Films from PVA and *Sansevieria trifasciata* Leaves Extracts as a Smartphone Protector with Radiation Reducing Property and Its LC-MS Analysis

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Abstract: Sansevieria trifasciata *(mother-in-law's tongue), an ornamental plant widely found in Indonesia, can absorb electromagnetic radiation in various electronic devices. This study aims to find the best* S. trifasciata *extract as an electromagnetic and thermal radiation reducer emitted from a smartphone.* S. trifasciata *leaves were macerated using ethanol, acetone, and dichloromethane. The extract was mixed with PVA as a film and tested for electromagnetic radiation using a radiation measuring device type GM-3120. Thermal radiation was tested using a temperature sensor (PASCO CI-6505B) connected to a PASCO 550 Universal Interface. All smartphone protective films decreased radiation from the smartphone, and the acetone extract caused the most significant radiation decrease, with the best results at a concentration of 5%. An* S. trifasciata *extract contained alkaloids, saponins, steroids, phenolics, and tannins based on the phytochemical tests. Based on LC-MS data, the dominant compounds identified from the three extracts of* S. trifasciata *is a group of alkaloids, fatty acid, and steroid. The functional groups that are thought to play a role in reducing radiation are the C-O, C=O, and C-OH functional groups. A compound that is thought to contribute to the reduction in radiation is neuroscogenin, a steroid group.*

Keywords: *electromagnetic; radiation; smartphone;* S. trifasciata*; thermal*

INTRODUCTION

Sansevieria trifasciata, with the local name mother-in-law's tongue or snake plant, is quite popular in Indonesia as an ornamental plant. The popularity of this plant has increased since NASA reported that this plant could absorb indoor pollutants such as formaldehyde, benzene, and trichloroethylene [1]. *S. trifasciata* shows potential for medicinal uses as an antioxidant [2], antibacterial [3], antidiabetic [4], hepatoprotective [5], antiallergic, anti-anaphylactic [6], cytotoxic [7], xanthine oxidase inhibitor [8], agents, as well as it has a therapeutic effect [9].

Besides that, *S. trifasciata* also shows activity as an absorber of pollutants and radiation, e.g., pollutant absorber [10], CO_2 emission reduction [11], removal of fishy odor [12], and adsorber of heavy metals [13-15]. Several reports show that the genus *Sansevieria* can absorb electromagnetic radiation from various electronic devices. The leaves of *S. trifasciata* var. Laurentii were reported to reduce exposure to electromagnetic radiation from television for one hour [16]. Another study reported that the extract could reduce indoor electromagnetic radiation by up to 16% [17]. Likewise, an anti-radiation bio screen made of this species can reduce radiation from laptops by 24.45% [18]. There are also reports of differences in computer radiation before and after contact with *S. trifasciata* Laurentii and Golden Hahnii, with the most considerable radiation reduction of 53.86% [19].

Another device that has the potential to emit harmful radiation is the cell phone. Mobile phones have become a significant need in various circles of society, along with the development of models and features that are increasingly sophisticated so that they are dubbed smartphones. Without realizing it, its use poses dangers because of the radiation produced. Mobile phones' regular and long-term use can negatively impact biological systems, especially the brain. It also may cause neurodegenerative diseases [20]. The possible health hazard of cell phones can be classified into thermal and non-thermal effects. The thermal effect from the phone should not exceed the average body temperature, and if body core temperatures are > 40 °C, it can lead to thermal stroke, which can be fatal [21]. The non-thermal effect comes from the electromagnetic radiation generated. Electromagnetic radiation from the phone significantly correlates with increasing thyroid-stimulating hormone [22] and can decrease sperm motility [23]. Therefore, a smartphone protector that could reduce smartphone radiation is needed.

One way to protect a smartphone is to use a casing or screen protector. Currently, no casing or screen protector can reduce radiation generated by smartphones. Therefore, we need a smartphone protector that can reduce radiation on smartphones. In a previous study, we tested an extract of *S. trifasciata* as a reducer of thermal radiation on smartphones. The film from a combination of polyvinyl alcohol (PVA) and 0.02% dichloromethane (DCM) fraction succeeded in reducing thermal radiation by 4.4 °C in the first minute and was stable for up to 20 min. This composite film was more effective than commercial casing used as controls [24]. That research only tested heat radiation on smartphones, even though electromagnetic radiation from smartphones is also dangerous. Therefore, this study tested the activity of reducing heat and electromagnetic radiation from the film. Besides that, the previous research only used one solvent for extraction. Unlike this study, the film was optimized using extracts from various solvents and found the best extract to be used as a casing or screen protector on a smartphone. It also analyses the components present in each extract to estimate which components play a role in reducing radiation.

For the first time, the activity of reducing thermal and electromagnetic radiation has been reported from various extracts of *S. trifasciata* with the comparison of LC-MS analysis of its various extracts.

■ EXPERIMENTAL SECTION

Materials

Samples of *S. trifasciata* were obtained from Tropical Biopharmaca Research Center (TropBRC), IPB University, Bogor, Indonesia. The plant is washed, dried, and mashed to 80 mesh. Ethanol 96%, acetone, and DCM were used as solvents for the isolation process and were obtained from Merck (Darmstadt, Germany). Film layers were formed from PVA with a molecular weight of 3,000 g/mol.

Instrumentation

LC-MS was utilized for structure analysis employing an LC system called Ultra Performance Liquid Chromatography (UPLC) and a mass spectrometer called the Vanquish Tandem Q Exactive Plus Orbitrap HRMS ThermoScientific. The following conditions were used in the column: C18 (1.5 µm, 100 × 2.1 mm), temperature: 30 °C (column), flow rate: 0.2 mL/min running 25 min, injection volume: 5 µL with MS system of ES (electrospray ionization) in positive ion mode, the capillary temperature of 320 °C and detection at 50 eV, the solvent is methanol, and mobile phase: (a) H_2O + 0.1% formic acid and (b) acetonitrile + 0.1% formic acid. Electromagnetic radiation using a radiation measuring device BENETECH type GM-3120. Thermal radiation was tested using a temperature sensor (PASCO CI-6505B) connected to a PASCO 550 Universal Interface.

Procedure

Extraction and fractionation

Powdered *S. trifasciata* (750 g) leaves were divided and macerated with three solvents (ethanol 96%, acetone, and DCM) for 3 × 24 h and were filtered. The filtrate was collected and concentrated with a rotary evaporator to obtain the blackish-brown concentrated extract. Then the extracts were prepared to be made into a film and tested for electromagnetic and thermal radiation on smartphones. The extract was tested for phytochemicals, including alkaloid, flavonoid, terpenoid, saponin, steroid, phenolic, and tannin compounds [25].

Preparation of blended film

The blended film uses a ratio of extract/fraction: PVA of 1:1 with a final volume of solution is 100 mL. The concentration of PVA used was 5%, while the extracts used were 0.5%, respectively. PVA solution with a concentration of 5% was prepared by dissolving 15 g of PVA in 300 mL of distilled water at 90 °C and adding 0.6 mL of glycerol as a plasticizer. Extract with a concentration of 0.5% was prepared by dissolving 0.25 g of extract in 50 mL of each solvent. Furthermore, the two solutions were allowed to stand until they reached a temperature of ± 25 °C. After reaching a temperature, the two solutions were homogenized for 10 min [26] (with modification). After degassing the solution in a vacuum desiccator, the homogeneous solution was poured onto an aluminium pane (18 × 10 × 4 cm). The solution was dried in an oven at 60 °C for 15 h per day to remove the residual solvents, followed by a drying process at ± 25 °C for 24 h. Then the films were peeled from the pane and kept until use [27].

Testing electromagnetic and thermal radiation on smartphones

The smartphone used in this test is the Vivo Y55 brand, which has been used for one year. Smartphones are made to do the same activity, making a call. Electromagnetic radiation from the rear and front of the smartphone was measured using a GM-3120 radiation meter for 10 s without and with a film protector. The protector tested were PVA + extract and PVA film only. The commercial casing (soft case) was also used as a comparison. The data is obtained by measuring the radiation from the smartphone before being covered by a protector (A) and after being covered by a protector (B), then calculating the percentage change with Eq. (1).

$$\%\ \text{reduction of E} - \text{Field} = \frac{A - B}{A} \times 100\% \quad (1)$$

Thermal radiation was measured using a temperature sensor (PASCO CI-6505B) connected to the PASCO 550 Universal Interface. Each film formed is affixed to the smartphone's rear, making a video call, and placed in a closed box. Then, the temperature rise was recorded for 20 min by the sensor. The radiation was measured from a smartphone without a protector, with a commercial casing, a smartphone with PVA film, and a smartphone with film PVA + extract. All measurements were carried out 3 times, and the average value was taken.

■ RESULTS AND DISCUSSION

Radiation Absorption Activity

There are 2 types of electromagnetic radiation being measured, namely E-field and H-Field. The experimental results found that the E-field radiation gave a higher value (87–230 V/m) than the H-field radiation value (0–0.25 μT). According to the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the radiation limit level allowed for the unit of magnetic flux density is 0.3–0.4 T [28], along with the safety limit of the electric field is 90 and 127.27 V/m at 900 and 1800 MHz, respectively [29]. Corresponding on those data, we could notice that smartphone's magnetic field has the potential to cause danger.

Preliminary testing on the smartphone's rear shows a radiation range of 8.9 to 59 V/m, while the front of the smartphone shows a radiation range of 185 to 737 V/m. The front of the smartphone emits more radiation than the rear, so further testing focuses on the front. The measurement is carried out for 10 s to get the average value of the radiation because the radiation value is prone to change. The measurement results of electromagnetic and thermal radiation are presented in Fig. 1.

All treatments decreased the radiation compared to the initial conditions from the measurement results, and the percentage reduction of electromagnetic radiation on the front of the smartphone is presented in Fig. 1(a). It can be seen that the treatment that gave the most significant reduction in electromagnetic radiation was a film from a mixture of PVA + acetone extract, with a radiation reduction value of 47%, followed by a mixture of PVA + DCM extract of 32%. The ethanol extract did not have a significant effect, as shown by the reduction in radiation was not too significant (11%). The decrease in radiation by the mixed PVA + acetone extract gave more excellent value than the commercial case used as a control and also more remarkable than the PVA film alone. It can be assumed that the effect of the decrease in electromagnetic radiation came from the acetone extract, not from PVA.

The measurement of thermal radiation was carried out for 30 min with 1200 data (1 data per second). However, the data used in the image represents the smartphone's temperature every 5 min (Fig. 1(b)). Smartphones without a protector (the films or casing) give higher thermal radiation than smartphones with a protector. The results show that film from PVA + acetone extract and ethanol extract gave the best results (overlapping blue lines), followed by DCM extract. *S. trifasciata* plants have a significant effect in absorbing thermal radiation on smartphones compared to commercial casings; also, this effect comes not from PVA, which is used as a film mixture. As the measurement of electromagnetic radiation, the extract that gave the most extensive absorption in thermal radiation was acetone extract. It was seen that the film PVA + acetone extract was able to maintain the smartphone's temperature at around 32–33 °C. In contrast, the smartphone without the film had a temperature that increased to 37 °C.

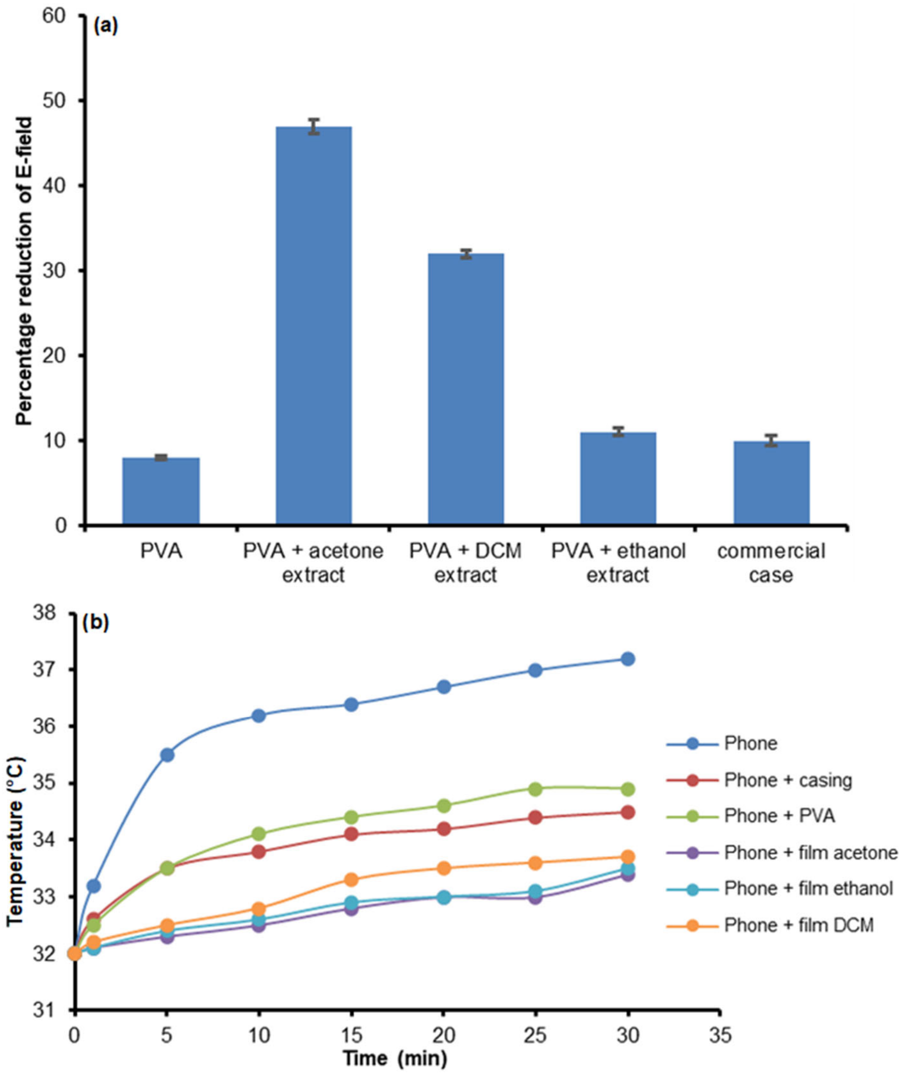


Fig 1. Percentage reduction of (a) E-field and (b) thermal radiation from the smartphone with various treatment

The radiation test was continued by varying the concentration ratio of the extract to PVA to ensure that the radiation reduction was due to the extract (not PVA). The results are presented in Fig. 2.

Based on the electromagnetic radiation test data in Fig. 2(a), it was seen that the film PVA + acetone extract gave the best results compared to other films, the same as before. However, the variation in the PVA:extract ratio did not seem to have any effect. Percentage reduction in radiation was not significantly different between the ratio of PVA:extract 1:2 and 2:1, as well as for other extracts. This means that the amount of extract to the amount of PVA does not affect the activity of the film, but it is clear that the mixture of PVA film with extract gives better results than PVA without extract. PVA has dielectric properties and thermal conductivity [30], so it can be used as a base material to reduce electromagnetic radiation and accelerate heat transfer. However, the dielectric properties and thermal conductivity of PVA are still low, and the combination with the compounds present in *S. trifasciata* can improve the physical and mechanical properties of PVA. The number of compound components present in the extract or PVA did not affect the results, indicating that the compounds that play a role in *S. trifasciata* have the same active site as an absorber of electromagnetic radiation, which is thought to be a polar group.

The measurement results of thermal radiation (Fig. 2(b)) showed slightly different results with electromagnetic radiation. Overall the film derived from PVA:extract = 1:2 provides a better thermal radiation absorption effect than PVA:extract 2:1, even PVA:acetone

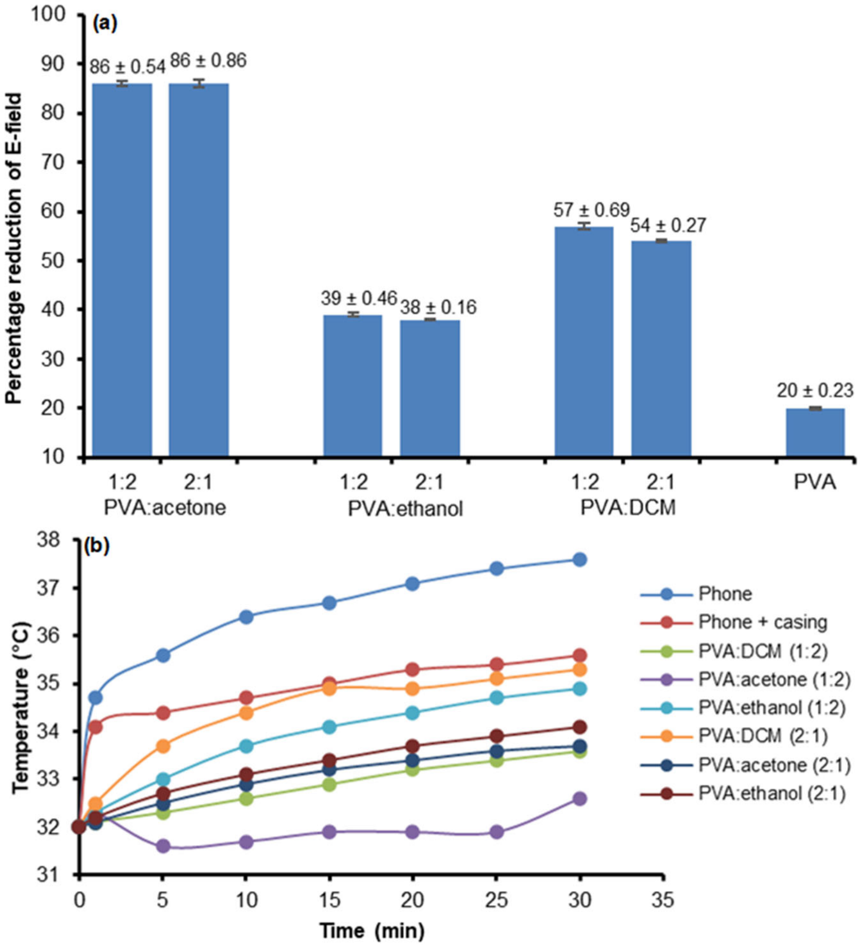


Fig 2. Percentage reduction of (a) E-field and (b) thermal radiation smartphone with films PVA:extract at various ratios

extract 1:2 (purple line) can reduce heat radiation to below the initial measurement temperature (32 °C). However, the film with a ratio of PVA:ethanol extract 2:1 had better activity than PVA:ethanol extract 1:2. Hence, variations in the concentration of PVA and extract on the absorption activity of electromagnetic and thermal radiation do not have a significant effect. However, the extract in the film makes the activity better than the control (commercial casing).

Furthermore, radiation testing was focused on the film PVA + acetone extract, and a comparison of the concentration of acetone extract was made to determine the best concentration of acetone extract. Variations of the concentration of acetone extract used are 0.01, 0.05, 0.1, 0.5, 1, and 5%. The data are presented in Fig. 3.

Based on the data in Fig. 3(a), it can be seen that the decrease in electromagnetic radiation was more significant with an increase in the concentration of acetone extract used. However, the results fluctuated at a concentration of 0.1 to 1%. The most considerable radiation reduction was obtained from film PVA + acetone extract 5% with a radiation reduction value of 62%. Therefore, the number of components in the acetone extract positively reduces electromagnetic radiation. Further research is needed at higher concentrations to obtain optimum concentrations.

The measurement of thermal radiation (Fig. 3(b)) shows slightly different results from the measurement of electromagnetic radiation. In the early minutes of the thermal radiation test, 0.1 and 0.5% acetone extracts could

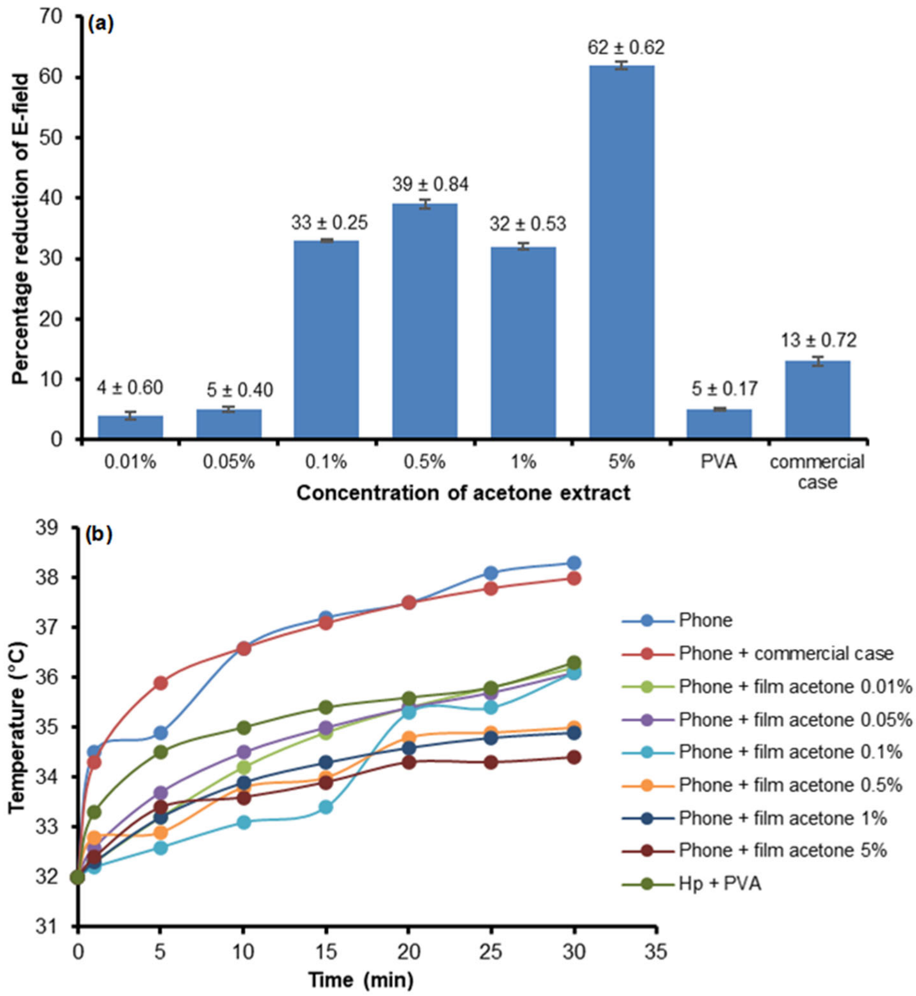


Fig 3. Percentage reduction of (a) E-field and (b) thermal radiation smartphone with film PVA + acetone extract at various ratios of extract

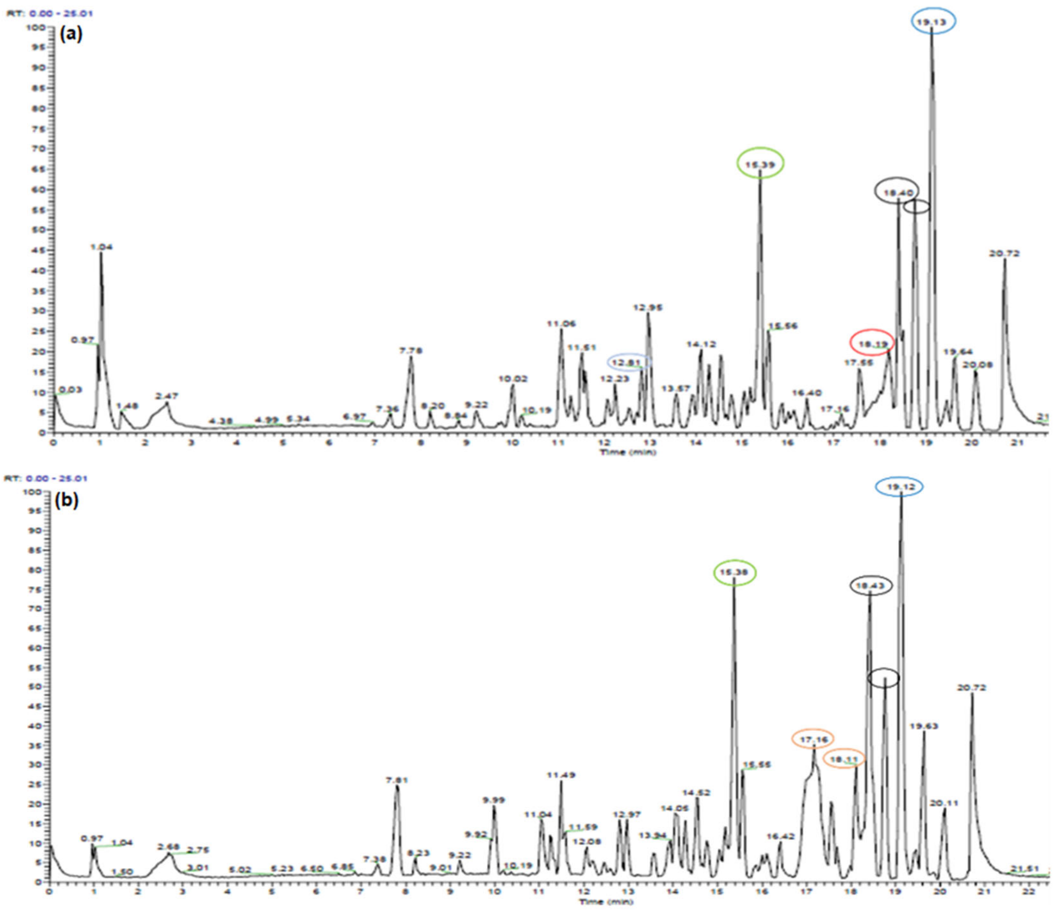
maintain smartphone temperatures better than 5% acetone extracts. However, starting at the 20th min, both extract concentrations showed a significant increase in temperature, in contrast to 5% acetone extract, which could stably maintain the smartphone's temperature up to the 30th min. Hence, higher acetone concentration will absorb thermal radiation stably. In contrast, the compounds present in the extract can absorb heat radiation at low concentrations. However, its ability will decrease because the number of components present is small or insufficient to withstand thermal radiation. Thus, it can be said that the best extract concentration for reducing electromagnetic and thermal radiation is 5%.

Identification of Compound

Maceration of *S. trifasciata* simplicia obtained 51.45 g of ethanol extract, 6.6 g of acetone extract, and 5.15 g of DCM extract, so the yield is 17.01, 2.95, and 2.3%, respectively. Ethanol solvent can extract more compounds than the other two solvents. Furthermore, all extracts were tested for phytochemicals, and their mass was measured using LC-MS to identify the predicted compounds present in the three extracts. The results are presented in Table 1, as well as Fig. 4. Table 1 shows that the three extracts have similarities in the results of phytochemical tests, where all extracts are positive for alkaloid, saponin, phenolic, steroid, terpenoid, and tannin,

Table 1. Phytochemical test results extract of *S. trifasciata*

Functional group	Extract		
	Acetone	DCM	Ethanol
Alkaloid	+	+	+
Flavonoid	-	-	-
Saponin	+	+	+
Phenolic	+	+	+
Steroid	+	+	+
Terpenoid	+	+	+
Tannin	+	+	+



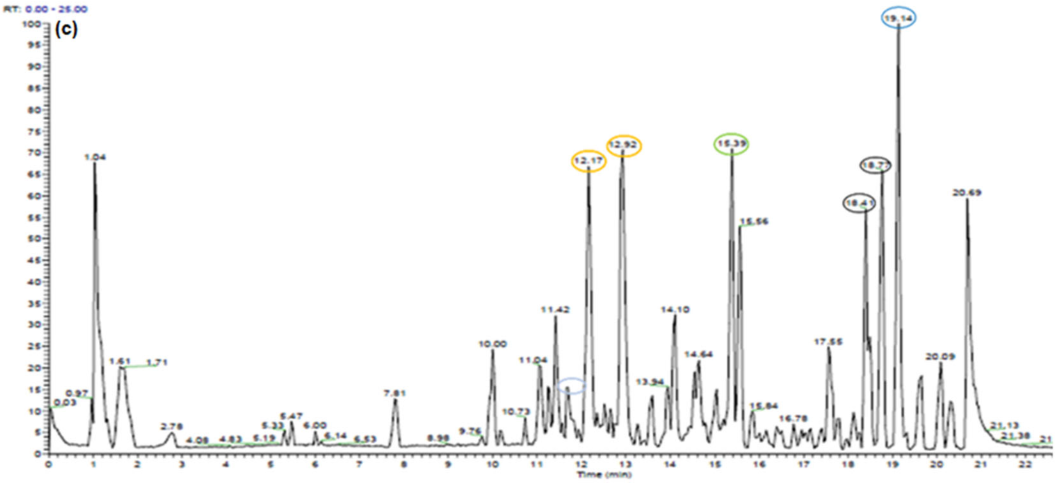


Fig 4. LC-MS chromatogram of S. *trifasciata* extract: (a) acetone, (b) DCM, and (c) ethanol extract

while negative for flavonoid. These results differ from previous studies using the same species but with different origins [24]. In a previous study, the phytochemical test of the ethanolic extract of *S. trifasciata* obtained positive results only for saponin and steroids. The place of growth will affect the secondary metabolites produced by a plant.

Based on the LC-MS chromatogram, it was seen that the three extracts had similar peaks, only different in intensity. The peak at the retention time of 20 min was indicated as the solvent peak. The LC-MS chromatograms of all extracts show four peaks at the retention time of 19.16, 18.79, 18.43, and 15.41 min with a high abundance. The mass spectrum peak with a 19.1 min retention time (blue circle in Fig. 4) makes it possible to have a $C_{35}H_{36}N_4O_5$ molecular formula with a 100% resemblance to a base peak of 593.28 identified as $[M+H]^+$. Based on search results with ChemSpider, Massbank, and Human Metabolome Database (HMDB) software, some possible compounds are presented in Table 2.

All compounds estimated are alkaloids and the compounds that are predicted to be present in *S. trifasciata* extract is pheophorbide A (**1**) because it has a mass error of 2.39 ppm. This compound has also been identified in the 70% ethanol extract of *S. trifasciata* from Bogor [8]. Pheophorbide A is a chlorophyll derivative often present in green plants, such as *S. trifasciata*.

The peak mass spectrum with an 18.7 and 18.4 min retention time (the black circle in Fig. 4) can have a $C_{33}H_{40}N_2O_9$ molecular formula with a 100% resemblance to a base peak of 609.27 identified as $[M+H]^+$. Based on search results with ChemSpider, Massbank, and HMDB software, the possible compound is reserpine (**7**) and its derivative (isoreserpine) (**8**) (Fig. 5).

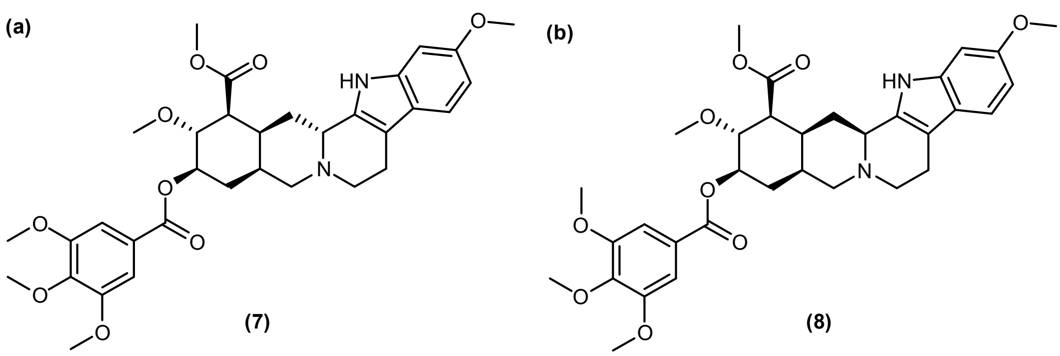


Fig 5. Structure (a) reserpine and (b) isoreserpine

Table 2. Several possible compounds at a retention time of minute 19.16

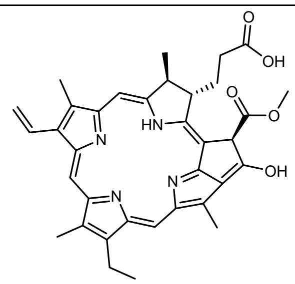
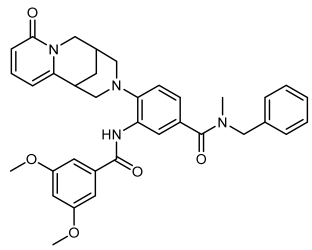
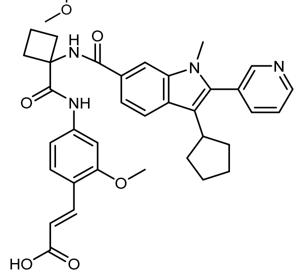
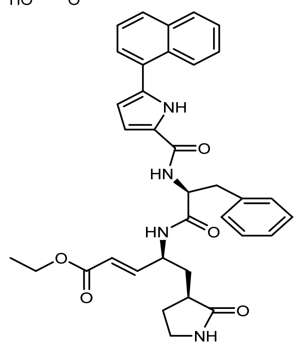
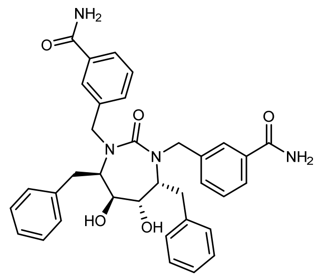
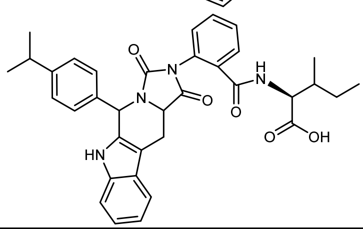
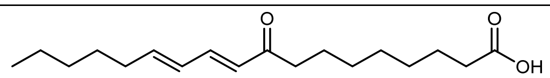
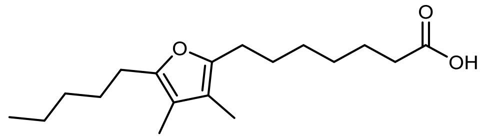
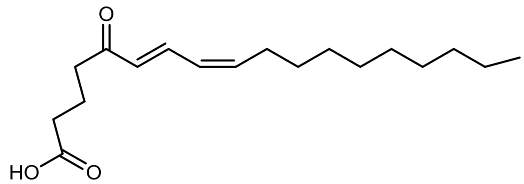
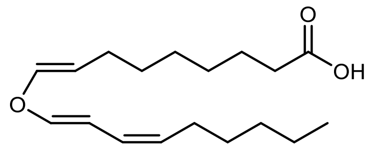
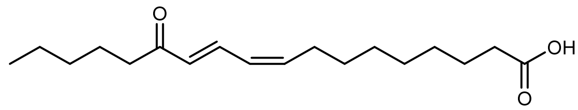
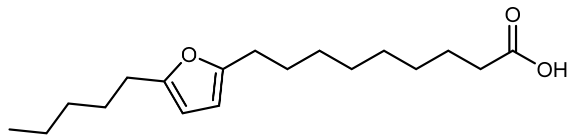
Compound	Functional group	Mass Error (ppm)	Structure
Pheophorbide A (**1**)	Alkaloid	2.93	
N-Benzyl-3-[(3,5-dimethoxybenzoyl)amino]-*N*-methyl-4-(6-oxo-7,11-diazatricyclo[7.3.1.02,7]trideca-2,4-dien-11-yl)benzamide (**2**)	Alkaloid	2.99	
(2*E*)-3-[4-({[1-({[3-Cyclopentyl-1-methyl-2-(2-pyridinyl)-1*H*-indol-6-yl]carbonyl}amino)cyclobutyl]carbonyl}amino)-2-methoxyphenyl]acrylic acid (**3**)	Alkaloid	2.99	
Ethyl (2*E*,4S)-4-[(*N*-{[5-(1-naphthyl)-1*H*-pyrrol-2-yl]carbonyl}-L-phenylalanyl)amino]-5-[(3*S*)-2-oxo-3-pyrrolidinyl]-2-pentenoate (**4**)	Alkaloid	2.99	
3,3'-{[(4*R*,5*S*,6*S*,7R)-4,7-dibenzyl-5,6-dihydroxy-2-oxo-1,3-diazepane-1,3-diyl]dimethanediyl}dibenzamide (**5**)	Alkaloid	2.99	
N-{2-[(11a*S*)-5-(4-Isopropylphenyl)-1,3-dioxo-5,6,11,11a-tetrahydro-1*H*-imidazo[1',5':1,6]pyrido[3,4-b]indol-2(3*H*)-yl]benzoyl}-L-isoleucine (**6**)	Alkaloid	2.99	

Table 3. Several possible compounds at a retention time of minute 15.41

Compound	Functional group	Mass error (ppm)	Structure
(10*E*,12*E*)-9-Oxo-10,12-octadecadienoic acid (**9**)	Fatty acid	2.37	
7-(3,4-dimethyl-5-pentylfuran-2-yl)heptanoic acid (**10**)	Fatty acid	2.38	
5-oxo-octadecenoic acid (**11**)	Fatty acid	2.38	
Colneleic acid (**12**)	Fatty acid	2.38	
13-Oxo-9*E*,11*E*-octadecenoic acid (**13**)	Fatty acid	2.38	
8-(5-Hexyl-2-furyl)octanoic acid (**14**)	Fatty acid	2.38	

The peak mass spectrum at minute 15.4 (green circle in Fig. 4) may have a $C_{18}H_{30}O_3$ molecular formula with a 100% resemblance to a base peak of 295.23 identified as $[M+H]^+$. Based on search results with ChemSpider, Massbank, and HMDB software, some possible compounds are presented in Table 3.

All compounds estimated are fatty acids. Based on literature searches, there have been no reports regarding discovering these compounds from the *Sansevieria* plant. However, octadecanoic acid and its derivatives were identified in *S. trifasciata* and positively correlated with trimethylamine (TMA) adsorption [31].

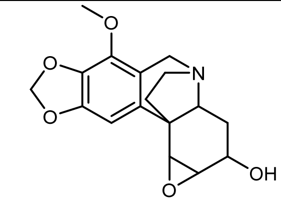
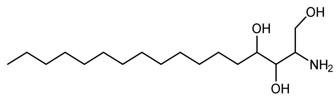
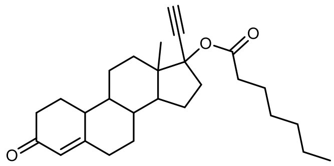
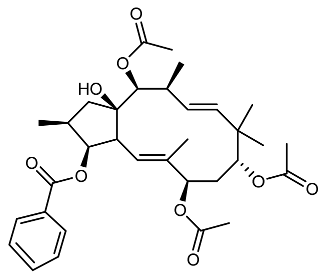
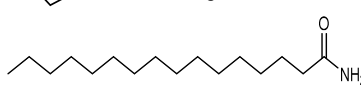
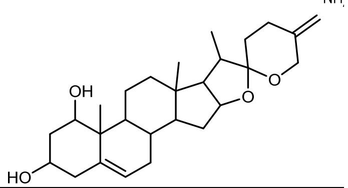
Overall, the ethanol extract was seen to have more peaks with a higher peak intensity than the other extracts, as the yield of the ethanol extract was much larger than the other two extracts. The peaks that were different in intensity were at retention times of minute 12.92 and 12.17 (oranges circle in Fig. 4(c)), possibly having a $C_{17}H_{19}NO_5$ and $C_{17}H_{37}NO_3$ molecular formula, respectively, with *m/z* 318.30 and 304.28 identified as $[M+H]^+$, which were estimated to be crinamidine (**15**) and 2-amino-1,3,4-heptadecanetriol (**16**). These two compounds appeared to have a reasonably large concentration in the ethanol extract but slightly in the acetone and DCM extracts. Crinamidine (**15**) was reported to have been isolated from *S. liberica* [32]. Meanwhile, the retention time of 12.8 min (light blue circle in Fig. 4(a) and 4(c)) was only found in acetone and ethanol extracts and not found in DCM extracts. It is possible to have a $C_{27}H_{38}O_3$ molecular formula, with *m/z* 411.29 identified as $[M+H]^+$, which was estimated to be norethisterone enanthate (**17**).

The compound present in the DCM extract but not in the acetone and ethanol extracts were estimated to be compound (1*S*,2*S*,3a*R*,4*S*,5*S*,9*R*,11*R*,13a*S*)-4,9,11-tris(acetyloxy)-3a-hydroxy-2,5,8,8,12-pentamethyl-1*H*,2*H*,3*H*,3a*H*,4*H*,5*H*,8*H*,9*H*,10*H*,11*H*,13a*H*-cyclopenta[12]annulene-1-yl benzoate (**18**) and hexadecanamide (**19**) with molecular formula $C_{33}H_{44}O_9$ and $C_{16}H_{33}NO$, respectively, which were the base peaks at retention times of 17.16 and 18.11 min (purple circle in Fig. 4(b)) with *m/z* 585.29 and 256.26 identified as $[M+H]^+$. While the compounds contained in the acetone extract but not in the ethanol and DCM extracts are estimated to be a compound neoruscogenin (**20**) with the molecular formula $C_{29}H_{40}O_4$ which is the base peak at the retention time of 17.68 min (red circle in Fig. 4(a)) with *m/z* 429.37 identified as $[M+H]^+$. This compound was reported to have been isolated from *S. trifasciata* in Spain [33]. All critical data LC-MS are presented in Table 4.

Based on these data, it can be predicted that abundant components in the ethanol extract reduce radiation absorption activity; this may be due to the antagonistic effect of the compounds present in the extract. In order to find out what functional groups are present in the best extracts, FTIR measurements were carried out on acetone extracts. The results are presented in Fig. 6.

Based on the FTIR spectrum, there is band 1, which is broad at wave number 3437 cm^{-1}, which is O–H stretching vibration, band 2 with sharp peak at 2944 cm^{-1}, which is methylene stretching vibration, band 3 with a sharp peak at 1733 cm^{-1} which is carbonyl stretching vibrations, band 4 with weak peak at 1669 cm^{-1} which is C=C stretching vibration. In addition, there are bands 5, 6, 7, and 8 with sharp peaks. Band 5 at 1435 cm^{-1} which is a shear bending vibration of methylene, band 6 at 1372 cm^{-1} which is an O–H bending

Table 4. Data LC-MS major in extract of *S. trifasciata*

Compound	RT (min)	Group Area			FG	MF	Mass error (ppm)	*m/z*	Structure
		Acetone	DCM	Ethanol					
Crinamidine (**15**)	12.92	1.58×10^9	7.24×10^8	3.53×10^9	Alkaloid	$C_{17}H_{19}NO_5$	2.90	317.13	
2-Amino-1,3,4-heptadecanetriol (**16**)	12.17	4.80×10^8	2.20×10^8	2.44×10^9	Alcohol	$C_{17}H_{37}NO_3$	3.23	303.27	
Norethisterone enanthate (**17**)	12.81	4.04×10^8	-	1.45×10^8	Steroid	$C_{27}H_{38}O_3$	3.22	410.28	
(1*S*,2*S*,3a*R*,4*S*,5*S*,9*R*,11*R*,13a*S*)-4,9,11-tris(acetyloxy)-3a-hydroxy-2,5,8,8,12-pentamethyl-1*H*,2*H*,3*H*,3a*H*,4*H*,5*H*,8*H*,9*H*,10*H*,11*H*,13a*H*-cyclopenta[12]annulen-1-yl benzoate (**18**)	17.16	-	6.41×10^9	-	Terpenoid	$C_{33}H_{44}O_9$	0.98	584.30	
Hexadecanamide (**19**)	18.11	-	1.33×10^9	-	Amide	$C_{16}H_{33}NO$	1.80	255.26	
Neoruscogenin (**20**)	17.69	5.84×10^8	-	-	Steroid	$C_{29}H_{40}O_4$	2.60	428.30	

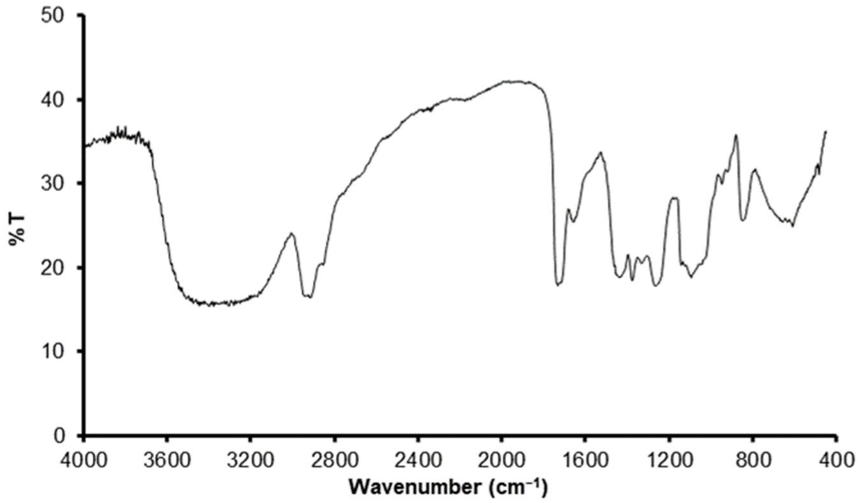


Fig 6. FTIR spectrum of PVA film + acetone extract

Table 5. FTIR absorption band of film PVA + acetone extract

Band	Wavenumber (cm^{-1})		Functional group
	Acetone extract	Literature [34]	
1	3437	3200–3650	O–H stretching (broad)
2	2944	~2926	$-CH_2$ stretching
3	1733	1650–1850	C=O stretching
4	1669	1600–1660	C=C stretching
5	1435	~1465	$-CH_2-$ bending
6	1372	1220–1440	O–H bending
7	1265	1000–1300	C–O stretching
8	1101	1000–1260	C–OH stretching

vibration in the plane, band 7 at 1265 cm^{-1} which is a vibration C–O stretching, and band 8 at 1101 cm^{-1} which is C–OH stretching vibration. Data for the 8 bands can be seen in Table 5.

According to a literature search by the authors, there have been no reports of compounds from natural materials that have activity as radiation absorbers. However, there are reports of Rubber magnets based on NBR and lithium ferrite that can absorb electromagnetic radiation [35]. However, based on our previous research, the fraction has the potential to be identified as steroid compound [24]. Moreover, the literature reports that the C–O, C=O, and C–OH functional groups are common functional groups contained in electromagnetic radiation-absorbing materials and work with a dipolar polarization mechanism [36]. In addition, the presence of a methyl group increases thermal conductivity more than halide because the methyl group creates lattice vibrations or increases the phonon-free path [37]. In this study, the FTIR data showed the presence of the C–O, C=O, and C–OH functional groups, thus indicating that these functional groups contribute to reducing smartphone radiation. Neuroscogenin (**20**) was identified as a compound in acetone extract but not found in other extracts. This steroid compound has two C–OH groups, two C–O groups, and three methyl substituents. Based on this data, it could imply that neoruscogenin in the acetone extract contributes to the absorption of smartphone radiation.

■ CONCLUSION

In this study can be concluded that the acetone extract of *S. trifasciata* has the potential to be used as a screen protector on smartphones to reduce electromagnetic and thermal radiation emitted by smartphones. However, it is suspected that the compound that has a role in increasing radiation absorption in smartphones is neoruscogenin, a steroid group.

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AUTHOR CONTRIBUTIONS

Melinia Falestin conducted the experiment and calculation, Auliya Ilmiawati contribute to analyzing data and monitoring research, Akhiruddin Maddu contribute to providing tools and materials for heat radiation testing. Purwantiningsih Sugita, Budi Arifin, and Luthfan Irfana contribute to providing suggestions and input related to research. Auliya Ilmiawati wrote and revised the manuscript. All authors agreed to the final version of this manuscript.

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