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Comparative study on Manuka and Indonesian honeys to support the application of plasma jet during proliferative phase on wound healing

Eka Sakti Wahyuningtyas[a,f,g], Arya Iswara[b], Yunita Sari[c], Sodiq Kamal[a], Budi Santosa[b,g], Tatsuo Ishijima[d], Toshio Nakatani[e], Indri Kartika Putri[f], N Nasruddin[b,f,g,*]

[a] Department of Nursing, Faculty of Health Sciences, Universitas Muhammadiyah Magelang, Indonesia
[b] Department of Medical Laboratory Science, Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang, Semarang, Indonesia
[c] Department of Nursing, Faculty of Health Sciences, Jenderal Soedirman University, Indonesia
[d] Research Center for Sustainable Energy and Technology, Kanazawa University, Kanazawa-shi, Japan
[e] Division of Nursing, Faculty of Health Sciences, Institute of Medical, Pharmaceutical, and Health Sciences, Kanazawa University, Kanazawa-shi, Japan
[f] Research Center for Experimental Wound Healing, Universitas Muhammadiyah Magelang, Indonesia
[g] Muhammadiyah Research Network for Plasma Medicine (M-Plasmed), Semarang, Indonesia

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ABSTRACT

Purpose: A comparative investigation was conducted to determine the effectiveness of Manuka and Indonesian honeys to support the application of plasma jet treatment during the proliferative phase of cutaneous wound healing in 8-week-old, BALB/c male mice.

Methods: The effect of honey containing different concentrations to reactive oxygen and nitrogen species (RONS) produced by plasma jet in liquid medium using H_2O_2 as the indicator was conducted using chemical-enzymatic method. Plasma jet treatment was applied perpendicularly to wounds through holes punched in multiple micro-well dressings (MMD) using direct contact. Mice were divided into 4 groups: Hydrocolloid dressing alone (Control group or C), plasma application followed by hydrocolloid dressing (PH), plasma application followed by treatment with Indonesian honey (PI), and plasma application followed by treatment with Manuka honey (PM). Two full-thickness acute wounds were created on both sides of the mouse dorsum using a disposable biopsy punch. The wounds of the control group were covered with a hydrocolloid dressing (HD), whereas wounds in the other groups were covered with a HD from days 0 to 3, treated with plasma followed by 0.1 mL of the relevant honey or HD from days 4 to 7 post-wounding, and then were covered with a HD from days 8 to 14.

Results: On day 7the wound area in the PI and PM groups was smaller than in the control group. On days 12, 13, and 14, however, the wound area in PI-treated mice was significantly larger than in PM mice.

Conclusion: Manuka honey may better support plasma jet treatment than Indonesian honey on account of its chemical characteristics.

1. Introduction

Theoretically, wound healing occurs over several overlapping phases, namely, inflammation, proliferation, and remodelling [1]. Sen et al. [2] reported that numerous events of wound healing, like haemostasis, inflammation, re-epithelialization, and vascularization, are subject to biological redox control. Reactive oxygen species (ROS) like hydrogen peroxide (H_2O_2), and reactive nitrogen species (RNS) like nitric oxide (NO), are key players in such mechanisms. These reactive species are well known oxidants that function as signal messengers.

In the clinical setting of wound care management, there are many established biological and biophysical therapies capable of promoting wound healing, from natural products like hormones [3, 4]and honey [5],to sophisticated technologies like negative pressure wound therapy [6], hyperbaric oxygenation [7], electrical stimulation [8], ultra-violet light and ultrasound [9] and green light [10]. The drawbacks of these therapies are that, to date, there is no single one treatment capable of improving all healing phases, and that most therapies have side effects. The importance of finding new healing agents is therefore clear. For this purpose, wound therapies based on the combination of plasma medicine and honey are being developed.

Generally, plasma medicine is defined as the application of man-made

* Corresponding author at: Department of Medical Laboratory Science, Faculty of Nursing and Health Sciences, Universitas Muhammadiyah Semarang, Jalan Kedungmundu Raya No.18, Semarang, Central Java 50273, Indonesia.
E-mail address: nasruddin@unimus.ac.id (N. Nasruddin).

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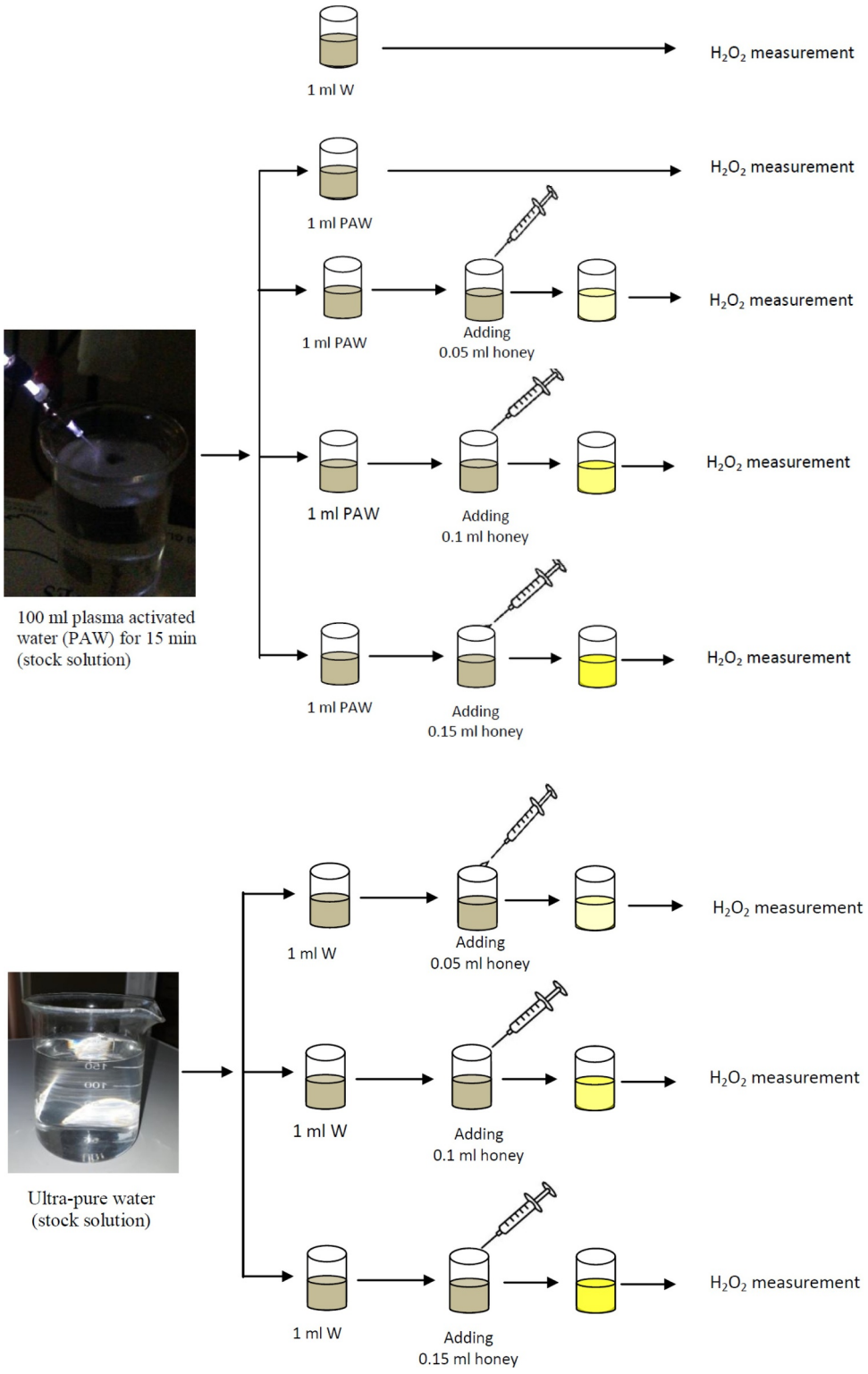


Fig. 1. Evaluation procedure of H_2O_2 in the PAW dropped by honey.

plasma for medical purposes [11, 12], for example, the killing of micro-organisms on the body or teeth [13, 14], in cancer therapy [15, 16] and in wound healing [17, 18]. It is well known that the clinical value of plasma is derived from its ability to generate reactive oxygen and nitrogen species (RONS) [19]capable of influencing biological systems, with wounds being one example [2]. Roy et al. [20] reported that topical treatment with H_2O_2at micromolar concentrations is able to improve the healing of acute wounds. Conversely, at relatively high doses it can damage normal, healthy tissue [21].

Although RONS are key players in wound healing, recent investigation has shown that the medical and biological effects of RONS depend on the environmental conditions of living cells. Weltmann and Woedtke [22] make the claim that the biological effects of plasma are rooted on two basic principles. Firstly, the biological effects of plasma are due to plasma-induced changes to the liquid zone surrounding cells. Secondly, RONS that are produced in, or transported into, liquid phases play a pivotal role in

Table 1
Wounds conditions for each group during the 14 days of the experiment.

Group	Experiment days		
	0 – 3	4 – 7	8 – 14
Control	under hydrocolloid dressing	under hydrocolloid dressing	under hydrocolloid dressing
PH	under hydrocolloid dressing	in line with plasma treatment procedure as described in Fig. 2	under hydrocolloid dressing
PI	under hydrocolloid dressing	in line with plasma treatment procedure as described in Fig. 2	under hydrocolloid dressing
PM	under hydrocolloid dressing	in line with plasma treatment procedure as described in Fig. 2	under hydrocolloid dressing

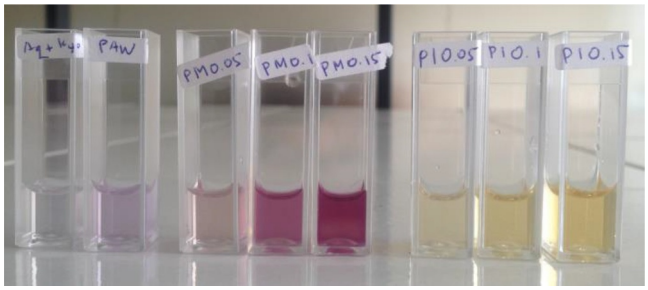


Fig. 3. Liquid appearance 8 min after the reaction of Kyoritsu's reagent with samples W (Aq + Kyo), PAW, PAWM-0.05(PM0.05), PAWM-0.1 (PM0.1), PAWM-0.15(PM0.15), PAWI-0.05(PI0.05), PAWI-0,1(PI0.1), and PAWI-0.15(PI0.15).

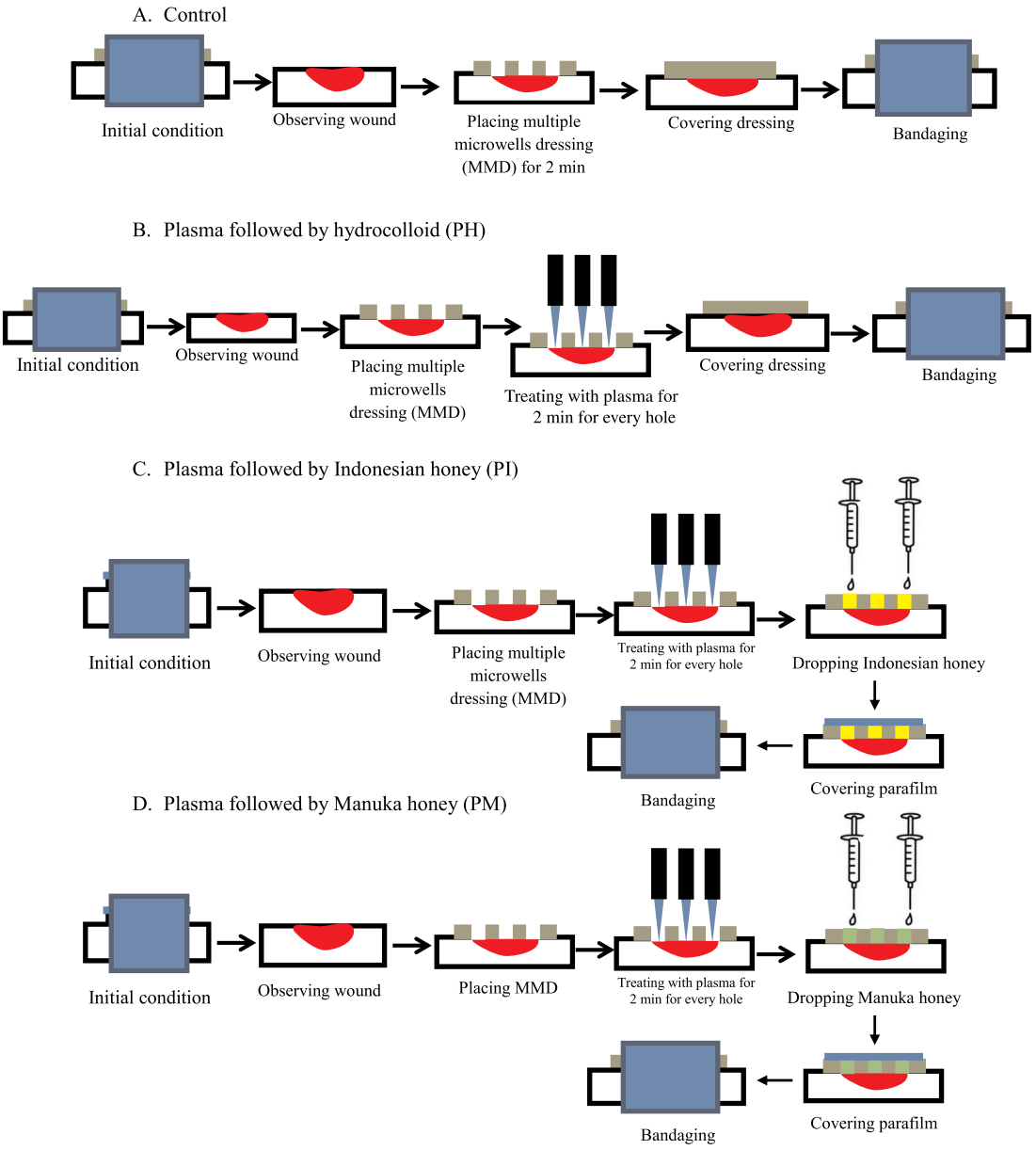


Fig. 2. Experimental procedure from day 4 till 7.

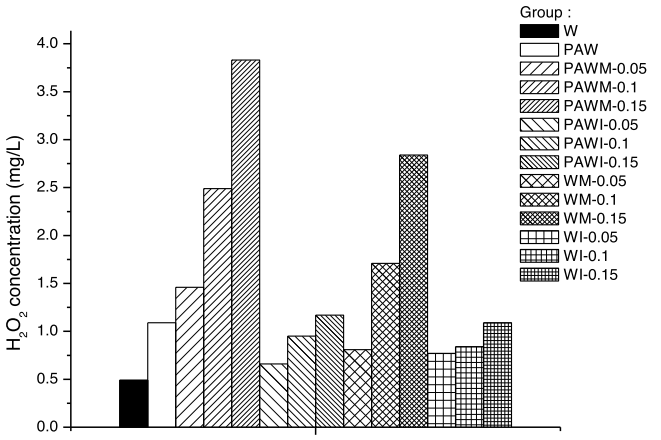


Fig. 4. H_2O_2 concentration 8 min after reaction with Kyoritsu's reagent for each sample.

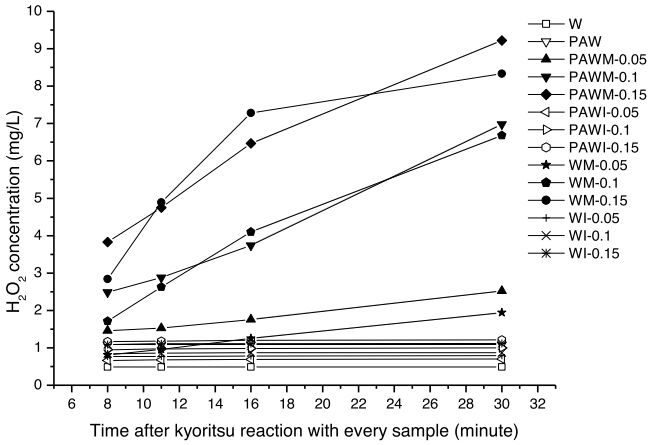


Fig. 5. Relationship between times after the reaction of Kyoritsu's reagent and H_2O_2 concentration for each sample.

plasma-induced biological responses.

Topical wound management is the manipulation of wounds to restore a physiologic environment; an environment that is characteristic of an organism's healthy or normal state. Adequate moisture levels, temperature control, pH regulation, and control of bacterial burden are key factors of a physiologic wound environment [23]. Wound dressing are materials used to imitate the skin so that a physiologic local wound environment can be emulated. There are many types of dressings, some of which use honey, with its many biological activities that work to support the healing processes, as a natural dressing. It has been reported that honey's strong osmotic pressure can promote autolysis by pulling lymph fluid from surrounding tissues, thereby adding moisture to the wound [24]. Honey also plays a role as an antioxidant [25]. Using animal models mimicking clinical settings, it was reported that Indonesian honey is almost as effective for wound healing as Manuka honey and hydrocolloid dressings [26].

Plasma-activated water (PAW),or water exposed to atmospheric pressure plasma, has recently been put forward as one of the most sophisticated themes in plasma medicine [27–29]. The efficacy of a combinative treatment of plasma jets and distilled water for acute wound healing using small experimental animals has recently been reported [30]. The possibility of a combinative treatment involving plasma medicine and liquid containing natural products derived from honey was also reported, but its efficacy to support wound healing was low [31].

To improve this result, a new strategy combining plasma jet treatment and honey was explored in the current study. In our previous experiments we combined plasma jets and honey to wounds through direct contact, in which honey applied directly to wounds was exposed to a plasma jet. In the current experiment honey solutions were dropped onto wounds through holes in a micro-well dressing following plasma jet treatment. There was no direct contact between honey and the plasma jet. Two types of honey with different origins, namely Indonesian and Manuka honeys, were used. As plasma jet treatment has been found to be more effective during the proliferative wound-healing phase [30–32], plasma treatments were only conducted during the aforementioned phase, on days 3 till 7.

2. Methods and materials

2.1. Cold plasma jet system

This research used an atmospheric pressure plasma jet system in which plasma is applied perpendicular to the wound. This system was developed based on Teschke et al. [33] and has been described previously [31]. It had a quartz tube with inner and outer diameters were 1.5 and 2.7 mm, respectively. Two electrodes from aluminium foil ring were applied around the quartz tube for this system. AC high voltage produced by high voltage power supply (CR-N16, Kodera, Japan), with a peak-to-peak voltage of 14.65 kV and a frequency of 12.72 kHz, was applied to the upper ring electrode when argon gas at a flow rate of 2 standard litres per minute (slm) was flowed from one end of the quartz tube. The lower electrode was linked to the ground. Ultra-pure argon gas (99.999% purity) produced for clinical purposes by the Samator Company (Indonesia) was used as a carrier gas.

2.2. Honey solution

Two types of commercial honey, namely Indonesian honey (I) (Solo, Indonesia) and Manuka honey with Unique Manuka Factor (UMF) 5 + (M) (Auckland, New Zealand), were used in this research.

2.3. Multiple-holes dressing (MHD)

The placement of commercial honeys, Manuka and Indonesian honeys, on wound surfaces was supported using multiple-holes dressings (MHD). MHD is a commercial hydrocolloid dressing that was modified by making four holes (diameter ~2 mm for each hole) in it.

2.4. Evaluation ofH_2O_2 in the PAW dropped by honey

The human body is composed of more than 65% water, and loss of this moisture is prevented principally by the epidermis [34]. The presence of liquid or water around cells in living tissue is a critical factor in the efficacy of plasma medicine [22].Considering that wound tissue was rich in water, it was assumed that a “plasma activated wound” followed by treatment with honey would be analogous with “plasma activated water (PAW)” followed by treatment with honey. An experiment was conducted to evaluate the effect of honey containing different RONS concentrations produced by plasma jets in liquid medium using H_2O_2 concentration as indicator. The general procedure is described in Fig. 1. There are two stock solutions, namely ultra pure water (W) and plasma-activated water (PAW). PAW is 100 ml ultra-pure water exposed to an atmospheric plasma jet for 15 min with following parameters: argon gas flow rate = 2 SLM; peak-to-peak voltage = 14.65 kV; nozzle tip-water surface distance = approximately 15 mm. Samples were classified into 14 groups: only water (W), only Plasma Activated Water (PAW), PAW followed by M at volumes of 0.05, 0.1, and 0.15 mL (PAWM-0.05, PAWM-0.1, PAWM-0.15), PAW followed by I honey at volumes of 0.05, 0.1, and 0.15 mL (PAWI-0.05, PAWI-0.1, PAWI-0.15), W followed by M at volumes of 0.05, 0.1, and 0.15 mL (WM-0.05, WM-0.1, WM-0.15), W followed by I at volumes of 0.05, 0.1, and 0.15 mL (WI-0.05, WI-0.1, WI-0.15).

H_2O_2 accumulation in every sample was analysed with a peroxidase enzyme method using a commercial reagent (Kyoritsu Chemical-Check Lab., Model WAK-H2O2) as reported previously [31].The presence of H_2O_2 was identified based on the change of the liquid's colour and then was confirmed using the absorbance rate change of a spectrophotometer using the absorption

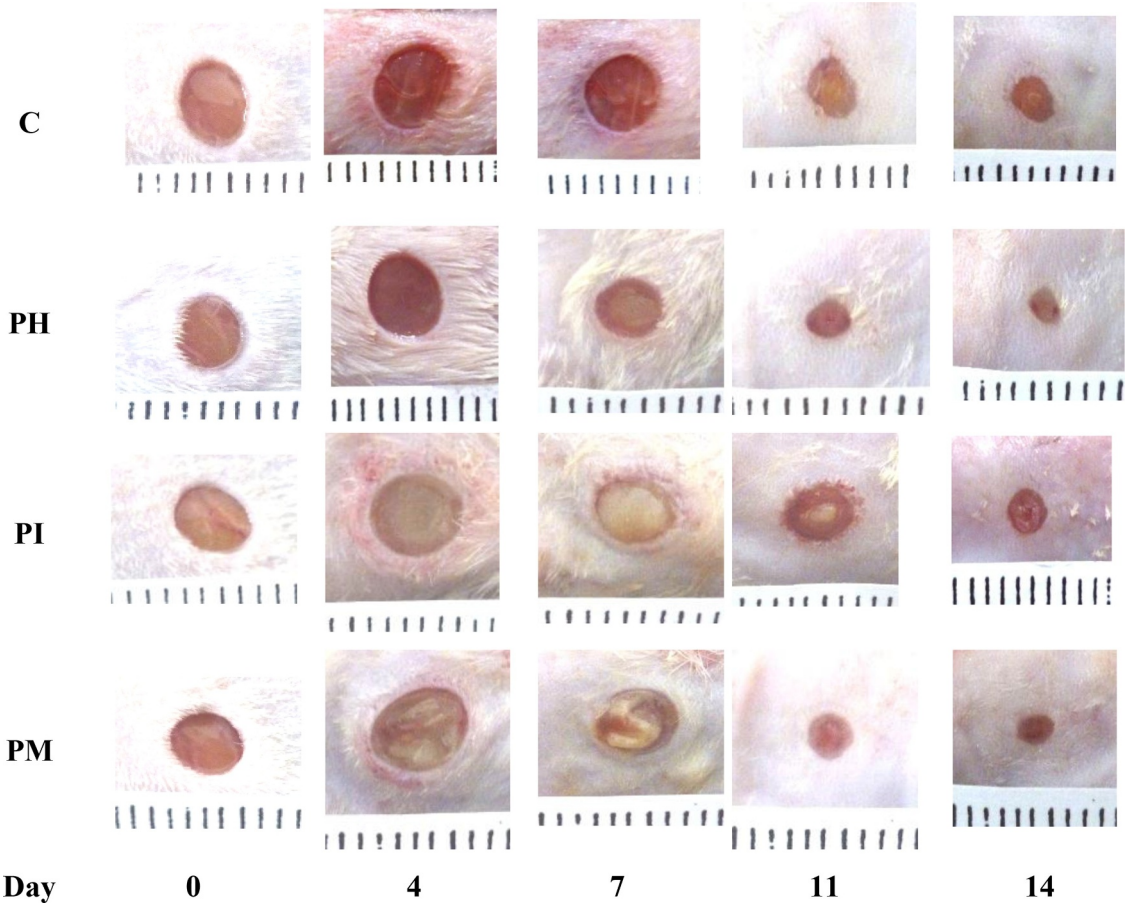


Fig. 6. Macroscopic observation of wounds on days 0, 4, 7, 11, and 14.

peak at 540 nm. To evaluate the possibility of H_2O_2 accumulation change from minute to minute, the analysis was conducted 8, 10, 15, 20, 25, and 30 min after the reaction between sample and reagent was initiated.

2.5. Animals and investigation protocol

This investigation was conducted at the Research Center for Experimental Wound Healing, Universitas Muhammadiyah Magelang, Central Java, Indonesia. The experimental procedures and animal care were conducted according to the Guidelines for the Care and Use of Laboratory Animals of Laboratorium Penelitian dan Pengujian Terpadu/Integrated Research and Testing Laboratory (LPPT UGM), GadjahMada University, Yogyakarta, Indonesia (certificate number: 00086/04/LPPT/VII/2017). LPPT UGM is operated under the accreditation of the ISO/IEC 17025 and the National Accreditation Committee of Indonesia (Komite Akreditasi Nasional/KAN, Indonesia). Thirty-six BALB/c male mice aged 8 weeks and weighing 21.0–28.0 g purchased from LPPT UGM were used. Mice were caged individually in an air-conditioned room at 28.0 ± 2.0 °C with light from 09:00 to 21:00 h and under *ad libitum* feeding conditions.

2.6. Wound healing model and plasma treatment

Mice was completely anaesthetised by injection of ketamine-xylazine,(K) 50 mg/kg and (X) 5 mg/kg, into the peritoneal cavity [35].A previously described technique [31] was applied to create 2 circular (4 mm in diameter) full-thickness skin wounds including the panniculus on both sides of the mouse dorsum using a sterile, disposable 4 mm biopsy punch (Kai Industries Co. Ltd., Gifu, Japan). A plasma jet was applied perpendicular to the wound surface through 4 holes in the multi-hole dressing once daily for 1 min per hole over 14 days. The position of the wound surface was about 10 mm from the nozzle tip. Contact between the plasma jet and the wound in each respective hole was observed.

Mice were divided into 4 groups: hydrocolloid dressing alone (Control group or C), plasma followed by hydrocolloid dressing (PH), plasma followed by an Indonesian honey (PI), and plasma followed by a Manuka honey (PM). The wounds of the control group were covered with a hydrocolloid dressing (HD), whereas wounds in the other groups were covered with a HD from days 0 to 3, treated with plasma followed by 0.1 mL of the relevant type of honey or HD from days 4 to 7 post-wounding, and were covered with a HD from days 8 to 14.Wound conditions for each group from days 0 to 14 are shown in Table 1. The experimental procedure from days 3 to 7 is shown in detail in Fig. 2.

2.7. Macroscopic evaluation of wound

The day of wound creation was plotted as day 0, and the progress of wound healing was observed daily from days 0 to 14. Macroscopic evaluation procedures were carried out using a previously-described technique [17].

2.8. Estimated day of healing

Determination of the day upon which wound healing was completed was conducted based on the technique described by Nasruddin et al. [30]. Briefly, the completion of wound healing was estimated based on visual evaluation of the wounds. The ratio of the wound area on each day was plotted against the wound area on day 0 and the overall trend of this graph was evaluated. The healing day was determined from the y-axis when the trend of reduction of the wound size levelled off, as reported previously, at y = 0.3 (Fig. 7a). From that point, line z was made, crossing the lines of reduction for each group. Wound

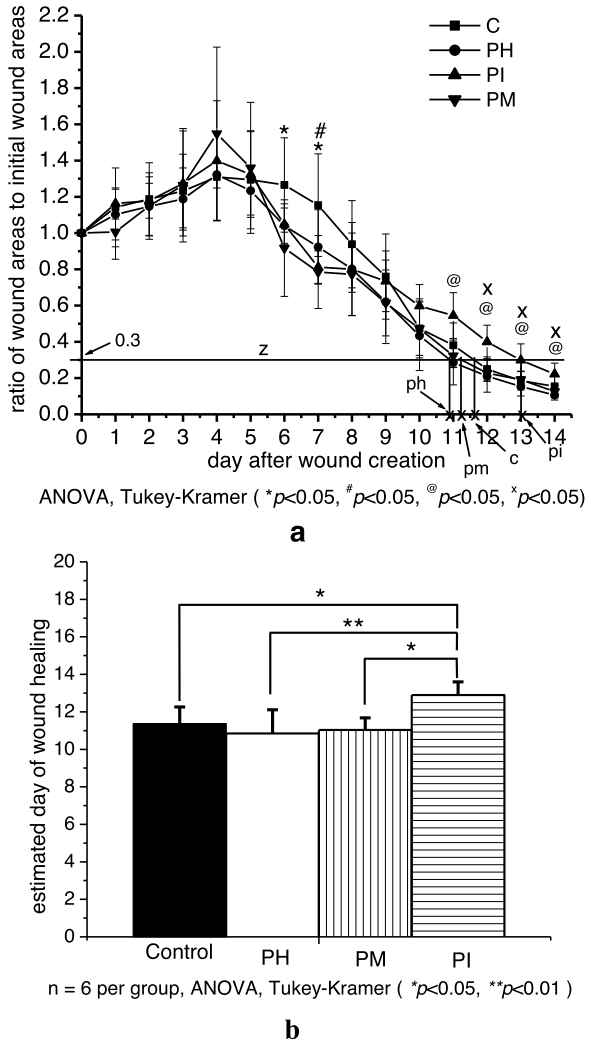


Fig. 7. (a)Ratio of wound areas to initial wound areas during healing. On day 7, the sizes of the wounds in PM and PI were significantly smaller than in C; however,they were almost the same size as those in PH. Conversely, on days 12–14 the wounds sizes in PM and PH were significantly smaller than in PI. Note that * shows the significance level of PM to C, while #, x, and @ show those of PI to C, PH to PI, and PM to PI, respectively. At point 0.3 on the y-axis, it was assumed that re-epithelialization covered the wound surface completely in all groups.Points ph, pm, c, and piindicate estimated days of healing for PH, PM, C, and PI, respectively.(b)A histogram estimating number of days until healing for every group. PH, PM, Control (C), and PI were10.85 ± 1.26, 11.03 ± 0.65, 11.37 ± 0.89, and 12.90 ± 0.70 days, respectively.

healing days at points c, pi, pm, and ph were determined based on their points of intersection with the x-axis.

2.9. Tissue processing and histological analysis

The experimental animals were euthanized by injection with ketamine-xylazine, administered via IP injection on days 7, 11, or 14 post-wounding. Tissue harvesting was conducted on the wound and its surrounding skin. Tissue processing was then conducted by means of a previously described technique [32].The sampled wound tissue was stapled onto polypropylene sheets to hinder over-contraction of the samples, and then fixed for approximately 15 h in neutral-buffered 10% formalin solution in 0.01 M phosphate buffer, pH 7.4.The sheets were then rinsed in 0.01 M PBS for approximately 8 h.Tissue bisection was carried out at the wound centre. Subsequently, sections were dehydrated in an alcohol series, cleaned in xylene, and embedded in paraffin to prepare serial 5 μm sections. The sections containing the wound centre were stained with haematoxylin-eosin (HE) for histological analysis. Re-epithelialisation percentages were calculated using a formula, as reported previously [31].

2.10. Statistical analysis

Data were subjected to statistical analyses using SPSS 16.0. The ratios between the average wound area to the original wound area and the number of days required for wound healing were evaluated by ANOVA followed by the Tukey–Kramer method;*P*-values < 0.05 were considered significant.

3. Results

3.1. Evaluation of H_2O_2 in the PAW dropped by honey

Colour differences between Manuka and Indonesian honeys in PAW are reported in Fig. 3,with Manuka being purplish, and Indonesia yellowish. In both Manuka and Indonesia honey, the colour of the liquid was found to change with changes in its concentration. Higher concentrations of honey featured decreased transparency. Fig. 4shows that theH_2O_2 concentration in PAW was significantly higher than in W, indicating that plasma jet treatment generated H_2O_2in W.

Fig. 4 also shows that, in both PAWM and PAWI groups, higher honey concentrations were associated with higher H_2O_2concentrations. H_2O_2concentrations in the PAWM (PAWM-0.05, PAWM-0.1, and PAWM-0.15) and WM (WM-0.1 and WM-0.15) groups was higher than in PAW. However, when equal volumes of honey were used, the H_2O_2 concentration in PAWM was higher than in WM. In contrast to this, the H_2O_2 concentrations in the PAWI and WI groups was almost the same as, or lower than, those found in PAW. This indicated that Manuka honey increased the amount of H_2O_2 in PAW, while Indonesian honey did not.

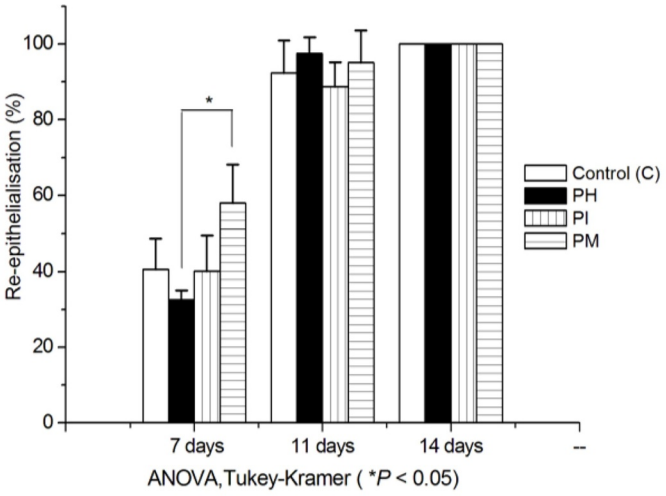
As seen in Fig. 4, over the 30 min following reaction with Kyoritsu's reagent with the liquid samples, H_2O_2 concentrations in the Manuka honey groups (PAWM and WM) increased significantly, while H_2O_2 concentrations in the Indonesian honey and other groups were clearly stable (Fig. 4). This indicated that the Kyoritsu chemical reagent influenced the chemical stability of Manuka honey, producing H_2O_2. The reagent, however, had no effect on the Indonesian honey groups, PAW and W.

3.4. Macroscopic observation

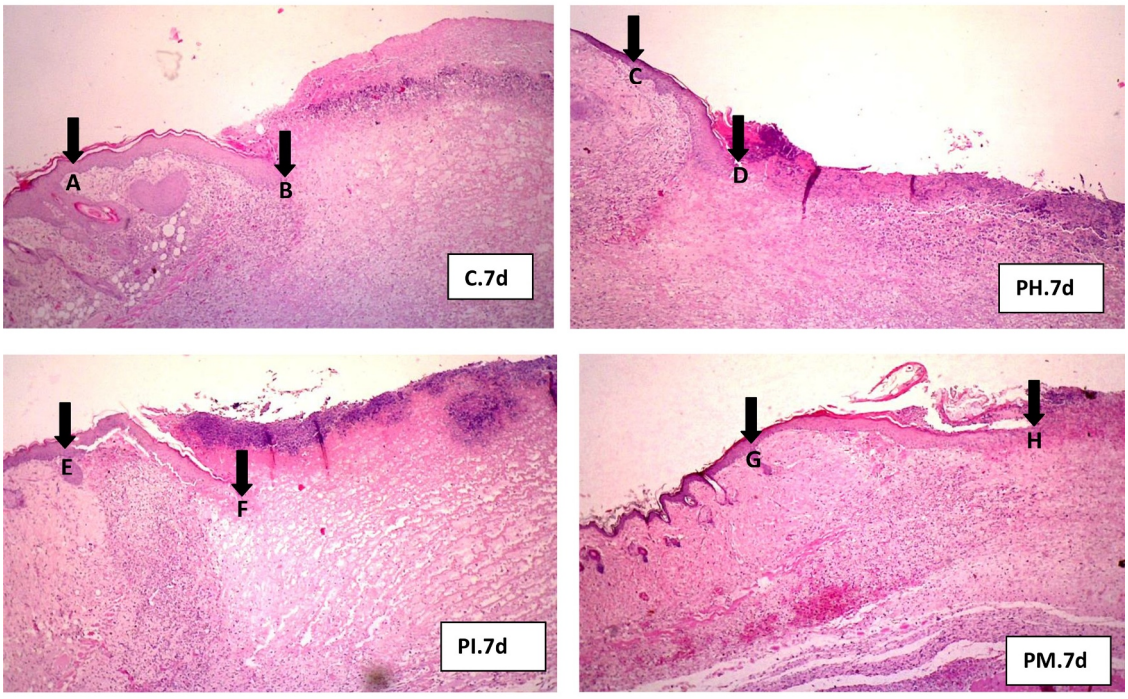
Wounds were observed in every group from days 0 to 14, as shown in Fig. 6. Generally, wound areas in all groups increased over the first four days and then gradually decreased until the end of the observation period. Wound areas in PM and PI on day 7 were smaller than those observed in C. On day 14, wound areas in PM and PH were smaller than those in C. However, those in the PM and PH were smaller than those in PI. Wounds were inspected every day and mostly found to be fresh.

3.5. Wound area reduction and estimated day of healing

Fig. 7 shows ratios of wound areas to initial wound areas during healing. On day 7, wound areas in PM and PI were significantly smaller than in C (PM vs C: $P < 0.05$; PI vs C: $P < 0.05$), but were almost the same as in PH (PH vs PM: $P > 0.05$; PH vs PI: $P > 0.05$). Conversely, on days 12–14 the wound areas in PM and PH were significantly smaller than in PI (PM vs PI: $P > 0.05$; PH vs PI: $P > 0.05$). This indicated that during plasma jet treatment over the proliferative phase from day 4 until day 7improved healing in PM and PI compared to C. After the proliferative phase, however, from days 12 until 14 healing in PI was delayed, while the healing seen in PM and PH was almost same as in C. A histogram estimating number of days until complete healing in every group (Fig. 7b) shows that PH, PM, Control (C), and PI required 10.85 ± 1.26, 11.03 ± 0.65, 11.37 ± 0.89, and 12.90 ± 0.70 days, respectively.



(a)



(b)

Fig. 8. (a) Percentage of re-epithelialisation; (b)Representative histological images of new epithelial tissue on day 7: (C.7d) HE staining of the control. (P.7d) HE staining of the plasma followed by hydrocolloid treatment. (PI.7d) HE staining of the plasma followed Indonesian honey. (PM.7d) HE staining followed by Manuka honey treatment. AB, CD, ED, and GH show the outer boundaries of new epithelium at magnification 200× . Re-epithelialisation increased more rapidly in the PM tissue than in the others.

3.6. Histological analysis

On days 7, 11, and 14, re-epithelialisation during healing was evaluated (Fig. 8**).** On day 7, the re-epithelialisation percentage in PM was significantly higher than in PH ($P < 0.05$). On other hand, on same day re-epithelialisation percentages for C, PH, and PI did not differ significantly. From days 7 to 11, the re-epithelialisation percentage for all groups increased dramatically. On day 11, the re-epithelialisation percentage for all groups did not differ significantly. On day 14, all the wounds in each of the groups were completely covered by new epithelium.

While normal matured wounds were observed in the C, PM, and PH groups on day 14, an abnormal condition(necrotic tissue)was observed in newly-formed epidermal tissue from the PH group, as shown in Fig. 9. An island of inflammatory cells, which may indicate residual inflammation, was observed.

4. Discussion

The hydrogen peroxide (H_2O_2) content of honey is reported to be a critical factor in its utility as a therapeutic agent. H_2O_2 is naturally fabricated through the glucose oxidase (GOX)-mediated conversion of glucose under aerobic conditions in diluted honey. It has been reported that the H_2O_2 concentration (or accumulation level) is highest when honey is diluted by 30–50% [36]. These (H_2O_2) levels, however, may vary from honey to honey [37].

Firstly, this investigation showed that while, in the reaction between water (W) or plasma-activated water (PAW), Manuka honey and Kyoritsu reagent cause significant H_2O_2 accumulation over time, Indonesian honey and Kyoritsu reagent did not cause H_2O_2 accumulation. This indicated that the former reaction may affect the factors influencing H_2O_2 accumulation,

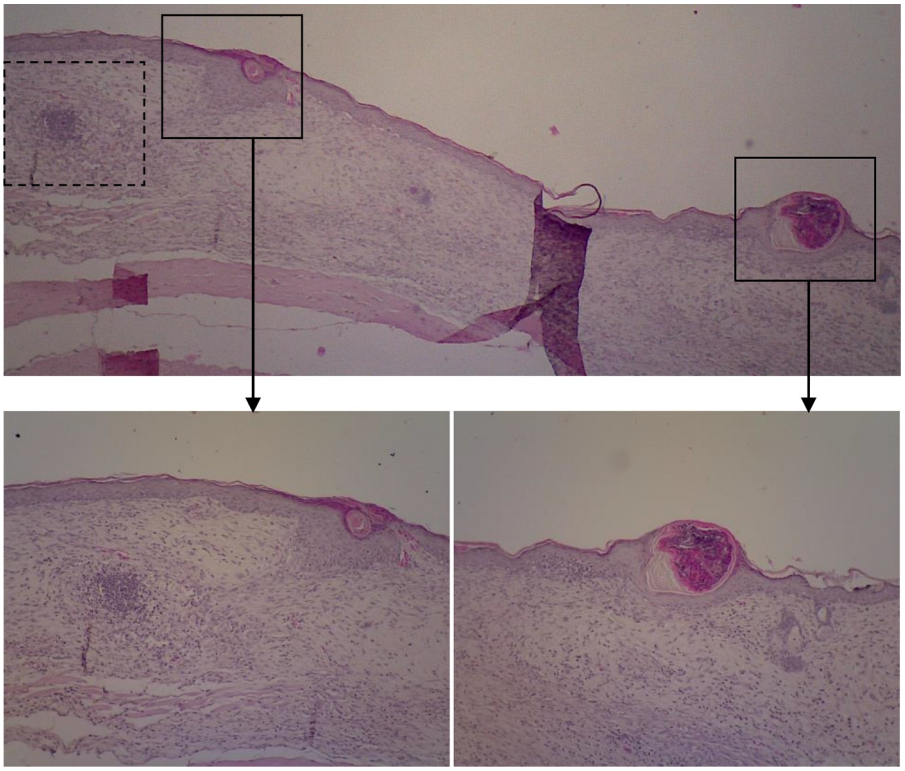


Fig. 9. Histological condition of wound samples in PH group on day 14. Insets with solid borders show the abnormal condition of new epidermal tissue.The dash-lined insert shows an island of inflammatory cells possibly indicating that the inflammation remains.

as stated by Majtan et al. [38]. Majtan et al. highlighted factors that influence H_2O_2 accumulation in honey, namely (1) H_2O_2 degradation by catalase enzyme originating from pollen, (2) low concentrations of GOX in honey, (3) inactivation of GOX by heating. Further investigations into the effects of the former reaction on the catalase enzyme, GOX rate, and GOX inactivation in Manuka honey should be conducted.

Secondly, our investigation showed that, following reaction with Kyoritsu reagent for 8 min, the levels of H_2O_2 accumulation in PAWM groups was higher than in WM groups, while levels in PAWI groups did not differ from those in WIs, as shown in Fig. 4. It is indicated that, compared with water, plasma-activated water may have a greater ability to accelerate H_2O_2 accumulation in Manuka honey. Conversely, the abilities of plasma-activated water and unactivated water to influence H_2O_2 accumulation in Indonesian honey may be equal.

It has been reported that variability in the outcomes of plasma medicine treatments may be correlated with differences between applied plasma parameters and treatment modes [31]. To the best of our knowledge, this is the first report to investigate the efficacy of limiting the application of plasma jet treatment to the proliferative phase of skin wound healing.

A previous study reported the efficacy of contact plasma jet application to wounds [39], while others confirmed the efficacy of non-contact plasma jet procedures [30, 32].Direct contact plasma jet application to normal skin of mice, however, has detrimental effects [30]. In this investigation, two types of honey, namely Indonesian and Manuka honey, were evaluated to support direct contact plasma application for the treatment of acute wounds. The results showed that during the proliferative phase both Indonesian and Manuka honey (PI and PM) have similar positive supportive effects on plasma jet improvement of wound healing. During the remodelling phase or after the termination of the plasma jet treatment, however, wound healing in the Manuka-supported group (PM) was significantly faster than in the Indonesian honey-supported group (PI). This research also showed that re-epithelialisation in PM, but not in PI, was significantly higher on day 7 than in PH. It can be concluded that Manuka honey was better than Indonesian honey at supporting plasma jet application as a topical wound therapy. Additionally, we suspect that the superiority of Manuka may be linked to its intrinsic H_2O_2 characteristics, as discussed previously.

This experiment also revealed the presence of necrotic tissue and inflammatory cells on new epidermis and dermis, respectively, on day 14 in the PH group. It is hypothesized that the appearance of such cells may be consequent to the combinative application of the plasma jet and the multiple holes dressing, followed by the hydrocolloid dressing alone. During treatment, a plasma jet may dry or necrotise the wound surface, and hydrocolloid dressings by themselves may have a lower ability to minimize such an effect than hydrocolloid dressings containing honey. In wound healing studies, it is well known that desiccative treatments impede healing [40]. The possible drying effect of plasma jets on wounds has been reported previously [32]. Our study had three main findings. Firstly, daily plasma jet treatments from days 4 till 7 had an impact on wounds which lasted until day 14. Secondly, the dimensions of abnormal tissue may be representative of the wound area exposed to plasma through holes in the dressing. Finally, the utilization of honey, whether Manuka and Indonesian, as applied in this study, may be better able to prevent the formation of abnormal tissue in wounds than hydrocolloid dressings alone.

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Conflict of interest

We wish to draw the attention of the Editor to the following facts

which may be considered as potential conflicts of interest and to significant financial contributions to this work. We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

Ethical Statement

We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

In detail, the experimental procedures and animal care were conducted according to the Guidelines for the Care and Use of Laboratory Animals of Laboratorium Penelitian dan Pengujian Terpadu/Integrated Research and Testing Laboratory (LPPT UGM), Gadjah Mada University, Yogyakarta, Indonesia (certificate number : 00086/04/LPPT/VII/2017). LPPT UGM is operated under the accreditation of the ISO/IEC 17025 and the National Accreditation Committee of Indonesia (Komite Akreditasi Nasional/KAN, Indonesia).

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Author contributions

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cpme.2018.08.001.

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