Jurnal Ilmu Pertanian Indonesia (JIPI), April 2026
(Indonesian Journal of Agricultural Sciences)
ISSN 0853-4217 EISSN 2443-3462

Vol. 31 (2): 269–275
http://journal.ipb.ac.id/index.php/JIPI
DOI: 10.18343/jipi.31.2.269

Influence of Potassium Permanganate on Physicochemical Quality Attributes of Oil Palm (Elaeis guineensis Jacq.) Fresh Fruit Bunches

Imelya Ramanis[1]*, Deden Saprudin[2], Sudradjat[3]

(Received June 2023/Accepted December 2025)

ABSTRACT

The physical and chemical properties of fresh fruit bunches (FFB) determine the quality of crude palm oil (CPO). The damage to the palm oil fruit accelerates the hydrolysis process, increasing the free fatty acid (FFA) content while decreasing the oil concentration. Damage is caused by the fruit's postharvest procedure, such as transportation time to the manufacturer and collection delays. The processing latency must be appropriate so that FFB damage can be reduced with potassium permanganate ($KMnO_4$). The purpose of this study was to determine the effect of $KMnO_4$ on the physical and chemical properties of palm oil FFB, as well as the relationship between the observed variables. The FFB samples were taken from the IPB-Cargill Palm Oil Teaching Farm in Jonggol Bogor, Indonesia. This study employed a randomized complete block design. The experiment included four different concentrations of $KMnO_4$ (0%, 0,025%, 0,050%, and 0,075%). Each treatment was reproduced three times. The results showed that using $KMnO_4$ could preserve the physical quality of palm oil fruit in terms of weight loss, fruit fall, respiration rate, and microbiological content. The chemical quality of fruit is determined by its moisture content and FFA concentration. The optimal $KMnO_4$ concentration was 0.075%. The correlation analysis results show that the observed variables have a positive association. Variables with a strong relationship included weight loss and fruit fall, weight loss and several microbes, weight loss and number of microbes, water content and number of microbes, and FFA and number of bacteria.

Keywords: crude palm oil, fresh fruit bunches, potassium permanganate, weight loss

INTRODUCTION

Harvesting and product processing are the final stages of palm oil farming. The issue with harvest management is that fresh fruit bunches (FFB) of palm oil must be collected on time, with adequate maturity, and quickly brought to the mill. Harvest timing for palm oil fruit has a significant impact on the quantity and quality of oil produced. The optimal time to harvest will yield the highest oil content, but harvesting fruit that is too ripe may increase free fatty acids (FFA), which can be negative because some of the oil content will convert to FFA, lowering the quality of the oil. Harvesting immature fruit, on the other hand, reduces oil content despite having a low FFA (BBP2TP 2008). FFB must be processed right away to avoid hydrolytic reactions that break down triglycerides into glycerol and FFA. A rise in FFA directly lowers the quality of crude palm oil (CPO). Although the bleaching procedure in palm oil mills (POM) can partially suppress this reaction, transportation delays are frequently a limiting factor, resulting in increased FFA levels prior to sterilization (Maulana & Susanto 2015).

The effectiveness of postharvest management procedures, as well as the degree of fruit maturity, were used to define CPO quality. Physical damage includes injured fruit mesocarp, weight loss, and fruit fall (Pahan 2012). Good CPO has no more than 5% FFA content (SNI 01-2901-2006). After processing, quality palm oil will generate oil yields of 22,1% to 22,2% and FFA concentration of 1,7% to 2,1% (Ministry of Industry 2007). As a result, the treatment throughout the waiting phase of the processing process must be proper to reduce the harm caused by the fruit, one example being the use of potassium permanganate ($KMnO_4$).

$KMnO_4$ is an essential compound for controlling the hormone ethylene in plants, where the hormone ethylene plays a critical role in fruit ripening during the post-harvest period. This compound is an ethylene oxidizer that can prevent fruit ripening (Hasibuan & Widodo 2015). $KMnO_4$ prevents ripening by oxidizing the fruit's ethylene double bond, turning it into manganese dioxide (MnO_2), KOH, and CO_2 (Pradhana *et al*. 2013). According to Sholihati *et al*. (2015), using it as an ethylene oxidizer can prevent banana yellowing, preserve flavor for 15 days at 28°C, and increase fruit shelf life to 45 days at 13°C. The addition of $KMnO_4$ to palm oil fruit can maintain physical quality

[1] Department of Agricultural Business, Politeknik Pertanian Negeri Payakumbuh, Lima Puluh Kota 26271, Indonesia.
[2] Department of Biochemistry, Faculty of Mathematics and Natural Sciences, IPB University, IPB Darmaga Campus, Bogor 16680, Indonesia.
[3] Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, IPB Darmaga Campus, Bogor 16680, Indonesia.
* Coressponding Author: E-mail: imelyaramanis@politanipyk.ac.id

in terms of weight loss, hardness, fruit fall, and temperature respiration rate (Adiningsus 2017; Laily 2020). The purpose of this study was to examine the effect of $KMnO_4$ on the physical and chemical properties of palm oil FFB. This study also seeks to establish the relationships between observational factors.

METHODS

The research lasted from June 2022 to September 2022, at the IPB-Cargill Palm Oil Teaching Farm in Jonggol, the Postharvest Laboratory of the IPB Department of Agronomy and Horticulture, and the IPB Biochemistry Laboratory. The experiment's material was the FFB of the D × P Dami Mas palm oil variety grown on the IPB-Cargill plantation. Other materials were potassium permanganate, phenolphthalein indicator solution, and 0.1 N NaOH. The equipment employed included a sprayer, jar, penetrometer, analytical balance, cosmotector, hydraulic press, freezer, hot plate, and desiccator.

This study employed a randomized complete block design (RCBD). Experiments with $KMnO_4$ concentrations included four levels: 0, 0.025, 0.050, and 0.075%. There were four treatments, and each treatment was in triplicates, resulting in 12 experimental units. Treatment was used after the harvest. Each experimental unit utilized 6 FFBs, for a total of 72 FFBs.

FFBs were selected in five blocks at the IPB-Cargill Palm Oil Teaching Farm in Jonggol. The FFB used was fraction 2, and it weighed between 15–20 kg on average. Harvesting was done in the morning to limit transpiration rates. The collected FFBs was taken to an open field that was dry, shaded, and not moist. Labeling FFBs with labels for each treatment and replication. $KMnO_4$ was liberally sprayed on the bunches' surfaces with a sprayer. According to the experimental concentration, using a spray volume of 500 mL^{-1} FFB. Oil was extracted using a hydraulic press.

FFB weight loss (%), fruit fall (day^{-1} item), fruit respiration rate (mL CO_2 kg^{-1} $hour^{-1}$) with a cosmotector type XP-314, fruit mesocarp firmness (mm^{-1} g^{-1} sec^{-1}) with a Standhope-SETA penetrometer, number of microbes on the surface of FFB (CFU mL^{-1}), oil yield (%) with a hydraulic press, and free fatty acid content (%) were all measured. The collected data was evaluated using analysis of variance (ANOVA), followed by the Duncan Multiple Range Test (DMRT) at 5% significance. The correlation analysis was between variables. The data was analyzed using Microsoft Office Excel 2010 and R Studio 9.1.

RESULTS AND DISCUSSION

Weight Loss of FFB

$KMnO_4$ treatment can minimize FFB weight loss at one, two, and four days after application (DAA) (Figure 1). The K0 therapy demonstrated more weight loss than the other treatments. At 1 DAA, the treatment reduced weight loss by 67.90% (K1), 75.11% (K2), and 68.86% (K3) compared to the control (K0). At 2 DAA, $KMnO_4$ treatment reduced weight loss by 32.37% (K1), 48.32% (K2), and 50.49% (K3) compared to the control (K0). At 4 DAA, the reduced weight loss was 24,03% (K1), 31,62% (K2), and 35,44% (K3) compared to the control (K0). Higher $KMnO_4$ concentrations can help to minimize FFB weight

Fruit weight loss is caused by the process of respiration and transpiration, which results in physicochemical changes such as water absorption and release into the environment (Sutrisno *et al*. 2008). Weight loss increased due to increasing respiration rates and ethylene production (Kowitcharoen *et al*.

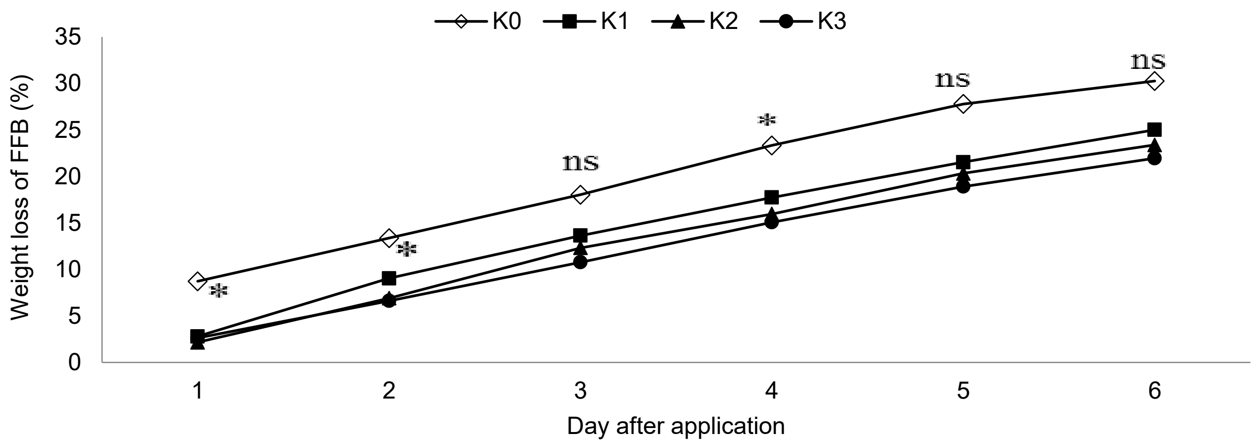

Figure 1 Effect of $KMnO_4$ application on the weight loss of FFB. Differences between means are labelled with * (α = 0,05); ns (not significant), K0 = 0%, K1 = 0.025%, K2 = 0.050%, K3 = 0.075%.

2018). The use of $KMnO_4$ is hypothesized to decrease ethylene production, hence reducing fruit ripening during storage and preventing weight loss due to transpiration and respiration.

Fruit Fall

$KMnO_4$ treatment can reduce palm oil fruit falling from 1 to 6 DAA, except for 4 DAA (Figure 2). The results demonstrate that KI and K3 can reduce palm oil fruit loss compared to K0 at 5 and 6 DAA. During 1 to 3 DAA, the K0 treatment resulted in less loss than the $KMnO_4$ treatment, but the quantity of loss increased during 4 to 6 DAA observations. This specific chemical application can reduce fruit loss at 4 to 6 DAA. Based on the total number of fallen fruits, the K0 treatment had the highest (230 grains), whereas the K3 treatment had the fewest (184 grains).

The fruit that fell off indicated that hardness and degradation had happened in the cell walls of the fruit and spikelet; the fruit that fell had more FFA than the fruit that remained attached to the spikelet. Fallen fruit is more vulnerable to fungal infection than normal fruit (Corley & Tinker 2016). The low auxin concentration and high ethylene content in the abscission zone cause fruit fall (abscission) (Taiz & Zeiger 2002). $KMnO_4$ is an environmentally friendly oxidant that can convert ethylene into CO_2 and H_2O (Alvarez-Hernandez *et al*. 2018). The application of $KMnO_4$ to FFB is expected to oxidize ethylene, reducing fruit fall during the waiting period in the field.

Fruit Respiration Rate

Except for day 5, there were substantial variations in respiratory rate between days 1−6 DAA (Figure 3). In general, the control (K0) and lower concentration treatment (K1) displayed higher respiration rates than treatments with higher concentrations of $KMnO_4$ (K2, K3). On the fifth day, no significant variations were seen between treatments, showing that the fruit's respiration rate was largely consistent throughout all treatments. This shows that $KMnO_4$ has a role in slowing down fruit metabolism. However, at certain

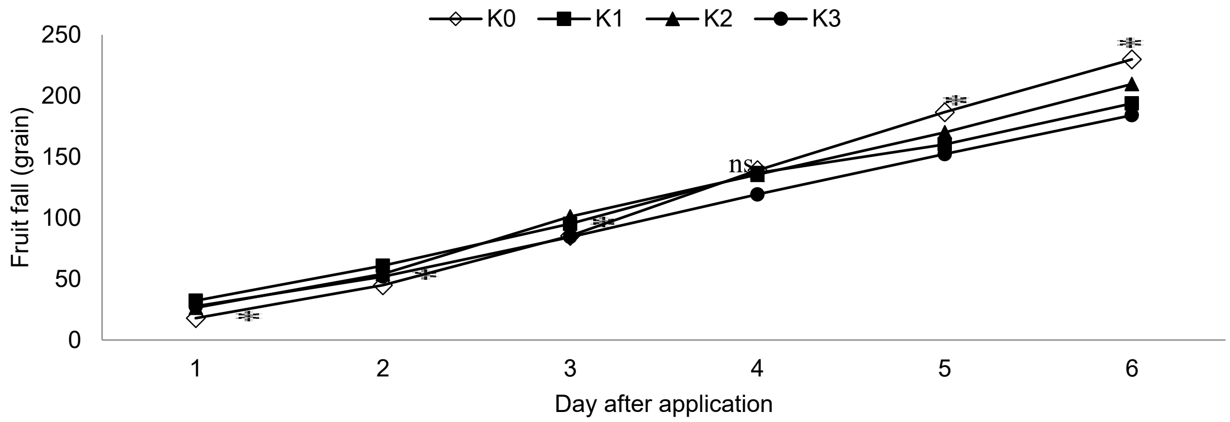

Figure 2 Effect of $KMnO_4$ application on the fruit fall. Differences between means are labelled with * (α = 0.05); ns (not significant), K0 = 0%, K1 = 0.025%, K2 = 0.050%, K3 = 0.075%.

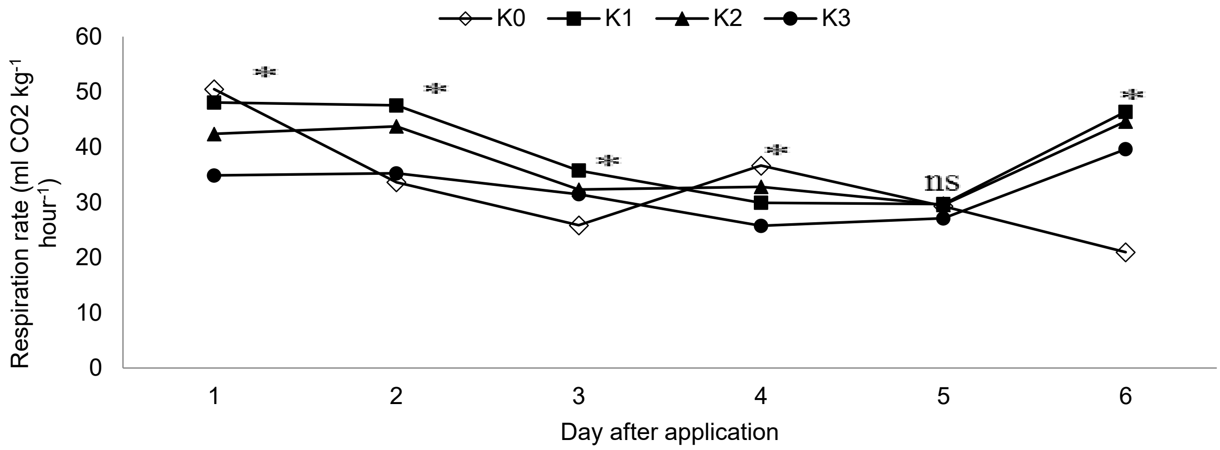

Figure 3 Effect of $KMnO_4$ application on the fruit respiration rate. Differences between means are labelled with * (α = 0.05); ns (not significant), K0 = 0%, K1 = 0.025%, K2 = 0.050%, K3 = 0.075%.

intervals (day 5), the treatment effect was no longer substantial.

After harvest, the respiration rate remained steady or fell slightly to a minimum before rapidly increasing to a maximum. There was a significant distinction between the ripening and ripening phases, and exogenous ethylene was found to initiate and accelerate ripening in climacteric fruits (Liu *et al*. 2015; Chen *et al*. 2018). Adding $KMnO_4$ will keep the ethylene content low, extending the fruit's shelf life. Ethylene in the air can be converted to O_2 and CO_2 by $KMnO_4$ (Alvarez-Hernandez *et al*. 2018).

Fruit Mesocarp Firmness

At 6 DAA, the application of $KMnO_4$ decreased mesocarp firmness (Figure 4). The control treatment had a lower fruit firmness value at 1 DAA, but the value the next day was higher than the other treatments. The hardness of the mesocarp grew gradually throughout the observation. At 6 DAA, the $KMnO_4$ treatment reduced fruit firmness by 6.19% (K1), 9.31% (K2), and 12.3% (K3) when compared to the K0 treatment. The higher the quantity of $KMnO_4$, the greater the loss in mesocarp stiffness.

During fruit ripening, the cell wall changes, causing the fruit to lose its hardness (Wang *et al*. 2018; Zhang *et al.* 2019). Fruit firmness is caused by a mechanism that occurs within the fruit. Fruit respiration has several impacts, including increased fruit firmness. The respiration rate is proportional to the firmness and temperature of the palm oil fruit, with firmness increasing as the respiration rate increases (Adiningsus 2017).

Number of Microbes on the Surface of the Fruit Mesocarp

$KMnO_4$ treatment can decrease the number of bacteria and fungus (Table 1). The quantity of bacterial colonies exceeds the amount of fungus. The G0 treatment produced the most colonies, 9.3×10^8 CFU mL^{-1} (bacteria) and 5.1×10^5 CFU mL^{-1} (fungi). The number of microorganisms on the mesocarp surface decreases as the quantity of $KMnO_4$ increases. The K1 treatment included the most microorganisms compared to the other treatments, with 5.2×10^8 CFU mL^{-1} colonies (bacteria) and 1.5×10^5 CFU mL^{-1} (fungi). The K2 treatment produced 2.8×10^8 CFU mL^{-1} bacterial colonies and 1.3×10^5 CFU mL^{-1} fungal colonies. The K3 treatment exhibited the lowest microbial count, with 1.5×10^8 bacterial colonies and 0.4×10^5 fungal colonies per mL. Bacteria and fungus are the microbes that live on the mesocarp's surface. $KMnO_4$ is a powerful oxidizing agent (Dash *et al*. 2009). The drop in the quantity of germs is thought to be caused by $KMnO_4$, a strong oxidizing chemical that can damage bacterial structures.

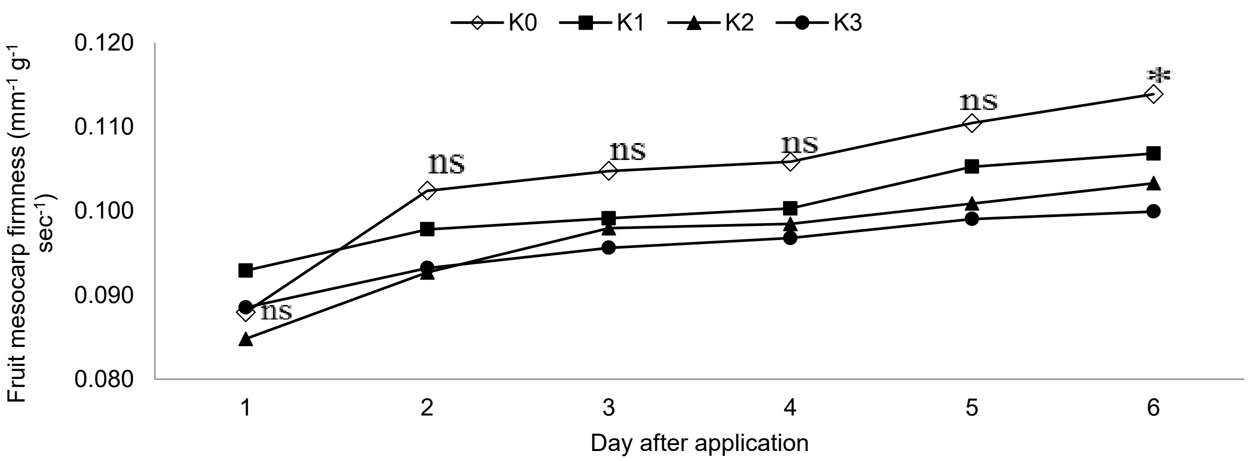

Figure 4 Effect of $KMnO_4$ application on the fruit mesocarp firmness. Differences between means are labelled with * (α = 0.05); ns (not significant), K0 = 0%, K1 = 0.025%, K2 = 0.050%, K3 = 0.075%.

Table 1 Effect of $KMnO_4$ application on the number of microbes on the surface of the fruit mesocarp

Treatment	Colony count (CFU ml^{-1} at 5 DAA	
	Bacteria	Fungi
K0 (0 %)	$9.3 \times 10^{8\,a}$	$5.1 \times 10^{5\,a}$
K1 (0.025 %)	$5.2 \times 10^{8\,b}$	$1.5 \times 10^{5\,ab}$
K2 (0.050 %)	$2.8 \times 10^{8\,c}$	$1.3 \times 10^{5\,ab}$
K3 (0.075 %)	$1.5 \times 10^{8\,c}$	$0.4 \times 10^{5\,b}$

Remarks: Means in the same column followed by the same letter are not significantly different based on DMRT at 0.05 level. DAA: day after application.

Oil Yield Content

Oil yield was detected on days 1 and 3 of DAA, since extraction on day 5 was not optimal due to partial water removal from the oil. Adding $KMnO_4$ significantly increased oil yields. The oil output dropped from day 1 to day 3 DAA (Table 2) demonstrating that oil recovery decreased during FFB storage. On day 1 of DAA, fruits treated with $KMnO_4$ yielded more oil than the control (K0). Among treatments, K1 had the highest yield, with 23.07% on day 1 DAA and 20.69% on day 3 DAA, while K2 had the lowest yield, with 22.26% on day 1 DAA and 20.03% on day 3.

Free Fatty Acid Content

FFB treatment exhibited the greatest levels of FFA on each observation day. The lower the quantity of $KMnO_4$, the more FFA is generated. CPO treated with $KMnO_4$ can meet SNI-01-2901-2006, with an FFA concentration of less than 5%. The K0 treatment at 5 DAA did not meet SNI-01-2901-2006's FFA requirement of 5.11%.

$KMnO_4$, an antibiotic, can reduce the quantity of bacteria on the FFB surface (Table 3). According to Mangoensoekarjo and Semangun (2003), the activities of bacteria and fungus gradually cause harm to the oil in the fruit, one of which is a rise in FFA concentration due to oxidative reactions. According to Pahan (2008), fruit soreness is caused by the activities of microorganisms like bacteria and fungi. One of the diseases of palm oil is bunch rot, which is caused by the fungus *Marasmius palmivorus*. Fruit bunches that are severely afflicted by this disease can raise FFA levels in the oil. According to Lukito and Sudradjat (2017), poor physical quality of the fruit can considerably increase FFA content when combined with CPO processing. Every 1% of poor-quality fruit processed increases the FFA concentration of CPO by 0.04%. The poor physical quality in concern includes unripe and overripe fruit, empty fruit bunches, rotten fruit, and abnormal fruit.

Correlation between Observed Variables

Correlation coefficient values are divided into numerous categories: deficient (0.00−0.199), low (0.20−0.399), moderate (0.40−0.599), high (0.60−0.799), and extremely strong (0.80−1.00). There was a relationship between FFB weight loss, fruit mesocarp stiffness, fruit respiration rate, FFA content, and the quantity of bacteria and fungi (Table 4). The relationship between variables is either positive or

Table 2 Effect of KMnO4 application on oil yield content

Treatment	Oil yield (%)	
	1 DAA	3 DAA
K0 (0 %)	20.95^{c}	20.69^{a}
K1 (0.025 %)	23.07^{a}	20.69^{a}
K2 (0.050 %)	22.26^{bc}	20.03^{b}
K3 (0.075 %)	22.43^{ab}	20.05^{b}

Remarks: Means in the same column followed by the same letter are not significantly different based on DMRT at 0.05 level. DAA: day after application. K0 = 0% KMnO4, K1 = 0,025% KMnO4, K2 = 0,050% KMnO4, K3 = 0,075% KMnO4

Table 3 Effect of $KMnO_4$ application on free fatty acid content

Treatment	Free fatty acid (%)		
	1 DAA	3 DAA	5 DAA
K0 (0 %)	3.69^{a}	4.40^{a}	5.11^{a}
K1 (0.025 %)	3.16^{ab}	3.83^{b}	4.35^{ab}
K2 (0.050 %)	3.00^{b}	3.40^{b}	3.70^{b}
K3 (0.075 %)	3.02^{b}	3.31^{b}	3.49^{b}

Remarks: Means in the same column followed by the same letter are not significantly different based on DMRT at 0.05 level. DAA: day after application. K0 = 0% KMnO4, K1 = 0,025% KMnO4, K2 = 0,050% KMnO4, K3 = 0,075%.

Table 4 Correlation coefficient of $KMnO_4$ application between variables at 5 DAA

Variable	WL	FF	RR	FFs	FFA	NB
FF	0.841*					
RR	0.555*	0.631*				
FFs	0.612*	0.567*	0.493^{ns}			
FFA	0.790*	0.627*	0.620*	0.656*		
NB	0.853*	0.657*	0.416^{ns}	0.734*	0.843*	
NF	0.824*	0.633*	0.465^{ns}	0.728*	0.693*	0.693*

Remarks: *: significant α = 5%; ns: not significant. WL: weight loss; FF: fruit fall; RR: respiration rate; FFs: fruit firmness; NB: number of bacteria, NF: number of fungi, FFA: free fatty acid. DAA: day after application.

unidirectional. The variable's direction is positive/unidirectional, which indicates that if one variable's value increases, so will the other, and *vice versa*.

FFB weight loss and fruit respiration rate (0.555) showed a moderate unidirectional association, as did fruit fall and fruit mesocarp hardness (0.567). FFB weight loss and fruit mesocarp moisture content (0.762); FFB weight loss and fruit mesocarp firmness (0.612); FFB weight loss and FFA content (0.790); fruit fall and fruit respiration rate (0.631); loss of fruit and FFA content (0.627); fruit fall and bacterial count (0.657); fruit fall and the number of fungi (0.633); fruit respiration rate and FFA level (0.656); The hardness of fruit mesocarp and the number of bacteria (0.734); the firmness of fruit mesocarp and the number of fungi (0.728); the content of FFA and the number of fungi (0.693); and the number of bacteria and fungus (0.693). Simultaneously, the weight loss of FFB and fruit fall (0.841); weight loss of FFB and the number of bacteria (0.853); weight loss of FFB and the number of fungi (0.824); fruit mesocarp moisture content and the number of bacteria (0.854); and FFA content and the number of bacteria (0.843) all show a strong unidirectional association.

CONCLUSION

The application of $KMnO_4$ preserved the physical and chemical quality of palm oil FFB, ensuring that the shelf life of FFB and the quality produced were ideal. $KMnO_4$ concentrations of 0.05% and 0.075% were the best in controlling FFB weight loss, fruit fall, fruit respiration rate, and fruit mesocarp stiffness for 6 DAA. $KMnO_4$ concentrations of 0.05% and 0.075% can prevent an increase in free fatty acid level of up to 5 DAA. KMnO4 values of 0.05% and 0.075%. A $KMnO_4$ concentration of 0.025% is the most effective in preventing oil content decline by up to 3 DAA. The following $KMnO_4$ application factors are related: weight loss of FFB, fruit mesocarp firmness, fruit respiration rate, FFA content, and the quantity of bacteria and fungi. The relationship between variables is either positive or unidirectional. Variables with a strong unidirectional relationship include FFB weight loss and fruit fall, weight loss of FFB and bacteria, weight loss of FFB and fungi, fruit mesocarp moisture content and bacteria, and FFA content and bacteria.

REFERENCES

Adiningsus Y. 2017. Aplikasi kalium permanganat untuk menjaga mutu fisik tandan buah segar kelapa sawit (*Elaeis guineensis* Jacq.) [Undergraduate thesis]. Bogor (ID). Institut Pertanian Bogor.

Alvarez-Hernandez MH, Artes-Hernandez F, Avalos-Belmontes F, Castillo-Campohermoso MA, Contreras-Esquivel JC. Ventura-Sobrevilla JM, Martínez-Hernández GB. 2018. Current scenario of adsorbent materials used in ethylene scavenging systems to extend fruit and vegetable postharvest life. *Food and Bioprocess Technology* 11: 511–525. https://doi.org/10.1007/s11947-018-2076-7

[BBP2TP] Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian. 2008. Teknologi Budi Daya Kelapa Sawit. Lampung (ID): Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian.

Chen Y, Grimplet J, David K, Castellarin SD, Terol J, Wong DCJ, Luo Z, Schaffer R, Celton JM, Talon M, Gambetta GA, Chervin C. 2018. Ethylene receptors and related proteins in climacteric and non–climacteric fruits. *Plant Science*. 276: 63–72. https://doi.org/10.1016/j.plantsci.2018.07.012

Corley RHV, Tinker PB. 2016. The Palm Oil, World Agricultural Series. 5th Ed. Chichester (UK): Wiley Blackwell.

Dash S, Patel S, Mishra B. 2009. Oxidation by permanganate: Synthetic and mechanistic aspects. *Tetrahedron*. 65(4): 707–739. https://doi.org/10.1016/j.tet.2008.10.038

Hasibuan HA. 2016. Deterioration of bleachability index pada crude palm oil: Bahan review dan usulan untuk SNI 01–2901–2006. *Jurnal Standardisasi*. 18(1): 24–33. https://doi.org/10.31153/js.v18i1.694

Kowitcharoen L, Wongs AC, Setha S, Kukhunthod R, Kondo S, Srilaong V. 2018. Pre-harvest drought stress treatment improves antioxidant activity and sugar accumulation of sugar apple at harvest and during storage. *Agriculture & Natural Resources*. 52: 146–154. https://doi.org/10.1016/j.anres.2018.06.003

Kusumiyati K, Farida F, Sutari W, Hamdani JS, Mubarok S. 2018. Pengaruh waktu simpan terhadap nilai total padatan terlarut, kekerasan dan susut bobot buah mangga Arumanis. *Jurnal Kultivasi*. 17(3): 766–771. https://doi.org/10.24198/kultivasi.v17i3.18698

Laily M. 2020. Pengaruh kalium permanganat terhadap mutu fisik tandan buah segar kelapa sawit (*Elaeis guineensis* Jacq.). [Undergraduate thesis]. Bogor (ID): Institut Pertanian Bogor.

Liu M, Pirrello J, Chervin C, Roustan JP, Bouzayen M. 2015. Ethylene control of fruit ripening: revisiting the complex network of transcriptional regulation. *Plant Physiology*. 169: 2380–2390. https://doi.org/10.1104/pp.15.01361

Lukito PA, Sudradjat. 2017. Pengaruh kerusakan buah kelapa sawit terhadap kandungan *free fatty acid* dan rendemen CPO di Kebun Talisayan 1 Berau. *Buletin Agrohorti*. 5(1): 37–44. https://doi.org/10.29244/agrob.5.1.37-44

Mangoensoekarjo S, Semangun H. 2003. *Manajemen Agrobisnis Kelapa Sawit*. Yogyakarta (ID). Gajah Mada University Pr.

Maulana AF, Susanto WH. 2015. Pengaruh penyemprotan larutan kalsium propionat dan kalium sorbat pada pascapanen kelapa sawit (*Elaeis guineensis* Jacq.) terhadap kualitas CPO. *Jurnal Pangan dan Agroindustri*. 3(2): 453–463.

Pahan I. 2008. *Kelapa Sawit Manajemen Agribisnis dari Hulu hingga Hilir*. Jakarta (ID): Penebar Swadaya.

Pradhana AY, Hasbullah R, Purwanto YA. 2013. Pengaruh penambahan kalium permanganat terhadap mutu pisang (cv Mas Kirana) pada kemasan atmosfer termodifikasi aktif. *Jurnal Pascapanen*. 10(2): 83–94. https://doi.org/10.21082/jpasca.v10n2.2013.83-94

Sholihati, Abdullah R, Suroso. 2015. Kajian penundaan kematangan pisang raja (*Musa paradisiaca* var. Sapientum L.) melalui penggunaan media penyerap etilena kalium permanganat. *Jurnal Rona Teknik Pertanian*. 8(2): 76–89. https://doi.org/10.17969/rtp.v8i2.3005

[SNI] Standar Nasional Indonesia. 2006. SNI 01–2901–2006 Minyak Kelapa Sawit Mentah (Crude Palm Oil). Jakarta (ID): Badan Standardisasi Nasional.

Sutrisno, Mahmudah I, Sugiyono. 2008. Kajian penyimpanan dingin buah manggis segar (*Garcinia mangostana* L.) dengan perlakuan kondisi proses penyimpanan. In: Yogyakarta (ID): *Seminar Nasional Teknik Pertanian.*

Taiz L, Zeiger E. 2002. *Plant Physiology*. 3rd Ed.. Sunderland, Massachusetts (US): Sinauer Associates Publ.

Wang D, Yeats TH, Uluisik S, Rose JKC, Seymour GB. 2018. Fruit firmness: Revisiting the role of pectin. *Trends Plant Science*. 23: 302–310. https://doi.org/10.1016/j.tplants.2018.01.006

Zhang C, Xiong Z, Yang H, Wu W. 2019. Changes in pericarp morphology, physiology and cell wall composition account for flesh firmness during the ripening of blackberry (*Rubus* spp.) fruit. *Scientia Horticulturae*. 250: 59–68. https://doi.org/10.1016/j.scienta.2019.02.015