

EFFECT OF BANANA FLOUR COATING ON PHYSICAL PROPERTIES OF BANANA

Natcharee Jirukkakul^{1,2,*} and Nachayut Chanshotikul¹

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Abstract

Kluai Hom Thong (*Musa* AAA group) banana is an economic plant of Thailand with relatively short shelf life. Certain coating substances can slow down ripening stages of banana, eventually prolonging their commercial life. This study investigated the effects of coating, on bananas' physical features and CO₂ emission. The weight and firmness decreased but total soluble solids and color difference increased for every trial experiment. The coated banana was not affected to the weight and firmness from uncoated banana. The coated bananas had a slower peel color change and reduced CO₂ emission. The zeolite and activated charcoal carbon were not affect banana storage because of low concentration. However, the banana treated with banana flour + activated charcoal coating usually had tiny black spots on its peel, which is less popular with consumers. Banana flour from *Musa* AAA group was more effective coating than banana flour from *Musa* ABB group. The bananas coated with banana flour solution, and the uncoated bananas cloud be stored for 12 days and 6 days, respectively. The evaluations of sensory properties, including smell, taste, texture, and preference, were similar with no statistical significance ($p < 0.05$). This study demonstrated that banana flour solution can extend the storage period of bananas from 6 to 12 days.

Keywords: *Musa* AAA group banana, coating, banana flour, zeolite, activated charcoal

Introduction

Kluai Hom Thong (*Musa* AAA Group) banana is one of economic crop of Thailand, with about 86,270 Rai cultivated area and 234,220 tons of total production in 2016 (Center for Agricultural Information office of Agricultural Economics, 2016). Kluai Hom Thong banana

¹ Department of Agro- Faculty of Applied Science and Engineering, Nong Khai Campus, Khon Kaen University, Nong Khai 43000. E-mail: pnatch@kku.ac.th

² The Indo-China Country International Trade and Economic Research Sector, Nong Khai Campus, Khon Kaen University, Nong Khai 43000.

* Corresponding author

is popular worldwide due to its pleasing aroma and taste with high nutrition value. Moreover, it is widely used in food processing, which results in a number of food products, for instance, banana powder, snack, freeze, yogurt, dried banana, cake, cookies, candy, crisp, desert, sauce, juice, puree, and flour (Jirukkakul, 2016). However, the banana has an early maturity stage, which requires a short shipping time, and it also has a very short shelf life before rotting. Post-harvest changes in bananas include an increase in membrane permeability (ion leakage), loss of flesh firmness, decreased starch content, increased sugar levels, color change, increased respiration rate and loss of turgor (Thakur *et al.*, 2019). Numerous studies have suggested that the 'green ripe' AAA group (24-35°C). Chlorophyll molecules are degraded in a stepwise manner by the action of a series of enzymes. Bananas mainly result from the repression of Chlorophyll degradation by high temperatures (Wu *et al.*, 2019). The ripening process occurs due to physical and chemical changes. Changes in organic acid and chemical elements convert starches to sugars, which results in an increase in total soluble solids (TSS) and a decrease in acidity. The softer texture of a ripe banana is caused by changes in the composition of pectin in the cell wall (Soradech *et al.*, 2016). It is well known that the metabolism can be minimized by lowering the temperature and oxygen reduction. Whereas, in climacteric fruits and vegetables, the metabolism will be accelerated by the presence of low concentrations of ethylene (C₂H₄) emission from the store fruits (Cisnerosa *et al.*, 2019). The coating of fruit has been investigated to delay fruit ripening (Thakur *et al.*, 2019).

Edible coatings are widely used in post-harvest product preservation, as they can reduce ethylene emission and water loss. The choice of coating treatment must be consistent with the deterioration characteristics of the product, for example, protein-based coatings are hard and provide good prevention of osmosis of gases and water vapor. Guillaume *et al.* (2013) studied a wheat gluten edible coating on shelf-life extension of parsley

leaves and found the leaves remained acceptable during 8 days of storage with only 28% loss of chlorophyll content. Another study using protein soy protein-cysteine based edible coating with modified atmosphere packaging could extend the shelf life of fresh-cut eggplant for 9 days (Ghidelli *et al.*, 2014). Lipid-based coatings such as shellac and gelatin composite coating are low gas permeability and have been used to add glossiness and extend shelf life of many fruit including banana (Soradech *et al.*, 2016). On the other hand, polysaccharide-based coatings provide a high-quality film or coating gas permeability. Such as carrageenan mixed with 1% calcium chloride, 0.75% ascorbic acid, and 0.75% cysteine has reduced produce weight loss and increased polyphenol oxidase activity during 5 days of fresh-cut banana storage (Bico *et al.*, 2009). Carrageenan with glycerol coating for papaya resulted in higher firmness and lower color component values, delaying ripening and extending shelf life (Hamzah *et al.*, 2013). Unripened banana contains large amounts of starch, cellulose, hemicellulose and lignin in its pulp. Therefore, economic strategies to increase utilization of banana include banana flour production. The film made from banana flour would be applicable for food packaging to protect foods (Jirukkakul, 2016).

The ability to extend shelf life of banana can be control or delay ethylene biosynthesis using an edible coating with ethylene scavenging additive. Ethylene accelerates respiration, leading to maturity and also softening and ripening of many kinds of fruits. Although ethylene has some positive effects, it is often hazardous to the quality and shelf-life of fruits and vegetables. The removal of ethylene to maintaining postharvest quality of climacteric produce (Coloma *et al.*, 2014). The ethylene absorber or zeolite is widely used due to its ethylene scavenging ability. Zeolite adsorption of ethylene has been well characterized. Since zeolites and zeolite-impregnated films are being marketed for ethylene adsorption with horticultural commodities (Peiser and Suslow, 1998). Charcoal that contains amorphous carbon and has a gas absorber characteristic which helps

in purifying the gas (Lee, 2016). Activated carbon and zeolite are often used as supporters for preparing ethylene absorbers, since they are relatively inexpensive, possess a complex porous structure and high surface area to support catalysts. Recently, much interest has focused on palladium (Pd)-based ethylene scavengers to increase the efficacy of ethylene removal for fresh horticultural produce in storage (Cao *et al.*, 2015). This study focuses on the effects of 2 types of banana flour coatings (*Musa* AAA group and *Musa* ABB group or Khuai Hom Thong and Khuai Namwa) and 2 additives (zeolite and activated charcoal powder) on the physical qualities and respiration of coated versus uncoated bananas.

Materials and Methods

Coating Substance Preparation

Banana flours from 2 types of bananas Khuai Hom Thong (*Musa* AAA) and Khuai Namwa (*Musa* ABB) using mature green bananas (stage 1). Bananas were washed, peeled, cut, and soaked in 0.5% acetic acid solution for 30 min. They were then drained and dehydrated prior to meshing through 80 wire mesh. The coating solution was prepared by diluting the banana flours in distilled water (4% w/w). The solution was heated at 85°C for 10 min to achieve gelatinization and 1% glycerol was added and the solution was thoroughly mixed before adding 1% activated charcoal powder or zeolite. The 100 ml of coating solution was prepared for 1 bunch, so 1 g of activated charcoal powder or zeolite was spread on 1 bunch of banana skin.

The content of fat, protein, ash, fiber, and moisture of the banana flours were determined according to AOAC (2000). The pasting properties of the flours were measured using a Rapid Visco Analyzer (Model 4, Newport Scientific Pvt. Ltd., Australia). To prepare a suspension, about 3 g flour with 14% moisture content was added to 25 ml of distilled water. The flour solution was kept at 50°C for 1 min and then heated up to 95°C and held for 2.5 min. It was then cooled down to 50°C and a final isothermal step was carried

out at 50°C. The obtained RVA curve was used to determine the peak viscosity, trough, breakdown, final viscosity, set back in rapid visco units (RVU), and peak time (min). The evaluation of the banana flour colors was conducted using a HunterLab spectrophotometer (model TC-P III A, Tokyo Denshoku Co., Ltd., Japan). The 20 g of the banana flour was poured into the test cup, it was covered with a lid, and the color value was read and recorded.

Plant Material and Treatment

Mature green of Kluai Hom Thong bananas (stage 1) with a width of 3-4 cm and length of 21-25 cm were collected from Phon Phisai District, Nong Khai Province. The 30 bunches per treatment were prepared for 0, 3, 6, 9, and 12 days of sampling which divided to 6 bunches each time (3 bunches for weight, color, firmness and total soluble solid and 3 bunches for CO₂ emission measurement). Samples were tested repeatedly 3 times. The bananas were washed by tap water and air-dried. They were subsequently dipped into the 4% banana flour or 4% banana flour with 1% zeolite or 4% banana flour with 1% activated charcoal carbon coatings solution for 5 min (Soradech *et al.*, 2016). There were 7 treatments: HF = banana coated with Hom Thong flour, HFZ = banana coated with Hom Thong flour + zeolite, HFC = banana coated with Hom Thong flour + charcoal powder, NF = banana coated with Namwa flour, NFZ = banana coated with Namwa flour + zeolite, NFC = banana coated with Namwa flour + charcoal powder. The coated bananas were dried on the grill before placing each bunch in an open paper box for storage at room temperature (approximately 30°C, with 70% RH). Uncoated bananas served as the control. Banana fruits were evaluated every 3 days for 15 days for weight loss, firmness, peel color, total soluble solid.

Evaluation of Banana Fruit Ripening Characteristics

Measurement of Weight Loss

The initial weight was measured before the bananas were stored in open paper boxes, and subsequent weight measurements took

place every 3 days throughout the storage period. Weight loss values were calculated according to the following equation:

weight loss% = (initial weight – weight at the inspection date) × 100/initial weight

Measurement of Firmness

Flesh firmness of the banana fruit was measured by a firmness tester (model GY-3, Domestic Product, China) fitted with a 8 mm diameter stainless steel head, which was inserted into the flesh of the banana fruit to certain depth and the penetration force was recorded and expressed as Newton (N).

Measurement of Peel Color

The banana fruit peel colors were measured at 3 sites, on the upper, middle, and lower side of the bananas using a HunterLab spectrophotometer (model TC-P III A, Tokyo Denshoku Co., Ltd., Japan). Each site measurement was repeated 5 times. The values were represented as L*, a*, and b*. Then the color analysis was calculated according to the formula $\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$.

Measurement of Total Soluble Solids

Soluble solids were measured using a hand refractometer (model N-1 α , Atago, Japan). Banana juice which extracted by fruit compression at 25°C was dropped onto the hand refractometer and obtained values were measured and expressed in °Brix.

CO₂ Emission Measurement

The bananas (2 kg) were stored in container (5 liters) with CO₂ detectors (model CO220, Extech instruments, Taiwan). Values of CO₂ emissions were recorded in ppm/h.

Unit has been conversed to mg CO₂/kg banana. h by multiplied mass of the air in container and divided by mass of banana.

Sensory Evaluation

The bananas that could be kept in storage for the longest period with qualifying physical properties were selected for sensory evaluation. Sensory evaluation of banana fruit was conducted using 9-point hedonic scale with peel colors, aroma, flavor, texture, and overall quality of the fruit were evaluated by a group of 30 partially trained panelists.

Statistical Analysis

Differences were analyzed using an SPSS program with one-way analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) at 95% significance.

Results and Discussion

Properties of Banana Flour-Based Coating

The Hom Thong flour had higher L*, a*, and b* than the Namwa flour with significance ($p < 0.05$) (Table 1), which was similar to the banana flour in a study by Campuzano *et al.* (2018). The ripeness of banana affected the chemical elements of the banana flours. Banana in the 1st-2nd stages of ripeness had low protein but was high in carbohydrates. The amount of protein increased while carbohydrates decreased when the banana reached the 3rd stage of ripeness (Campuzano *et al.*, 2018). The Namwa flour was high in fiber but had lower ash levels than the Hom Thong flour ($p < 0.05$). The L*, a*, and b* values of Hom Thong flour were higher than Namwa flour. Both types were similar to each other in protein

Table 1. Chemical elements and colors of banana flours

Banana Flour	Protein (%db)	Fat (%db)	Fiber (%db)	Ash (%db)	Carbohydrate (%db)	Color		
						L*	a*	b*
Hom Thong Flour	3.14±0.20 ^a	0.79±0.19 ^a	5.73±0.13 ^b	4.46±0.92 ^a	85.89	74.52±0.09 ^a	10.31±0.05 ^a	29.64±0.16 ^a
Namwa Flour	2.98±0.32 ^a	0.45±0.19 ^a	7.84±0.25 ^a	2.02±0.58 ^b	88.72	72.37±0.16 ^b	8.22±0.07 ^b	28.70±0.18 ^b

Values represent means ± SD of each analyzed in duplicate.

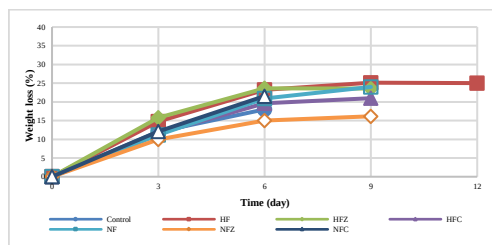
Means with the same lower case letter in the same column did not differ significantly at $P < 0.05$.

Table 2. Viscosity of banana flours

Banana flour	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (°C)
Hom Thong Flour	1,688.00±66.47 ^a	1,412.50±61.52 ^a	275.50±4.95 ^a	1,900.00±46.67 ^a	487.50±14.85 ^a	5.37±0.05 ^a	67.65±19.59 ^a
Namwa Flour	1,258±171.12 ^b	1,007.50±125.16 ^b	250.50±45.96 ^a	1,298.50±167.58 ^b	291.00±42.43 ^b	5.14±0.09 ^b	80.18±0.53 ^a

Values represent means ± SD of each analyzed in duplicate.

Means with the same lower case letter in the same column did not differ significantly at $P < 0.05$.

**Figure 1. Weights of bananas throughout storage period**

HF = banana coated with Hom Thong flour

HFZ = banana coated with Hom Thong flour + zeolite

HFC = banana coated with Hom Thong flour + charcoal powder

NF = banana coated with Namwa flour

NFZ = banana coated with Namwa flour + zeolite

NFC = banana coated with Namwa flour + charcoal powder

and fat levels ($p > 0.05$). Also, both flour types were similar in terms of chemical elements as previous reported, comprising of 78-85% carbohydrate, 2.9-4.6% protein, 2.1-2.5% ash, 0.32-1.87% fat, and 4.33-10.52% fiber (Sarawong *et al.*, 2014; Sarda *et al.*, 2016; Bi *et al.*, 2017; Campuzano *et al.*, 2018). There was a high level of ash (more than 2%) and a low level of fat (less than 1%) (Bi *et al.*, 2017). The Hom Thong flour consisted of higher levels of ash (2.1-2.5%) than banana flour from the same group studied by Bi *et al.* (2017) and Campuzano *et al.* (2018). Ash levels indicate the amount of mineral. The obtained values of this study were similar to those of commercial banana flour (Sarda *et al.*, 2016). The viscosity of banana flour indicates the resistance to mechanical force and absorbent and adhesion properties which is presented in Table 2. The Hom Thong

flour had a significantly higher viscosity than the Namwa flour ($p < 0.05$). Preliminarily, it was found that Hom Thong flour served as a good coating substance owing to its high viscosity and brightness properties. Compared to previous study by Jirukkakul (2016), the viscosity found in this study was higher maybe due to a lower initial humidity and different pretreatments

Effects of Banana flour-based coating on Weight Loss of Banana Fruit

Weight loss of banana fruit increased over the storage time in every treatment. The coated bananas were not different moisture loss with uncoated banana. In the first 3 days of storage, the bananas lost 10-15% of their weight, and the loss increased by 15-23% by the 6th day of storage (Figure 1). This was because the present study used the whole banana bunch, including the crown; therefore, the moisture loss of the crown was included. In addition, storage below 99% relative humidity could cause a higher moisture loss (Bico *et al.*, 2009). The bananas in this study were stored at room temperature (30°C and 75% relative humidity); therefore, the high moisture loss was also observed as weight loss. However, the weight loss of HF at 9th day was similar to 12th day.

Effects of Banana flour-based coating on Firmness of Banana Flesh

When banana ripening occurs, the structure is breaking down due to the destruction of the cell wall (Bico *et al.*, 2009) and cell decay resulting from water loss (Harnzah *et al.*, 2013). These processes gradually soften the tissue as the storage period progresses. The bananas treated with banana flour coating (Hom Thong and Namwa flours)

had firmness values which slowly decreased in the first 3 days of storage, and the two types of banana flours had equal firmness values by the 9th day of storage (Figure 2). The obtained firmness values in this study were similar to those found in shellac/gelatin coated bananas, which had decreased firmness from depolymerization and deesterification of protopectin in the middle lamella of the cell wall, resulting in a softened cell wall (Soradech *et al.*, 2016). The coated banana and uncoated banana were similar in firmness value. However, this clearly showed that the banana flours preserved the fruit firmness effectively HF after the 6th day of storage.

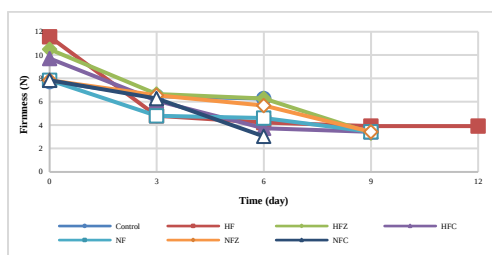


Figure 2. Firmness values of bananas throughout storage period

HF = banana coated with Hom Thong flour

HFZ = banana coated with Hom Thong flour + zeolite

HFC = banana coated with Hom Thong flour + charcoal powder

NF = banana coated with Namwa flour

NFZ = banana coated with Namwa flour + zeolite

NFC = banana coated with Namwa flour + charcoal powder

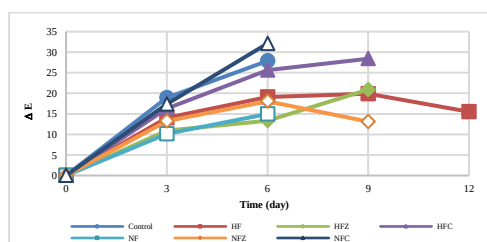
Effects of Banana flour-based coating on Color of Banana Peel

The colors of the banana peel are the essential indicator according to the ripening index for harvesting and trading. A raw banana has a green peel. During the ripening process, chlorophylls degrade, and the green color gradually disappears (Guillaume *et al.*, 2013), while the yellow color from carotenoids clearly appears. After that, there is a presence of brown spots caused by changes in phenolic compounds resulting from enzyme polyphenol

oxidase, which produces quinone and results in polymerization (Soradech *et al.*, 2016). The values of the yellow color increase progressively from stage 1 ripening to stage 2 ripening, whereas brightness and redness increase and then decrease in stage 7 of ripening, when brown spots begin to present (Gomes *et al.*, 2013). This study used bananas in the 1st stage of ripening, with green peels and no ridges. The peels changed to yellow in 3 days. The changes in color correlated with respiration and with moisture loss; therefore, rapid color changes were observed in the beginning of the storage period and gradually slowed by the end of the storage period. The findings were consistent with those from an experiment conducted by Soradech *et al.* (2016), which found that shellac coated bananas stored for 30 days in temperatures of 25°C had increasing values of brightness in the first 3 days with values decreasing by the 6th day. Moreover, an experiment on Long Gong fruit by Pithakpol *et al.* (2015) also demonstrated that the brightness of the fruit increased in the first week of storage and decreased after that period. The values of redness in Hom Thong flour coated bananas increased and subsequently decreased by the 9th storage day, whereas the values of redness in the other samples decreased by the 6th day of storage (Table 3). However, the values of yellowness gradually increased and then began to decrease when brown spots appeared. This was consistent with an experiment on fresh-cut mango treated with gum arabic coating, which found that the values of yellowness increased in the first day and decreased subsequently (Pengnet *et al.*, 2014). The color change values of the treated bananas were lower than those of the control banana samples (Figure 3). The coating from Hom Thong flour expressed higher color differences than those of the coating from Namwa flour because of the initial flour color (Table 2). The HFZ provided lower values of color differences than those of the HF samples and HFC with statistical significance ($p < 0.05$). The samples treated with activated carbon powder had black spots that looked like dust in the banana skin, making them unpopular in the market.

Table 3. Color of bananas throughout the storage period

Day of Storage	0	3	6	9	12
L*					
Control	54.64±0.68	56.79±1.00	42.41±6.79		
HF	51.14±0.15	53.77±0.61	42.91±1.95	39.67±2.78	53.11±0.61
HFZ	54.39±0.42	54.67±0.48	50.11±0.51	40.91±2.03	
HFC	54.23±0.68	43.23±1.01	32.19±2.33	33.01±0.40	
NF	52.53±0.40	53.82±1.18	45.40±1.37		
NFZ	53.79±0.43	55.85±0.59	39.29±1.62	51.31±2.36	
NFC	54.23±0.68	46.20±1.30	38.76±1.54		
a*					
Control	(-9.20)±0.29	8.49±0.49	13.67±1.55		
HF	(-10.11)±0.25	(-1.96)±1.07	1.77±0.47	0.29±1.79	(-1.3)±0.16
HFZ	(-8.58)±0.21	(-0.52)±0.40	(-0.79)±0.32	(-1.17)±0.78	
HFC	(-7.28)±0.35	(-2.72)±0.31	(-0.94)±0.62	0.58±2.06	
NF	(-8.60)±0.22	(-2.32)±1.72	(-6.02)±2.40		
NFZ	(-7.54)±0.38	(-2.64)±1.91	1.02±0.56	3.91±0.40	
NFC	(-7.28)±0.35	(-0.86)±0.25	(-2.06)±0.60		
b*					
Control	34.88±0.64	41.41±0.90	24.68±0.04		
HF	39.91±1.39	33.31±1.10	27.40±0.39	27.41±3.67	27.28±4.74
HFZ	36.19±0.06	28.78±1.57	26.27±0.62	22.05±5.82	
HFC	33.12±1.04	21.99±0.79	21.71±2.26	15.94±4.14	
NF	36.72±0.94	28.82±1.86	23.80±0.60		
NFZ	32.21±1.10	23.98±0.26	25.71±2.59	26.34±5.70	
NFC	33.12±1.04	19.05±0.88	5.47±1.04		

**Figure 3. Color differences of bananas throughout the storage period**

HF = banana coated with Hom Thong flour

HFZ = banana coated with Hom Thong flour + zeolite

HFC = banana coated with Hom Thong flour + charcoal powder

NF = banana coated with Namwa flour

NFZ = banana coated with Namwa flour + zeolite

NFC = banana coated with Namwa flour + charcoal powder

Effects of Banana flour-based coating on Total Soluble Solids of Banana Flesh

Total soluble solids were mostly sugar, which increased progressively in the ripening

stages. This is caused from hydrolysis of starch and other carbohydrates. In the first 3 days of storage, the control banana samples had a low but increasing amount of solids similar to the other samples. By the 6th day of the storage period, the values were in the range of 12-18 Brix. The bananas treated with Hom Thong flour coating had a slowly increasing amount of solids after the 3rd day of storage, which reached 17.3 Brix by the 12th day of storage, close to the brix value reached by other samples by the 9th day of storage (Figure 4). This was due to the effect of the coating, which reduced the respiration rate and also resulted in lower hydrolysis of starch (Soradech *et al.*, 2016). This was not consistent with an experiment on lemons, which found that lemons presented the same total soluble solid content values throughout the storage period due to the lack of starch in lemon (Pithakpol *et al.*, 2015).

Effects of Banana flour-based coating on Carbon Dioxide of Banana Fruit

Both ripening and the climacteric respiratory rise are triggered by the endogenous production of ethylene. Therefore, besides increased levels of ethylene emission, the

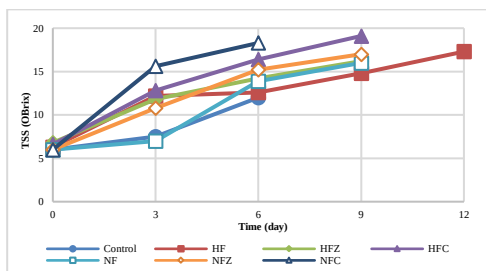


Figure 4. Total soluble solids in bananas throughout the storage period
HF = banana coated with Hom Thong flour

HFZ = banana coated with Hom Thong flour + zeolite

HFC = banana coated with Hom Thong flour + charcoal powder

NF = banana coated with Namwa flour

NFZ = banana coated with Namwa flour + zeolite

NFC = banana coated with Namwa flour + charcoal powder

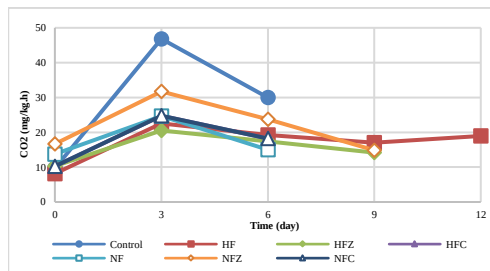


Figure 5. CO₂ emissions from bananas throughout the storage period
HF = banana coated with Hom Thong flour

HFZ = banana coated with Hom Thong flour + zeolite

HFC = banana coated with Hom Thong flour + charcoal powder

NF = banana coated with Namwa flour

NFZ = banana coated with Namwa flour + zeolite

NFC = banana coated with Namwa flour + charcoal powder

fruits produce elevated level of CO₂ (Silva, 2011). Carbon dioxide emission increased in the 3rd day of the storage period. This correlated with peel color, soluble solids, and firmness values, which changed significantly in the first 3 days. There were agree with the peels color changed to yellow in 3 days. After that, CO₂ emission decreased gradually as the ripening stages progressed (Figure 5). This finding is consistent with a previous experiment on delaying banana ripening using an ethylene stick on bananas stored at 25°C for 20 days (Zhu *et al.*, 2015). However, the temperature for the present study was 30°C, and the bananas were stored for 12 days. The CO₂ emission of HF was stable from 6 days to 12 days. The bananas treated with the Hom Thong banana flour coatings had lower CO₂ emission values than those in the Namwa banana flour coatings and the control banana samples with statistical significance ($p < 0.05$). However, the different conditions for the coated bananas showed no difference in CO₂ emission with statistical significance ($p > 0.05$) because of low concentration of zeolite or activated carbon.

This is consistent with an experiment on fresh-cut mango coated with soybean protein, which found that CO₂ emission was clearly reduced. In general, coating substances consisting of protein and polysaccharide are effective in reducing respiration in fresh-cut fruits (Ghidelli *et al.*, 2014).

Sensory Evaluation

The HF could be kept in storage for the longest period with qualifying physical properties. Therefore, the sensory properties of these sample were evaluated. The findings of the evaluation illustrated that the HF and the control banana samples had no statistically significant difference in levels of aroma, flavor, texture and overall preference (Figure 6). Preference levels varied from like to like very much. On the 6th day of the storage period, the coated bananas' peels remained green, which led to a low level of color preference. On the 9th day and 12th day of the storage period, the aroma and texture of HF remained constancy whereas the control banana samples could not be detect.

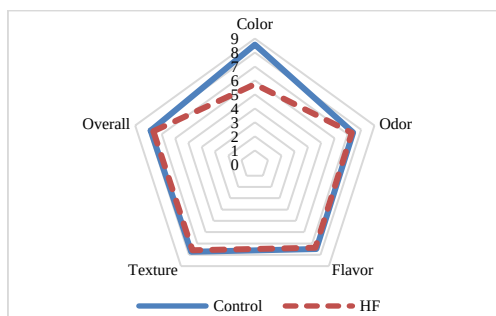


Figure 6. Sensory properties of bananas on the 6th day of the storage period
HF = banana coated with Hom Thong flour

Conclusions

The zeolite and activated charcoal carbon were not affect banana storage because of low concentration. The bananas treated with Hom Thong flour coating demonstrated the longest storage period at 12 days with the constant of weight loss, firmness and CO₂ emission. The uncoated bananas maintained only a 6-day storage period. The bananas treated with Hom Thong flour coating had firmness and acidic values similar to the uncoated bananas, but the treated bananas maintained their green peels. Flavor, firmness, and ripeness preference levels for the coated and uncoated bananas were from like to like a lot, with no statistical significance ($p > 0.05$).

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