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Production of Active Packaging from Debris of Heliconia and Thai Herbs for Reducing Anthracnose Disease of Mango and Papaya

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Abstract

A study of production of active packaging from debris of Heliconia and Thai herbs for reducing anthracnose disease of mango and papaya comprises four steps: 1) create mold for producing packaging 2) prepare pulp from agricultural waste, 3) produce active packaging, and 4) test of packaging efficiency to reduce anthracnose disease in mango and papaya. The study revealed that creating mold from white cement was easy and quick, and the mold was strong. Regarding the method to produce packaging, pouring of pulp onto muslin cloth in the mold did not give uniform thickness, whereas hand tapping of pulp into the mold offered uniform thickness but it took more time to do. However, the latter took only one day to dry while the first took 2-3 days. The packaging was less shrink by tapping than pouring method. The shape of packaging can well support mango and papaya fruits, and its strength and thickness was adjustable by the amount of pulp used. Heliconia pulp can be used to produce packaging and provided natural color as well as the identity of hand-made products which is free from harmful chemicals in the pulping process. The active packaging produced from Heliconia pulp and herbal extracts from galangal stem, kaffir lime leaves, cassia leaves and Plai essential oil was found to be effective in controlling anthracnose disease. The anthracnose lesions on mango fruits were smaller than those on papaya fruits.

Keywords: agricultural debris, extension of self-life of fruits, active packaging, anthracnose disease

1. Introduction

Vegetables and fruits are major agricultural goods of Thailand to be used for domestic consumption and for exporting which provide substantial revenue for the country. In January 2015, their export volume was 122,025 tons with a values of US$ 99.84 million. The exported Namdokmai mango fruits follow Thai standards, i.e. the fruit has medium size of 280-450 g., beautiful and uniform skin color, unblemished skin, full maturity and uniform sweetness of more than 17° brix when ripen, and is free from diseases and insects. Papaya is another kind among economic crops which is popular among Thai people for consumption either raw or ripe. Holland papaya is for ripe consumption. Its general traits include large trunk with one petiole in the middle of the leave, flowering as panicles, bearing a lot of fruits, harvest age of 8 months. Each fruit weights about 2-3 kg., the flesh is orange red and firm, with 2.5 – 3.0 cm. thickness and 12-14° brix of sweetness. One papaya tree yields 60-80 kg. of fruits. The fruit has smooth skin and is ready to harvest when its skin starts to have orange patches. The yield per Rai is about 5-8 tons. Mango and papaya both have a postharvest problem with the disease from Anthracnose fungus that causes black spots on their skins. When mango and papaya fruits begin to mature during ripening or transportation, the spots will enlarge and spread to cause fruit rot which leads to a lot of damages. Today, the agriculturalists prevent the disease by using chemicals at every stage from cultivation to the harvest and exportation (Kajornsak, 1986; Kiattisak, 2003). However, due to chemical residues, a number of studies on such disease control by using herbs were conducted. It was reported by Varaporn et al. (2014) that the crude extract of galangal stem and kaffir lime leaves at 20,000 ppm concentration can inhibit the growth of *Colletotrichum* sp. fungus as a cause of anthracnose. Similarly, Watcharee and Kaltima (2010) found that the extracts of cussumunar, curcuma, galingal, rose-colored leadwort, moringa leaf and papaya leaf had inhibitory ability on the growth of *Colletotrichum* sp., respectively from high to low effectiveness. Whereas, Raweewon (2003) in her study on the

control of postharvest anthracnose of mango fruit by using the essential oils from 6 plants i.e. eugenia caryophyllus, cymbopogon citratus, cymbopogon nardus, illicium verum, zingiber purpureum, and acorus calamus reported the efficacy of these plants to inhibit the growth of *Collectotrichum gloeosporioides.*

Nowadays, the flower cut for sales leaves a large amount of waste in both the orchards and the flower markets. For some of these plants, after the flower cut, the trees are also cut down since they can give flowers only once. Those trunks and branches are agricultural waste which can be made use in many other ways such as making paper and packaging. The investigator is thus interested to produce fruit-shape packaging from plant waste in order to prevent bumping between fruits and can also be opened for display when placing for selling. In the process, herbal extracts are added to prevent fungi. The current study focused on Namdokmai mango and Holland papaya. The packaging were produced from the debris of Heliconia (Heliconia, *Heliconia* spp.) Heliconia comprises many varieties with different Thai names such as Dhammaruksa, Garm-Goong (upright heliconia), Garm-Gung or Sroykuttali (hanging heliconia). This tropical plant is popularly used as cut flower and as potted plant and ornamental plant. There are a range of Heliconia varieties both in Thailand and overseas. Heliconia is a standing semi-succulent plant with underground stem called rhizome and aerial stem called pseudostem consisting of leaf sheaths growing alternately opposite one another. The flowers are produced as infloescemce with the flowers extending from the middle of pseudostem and as the last part to grow. The panicles can be upright or drooping depending on species (Gate-orn, n. d.). After the flower cut, the pseudostem will die. Stems containing fibers will be utilized to produce paper packaging.

It was however found that mango and papaya fruits are often damaged during the transport and display for selling. Packaging of products at postharvest is thus another important procedure to help maintain the freshness and quality of products. In general, the 4 main functions of packaging are to protect the products from damage by external environment, communicating with consumers as a marketing tool, making it convenient to use and save time for consumers, and containing products with different shapes and sizes. At present technological development of packaging for agricultural products and foods is aimed to respond the demand of consumers in the areas of production process, safety, environment as well as legal issues. Accordingly, packaging innovation was developed to serve the demand of consumers which include such as "Active Packaging". Active packaging refers to the packaging system in which the package, product and environment interact productively to prolong shelf-life or develop certain desirable traits (Valero & Serrano, 2010). Apart from its functioning as container to envelope and protect products and goods from damage during the transport and display for sales, packaging is also developed to extend shelf life and retain the quality and freshness of product and food for a long period. Active packaging was developed in order to modify physical environment or factor within the package by such as filling some active ingredients into packaging materials or placing them inside of the package such as moisture absorbers, oxygen absorbers, ethylene absorbers (Butler, 2001). The present research applied the properties of Thai herbs with inhibitory ability on the growth of *Colletotrichum* sp. as the cause of anthracnose disease in mango and papaya. These herbs were added as an ingredient in making paper for producing active packaging that act to control and inhibit the growth of fungi which in turn prevent and reduce the development of anthracnose disease in mango and papaya fruits during the transport and display for sales.

2. Research Objectives

(1) To develop for producing packaging on development in utilizing debris from flower harvest for sales to produce packaging that reduces anthracnose disease in mango and papaya fruits.

(2) Test of packaging efficiency to reduce anthracnose disease in mango and papaya.

3. Research Methodology and Results

This study is part of the research project on development in utilizing debris from flower harvest for sales to produce packaging that reduces anthracnose disease in mango and papaya fruits. It aimed to promote the community enterprise to prepare pulps from agricultural waste in the community and produce packaging used for community products. The study comprised 4 steps, i.e. 1) create mold for producing packaging 2) prepare pulps from agricultural waste, 3) produce active packaging, and 4) test of packaging efficiency to reduce anthracnose disease in mango and papaya.

3.1 Create Mold for Producing Packaging

1. Make a plywood box for molding with the width and length of average size of mango and papaya fruits as a frame for a mold.

2. Halve mango and papaya fruits and place them in the middle of the box as the model of fruit shape and size.

3. Mix 3 kg. of white cement with 1 lite of water and pour it into the box. To make the upper mold, spread food

wrap onto the lower mold, mix 3 kg. of white cement with 1 liter of water and then pour it onto the wrap to produce upper mold.

4. Make pores at the bottom side of mango and papaya molds to drain out excess water.

Figure 1. Plywood box for making mango mold

Figure 2. Pores at the bottom side of the lower mold. (left) The upper mold (right)

3.2 Prepare Pulps from Agricultural Waste

Cut heliconia into 3-4 inch pieces and refine with pulp refiner, then bring to boil in the autoclave by putting heliconia into the inner pot and fill to cover with water, boil at 120°C *for 1 hour. Leave the boiled heliconia to cool down, then put it into the pulp cleaner to wash and remove impurities* such as undigested fibers and other foreign matters.

Figure 3. Heliconia stem pieces for refining and boiling to prepare pulps

3.3 Producing Active Packaging

In this research, experiments were carried out using 2 methods to produce packaging, i.e. by pouring pulp onto muslin cloth in the mold and by hand tapping of pulp into the mold.

Producing packaging by pouring pulp onto muslin cloth in the mold

1. Mix 500 g. of pulp into 500 ml. of water, and stir well to diffuse pulp.

2. Lay muslin cloth into the lower mold, then pour the pulp onto muslin cloth in the mold and spread out the pulp evenly in the mold and the rim.

Figure 4. Produce packaging by pouring pulp

3. Press the upper mold onto the pulp being poured, let dry for 1 – 2 days and remove the molded pulp.

Figure 5. Press the upper mold onto the lower mold with pulp spread inside to produce packaging

3.4 Producing Packaging by Hand Tapping of Pulp into the Mold

Tapping the water immersed pulp onto the mold using fingers to tap the pulp to coat the mold in uniform thickness, then press the upper mold onto the lower mold already tapped with pulp, bring to dry in dimly sunlight in a room, let the pulp dry and remove it from the mold.

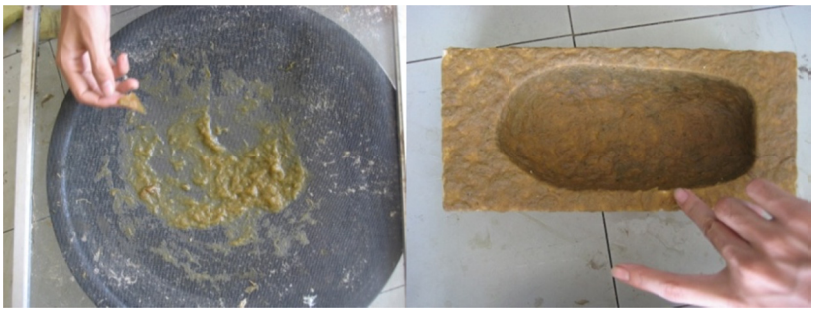

Figure 6. Pulp being prepared. (left) Tapping pulp onto the lower mold. (right)

Figure 7. Press the upper mold onto the lower mold with tapped pulp. (left)
The mold was sun dried (right)

3.5 Test of Packaging Efficiency to Reduce and Prevent Anthracnose Disease in Mango and Papaya

The current study tested the efficiency to reduce and prevent anthracnose disease of 4 kinds of herbs, i.e. galangal stem, kaffir lime leaves, cassia leaves and Plai. The test procedure was described below.

Prepare the mixture of pulp and herbal extract

Grind 300 g. of both young and old cassia leaves and add with 1 liter of water, then filter on muslin cloth to obtain extract water. Repeat the same method with galangal stem and kaffir lime leaves. Immerse 300 g. of pulp into each of the 4 herbal extract water *for 1 night, and use them to produce packaging molds by means of hand tapping as explained above.*

3.6 Test of Packaging Efficiency to Reduce and Prevent Anthracnose Disease

The comparative test of packaging efficiency was conducted with the packaging containing the 4 kinds of herbal extracts as follows: (1) packaging of heliconia pulp mixed with cassia leaves extract water, (2) packaging of heliconia pulp mixed with *kaffir lime leaves* extract water, (3) packaging of heliconia pulp mixed with *galangal stem* extract water, (4) packaging of heliconia pulp sprayed with 10% Plai essential oil, and (5) packaging of heliconia pulp containing Namdokmai mango and Holland papaya fruits. The test procedure is as follows.

1. *Select 5 Namdokmai mango fruits of export variety with similar size and weight to the molds.*

2. Wipe clean thoroughly the mango fruits with 70% ethyl alcohol*, then inoculate anthracnose fungi on the fruits by making 5 lesions on the skin using needle to softly prick for each lesion, i.e. a single lesion and another 4 lesions in parallel*.

3. Cut the anthracnose fungi cultured in potato dextrose agar to inoculate on the fruits in the 4 parallel lesions except the single lesion (control lesion)

4. Put the inoculated mango fruits into the packaging: (1) *packaging of heliconia pulp mixed with cassia leaves extract water, (2) packaging of heliconia pulp mixed with* kaffir lime leaves *extract water, (3) packaging of heliconia pulp mixed with* galangal stem *extract water, (4) packaging of heliconia pulp sprayed with 10% Plai essential oil, and (5) packaging of heliconia pulp. Repeat the same procedure with papaya fruit*.

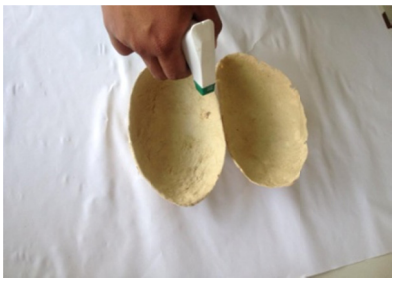

Figure 8. Spray thoroughly 10% Plai essential oil to coat the inner side of packaging before containing the inoculated mango fruit

Figure 9. Test of packaging performance in controlling anthracnose disease in papaya fruits

3.7 Creating the Mold for Producing Packaging for Mango and Papaya Fruits

The mold created from white cement is good for producing packaging by both methods of pouring and hand tapping of pulp. The making process is not complicated but easy and quick. The mold had proper weight and can function as presser. Making mold took low cost and the materials were widely available and suitable for household's production. The mold was strong with long period of use life without breaking easily if used with care.

Figure 10. The appearance of mold and the packaging produced

3.8 Producing Packaging by Pouring Pulp into the Mold

For packaging produced by pouring pulp into the mold, it was lacked of uniform thickness due to unevenly spread of pulp caused by uneven pressure of the upper mold. The test suggested that the thickness of packaging varied by the amount of pulp used, i.e. the pulp of 400 g., 500 g., and 600 g. gave the average thickness of 1.30 mm., 1.96 mm. and 2.07 mm., respectively. When dry, the packaging was shrink. It took much time to dry for a few days. The packaging was very shrink and not in beautiful and equal shape, with rolled edge. The dried packaging can be easily removed from the mold.

3.9 Producing Packaging by Hand Tapping of Pulp into the Mold

This method of hand tapping of pulp into the mold took much time and the maker needed to be meticulous for the packaging to be uniformly thick and smooth on its surface. It took 1 day for dryness but with less shrink. It must be careful when removing the packaging from the mold for it is rather thin. The packaging obtained was smooth and the thickness was better uniform than that of the pouring method.

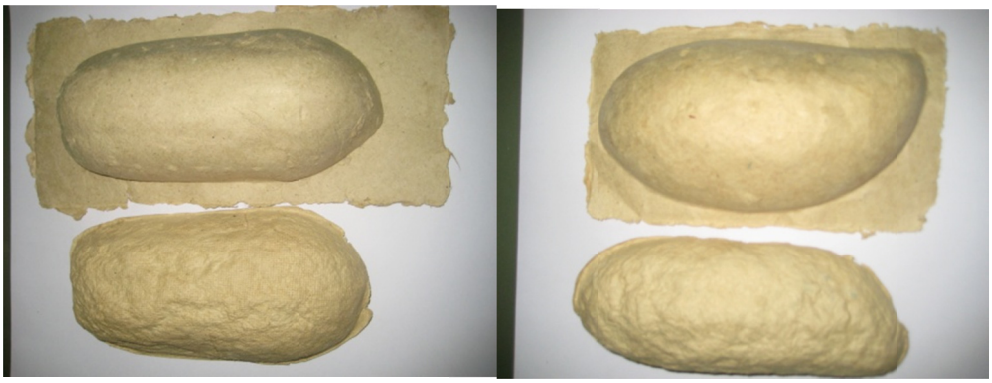

Figure 11. Comparison of packaging for papaya and mango fruits (top) produced by pulp tapping and (bottom) produced by pulp pouring.

Figure 12. Holland papaya and Namdokmai mango fruits were contained in active packaging

3.10 Packaging Efficiency to Reduce and Prevent Anthracnose Disease in Mango and Papaya

The experimental results on the reduction and prevention of anthracnose disease in mango and papaya of active packaging produced from heliconia pulp immersed in the extract water of galangal stem, kaffir lime leaves, cassia leaves, and sprayed with 10% Plai essential oil were displayed in Table 1.

Table 1. Sizes of anthracnose lesions on mango and papaya fruits contained in the tested packaging

Packaging type	Average lesion diameter on mango fruit (mm.)	Average lesion diameter on papaya fruit (mm.)
cassia leaves extract	0.4	0.9
kaffir lime leaves extract	0.4	0.8
galangal stem extract	0.3	0.7
10% Plai essential oil	0.4	0.8
Control	0.5	0.8

The test results were obtained 3 days after inoculation of anthracnose fungi on mango and papaya fruits contained in the packaging produced from heliconia pulp mixed with the extract water of galangal stem, kaffir lime leaves, cassia leaves, and sprayed with 10% Plai essential oil. It was found that mango fruits displayed the sign of anthracnose disease. The inoculated lesions were larger than the pricked lesion comparing to the control lesion with no enlargement. The average diameters of inoculated lesions were 0.4 mm., 0.4 mm., 0.3 mm., and 0.4 mm., respectively. For the control packaging without mixed herbal extracts, the average diameter of inoculated lesions was 0.5 mm. For papaya fruits, the average diameters of lesions were 0.9 mm., 0.8 mm., 0.7 mm., and 0.8 mm., respectively, while it was 0.8 mm. on average of the lesion for the control packaging. However, contamination of many other fungi was found on papaya fruit. The inoculated lesions were slightly larger than the control lesion. The lesions were deeply sunk into the papaya fruit which may be due to the soft skin and flesh of ripen papaya that was easy to bruise. There was no contamination of other fungi found on mango fruits. In the control of anthracnose disease with the packaging made from heliconia pulp mixed with herbal extracts, it was found for the packaging made from heliconia pulp immersed in galungal stem extract that the lesions on both mango and papaya fruits were slightly smaller than those for the packaging mixed with other herbal extracts. This suggested that the herbal extracts mixed into heliconia pulp for producing active packaging were effective to reduce and prevent the development of anthracnose disease in mango and papaya fruits, however depending on their maturity stage and storing period.

Figure 13. Packaging made from heliconia pulp mixed with cassia leaves extract water

Figure 14. Packaging made from heliconia pulp mixed with kaffir lime leaves extract water

Figure 15. Packaging made from heliconia pulp mixed with galangal stem extract water

Figure 16. Packaging sprayed with 10% Plai essential oil

Figure 17. Control packaging

4. Conclusion

1. Creating packaging mold from white cement was easy, quick, and cheap, and it provided the mold with just enough strength and pressing force, as well as proper but not too much weight for easy use.

2. The mold is good for manual producing of packaging both by pouring and hand tapping methods. The shape of packaging served well for mango and papaya fruits. The packaging offers natural appearance, identity of hand-made product, as well as strength. Its strength and thickness are adjustable by the amount of pulp used.

3. According to test result of efficiency to reduce and control anthracnose disease in mango and papaya fruits of the packaging made from pulp of agricultural waste immersed in herbal extract water of galangal stem, kaffir lime leaves, cassia leaves and sprayed with 10% Plai essential oil, they were found effective to control anthracnose disease. The anthracnose lesions on mango fruit were smaller than those on papaya fruit.

5. Recommendations

1. This study was intended to promote the community's capability to produce fruit packaging. The community can apply, other than suggested in here, different local agricultural waste to prepare pulp for making packaging. It can also be applied to create molds for other kinds of fruits in order to reduce the development of anthracnose disease and to prevent fruits from bumping or bruise, or to serve as a marketing media. The production of packaging is also possible for such as pomelo, cantaloupe, patiya, and golden banana.

2. Pouring pulp containing a large amount of water to make packaging may cause ununiformed spread of pulp and led to ununiformed thickness of packaging. Further study will experiment on producing packaging from damp paper to obtain uniform thickness of packaging.

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