Clay as Potassium Permanganate Carrier for Banana Storage in Indonesia

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Abstract

Clay is abundant in Indonesia. The objective of this experiment was to study usage of clay as potassium permanganate ($KMnO_4$) carrier during storage of banana var. Raja Bulu. Three levels of clay powder were used as treatment, i.e., 10 g, 30 and 50 g for six fingers of banana with three replicates. Results showed that clay powder effective as $KMnO_4$ carrier for storage of banana var. Raja Bulu. Level of clay powder 30 and 50 g significantly increased banana shelf life as indicated by skin color and hardness by 18 days after treatments, as compared to the control. Application of 30 g clay powder resulted in optimum banana storage as compared to other treatments. This experiment indicates that clay powder effective as KMnO4 carrier.

INTRODUCTION

Banana (*Musa paradisiacal* L.) is one of important fruits in Indonesia. By 2008, total annual banana production was nearly 5 million ton, but accounted ca. 0.1% was exported (Deptan, 2008) from total acreage ca 1 million ha. The low export of banana is particularly due to problem on quality. From the total acreage, mostly is managed by small scale farmer as intercrop or edge plant with diverse of variety planted. Recently, 8 leading varieties among 275 local varieties are planted widely (Deptan, 2008), i.e., var cavendish, var ambon, var raja, var tanduk (plantain), var emas, var barangan, var kepok and var uli. High diversity of variety planted in the farmer field causes complexity in handling and marketing.

In term of food security for the rural village, banana becomes important food as compared to roots and tuber crops because it is available throughout year, no record of allergy, no complicated for serving and rich of vitamins and minerals. Var Raja Bulu has substantial nutrient content as compared to other desert bananas mainly on thiamin, riboflavin, pyridoxine, vit C and calcium content (CTFS, 2005). Therefore, Indonesian government through Ministry of Research and Technology nominated banana as national commodity and intensively investigated under scheme National Strategic Research (RUSNAS) managed by Center for Tropical Fruit Studies.

Variety Raja Bulu is one of commercial banana (AAB) that usually consumed both as desert and after fried called as *pisang goreng*. Since the production area is patchy among farmer lands and among regions, lost during collection usually high range from 20-30%. Banana is climacteric fruit as indicated by marked respiration and ethylene production after harvest (Turner, 1997), causing low storage ability under normal condition. Banana easily deteriorates as indicated by changing peel color, lost of weight, and lost firmness few days after harvest. Prabawati *et al.* (1991) stated that without any storage treatment, banana quality Therefore, prolong banana storage is very important.

Many researchers have been conducted to increase var. Raja Bulu storage basically using ethylene absorber, where potassium permanganate ($KMnO_4$) is effective as compared to commercial ethylene block, lime stone (CaO) and $CaCl_2$ (Sambeganarko, 2008). Sholihati (2004) stated that application of $KMnO_4$ as ethylene absorber significantly detent banana yellowing, maintained flavor up to 15 days under ambient room temperature (28 °C) and prolonged to 45 days at 13 °C. $KMnO_4$) is strong oxidation to ethylene forms ethylene glycol and manganese dioxide (Hein *et al.*, 1984). For storage in Indonesian banana, direct application of $KMnO_4$ solution is not desirable because it tints peel color into blue, therefore, $KMnO_4$ is applied through a carrier. Pantastico (1986) recommend using carrier which has low density, low absorbent, and inert to $KMnO_4$. For small scale farmers, the carrier should available in local market, abundant and preferably cheap. Many materials have been evaluated such as charcoal, floating stone and sawdust (Jannah, 2008), and zeolite (Sholihati, 2004; Jannah, 2008). Jannah (2008) pointed out that using zeolite as carrier of $KMnO_4$ banana quality was prolonged 7 days as compared to control, while Sholihati (2004) recommend using pellet of charcoal where it was prolonged up to 15 days, however, charcoal causes black tint on banana peel. Furthermore, Jannah (2008) stated that zeolite as $KMnO_4$ carrier had similar effectiveness to commercial ethylene block; however, zeolite mineral is relatively more expensive for farmer as compared to clay. Objective of this research was to study effectiveness of clay as $KMnO_4$ carrier during storage of banana var. Raja Bulu. Clay is easily found elsewhere in Indonesia and very cheap as compared to commercial ethylene block as well as previous material evaluated.

METHODOLOGY

Research was conducted from July to August 2009 at Postharvest Laboratory of Center for Tropical Fruit Studies (CTFS), Bogor Agricultural University (IPB), Bogor, Indonesia. Banana bunch was collected from the experimental farm in which applied with 300 kg N (urea), 500 kg potassium (K_2O) and 200 kg phosphorus (P_2O_5) planted in dried lowland field in Bogor (250 m above sea level). At planting, the seedling was threatened with commercial anti *Fusarium* agent (antagonism) and manure of goat at rate 10 kg/plant. Water table was 60 cm below soil surface and well maintenance. Maintenance procedures was follow Banana standard procedure (SOP) released by CTFS (2008).

Bunch of banana var Raja Bulu was collected at optimum maturity (¾ criteria) indicated by green color and had sharp-peel fingers. The finger was clean manually and wiped carefully with moist cloth. The fingers had firmness value 0.80 kg/second, total soluble solid 16.2 ° brix, edible portion 41.85% and total acid 20.56 mg/100g. Hands of fruit were selected for any damage and wound. For local marketing objective, an original hand (ca 12-14 fingers) was cut using sterile knife into two pieces and trimmed so that each hand contained six fingers. Weight of hand contained six fingers ranged from 420-670 g.

Clay soil was obtained from IPB Campus, Darmaga-Bogor collected during dry season and used as $KMnO_4$ carrier (Fig.1.a). The clay contained N total (0.09%), medium phosphorus availability (18.0 ppm), total exchangeable cation 80 and medium potassium availability (17.0 ppm) with pH H_2O 6.5 and pH K_2O 7.0. Prior to application, 1,000 g air-dried-clay was incorporated well with 500 ml aquadest and then added 100 ml $KMnO_4$ solution (75 %) making into paste. After it mixed well, then formed flat paste with thickness 1-2 cm then dried in room temperature for 24 hours. The dried paste contained $KMnO_4$, then was milled into powder and placed into cloth bag sized 5 cm x 5 cm (Fig.1.b). The powder was applied at three levels, i.e., 10 g, 30 g and 50 g for two hands, replicated 3 times; control was used without any treatment.

Hand of banana was kept in a transparent plastic bag, two hands for a plastic bag. A silica gel (ca 10 g) to absorb excess water was added in each plastic bag. Then, the bags were arranged inside cartoon sized 45 cm x 25 cm x 10 cm and filled with paper (Fig.1.c) according to Nugraheni (2006) and Diennazola (2008). One cartoon was used for three plastic bags, then it was stored in room temperature (27-30 ^{0}C) (Fig.1.d). The treatment was carried out at the following day after harvest.

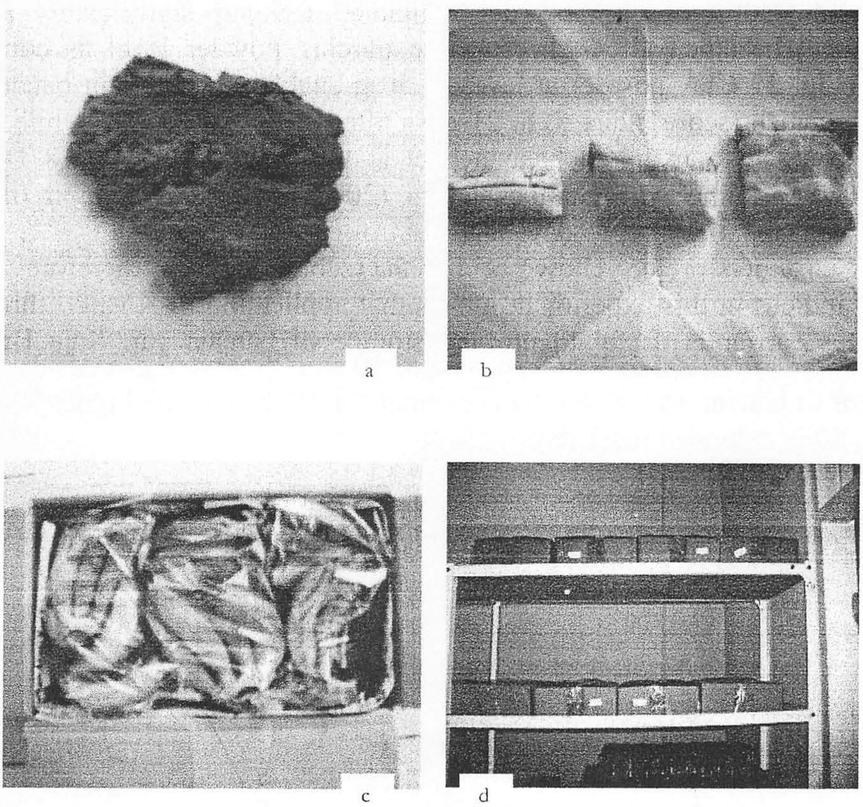

Fig.1. Clay soil used in this experiment as carrier of $KMnO_4$ (a), clay powder contained KMnO4 placed in cloth bag (b), banana hand kept inside plastic bag and arranged in cartoon (c) and stored in room temperature (d).

Observation was conducted up to 18 days after treatment (DAT) for color, texture, soluble solid, total acid, and weight. Color indices adopted Catalytic generator LCC 2006 and Turner (1997), i.e., 1-green, 2-green with light yellow, 3-green yellowish, 4-yellow with light green, 5-yellow with green at finger tip; 6-

yellow; 7-yellow with light brown spot and 8-yellow with wider brown spot. Total acid was measured from 50 g banana flesh diluted with 200 ml with aquadest. Then dropped 3-4 drops of phenolphthalein to a 25 ml filtrate then neutralized with NaOH 0.1 N until the solution became light red. Fruit texture was measured using hand hardness penetrometer (type) at half tip, middle and half bottom part of finger. Hand refractometer (type), was used to monitor total soluble solid as indicated by brix. Color index of commercial banana was used, i.e., 1-green to 8-yellow with wide brown spot. Statistical analysis for Tukey 5% significance was conducted using SPSS software.

Result and Discussion

Peel Color

Application of clay powder contained $KMnO_4$ significantly postponed banana peel became yellow, irrespective of clay powder level as compared to control (Fig. 2). Clay powder at level of 50 g enabled to maintain banana peel at yellow greenish (score index 5) at 21 days after treatment (DAT), while 30 g clay powder enabled to maintain banana peel at the same quality at 18 DAT. This finding was in line with Sambeganarko (2008) where application of $KMnO_4$ prolong banana more than 15 days than control.

Consumers prefer yellow peel banana (score index 6), therefore, according to color indices in this experiment means that application of $KMnO_4$ through clay powder as carrier is useful to prolong storage of banana var. Raja Bulu. Fig.2 indicates that application of clay powder of 10 and 30 g were effective to maintain peel color of banana acceptable by consumer for 18 days while higher level of clay powder, 50 g, extended to 21 days.

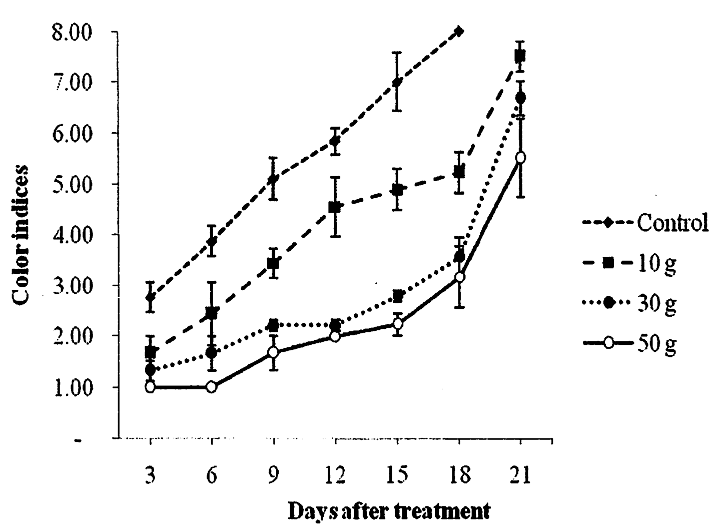

Fig. 2. Color indices of banana var. Raja Bulu peel from different clay powder level. No data was obtained from control treatment at 21 DAT due to the banana had deteriorated. Bars ± S.E.

Weight loss

Minimum weight loss during storage is preferable for banana, since fruit weight tended to decrease by time of storage due to respiration (Mikasari, 2004). Fig.3. indicated that banana weight decreased during storage. Marked weight loss happened within 9 DAT for control and 10 g clay powder treatments, e.g., reached nearly 10%. Treatments of 30 and 50 g clay powder minimized weight loss up to 18 DAT. After 18 DAT, all treatments showed marked weight loss, irrespective of level of the clay powder. However, rate of loss was likely inconsistent. It is probable that variation on moisture inside plastic bag caused different ethylene reduction by $KMnO_4$. Hein *et al.* (1984) pointed out that reduction of ethylene by $KMnO_4$ is affected by level of water. In the future research, it is important to control of moisture during storage of banana.

Tursiska (2007) showed that banana var Raja Bulu will lost the weight ca 22% during storage 10 days in room temperature without any treatment. Weight loss is parallel with banana appearance, where the weight loss below 3% is desirable, since non fresh banana come when it lost weight 3-5%. In this experiment, treatments of clay powder 30 and 50 gram maintained weight loss below 5% up to 18 DAT (Fig.3).

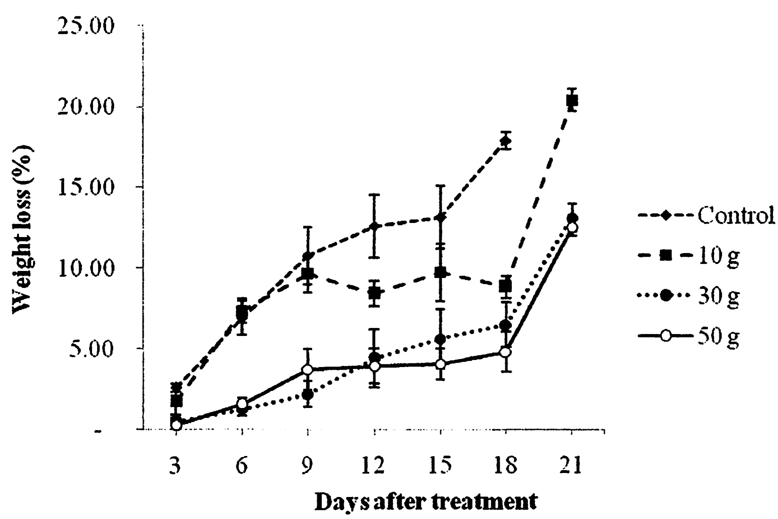

Fig.3. Percentage of weight loss during storage Banana var. Raja Bulu threatened with clay powder contained KMNO4. No data was obtained from control treatment at 21 DAT due to the banana had deteriorated. Bars ± S.E.

Hardness

Banana hardness decreased by time after harvest (Table 1), and became deteriorate after 21 DAT for control and 23 days for other treatments. Table 1 shows that treatment of 10 and 30 g clay powder contained $KMnO_4$ significant increased banana hardness as compared to control particularly at 6th day after harvest. In general, application of clay powder tended to increase banana hardness, irrespective of treatment. Application of clay powder, however, did not affect hardness significantly at 12 DAT. Application of clay powder at rate 30 g maintained longer hardness of banana, where the hardness decreased approximately 5% during storage. Moreover, preference test from 30 g clay powder application showed that the hardness was still acceptable.

Table 1. Hardness banana *var.* Raja Bulu at 6, 12 and 18 days after harvest threatened with clay powder contained $KMnO_4$

Treatment [x]	Hardness (kg/sec) [z]		
	6th day	12th	18th
Without KMnO4	0.740±0.015[y] b	0.713±0.009 a	0.623±0.033 b
10 g clay powder	0.793±0.003 a	0.710±0.006 a	0.660±0.030 ab
30 g clay powder	0.800±0.000 a	0.760±0.020 a	0.760±0.012 a
50 g clay powder	0.763±0.013 ab	0.733±0.026 a	0.713±0.012 ab

[z] Measured using hand penetrometer applied banana finger with peel attached

[y] Value in the same column followed by similar alphabet indicated non significantly different after Tukey 5%.

[x] Clay powder contained $KMnO_4$ 75%; Mean ± S.E.

Total soluble solid

Total soluble solid (TSS) reflects taste after harvest, where higher value indicates sweeter than the lower. As climacteric fruits, sugar content of banana increases after harvest up to reach optimum value before consumed (Mattoo *et al.*, 1989; Robinson, 1999) due to decreasing phenolic compounds. Table 2 indicated that application of clay powder irrespective of the level significantly retained increasing TSS at 12 DAT; application of clay powder 10 and 30 g being significantly had lower TSS than control at 12 DAT, but did not different significantly with 50 g. This finding was in line with result of Diennazola (2008). At 18th DAT, TSS content did not significantly different among treatments, although, application of clay powder tended to have lower TSS content than control ones. It indicates that effectiveness of treatment using clay powder as $KMnO_4$ carrier to maintain low TSS is less than 18 days.

Table 2. Total soluble solid of banana var. Raja Bulu treated with clay powder contained $KMnO_4$ at 6, 12 and 18 days after treatment

Treatment [x]	Total soluble solid (^{o} brix) [z]		
	6th day	12th day	18th day
Without $KMnO_4$	20.60±0.61[y] a	24.61±0.18 a	27.17±0.42 a
10 g clay powder	19.07±1.13 a	20.52±0.79 b	25.25±0.98 a
30 g clay powder	19.12±0.58 a	21.26±0.87 b	23.33±0.85 a
50 g clay powder	20.50±1.30 a	23.06±0.61 ab	23.34±1.19 a

[z] Measured for banana pulp after peel

[y] Value in the same column followed by similar alphabet indicated non significantly different after Tukey 5%.
[x] Clay powder contained $KMnO_4$ 75%; Mean ± S.E.

Edible portion, pulp/peel ratio and total acid

Edible portion and pulp/peel ratio tended to increase by time of storage (data not shown). The increasing in edible portion and pulp/peel ratio might relate to the loss moisture of peel. Hassan and Pantastico (1990) stated that pulp/peel ratio differences during storage presumably was caused by increasing sugar content of pulp and then mobilized the water from the peel.

Application of clay powder contained $KMnO_4$ did not affect significantly on both edible portion and pulp/peel ratio at 6, 12 and 18 DAT. Edible portion ranged from 36 to 44% at 6^{th} day and 38 to 44% at 12^{th} DAT; while pulp/peel ratio constant at ranged from 0.6 to 0.8 during storage (data not shown). On the contrary, Diennazola (2008) pointed out that treatment of $KMnO_4$ significantly had higher edible portion at 6 and 12 DAT ca. 50% higher than control treatment. After 18 days of storage, no significantly different was observed among treatment on pulp/peel ratio and edible portion (Table 3). This experiment indicated that application of $KMnO_4$ did not affect pulp/peel ratio and edible portion of banana var. Raja Bulu. It is probably that storage using plastic bag as a model of modified atmosphere modification protect moist lost from the banana as indicated by (Prabawati *et al.*, 1991), causing similar indiscernible response to $KMnO_4$ treatments.

Acid content increased during storage of banana and then slightly decreased after fully ripe. This result is in line with observation of Santoso and Purwoko (1995), due to the acid degradation. Table 3 indicated that acid content significantly lower at 30 g clay powder treatment as compared to other treatments particularly at 18 days after treatment.

Table 3. Edible portion, pulp/peel ratio and total acid of banana *var.* Raja Bulu threatened with different amount of clay powder contained $KMnO_4$ at 18 days after treatment

Treatment[x, y]	Edible portion (%)	Pulp/peel ratio	Total acid (mg/100 g) [z]
Control without $KMnO_4$	41.1±2.3[a]	0.75±0.08 [a]	30.75±0.18 [a]
10 g clay powder	39.8±2.1[a]	0.71±0.05 [a]	29.16±0.36 [a]
30 g clay powder	39.8±4.9[a]	0.69±0.14 [a]	25.24±0.64 [b]
50 g clay powder	43.9±2.2[a]	0.69±0.07 [a]	30.93±0.41 [a]

[z] Measured for banana pulp after peel
[y] Value in the same column followed by similar alphabet indicated non significantly different after Tukey 5%; Mean ± S.E.
[x] Clay powder contained $KMnO_4$ 75%

This experiment showed that clay powder could be used as carrier $KMnO_4$. Clay powder could absorb all $KMnO_4$ solution, while according to Jannah (2008), sawdust, floating stone, active charcoal and zeolite absorbed KMnO4 solution 3 times, 0.3 times, 0.4 times and 0.1 times of weight, respectively. Although sawdust had highest capacity to absorb KMnO4 solution among tested materials by Jannah (2008), however, it is likely that presence of organic compounds might bond to $KMnO_4$ causing low capability on ethylene absorption. On the other hand, free organic compound and neutral chemical properties of clay and the powdered-form increase the effectiveness of clay to absorb ethylene, even the absorbance is lower than sawdust. It needs further investigation to understand the mechanism of clay powder related to capacity to absorb ethylene. In the future, mass production of clay powder as $KMnO_4$ is promising as cheap and affordable material for rural farmers.

CONCLUSION

Application of clay powder as $KMnO_4$ carrier is effective for banana var. Raja Bulu storage as indicated by maintaining color, firmness and weight. Application of clay powder at rate 30 g, equal to 30 g/ kg fresh banana is desirable to maintain banana storage for 18 days. Marked increasing in moisture inside plastic bag during experiment should be investigated in the next experiment since this may promote peel decay, as this has been indicated by previous research.

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