make a study on the specific concentrations of garlic and tamarind which are best for treating the disease.
2. Make a study on the naturally occurring disease of bananas and not rely on inoculants only.
3. Consider specific factors that can affect weight loss in order to have more conclusive results.
4. Other than anthracnose, consider other postharvest diseases for comparison of effects.
5. Explore on other treatments which can be compared with the plant extracts.

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