Effect of Aloe Vera Gel on Quality and Shelf Life of Mango (Mangifera indica L.) Fruits cv. Nam Dok Mai and Technology Dissemination

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The European Conference on Sustainability, Energy & the Environment 2017
Official Conference Proceedings

Abstract
This study was designed to assess the suitable concentration of natural coating materials, namely, *Aloe vera* gel to control antracnose of mango *(Mangifera indica* L.*)* fruits cv. Nam Dok Mai taken from Bangkla, Chachoengsao Province. The experiment was to evaluate the benefits of this technology. It was found that coating with 20% *Aloe vera* gel gave the longest shelf life with good quality at 12 days at a storage temperature of 25 °C and 75±5 % relative humidity as well as slowing down the weight loss, firmness and changed in chemical compositioned such as titratable acidity (TA) and total soluble solids (TSS) significantly compared to control and other treatment ($p \leq 0.05$). The use of the *Aloe vera* gel coatings did not alter the quality of the fruit when ripe.
Technology dissemination to mango growers of Chachoengsao Co-orperatory Community was performed by using the training created by the researcher. The results of the pre-test and after training post-test showed that farmers increased their knowledge, skills, awareness and attitudes in the use of *Aloe vera* gel for prolonging shelf life of mango fruits.

Keywords: *Aloe vera* gel, shelf life, Nam Dok Mai, technology dissemination.

Introduction

Mango (*Mangifera indica* L.) is a tropical fruit that has economic importance in Thailand and can be grown in all regions of the country. Mango is mainly for domestic consumption and the rest is exported. The export volume and value of mangoes from Thailand increased respectively from 2016 at 33,347 tons (1,223 million baht) (Office of Agricultural Economics, 2017). The important exporting markets are Japan, Europe and America. Because of nutritional and sensory qualities, mangoes become favorite fruit for foreigners with exported varieties such as Nam Dok Mai, Tongdum, Nung Glang Wan, Koh Rong and Rad but the major problems of mango fruits during storage and export are weight loss, ripening during logistic, and formation of brown spot resulting in value decreased. Therefore, identifying the suitable coating compositions is a key role to extend the shelf life and reduce post-harvest deterioration which required efficient and safe methods of fruit coating. (Pongsotom et al, 2007). This research aimed to reduce the loss of productivity, give added value, extend the shelf life and propagate the information that will help the farmers to select the appropriate coating.

Material and methods

Aloe vera gel

Leaves of *Aloe vera* harvested from local farms, Bangkla, Chachoengsao Province, Thailand. only the fully extended mature leaves were harvested, then stored in plastic papers and transported to the laboratory within same day.

Preparing mango fruits

Mango (*Mangifera indica* L.) fruits 115 days old after flowering in March 2011 weight 300-350 g, which were selected from Bangkla, Chachoengsao Province. All of them were disease-free, no wounds on the skin and nature at the same stage selected by using water floating and putting in 2% brine. The fruits then were washed and air dried.

Coating method

Coating materials were prepared and used immediately. The mango fruits were dipped in the different coating *Aloe vera* gel for 30 s, air dried and weighed afterward. Then serial numbers were written on each of the mango fruits and stored under specified temperature.

Methodology

This study is a Completely Randomized Design (CRD) as follows.
Experiment 1 : To determine the type and concentration of the appropriate coating solutions. The mango fruits were divided into five groups. They were treated with uncoated (control) (A1), solvent (water) (A2), 10% *Aloe vera* gel (A3), 20% *Aloe vera* gel (A4) and 40% *Aloe vera* gel (A5). Each condition was tested using three mango fruits. Then the storage experiment was carried out at 25 ^{o}C (relative humidity.

75 ± 5%). The mango fruits were inspected every 2 days for a total of six times or 12 days.

Experiment 2 : *Aloe vera* based edible coating technology was disseminated to mango growers of Chachoengsao Co-orperatory Community (101 farmers and exporters), and was performed by using the training created by the researcher. A selection of participants for the training was performed by using purposive sampling.

In the workshop, the researcher constructed a test of knowledge, understanding, skills, awareness and attitudes in the following order:

1. Studied from books, journals and research papers related to the use of natural coatings in order to guide the creation of research questionnaires.
2. The data was collected from 20 multiple-choice questionnaires to measure their knowledge, skills, awareness and attitudes towards using Aloe vera gel coatings.
3. The questionnaire was completed. Five experts were provided to give suggestions for improvement, and considered the content, as well as the correctness of the language used.
4. The test to correct the defect was taken.
5. The test was applied to 50 mango growers in Chachoengsao Province. The test scores were analyzed to determine the difficulty, and the discriminative power of the test.
6. Chose a test with a difficulty value of 0.20 - 0.80 and a positive discriminative power and covered the test content of 10, and calculated the reliability of the test. Using the KR21 formula of Kuder-Richardson, the reliability of 0.91, which was a highly reliable test, should be used to measure the knowledge, skills, awareness and attitudes of the farmers and exporters.

Qualitative analysis

Experiment 1 : Disease and shelf life were analysed by determining the number of mango fruits affected with anthracnose by browning score with could be seen on mango skin. Browning score greater than 30% was considered expired storage. Weight loss, firmness, titratable acidity (TA), total soluble solid (TSS) were observed to assessed the overall acceptance by 8 trained testers. A nine point hedonic scale was accepted in this experiment (Peacock et al., 1986) as follows.
Overall acceptance (score)

1 = dislike extremely
2 = dislike very much
3 = dislike moderately
4 = dislike slightly
5 = like no dislike
6 = like slightly
7 = like moderately
8 = likes (like very much)
9 = like most (like extremely)

Sampling three mango fruits was done in each trial. Peeled mango, then sliced the mango on the cheeks on both sides, then sliced the transverse cut of the mango into 3

pieces and place in a white plate for each tester tasting 3 pieces per treatment by the tasting every process.

Percentage and analysis of variance were calculated by considering the differences in all experiment aspects. When the difference was statistically significant at the confidence level of 95 percent, Duncan's New Multiple Range Test was used. In experiment 2, the average of pre- and post-test scores was analyzed by using a t - test.

Results and discussion

Experiment 1 : Appropriate type and concentration of the coating solutions
The disease, and shelf life of mango fruits in all series of experiments showed that the brown spot was found in mango fruits coated with A4 later than the other groups with 12 days shelf life (Table 1), indicating that the coating was a slow ripening agent as the unripe fruits were more disease resistance compared to the ripe fruits. (Kumpoun et.al., 2005). This might be due to the antibacterial activity of *Aloe vera* gel (Chien et.al., 2007). The possible explanation may be that too low concentration was not enough for antibacterial activity and too high a concentration could inhibit anaerobic respiration thus increase susceptibility to the disease. Moreover, the coating limits the exchange of O_2 and increase CO_2, consequently slowing down the metabolism by inhibition of ethylene (Hagenmaier, 2005), resulting in a delay of mangoes ripening destruction of mango fruits by pathogens and making the shelf life longer (Boonyakiat et al., 2007; Worrell et al., 2002; Bai et al., 2003).

Table 1 Percentage of disease affected mango fruits cv. "Nam Dok Mai" when coated with different *Aloe vara* gel concentrations and then stored at 25 ^{o}C (relative humidity 75 ± 5%).

Treatment	% Disease day 12
A1	70
A2	70
A3	60
A4	30
A5	50

Weight loss of mango fruits in all treatments were time dependently increased (Figure 1a). Mango fruits coated with A4 was found to lose weight less than the others, the A4 group that showed the minimal weight loss only 5.14% on day 6 of storage while compared to the control group ($p \leq 0.05$) (Table 2). Transpiration of mango fruits depended on the specific properties of coating materials which the replace natural wax and closed the opening pores. The limitation of gases diffusion resulted in a decreased respiratory rate and decreased mango weight loss (Dang et al., 2004; Han et al., 2004). Weight loss is directly related to the concentration of the coating materials; low concentration gave less transpiration and gas exchange whereas the high concentration will limit gas exchange and decrease the tissue O_2 supply (Hagenmaier, 2005) resulting changes in the smell and flavor of the mango fruits.

The firmness of mango fruits in all treatments decreased throughout the shelf life (Figure 1b). Mango fruits coated with A4 were found to decelerate this process significantly compared to the control ($p \leq 0.05$) with a firmness of 15.95 kg/cm^2 for A4

on day 6 of storage (Table 2). The firmness of the fruits naturally decreased gradually when they ripened because pectin causes tight bonds in raw fruits changed to a smaller size and more water soluble resulting in loos of cell adhesion. The firmness was decreased when coated because of a limitation O_2 diffusion resulting in a decrease in ethylene (Hagenmaier, 2005). Since O_2 is involved in the process ethylene production and through activating enzymes is involved in cell wall degradation of the fruit resulting in soft tissue (Blankenship and Dole, 2003). This makes the coating beneficial in decelerating firmness loss (Ju and Curry, 2000).

Titratable acidity (TA), and total soluble solids (TSS) of mango fruits in every series of experiments tended to vary inversely. While the amount of TA in all mango fruits was decreased, the TSS in the fruits increased through the harvest period (Figure 1c and d). This means that when the storage period of mango fruits was longer, ripe mangoes tasted sweeter but less sour. Mango fruits coated with A4 was the best groups that could prevent the decline of TA and increase TSS, especially mango fruits coated with A4 on day 6 of storage with maximum amount of TA at 1.20 % but the lowest amount of TSS at 21.65% which were significantly different compared to the control and other treatments ($p \leq 0.05$) (Table 2). This implied that the coating could delay the amount in the TA and TSS in the fruit because the coating maintains a state of adaptation resulting in an increase of CO_2 which inhibits activity of ethylene thus delay ripening, and slow changes in the amount of TA in the vacuole. Most of the acids found in the fruit were citric acid and malic acid (Bai et al., 2003; Nabigol and Asghari, 2013). Moreover, coating could delay the decomposition of starch into sugar (glucose, fructose and sucrose), which was the majority composition of TSS (Chien et al., 2007). This is consistent with the report of Luengwilai et al., 2007 that an increase in the amount of TSS in ripe fruit had a direct relationship with the decomposition of starch.

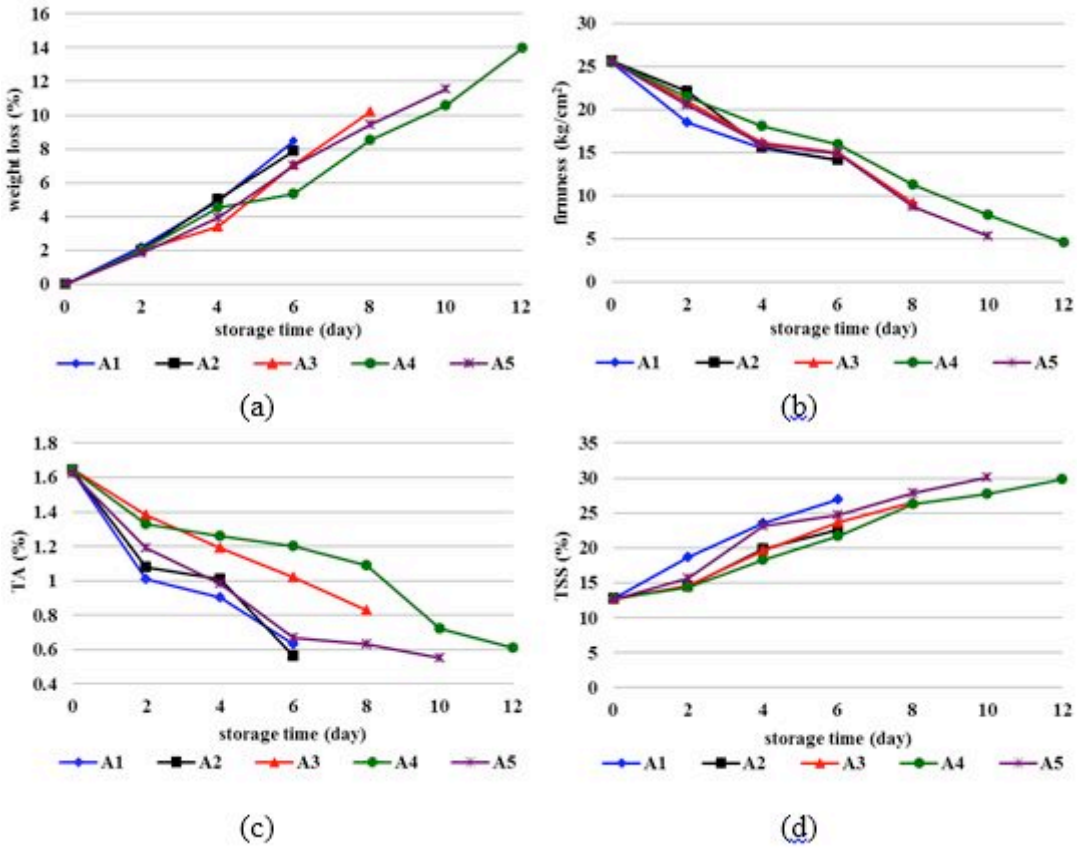

Figure 1 : Weight loss (a), firmness (b), TA (c) and TSS (d) of 'Nam Dok Mai' when coated with the different *Aloe vera* gel concentrations and then stored at 25 °C (relative humidity 75±5 %).

Table 2 Weight loss, firmness, TA and TSS of mango fruits cv. 'Nam Dok Mai' when coated with different *Aloe vera* gel concentrations and then stored at 25 °C (relative humidity 75 ± 5%).

Treatment	Weight loss (%)	Firmness (kg/cm²)	TA (%)	TSS (%)
	Day 6	Day 6	Day 6	Day 6
A1	8.46±0.94^{a}	14.15±0.27^{c}	0.63±0.16^{c}	26.95±0.53^{a}
A2	7.89±0.96^{a}	14.17±0.33^{c}	0.56±0.14^{c}	22.55±0.68^{c}
A3	7.04±0.95^{a}	15.03±0.82^{b}	1.02±0.17^{ab}	23.69±0.59^{b}
A4	5.14±0.93^{b}	15.95±0.51^{a}	1.20±0.25^{a}	21.65±0.62^{c}
A5	6.97±0.94^{a}	14.83±0.31^{bc}	0.67±0.14^{c}	24.74±0.50^{b}

Numbers followed by a letter in the column represents the statistical significance of the mean comparison according to Duncan's New Multiple Range Test ($p \leq 0.05$).

Overall acceptance score of mango fruits in all treatments showed an increasing tendency along with the shelf life and decreased again when mango fruits came to deterioration stage. Mango fruits coated with A4 were effective in helping to maintain the best quality, especially mangoes coated with A4 on day 6 of storage. Overall the acceptance score did not significantly differ from the control group ($p>0.05$) (Table 3). We found that on the 10th of storage, mango fruits coated with A4

had the overall acceptance score at 7.68 (Table 3). The concentration of the coating materials also affects the quality of the fruit (Boonyakiat et.al., 2007)., with a low concentration of materials or too thin a coating allowing transpiration and more O_2 exchange while a high concentration or too thick a coating causing materials to waste due to a lack of O_2 thus causes an accumulation of acetaldehyde and ethanol by anaerobic respiration causing a fermented smell and taste disorders (Hussain et al., 2004). This was not acceptable to the taste which consistent with the report of that the factors that affect the inclination of consumers to mango fruits was the texture (Kaswija et al., 2006).

Table 3 The overall acceptance score of mango fruits cv. 'Nam Dok Mai' when coated with *Aloe vera* gel concentrations and then stored at 25 ^{o}C (relative humidity 75 ± 5%).

Overall acceptance (score)		
Treatment	**Day6**	**Day10**
A1	8.08±1.05^{a}	ND
A2	5.83±1.14^{b}	ND
A3	4.55±0.98^{b}	ND
A4	7.90±0.88^{a}	7.68±1.04
A5	5.45±0.92^{b}	6.09±0.96

Numbers followed by a letter in the column represents the statistical significance of the mean comparison according to Duncan's New Multiple Range Test ($p \leq 0.05$).

Experiment 2 : Results of the coating technology propagation.

The analysis of the achievement, knowledge, skills, awareness and attitudes before and after training created by the researcher showed that the after training score was higher than the pre-test score. When analyzed by using a t-test we found that the post-test score was significantly higher than pre-test score ($p \leq 0.05$) (Table 4). This indicated that training helps farmers and exporters to improve knowledge skills and attitudes. We delivered what we found to farmers and exporters by reading, lecture and practice and learn from scenario and real situations and discussion. The participants cooperated in the implementation of activities as well as pleasure in learning as shown in figure 2: a) chemistry majored students received registration, b) Mr.Sakda Kuntipalo introduced researchers, lecturers and students majoring in chemistry to farmers and exporters, c)researchers discussed the use of *aloe vera* gel coatings to inhibit anthracnose in mango fruits cv. Nam Dok Mai, d) farmers and exporters listened to the research report intentionally, e) farmers and exporters divided the experimental groups using *aloe vera* gel coatings mango fruits cv. Nam Dok Mai, f) researchers farmers and exporters together discussed the results of the experiment, g) paid food together, and h) farmers and exporters responded to the questionnaire with the researchers and students helped and advised. The training budget was not much and did not take much time. Moreover, the trainees could use the knowledge immediately after training (Watanawong, 2004; Vella, 2002). In addition, the training manuals helped farmers and exporters to aware of the problems after the harvests, skills in the use of natural coating, attitudes and enthusiasm to cooperate in solving and preventing problems, being confident in using natural coating to reduce the yield loss. This will lead to an increase in value and prolong the storage life of mangoes.

Table 4 Comparison of the achievement, cognitive skills, awareness and attitudes before and after training.

Training interval	n	$\overline{X}$	S.D.	t – test	p – value
Before training	101	4.04	0.73	54.94*	0.001
After training	101	7.99	0.46		

* mean the significant difference ($p \leq 0.05$).

(a) (b) (c) (d) (e) (f) (g) (h)

Figure 2 : The participants cooperated in the implementation of activities as well as having pleasure to learn.

Conclusions

Coating Nam Dok Mai mangoes with different concentrations and temperature storage at 25 ^{o}C (relative humidity 75 ± 5%) indicated that *Aloe vera* gel 20 % could slow down the disease and prolong shelf life for the 12 days, delayed weight loss, firmness and changed in chemical compositioned such as titratable acidity (TA) and total soluble solids (TSS) significantly compared to the uncoated (control) and other treatments ($p \leq 0.05$). The overall acceptance score was not different from the control ($p > 0.05$) and the use of *Aloe vera* gel coatings had no negative impacts on the quality of the mango fruits when ripe.

The propagation of technology to farmers and exporters created by testing before and after training showed that farmers and exporters developed knowledge, skills, awareness and attitudes in the use of *Aloe vera* gel coatings significantly ($p \leq 0.05$).

Acknowledgements

Researcher would like to thank Rajabhat Rajanagarindra University who sponsored the grant for this research project and Post-harvest Technology and Engineering Center, Kasetsart University for kindly support research tools.

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