Journal of Innovation and Research in Agriculture
Vol. 03 No. 02 (2024)

Mortality of Dysmicoccus neobrevipes Beardsley and Mangosteen Shelf Life (Garcinia mangostana L.) Consequences of Applying Patchouli Essential Oil Concentration (Pogostemon cablin Benth) at the Maturity Level of Mangosteen in the Laboratory

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ABSTRACT

Mangosteen is a flagship fruit as a potential export commodity with high economic value. The export activities of Indonesian mangosteen are limited due to constraints of plant pest organisms (OPTK) and the quality of mangosteen fruit. The use of patchouli essential oil can be an environmentally friendly alternative control method that does not leave residues and can maintain the quality of mangosteen fruit. The purpose of this research is to identify the type of mealybugs that attack mangosteen fruit and the effect of patchouli essential oil on the mortality of mealybugs and the shelf life of mangosteen (color, weight loss, and firmness). The research was conducted at the Entomology Laboratory of Animal, Fish, and Plant Quarantine, West Java, from January to April 2024. The method used was an experimental method with a Split Plot Completely Randomized Design. Mortality and shelf life testing was conducted with 16 treatments, namely n0k1, n0k2, n0k3, n0k4, n1k1, n1k2, n1k3, n1k4, n2k1, n2k2, n2k3, n2k4, n3k1, n3k2, n3k3, and n3k4 (n= concentration of patchouli oil 10 ml/L; 20 ml/L; and 30 ml/L; k= fruit maturity level 3, 4, 5, and 6), each repeated twice. The results showed that the mealybug that attacks mangosteen fruit and was the subject of the study is Dysmicoccus neobrevipes. The use of patchouli essential oil at a test concentration of 30 ml/L could increase the mortality of Dysmicoccus neobrevipes at all levels of mangosteen fruit maturity. This concentration caused 100% mortality of Dysmicoccus neobrevipes at maturity level six 72 hours after treatment. The 30 ml/L concentration of essential oil also maintained the shelf life of mangosteen fruit, resulting in low color change values (0.24-0.35), low weight loss (50.35-61.91 g), and low fruit firmness levels (34.50-43.15 kg.s/mm).

Keyword : *Dysmicoccus neobrevipes, Quarantine, Fruit hardness, Color level.*

INTRODUCTION

Mangosteen (Garcinia mangostana L.) is a fruit native to Southeast Asia which is widely found in Myanmar, the Philippines, Thailand and Indonesia. There are approximately 100 types of mangosteen in Indonesia. This number is equivalent to 25% of the total 400 types of mangosteen around the world (Rizaty, 2023). The Central Statistics Agency (BPS) noted that mangosteen production in Indonesia was 341,850 tons in 2022. This amount increased by 12.5% compared to the previous year which was 303,934 tons (Muhammad, 2023).

The distinctive taste and good nutritional content for health make mangosteen a potential export commodity with high economic value. The government encourages the community to increase the production and quality of mangosteen so that it is able to compete with other commodities in the international market. The Government's efforts are to open market access to mangosteen fruit in several partner countries, such as China, Hong Kong, Southeast Asia, Europe and the Middle East. (Marina, I., et al. 2017).

China is one of the largest export destinations for mangosteen. This can be seen from the number of mangosteen requests that are always high every year to meet the needs of fresh fruit, religious celebrations, or as souvenirs when visiting family (Siboro, 2015). The requirements for mangosteen exports to China based on the protocol include that the fruit comes from a registered garden, the fruit has gone through a process of sorting, washing, spraying with high-pressure air, packaged in a registered container house, and the fruit must be free from Quarantine Plant Pests (OPTK), dirt and others. OPTK that is prohibited from being found in exported mangosteen include Planococcus minor (Maskell), Bactrocera carambolae Drew & Hancock, B. papayae Drew & Hancock, B. dorsalis (Hendel), B. zonata (Saunders), Dysmicoccus lepelleyi (Betrem), P. lilacinus (Cockerell),

Aspidiotus rigidus Reyne, Paraputo odontomachi (Takahashi), Exallomochlus hispidus (Morrison), Pseudococcus baliteus Lit, Paracoccus interceptus Lit, Hordeolicoccus heterotrichus Williams, Pseudococcus aurantiacus Williams, Rastococcus spinosus (Robinson), Ceroplastes stellifer (Westwood) and Dysmicoccus neobrevipes Beardsley. (Harti, A. O. et al. 2024).

Mangosteen export activities, in addition to being free of OPTK, food safety supervision is also a concern. The exported mangosteen fruit must be free from residue. The Chinese government claims that Indonesian mangosteen fruit contains cadmium chemical residue pollution of 0.065 milligrams, which far exceeds the tolerance limit set by the Chinese government of 0.05 milligrams (Hamdani, 2015). Therefore, the use of vegetable pesticides derived from essential oils is one of the control alternatives that can be done to free mangosteen from chemical residues. (Pangestika, D. N., et al. 2024).

Essential oils can be toxic to insects. The use of this insect repellent is expected not to affect food safety and not damage the environment. Exposure to essential oils results in changes in insect movement (locomotor) and tends to avoid toxic environments (Plata-Rueda et al., 2020). Essential oils are biodegradable so they do not pollute the environment and are relatively safe for humans (Libs and Salim, 2017). One of the essential oils from patchouli (Pogostemon cablin) can be used as a natural insecticide to control insects.

In addition to being free of OPTK and free of chemical residues, mangosteen must also meet quality requirements for export. The quality of mangosteen fruit is determined by various parameters, one of which is the ripeness level parameter based on the color index. The higher the ripeness color index, the smaller the shelf life of the mangosteen. (Galtieri, Y., et al. 2024). Factors The use of peppermint oil and lime oil in a ratio of 1:3 in mangosteen can inhibit fungal growth and decay so that it can delay the ripening process by reducing weight loss changes, maintaining the color and maturity of the fruit (Iyiola et al. 2021). Essential oils and plant extracts have shown their potential to protect and improve fruit quality before and after harvest due to their antimicrobial properties (Mohd Israfi et al., 2022). Therefore, it is necessary to test the shelf life of mangosteen by treating the concentration of patchouli essential oil solution at the maturity level of mangosteen in the laboratory.

MATERIALS AND METHODS

The method used was an experimental method with a Complete Random Design (RAL) Split Plot as many as 16 treatments with 2 replicates. This method was used by conducting experiments to study the effect of patchouli essential oil on the mortality of mealybugs D. neobrevipes and also its effect on the maturity index of mangosteen which at the same time affects the shelf life of mangosteen in the laboratory.

Place and Time of Research

The research was carried out from January 2024 to April 2024. The collection of test insects was carried out from a mangosteen container. The manufacture of essential oils and GC-MS analysis was carried out at the National Research and Innovation Agency (BRIN), Cibinong, Bogor, West Java Province. Furthermore, the research was carried out by the West Java Animal, Fish and Plant Quarantine Entomology Laboratory.

Materials and Tools

The materials used in this study are mealybug D. neobrevipes, aquades, kaboca, chayote and sprouted potatoes, gauze, tween 80, mangosteen fruit, petroleum jelly, tissues, cotton, and patchouli essential oil. The tools used in this study were microscopes, tweezers, fine brushes, plastic containers, petri dishes, pipettes, scissors, label paper, markers, cling wrap, 5 L plastic jars, digital timers, GCMS-QP2010 SE, analytical scales, durometers, Canon EOS 1100D cameras, color detection applications and documentation tools.

Research Preparation

Collection and Identification of Test Insects in the Field. Sampling of D. neobrevipes was carried out by purposive sampling method. The sample was obtained from mangosteen fruit. The mangosteen fruit found in D. Neobrevipes were taken using and then put into a 5-liter plastic jar containing a kaboca and then given a black gauze cover. Mealybugs are kept in the laboratory at a temperature and humidity of 28 ± 1oC and 70% ± 5% respectively. Irradiation was carried out for 12 hours of light and 12 hours of darkness using TL lamps (Kuswadi et al., 2016; Tanga et al., 2013). Maintenance aims to purify mealybugs so that mealybug populations of the same type are obtained. The identification of test insects was carried out in the insect laboratory of the West Java Animal, Fish and Plant Quarantine. The collection and identification were carried out by making permanent preparations for the first offspring of

propagation that had reached a young imago and then identified using the book Mealybugs of Southern Asia by Williams (2004).

Propagation of Dysmicoccus neobrevipes. The propagation technique is by using an alternative host, namely pumpkin (Cucurbita moscata) (Doan et al., 2016). Mealybugs can also be kept in kabocha (Cucurbita maxima) which is carried out in a laboratory with a room temperature of about 25±2oC and a humidity of 70±10% (Mamahit et al., 2008). In addition to pumpkin, another plant that can be used is chayote. The chayote to be used is washed with a 0.45% soap solution, dried and then placed in a plastic container (Syauqi, 2019). One female imago is infested using a fine brush into the kaboca which is then isolated. After producing offspring, ten adult imago are transferred to chayote or potato shoots until uniformly aged D. neobrevipes offspring are obtained that will be used for essential oil treatment. Temperature and humidity at the time of propagation are maintained at 28 ± 1oC and 70% ± 5°C respectively.

Essential Oil Manufacturing. The eucalyptus and patchouli essential oils used come from PT. WIGNJA Battra Indonesia (Bantul, Yogyakarta) from steam distillation distillation extraction. Patchouli plants are taken from leaves and twigs that are distilled at a temperature of 110 oC for 6 hours. Furthermore, at the stage of making patchouli essential oil, the leaves are distilled at a temperature of 94 oC for 10 hours.

Preparation of Test Solution. The essential oil to be used consists of patchouli. The preparation of the test solution begins by making a parent solution by taking 5 ml of essential oil and putting it into a 100 ml measuring flask. Next, a tween 80 concentration of 1% dissolved in aquades was made. The solution is put into a measuring flask containing essential oils until the volume reaches 100 ml and then shaken until homogeneous. Furthermore, the concentration was made by taking a parent solution of 10 ml, 20 ml, and 30 ml to make concentrations of 0 ml/l, 10 ml/l, 20 ml/l and 30 ml/l.

Test Implementation

The test was carried out by dipping the test mangosteen fruit into each test solution (10 ml/L; 20 ml/L; and 30 ml/L). The number of test mangosteen fruits per plot is 10 fruits with different levels of ripeness. So that the total number of mangosteen needed is 320 test mangosteens, including 80 test mangosteen with a maturity index of 3, 80 mangosteen with a maturity index of 4, 80 mangosteen with a maturity index of 5, and 80 mangosteen with a maturity index of 6 (attached). After dyeing the test mangosteen fruit for about 2 seconds into each test solution, then an infestation of mealybug D. neobrevipes was carried out on the test mangosteen that had been treated.

Pengamatan

Mortalitas Dysmicoccus neobrevipes

Pengamatan dilakukan sebanyak 6 kali dengan rentang 0, 12, 24, 36, 48, 60, dan 72 jam setelah perlakukan. Pengamatan mortalitas D. neobrevipes dihitung dengan rumus :

$$\text{Mortalitas (\%)} = \frac{\text{Jumlah D. neobrevipes yang mati}}{\text{Jumlah D. neobrevipes yang diuji}} \times 100\%$$

Daya Simpan Manggis

Indeks kematangan buah manggis digunakan tingkat kematangan dengan indeks 3, 4, 5, dan 6. Untuk mengetahuan daya simpan manggis ditentukan oleh:

Tingkat warna. Warna kulit buah manggis setelah perlakuan dan kontrol diukur dengan deteksi warna. Sistem deteksi warna dengan citra RGB (Red, Green and Blue) yang di konversi ke HSV (Hue, Saturation and Value). cara mengubah RGB ke HSV sebagai berikut :

$$H = \tan\left(\frac{3(G-B)}{(R-B)+(R-B)}\right)$$

$$S = 1 - \frac{\min(R,G,B)}{V}$$

$$V = \frac{R+G+B}{3}$$

Susut Bobot. Pengukuran susut bobot buah dilakukan dengan menghitung persentase selisih massa buah manggis yang diukur sebelum dan sesudah iradiasi dengan alat ukur timbangan analitik Denver Instrument T-214. Hasil pengukuran berupa persentase massa manggis yang hilang sebelum dan sesudah iradiasi. Nilai persentase susut bobot dinyatakan sebagai berikut:

Susut bobot (%) = (Wo-Wt)/Wo x 100%

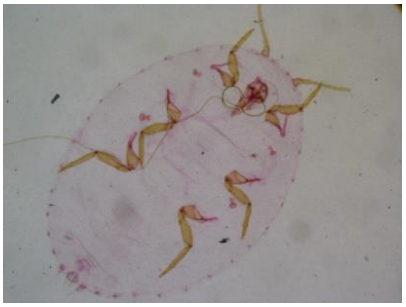
Keterangan: Wo = Bobot buah dengan tingkat kematangan ke-n sebelum perlakuan (g); Wt = Bobot buah dengan tingkat kematangan ke-n setelah perlakuan (g)

Kekerasan Buah. Tingkat kekerasan buah manggis diukur pada tiga bagian, yaitu: pangkal, tengah, dan ujung buah dengan alat ukur durometer. Pengukuran dilakukan pada buah manggis setelah diberi perlakuan dan kontrol. Hasil pengukuran dalam satuan Kg.sec/mm.
Kekerasan = (Gaya yang Diberikan)/(Luas Permukaan(πr^2)

RESULTS AND DISCUSSION

Identifikasi Kutu Puth Dysmicoccus neobrevipes Beardsley

Kutu putih D. neobrevipes diambil sampel pada buah manggis hasil panen di Kecamatan Puspahiang Kabupaten Tasikmalaya. Setelah dilakukan



Gambar 1. *Morfologi Dysmicoccus neobrevipes*

The results of identification using dichotomous keys in the book Mealbugs of Southern Asia by Williams (2004) are characterized by an oval body shape and have 17 pairs of cerarii, anal lobe cerarii has 2 conical setae, antennae consist of 8 segments, there is a discoidal pore adjacent to the eye, cerarii in the abdomen often has more than 2 conical seta, translucent pore only on the femur and posterior tibia, The multilocular disc pore is located around the vulva and in the ventral part of the VI abdominal segment, the dorsal sheath in front of the anal ring (segment VIII) is short, the same length as the other dorsal sheath and the oral collar tubular duct is 2 sizes. To ensure the results of identification, a referral was made to the Animal, Fish and Plant Quarantine Standard Test Center in Jakarta.

Effect of Patchouli Essential Oil Concentration on Mealybug Mortality of Dysmicoccus neobrevipes Beardsley

The use of patchouli essential oil and the maturity level of mangosteen showed a significant effect over control. The higher the concentration of the patchouli essential oil used and the higher the maturity level of the mangosteen fruit, the higher the mortality of Dysmicoccus neobrevipes. The mortality data of Dysmicoccus neobrevipes mealybug is presented in Table 1.

Table 1. Mortality of mealybugs Dysmicoccus neobrevipes due to patchouli essential oil treatment at several levels of mangosteen fruit ripeness

Observation to- (hours after treatment)	Patchouli Concentration (ml/L)	Mortality of Mealybug *Dysmicoccus neobrevipes* (%) at the maturity level of mangosteen			
		K1	K2	K3	K4
0	N0	0 a	0 a	0 a	0 a
	N1	0 a	0 a	0 a	0 a
	N2	0 a	0 a	0 a	0 a
	N3	0 a	0 a	0 a	0 a
12	N0	0,00 a A	1,25 a A	0,00 a A	2,50 a A
	N1	11,25 a B	18,75 b B	21,25 b B	21,25 b B
	N2	26,25 a C	27,50 a C	28,75 a C	31,25 a C

	N3	31,25 a D	32,50 a C	36,25 a D	38,75 a D
24	N0	0,00 a A	1,25 from A	0,00 a A	3,75 b A
	N1	21,25 a B	30,00 b B	32,50 bc B	37,50 c B
	N2	45,00 a C	47,50 from C	48,75 bc C	51,25 c C
	N3	55,00 a D	61,25 b D	63,75 b D	68,75 c D
36	N0	0,00 a A	1,25 a A	1,25 a A	3,75 a A
	N1	26,25 a B	31,25 b B	37,50 c B	42,50 D B
	N2	48,75 a C	52,50 b C	53,75 bc C	56,25 c C
	N3	65,00 a D	68,75 from D	77,50 bc D	81,25 c D
48	N0	2,50 a A	1,25 a A	1,25 a A	3,75 a A
	N1	29,00 a B	36,25 a B	42,50 c B	50,00 D B
	N2	58,75 a C	65,00 b C	68,75 b C	75,00 c C
	N3	82,50 a D	87,50 a D	93,75 b D	95,00 b D
60	N0	2,50 a A	1,25 a A	1,25 a A	3,75 d A
	N1	35,00 a B	42,50 b B	47,50 c B	56,25 d B
	N2	66,25 a C	72,50 from C	77,50 bc C	81,25 c C
	N3	90,00 a D	96,25 b D	98,75 b D	100,00 b D
72	N0	2,50 a A	1,25 a A	1,25 a A	3,75 a A
	N1	35,00 a B	42,50 b B	47,50 c B	56,25 d B
	N2	66,25 a C	72,50 from C	77,50 bc C	81,25 c C
	N3	90,00 a D	96,25 b D	98,75 b D	100,00 b D

Description: The number followed by the same letter did not differ significantly according to the Duncan double distance follow-up test at the real level of 5%. Lowercase letters are read in the horizontal direction (row) and capital letters are read in the vertical direction (columns). N0: without patchouli essential oil, N1,2,3: patchouli essential oil concentration 10 ml/L; 20 ml/L; and 30 ml/L, K1,2,3,4: the ripeness of mangosteen at indices 3, 4, 5 and 6.

Based on the data presented in the table above, Dysmicoccus neobrevipes mealybugs experience different mortality rates with each observation. Since observation 12 hours after inoculation, the use of patchouli essential oil has shown a significant difference in the mortality of mealybug D. neobrevipes when compared to control. This is because patchouli essential oil contains pogostone compounds that are contact toxins and antifeedants so that they can cause high mortality in insects in a relatively short time (Chen et al., 2020). Meanwhile, the maturity level also showed a significant

influence on the mortality of mealybugs D. neobrevipes since 12 hours of observation. This is because the water content is decreasing at a high level of maturity (Agricultural Research and Development Agency, 2000) which makes it difficult for mealybugs D. neobrevipes to penetrate the skin of mangosteen fruits.

The highest concentration treatment of patchouli essential oil showed a high mortality rate from 12 hours after treatment. This is suspected because the compound content in patchouli essential oil is very toxic so that it is able to increase the mortality rate of mealybugs in a short time. The results of the study are in accordance with the statement of Khater (2012) which stated that essential oils can cause high mortality in a short time. As time went on, the mortality of D. neobrevipes mealybugs increased. Until the last observation, mealybug D. neobrevipes with the highest mortality of 100% occurred in the treatment of patchouli essential oil 30 ml/L.

Effect of Patchouli Essential Oil Concentration on Color Level in Mangosteen Fruit

The color level is one of the characteristics that can indicate the level of maturity of the mangosteen fruit. The darker the color of the fruit, the higher the ripeness in the mangosteen fruit. The effect of the use of essential oils on mangosteen fruits is found in Table 2. Based on this data, patchouli essential oil is able to slow down the color change in mangosteen fruits.

Table 2. The color level of mangosteen fruit in the treatment of patchouli essential oil concentration

Pengamatan ke-	Konsentrasi Nilam (ml/L)	Tingkat warna buah manggis (…) pada tingkat kematangan ke-			
		K_1	K_2	K_3	K_4
1	N_0	0,68 b A	0,56 ab A	0,51 a A	0,47 a A
	N_1	0,61 c A	0,54 bc A	0,50 ab A	0,46 a A
	N_2	0,61 a A	0,54 a A	0,49 a A	0,45 a A
	N_3	0,59 b A	0,53 ab A	0,48 a A	0,44 a A
2	N_0	0,66 b A	0,56 ab A	0,50 a A	0,46 a A
	N_1	0,60 c A	0,54 bc	0,50 a A	0,45 a A
	N_2	0,59 a A	0,53 a A	0,48 a A	0,44 a A
	N_3	0,58 b A	0,51 ab A	0,48 ab A	0,43 a A
3	N_0	0,62 b B	0,55 ab A	0,47 ab A	0,44 a A
	N_1	0,57 c AB	0,52 bc A	0,44 ab A	0,41 a A
	N_2	0,54 c A	0,49 bc A	0,43 ab A	0,39 a A
	N_3	0,52 b A	0,45 ab A	0,41 ab A	0,37 a A
4	N_0	0,59 b D	0,53 ab B	0,46 a A	0,42 a B
	N_1	0,53 b C	0,49 b AB	0,39 a A	0,38 a B
	N_2	0,46 b B	0,41 ab A	0,35 ab A	0,31 a A
	N_3	0,41 b A	0,38 b A	0,35 ab A	0,30 a A

5	N_0	0,57 b D	0,51 ab C	0,44 a B	0,40 a B
	N_1	0,50 b C	0,47 b BC	0,37 a AB	0,36 a B
	N_2	0,44 a B	0,39 a AB	0,33 a A	0,32 a AB
	N_3	0,38 c A	0,36 bc A	0,32 ab A	0,27 a A
6	N_0	0,52 c D	0,47 bc C	0,41 ab B	0,37 a B
	N_1	0,48 b C	0,44 b BC	0,34 a AB	0,33 a AB
	N_2	0,41 a B	0,36 a AB	0,30 a A	0,29 a AB
	N_3	0,35 b A	0,31 a A	0,29 ab A	0,24 a A

Description: The number followed by the same letter did not differ significantly according to the Duncan double distance follow-up test at the real level of 5%. Lowercase letters are read in the horizontal direction (row) and capital letters are read in the vertical direction (columns). N0: without patchouli essential oil, N1,2,3: patchouli essential oil concentration 10 ml/L; 20 ml/L; and 30 ml/L, K1,2,3,4: the ripeness of mangosteen at indices 3, 4, 5 and 6.

The use of patchouli concentration treatment is able to reduce the color level of mangosteen fruits. The higher the test concentration used, the lower the color level that occurs in mangosteen. This is suspected to be due to the presence of compounds contained in patchouli essential oil that are able to maintain the color level of mangosteen so that it can increase the shelf life of mangosteen. Patchouli leaves contain secondary metabolites from the flavonoids, alkaloids, phenolics, tannins, saponins, terpenoids (Daniati et al., 2021). According to Munawaroh et al., (2015), flavonoid compounds are able to interact with anthocyanin structures so that they can produce copigmentation. The copigmentation process tends to be able to increase the color stability of anthocyanins and produce a brighter color and protected from oxidation in mangosteen fruits (Boulton, 2001).

The color change that occurred in the patchouli oil treatment was significantly different when compared to the control. According to Ropiah (2009), the change in the color of the skin of mangosteen fruit is caused by a change in the composition of the pigment between chlorophyll and anthocyanins. The more ripe the mangosteen fruit, the chlorophyll content decreases while the anthocyanins tend to be stable so that it produces an attractive color of the mangosteen fruit.

Effect of Patchouli Essential Oil Concentration on Mangosteen Weight Loss

Fruit weight loss is one of the parameters that indicates the shelf life of the fruit. The shelf life of mangosteen fruit will be quite long with minimal weight loss (Pantastico et al., 1989). The results of Duncan's further test in Table 3 show that the use of patchouli essential oil is able to produce low weight loss compared to the control from the beginning of the treatment to the end of the observation.

Table 3. Increase in the weight of mangosteen fruit due to patchouli essential oil treatment

Observation to	Patchouli Concentration (ml/L)	The weight of mangosteen fruit (g) at the level of maturity to			
		K1	K2	K3	K4
1	N0	63,76 a A	63,37 a OFF	66,64 b B	64,45 from
	N1	64,22 a A	63,98 a OFF	63,76 a A	64,72 a A
	N2	66,57 a A	65,50 a B	64,03 a OFF	66,09 a A
	N3	66,88 a A	59,19 a A	63,20 a A	63,28 a A

2	N0	63,00 a A	63,51 a B	62,98 a A	59,98 a A
	N1	62,30 c A	60,87 b A	60,09 from A	59,12 a A
	N2	63,77 d OFF	62,02 c OFF	60,13 b A	58,90 a A
	N3	65,40 D B	63,58 c B	61,49 a A	59,39 a A
3	N0	63,18 a A	61,78 a A	65,96 a B	64,13 a OFF
	N1	62,30 a A	61,87 a A	60,59 a A	59,12 a OFF
	N2	63,77 b A	62,02 b A	62.13 from A	62,90 a B
	N3	64,90 b A	61,08 from A	59,99 a A	58,39 a A
4	N0	61,90 D A	58,72 c A	55,88 b B	52,23 a BC
	N1	62,05 d A	58,72 c A	52,71 b A	49,73 a A
	N2	63,26 d OFF	60,71 c A	57,86 b B	52,99 a C
	N3	64,01 d B	60,41 A	55,89 b B	50,87 a BC
5	N0	60,62 d A	56,76 c A	52,18 b A	49,46 a A
	N1	61,30 D OFF	58,44 c A	52,62 b A	49,71 a OFF
	N2	62,52 c BC	59,02 bc A	55,53 b B	50,37 a BC
	N3	63,80 d C	60,28 c A	55,55 b B	50,88 a C
6	N0	60,16 d A	56,44 c A	52,01 b A	49,36 a A
	N1	60,70 D OFF	57,72 c A	52,06 b A	49,51 a A
	N2	62,01 c C	58,61 bc A	55,42 b B	50,12 a B
	N3	63,24 d C	60,23 c A	55,45 b B	50,62 a B
7	N0	57,97 c A	55,51 b A	50,15 a A	49,01 a A
	N1	59,32 d OFF	56,41 c OFF	51,51 b A	49,27 a A
	N2	60,45 c OFF	58,25 bc OFF	55,03 b B	49,57 a A
	N3	61,91 c B	59,73 c B	55,06 b B	50,35 a B

Description: The number followed by the same letter did not differ significantly according to the Duncan double distance follow-up test at the real level of 5%. Lowercase letters are read in the horizontal direction (row) and capital letters are read in the vertical direction (columns). N0: without patchouli essential oil, N1,2,3: patchouli essential oil concentration 10 ml/L; 20 ml/L; and 30 ml/L, K1,2,3,4: the ripeness of mangosteen at indices 3, 4, 5 and 6.

Based on observations, the weight of mangosteen fruit is getting lower as time goes by. This means that there is a shrinkage of fruit weight during the observation process. The control showed the highest weight loss at all levels of mangosteen ripeness. Meanwhile, the treatment of patchouli essential oil showed the lowest weight loss from the 5th observation. The treatment of patchouli essential oil with a test concentration of 30 ml/L showed the lowest weight loss among other test concentration treatments. This is suspected because patchouli oil is able to minimize the process of respiration rate in mangosteen fruits during the post-harvest process by closing the pores on the mangosteen peel. In line with the study of Harun et al. (2012) which stated that bee wax emulsion used as a "coating" on mangosteen fruit is able to have a real effect on shrinkage in red dragon fruit at room temperature. In addition, beet root extract is able to close the pores of mangosteen fruit so as to suppress the respiratory rate so as to reduce weight loss (Wijaya et al., 2004).

Effect of Patchouli Essential Oil Concentration on the Hardness Level in Mangosteen Fruit

The level of mangosteen hardness can be used as a parameter to determine the age of the mangosteen fruit. The harder the mangosteen fruit, the older the mangosteen fruit. The level of hardness of mangosteen fruit can be affected by the use of patchouli essential oil based on the data presented in Table 4.

Table 4. The level of hardness of mangosteen fruit due to patchouli essential oil treatment

Observation to	Patchouli Concentration (ml/L)	The hardness level of mangosteen fruit (kg.s/mm) at the level of maturity to			
		K1	K2	K3	K4
1	N0	17,00 a A	18,63 b A	19,91 c A	20,77 d A
	N1	17,39 a A	18,52 a A	20,11 a A	20,91 a A
	N2	16,99 a A	17,99 from A	18,38 from A	20,06 b A
	N3	16,71 a A	18,17 a A	20,13 a A	20,17 a A
2	N0	17,85 a A	18,88 from A	20,52 b A	22,35 c A
	N1	17,46 a A	18,63 a A	20,46 a A	21,55 a A
	N2	17,43 a A	18,45 from A	20,44 bc A	21,13 c A
	N3	17,15 a A	18,31 a A	20,25 a A	20,75 a A
3	N0	20,13 a B	20,61 a A	22,24 b A	23,35 b A
	N1	18,51 a OFF	19,30 a A	20,73 a A	21,57 a A
	N2	17,45 a A	18,47 from A	20,45 bc A	21,14 c A
	N3	17,18 a A	18,34 a A	20,28 a A	20,83 a A
4	N0	21,15 a B	22,33 from A	23,03 from A	24,30 b C
	N1	18,56 a A	20,03 from A	21,35 from A	22,65 b BC
	N2	17,57 a A	18,55 from A	20,47 bc A	21,16 c OFF
	N3	17,23 a	18,36 a	20,34 a	20,85 a

		A	A	A	A
5	N0	23,60 a B	25,16 a C	26,78 a A	29,88 a B
	N1	22.33 a OFF	23,78 from BC	25,15 from A	27,39 b OFF
	N2	19,24 a OFF	21,63 b OFF	22,81 c A	25,00 D OFF
	N3	18,07 a A	19,55 a A	21,23 a A	23,15 a A
6	N0	32,39 a A	33,55 from A	36,03 from B	38,02 b D
	N1	30,02 a A	32,34 from A	34,28 from OFF	36,03 b C
	N2	27,72 a A	29,07 a A	31,87 a OFF	34,15 a B
	N3	27,15 a A	28,50 a A	30,27 a A	32,33 a A
7	N0	40,25 a B	42,1 b A	48,75 bc A	52,25 c A
	N1	38,65 a OFF	40,88 a A	46,29 a A	50,13 a A
	N2	36,63 a OFF	38,88 from A	42,13 from A	47,50 b A
	N3	34,50 a A	37,13 a A	39,88 a A	43,13 a A

Description: The number followed by the same letter did not differ significantly according to the Duncan double distance follow-up test at the real level of 5%. Lowercase letters are read in the horizontal direction (row) and capital letters are read in the vertical direction (columns). N0: without patchouli essential oil, N1,2,3: patchouli essential oil concentration 10 ml/L; 20 ml/L; and 30 ml/L, K1,2,3,4: the ripeness of mangosteen at indices 3, 4, 5 and 6.

Based on these data, the level of hardness of mangosteen fruit will increase over time both in the control and treatment of patchouli oil concentrations. However, the concentration treatment of patchouli oil test was able to minimize the level of hardness in mangosteen during the storage process. This is suspected because the patchouli essential oil that coats the skin of the mangosteen fruit is able to slow down the rate of decline in water content in the fruit because the respiration and respiration processes are hindered by patchouli essential oil. The decrease in skin moisture content occurs due to transpiration and respiration of the fruit during storage (Hasbi et al., 2005, Suyanti & Setyadjit, 2007). Transpiration of fluid in the intercellular spaces causes the cell to shrink so that the intercellular space fuses and the pectin substance binds to each other (Qanytah, 2004).

CONCLUSIONS

1. The use of patchouli essential oil concentration treatment and the maturity level of mangosteen fruit showed an interaction on mealybug mortality and mangosteen shelf life in the laboratory. The higher the concentration and maturity level of mangosteen fruit, the higher the mealybug mortality.
2. The test concentration treatment of 30 ml/L of patchouli essential oil at each level of ripeness of mangosteen fruit can result in high mealybug mortality and be able to increase the shelf life of mangosteen fruit in the laboratory.

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