THE EFFECTS OF CHARCOAL FROM DIFFERENT AGRICULTURAL WASTES IN REDUCING ETHYLENE PRODUCTION OF BERANGAN BANANA (*Musa* sp. AAA *Berangan*)

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Abstract

Banana is a climacteric fruit, it produces enough ethylene bringing about speedy changes in physico-chemical characteristics, including colour, texture, aroma, chemical composition, respiration rate and senescence. Ethylene, a colourless gas, is the main regulator of ripening in climacteric fruits which leads to the short marketable life and increase postharvest losses. These losses can be reduced by adopting various postharvest management practices that are currently in practice all over the world. One of the most effective ethylene removals is potassium permanganate. However, the usage of non-commercial charcoal from agricultural wastes that capable to remove or absorb ethylene such as palm kernel shell (PKS), sugarcane bagasse (SB) and coconut shell (CS) is scarce. The treatments were i) control (without ethylene absorbent), ii) 25g PKS, iii) 25g CS, and iv) 50g SB charcoal with 3 replications. The postharvest parameters assessment were internal ethylene production, fruit colour indices, firmness, titratable acidity (TA), soluble solids concentration (SSC), weight loss and starch pattern index (SPI). Internal ethylene production was assessed on daily basis. Meanwhile, other quality parameters were assessed on every four days interval. PKS had the ability to delay the climacteric peak of the ethylene production and prolong the shelf life of Berangan banana, without significant reduction in its postharvest quality. In addition, PKS charcoal were light, easy to obtain and cheaper ethylene adsorbent. In contrast, SB charcoal was less effective in delaying the ripening of Berangan banana. The shelf life of Berangan banana can be extended up to 6 days with no apparent changes in colour and weight loss.

Keywords: Berangan banana, postharvest quality, ethylene, absorbent

BACKGROUND

Bananas are one of the most popular fruits in the world as it is cheap source of carbohydrate and rich source of potassium, calcium, antioxidants and other micronutrients (Mohapatra et al., 2010). In Malaysia, bananas were listed as the six important fruit crops in the National Key Economic Areas (NKEAs 2010-2012) and is the second most widely cultivated fruit, covering about 26,000 ha with a total production of 530,000 metric tonnes (Mak, 2004). Quality of banana is commonly affected by the changes of its component of the banana during the storage and transportation period and lead to economic loss.Abd. Shukor et al. (2003) reported that in ASEANcountries, improper handling and packaging, low-level technology, lack of basic equipmentand facilities at the packing houses, and lack of trained personnel, commonly contribute topost harvest losses.

From postharvest point of view, banana is classified as climacteric fruit which can continue its ripening once detached from its parent. Climacteric fruits normally show a peak of ethylene production and respiration rate during ripening. The higher the respiration rate and ethylene production, the higher the perishability of the fruit. Besides that, bananas have a short market life an average of 1 to 10 days which subjected to serious postharvest losses. Therefore, understanding the banana fruit metabolism and its physiology would support the rise of technology in delaying the production of ethylene and as well as its respiration rate.

Ethylene is a plant hormone that plays a significant role on the quality and storage life of many harvested fresh produce. The speedy changes in banana due to ethylene production and respiration rate lead to low quality of fruits and shortage market life. Many researches have been conducted to delay ripening and respiration rate by using various chemicals such as potassium permanganate, 1-Methycylopropane (1-MCP) and controlled atmosphere storage which can prolong the marketable life of the banana. However, there is lack of information in reducing ethylene by using charcoal. Currently, there is commercial charcoal that widely used in reducing ethylene concentration known as activated charcoal. However, this commercial charcoal is expensive and the outcome in delaying ripening and absorbing ethylene is sporadic. Therefore, new charcoal from cheaper source such as coconut shell charcoal (CS), sugarcane bagasse charcoal (SB) and palm kernel shell (PKS) should be explored and investigated its impacts in delaying ripening and reducing ethylene production. In addition, agricultural wastes could be considered as suitable raw materials for the production of activated carbon as claimed by Soleimaniand Kaghazchi (2007). Thus further investigation on this matter is highly important.

METHODS

The experiment was carried out at the Post-Harvest Laboratory, School of Food Science and Technology. Berangan bananas (Musa sp.AAA Berangan) at maturity stage 2were purchased from local supplier in Pahang. Sixty hands of Berangan banana with uniform weight and size, free from defects and decay were used in this experiment. The hand was washed with 200ppm of sodium hypochlorite to remove the microorganism. Then air dried at room temperature (22 ± 2°C) before treat with ethephon to trigger ethylene production. On the other hand, sixty polyvinylchloride (PVC) air tight containers, 20cm x 29cm x 19cm in size were sanitized with 70% of alcohol to avoid decay microorganism infection on fruit. Each hand was placed in the PVC container with assigned charcoal charcoal treatment and then seal with parafilm. Each container then was further stored at ambient temperature (22 ± 2°C) for 16 days. The experiment was arranged as according to the complete randomized design (CRD) with four treatments which were, i) control (without charcoal) + silica gel, ii) 25g coconut shell charcoal (CSC)+ silica gel, iii) 25g palm kernel shell charcoal (PKSC) + silica gel, iv) 50g sugarcane bagasse charcoal (SBC) + silica gel. Each treatment was replicated three times.

The postharvest parameter assessment are ethylene production, fruit colour indices, firmness, titratable acidity (TA), soluble solids concentration (SSC), weight loss and starch pattern index (SPI). The sample was assessed daily basis for ethylene production and every four days interval for other assessment.Internal ethylene concentration was measured using gas chromatography as according to the method of Wan Zaliha (2009). Ethylene concentration in the gas sample was determined by comparing its retention with authentic ethylene standard. Ethylene was estimated using the software program and was calculated from the integrated areas of the sample and the corresponding standard (Wan Zaliha, 2009). Two ml of ethylene gas was taken from the sealed containers with a lock-luer syringe and injected into GC. The ethylene concentration was expressed in µg/mL. While, starch pattern index was observed by cutting the banana fruit longitudinal into half and immersed in iodine solution for a few minutes. The starch present in the pulp was reacting with iodine causing a dark blue color change. Assessment of starch pattern of each banana was observed by comparing the stain cut surface with the Starch Pattern Chart (Kader, 2002). The starch patterns indicated the relative amounts of starch and sugars.Fruit firmness, SSC and fruit colour were measured as according to the method of Wan Zaliha et al. (2014). Percentage weight loss of banana was recorede on day 0, 4, 8, 12, and 16 by using weighing balance. The weight loss was expressed in percentage (%).

The data were subjected to the analysis of variance (ANOVA) using GLM (General Linear Models) procedures with SAS 9.3 software package, SAS Institute Inc, Cary, NC, USA. Treatments means were further separated by Tukey test for least significance at P≤0.05 (SAS Institute Inc., 1999).

RESULTS AND DISCUSSION

The ripening of fleshy fruits represents the unique coordination of developmental and biochemical pathways leading to peel colour, texture, aroma and nutritional quality of the fruits changed. The gaseous plant hormone, ethylene, plays an important role in ripening of many fruits, including some representing important contributors of nutrition and fibres to the diets of humans (Barry et al., 2007). Many researches have been conducted on the effects of ethylene removals and adsorbents but there was little information available on charcoal from agricultural wastes. Charcoal from different agricultural wastes such as PKS, CS and SB have been discovered that can retarded ripening and senescence. However, the outcomes were sporadic. Thus, these study focusing more on the effect of charcoal from different agricultural wastes in reducing the production of ethylene and maintaining the postharvest quality of Berangan banana. The PKS charcoal resulted in delaying the climacteric peak (day 3) whereas control and CS showed earlier climacteric peak on day 1 (Fig. 1). The climacteric peak of ethylene production in various climacteric fruits closely related to the ripening process. The earlier the occurrence of climacteric peak the rapid the deterioration process.
As reviewed by Zagory (1995), ethylene can be absorbed and adsorbed by a number of substances including activated charcoal. However, the effectiveness of the adsorption was depends on the type of agricultural wastes and their porous structure of the charcoal. In this study, PKS seemed to have a largest porous structure compared to others. The possible reason was PKS showed the climacteric peak at day 3 (Fig. 1) while other charcoal showed the climacteric peak at day 1 and day 2.

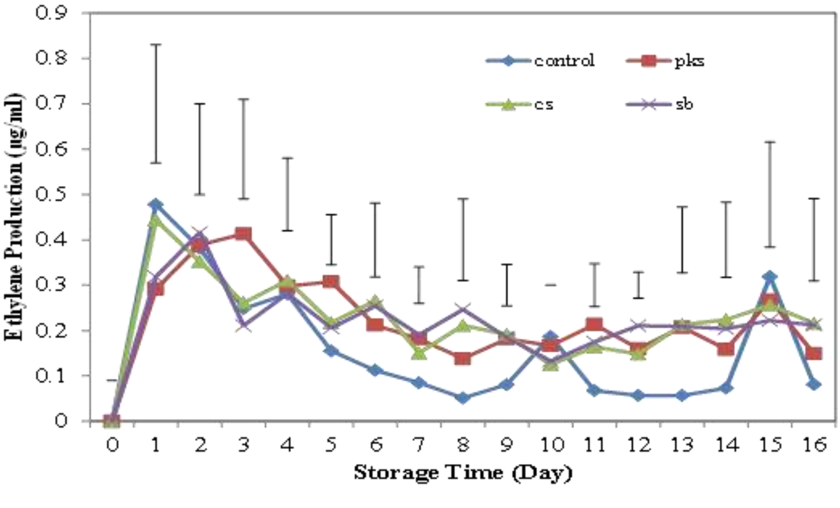
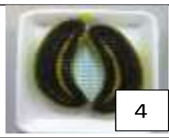
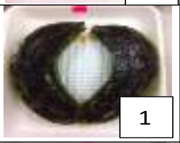
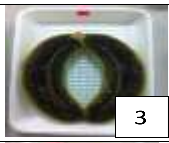
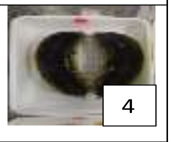
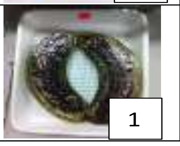
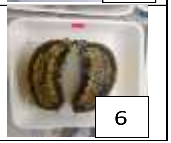


Figure.1: Effects of charcoal from different agricultural wastes in reducing ethylene production of Berangan banana (Musa AAA Berangan). Vertical bars represent HSD at 5% level.

Meanwhile, SPI of PKS-treated banana exhibit lower index of maturity stage (Table 1). Possibly, the delay in conversion of starch into sugar in PKS-treated-banana closely related to the climacteric The conversion of starch was pronounce in control fruit followed by coconut shell treated fruit continue with sugarcane bagasse treated fruit and palm kernel shell treated fruit. Starch was the principal component of green bananas, which undergoes important changes during ripening. Lii et al., (1982), investigated that change during ripening of dessert bananas with respect to physical and chemical properties of their starch and their content of reducing sugars and sucrose. Thompson (1996) reported that the softening of banana fruit during ripening was associated with the conversion of starch to sugar, breakdown of pectin substances and the movement of water from the rind of the banana to pulp during ripening.

Table 1: Effect of different charcoal from different agricultural wastes on the starch pattern index of Berangan banana. Number in the small box denotes to SPI score

Day / Treat-ment	0	4	8	12	16
Control	 1	 3	 4	 5	 7
PKS	 1	 1	 3	 4	 4
CS	 1	 1	 3	 5	 6
SB	 1	 2	 4	 6	 6

PKS treated bananas had score 4 on the day 16 while CS and SB showed index score 6 and control fruit showed index score 7. From Table 1, control and sugarcane bagasse treated fruits showed the earliest degradation of starch, index stage 3 and 2 respectively

On the other hand, ethylene stimulates chlorophylls losses and resulted yellow in colour of banana fruit and promotes the ripening of the pulp (Salviet, 1999). In addition, the changes in fruit colour might be ascribed to the degradation of chlorophylls to phytol which catalyzed by chlorophylase enzyme. The most important compounds responsible for the change in peel colour are chlorophylls and carotenoids. As reported by Gross and Flugel (1982), chlorophylls decreased rapidly and being absent in ripe fruit. Salviet (1999) claimed that, removal of ethylene or inhibition of its action can delay colour changes in storage and prolong the shelf life of selected commodities. Moreover, Frederick (1992) also reported that, pulp peel with ethylene is a major factor controlling peel yellowing and pulp softening. On the other hand, day 16 showed the peel colour of banana changed from green to yellow except for banana that had been treated with palm kernel shell charcoal (Fig. 2, 3, 4, 5 and 6) and related with the conversion starch into sugar in palm kernel shell fruit resulted in stage 4.

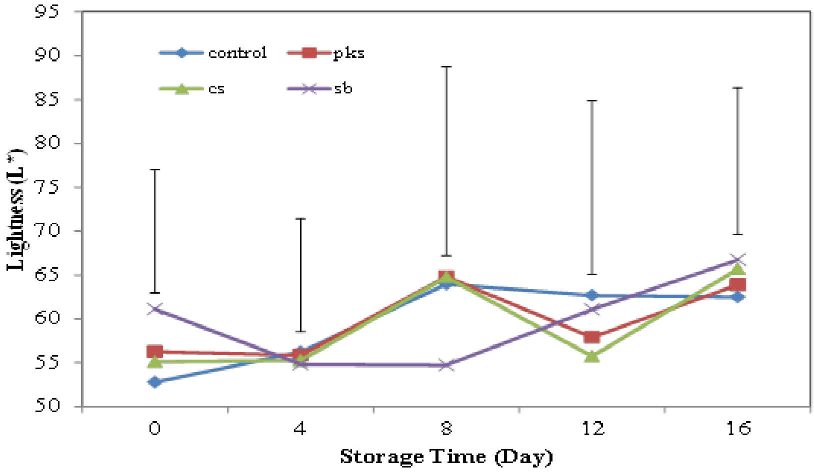


Figure 2. Effect of charcoal from different agricultural wastes on lightness of Berangan banana. Vertical bars represent HSD at 5% level.

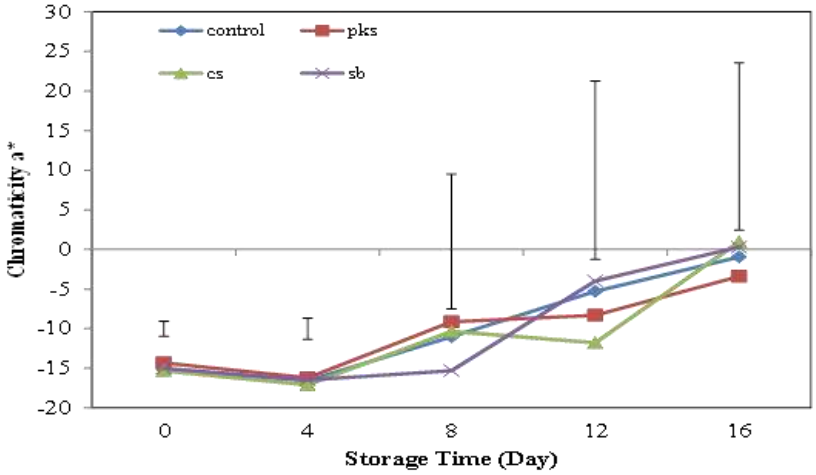


Figure. 3. Effects of charcoal from different agricultural waste on chromaticity a of Berangan banana. Vertical bars represent HSD at 5% level.

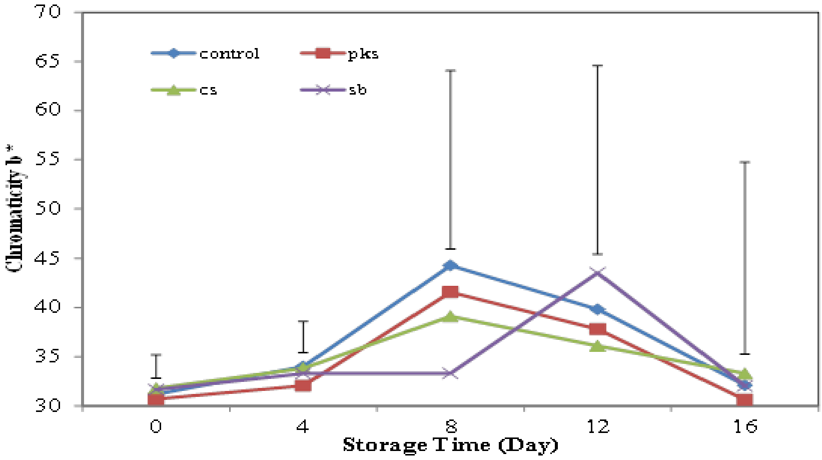


Figure. 4: Effects of charcoal from different agricultural waste on chromaticity b of Berangan banana. Vertical bars represent HSD at 5% level

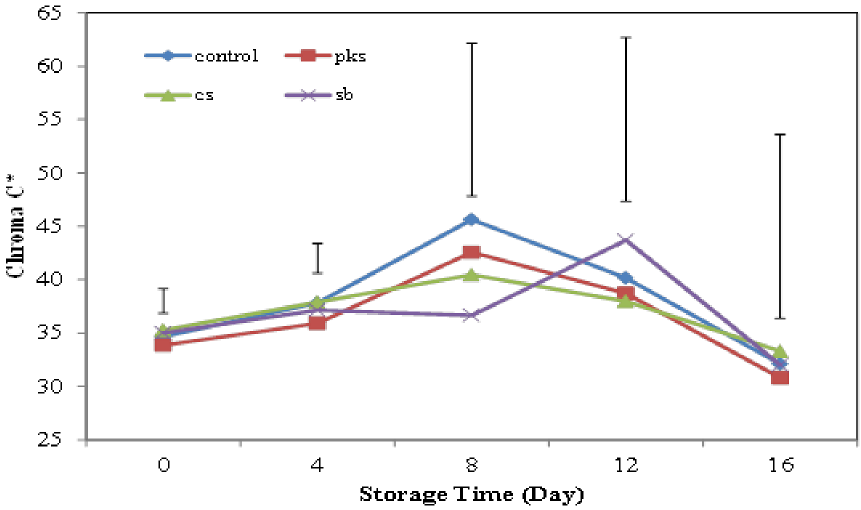


Figure. 5: Effects of charcoal from different agricultural waste on C* value of Berangan banana. Vertical bar represent HSD at 5% level.

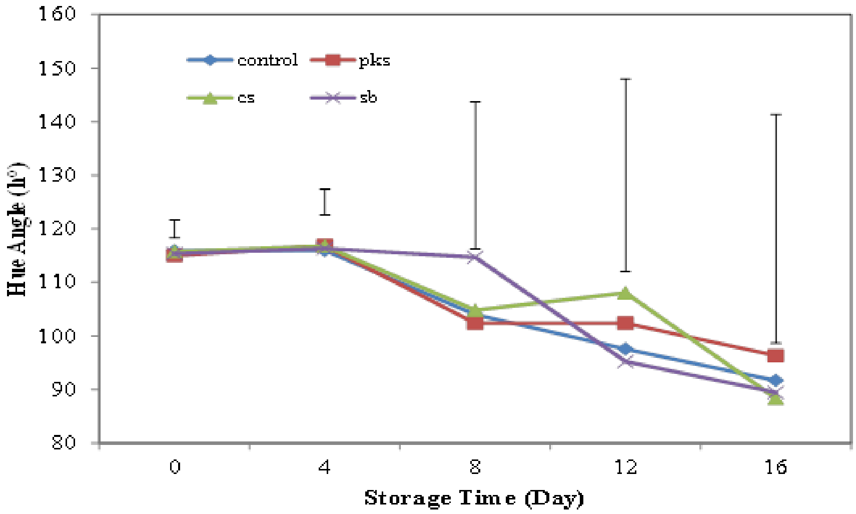


Figure. 6: Effects of charcoal from different agricultural waste on hue angle (h°) of Berangan banana. Vertical bars represent HSD at 5% level.

As shown in Fig. 7, 8 and 9, peel firmness, SSC and TA of treated and non-treated fruit had similar values. In general, as experimental period prolonged, the peel firmness had a decreasing trend which might be due to the loss of firmness or softening during ripening (Palmer, 1971; Smith et al.,1989). The breakdown of starch into sugar followed by the breakdown of cell walls or reduction in the cohesion of the middle lamella due to the solubilisation of the pectin substances and water migrates from the skin to the flesh as a result of osmosis might be contributed to the softening of banana fruits. The increases in osmotic pressure usually associated with the decrease in turgor pressure which may affect the softening of banana during ripening and cause the firmness to decrease (Finney et al., 1967). As claimed by Abe and Watada, (1991), charcoal combined with palladium chloride can prevented the accumulation of ethylene and effective in reducing the rate of softening in kiwifruits and bananas peak. However, in this present study, the treatment did not affect the firmness of the bananas. In contrast, SSC and TA of Berangan banana in all treatments showed an increasing trend throughout 16 days experimental period. The increment in SSC content during ripening of fruits and decrease after attaining peak levels followed natural fruit ripening and senescence processes are typical of postharvest change in climacteric fruit which was in agreement with the report of Dharmasenal and Kumari (2005).

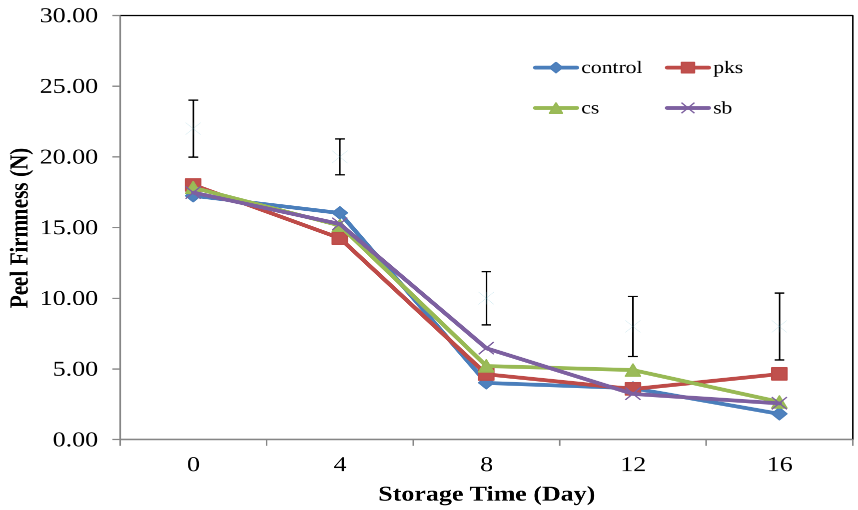


Figure 7. Effect of charcoals from different agricultural wastes on the peel firmness of Berangan banana (Musa.AAA Berangan). Vertical bars represent HSD at 5% level

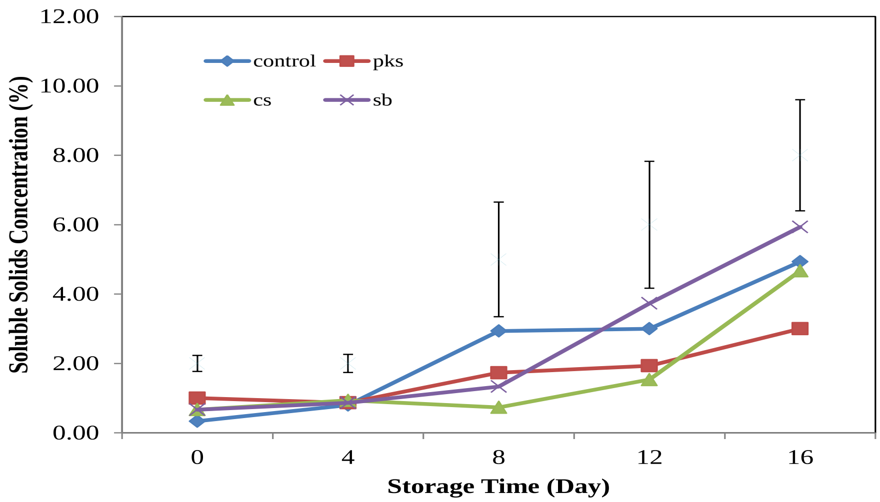


Figure 8. Effect of charcoal from different agricultural wastes on soluble solids concentration of Berangan banana. Vertical bars represent HSD at 5% level.

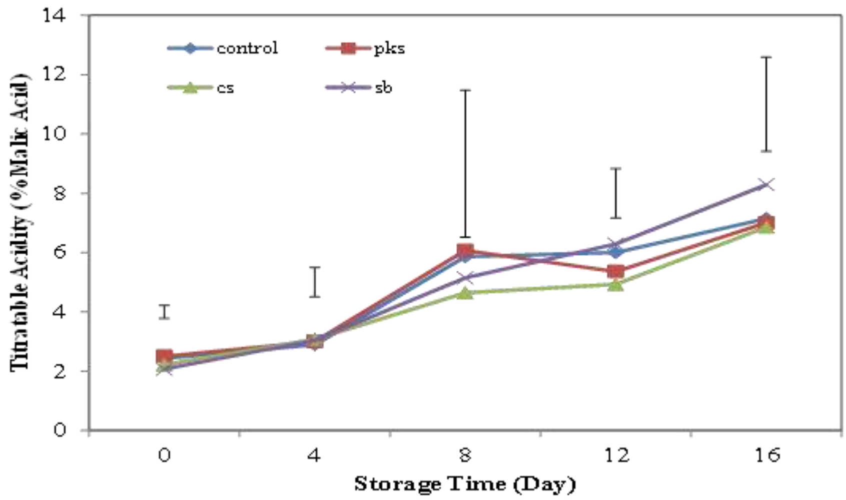


Figure. 9. Effect of charcoal from different agricultural wastes on titratable acidity of Berangan banana. Vertical bars represent HSD at 5% level.

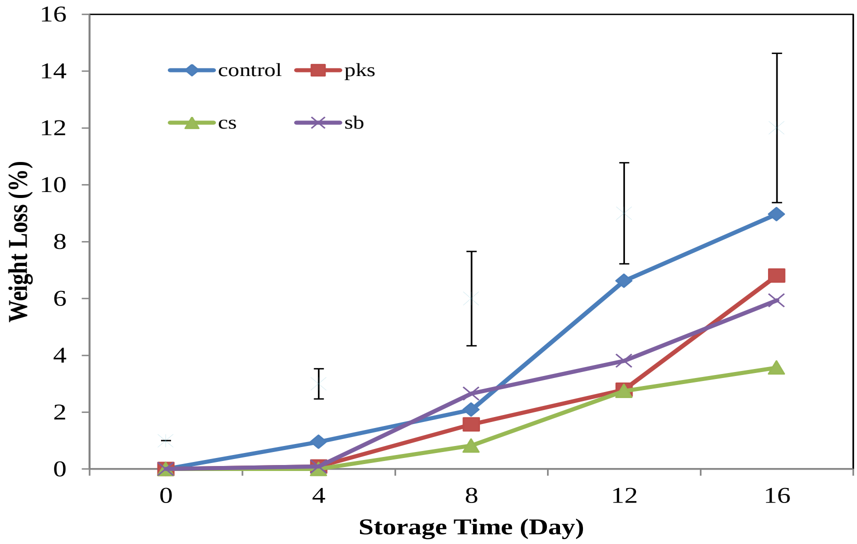


Figure. 10. Effect of charcoal from different agricultural wastes on weight loss of Berangan banana. Vertical bars represent HSD at 5% level

As illustrated in Fig. 10, the percentage weight loss of Berangan banana increase with storage time as ripening process occurred, which possibly resulted from transpiration and respiration of the fruits. Fruits treated with coconut shell charcoal resulted in 3% of weight loss are considered standard weight loss accepted in market value. However, fruits treated with palm kernel shell charcoal and sugarcane bagasse charcoal which gives 6% to 9% percentage weight loss are out of standard but still acceptable for market sale. Recent study by Irtwange (2006), transpiration is the process of evaporation water from plant tissues. Water loss is a loss of marketable weight and then adversely affects appearance (wilting and shriveling). Excess energy produced from the respiration process in the form of heat is released from the fruit by evaporation of water causing a weight loss (Siribon and Banlusilp, 2004; Dharmasena and Kumari, 2005). The removals of ethylene or inhibition of its effect in the storage enviroment is fundamental to maintaining the postharvest quality of climacteric produce (Salveit, 1999).

In conclusion, PKS had the ability to delay the climacteric peak of the ethylene production and prolong the shelf life of Berangan banana, without significant reduction in its postharvest quality. In addition, PKS charcoal were light, easy to obtain and cheaper ethylene adsorbent. In contrast, SB charcoal was less effective in delaying the ripening of Berangan banana. The shelf life of Berangan banana can be extended up to 6 days as no apparent changes in colour and weight loss was in the acceptable range. For further study, more researches should be conducted on various types of charcoal from different agricultural wastes such as rice husk, corn stover and saw dust with specific weight, amount and lighter PVC air tight container in order to prolong and maintain the shelf life of Berangan banana.

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