http://ejournal.seaninstitute.or.id/index.php/healt
Jurnal Eduhealt, Volume 14, No. 04 2023
ISSN. 2808-4608

Test of the Effectiveness of *Moringa Oleifera* Leaf Extract Cream on the Healing Process of Cut Wounds on the Skin Surface of Male Wistar Rats (*Rattus Norvegicus*)

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ARTICLE INFO

Keywords:
Moringa Oleifera, Skin Surface, Healing Process, Histopathological

ABSTRACT

Everyone there must have been injured in some way. Moringa Oleifera leaves have significant antioxidant activity and are just one of many plant-based treatments used to treat pain and speed wound healing. This study aims to ascertain if a cream made from the extract of moringa leaves (Moringa oleifera) accelerates the recovery of damages caused by cuts. This study strategy employs an actual or laboratory experimental design based on a pre-post test with a control group. Twenty adult male Wistar rats (Rattus norvegicus) were used. Mice were acclimatized, phytochemicals were screened, and treatment and monitoring were performed using dermapen wounds during the investigation. The Kolmogorov-Smirnov test, One-Way Analysis of Variance (ANOVA), and LSD post hoc Test were used to examine the research data in SPSS. Results from a 14-day study on the effects of a cream containing Moringa leaf extract on the wound healing of male Wistar rats (Rattus norvegicus) led researchers to this conclusion. In a recent phytochemical study, flavonoids, saponins, tannins, and alkaloids, known to have therapeutic benefits due to their high antioxidant content, were found in Moringa leaf extract. The secondary metabolite chemicals found in Moringa leaf extract significantly affected wound healing, with the best effects shown at an extract level of 10%.

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1. INTRODUCTION

A wound is a skin injury caused by detached, ripped, or damaged tissue (Afrylyani, Rachmawati, & Hardi, 2022). Skin wounds affect epithelial tissue and normal skin anatomy. Trauma from sharp or blunt items, temperature fluctuations, chemicals, explosions, electric shocks, or animal attacks can cause injuries (Prastika et al., 2020). Damage can be unintentional, like falls, wounds, and scratches, or purposeful, such as surgical incisions (Eka, Sahrial, Fikri, & Thohawi, 2016). Humans encounter daily accidents that might cause damage. Wounds can be open or closed, depending on the reason. Injury includes abrasions, cuts, tear or scar wounds, knife wounds, bite wounds, and burns (Weller & Sussman, 2006).

Open wounds can result from equipment or sharp objects, such as during surgery. A cut might result from scratching a rough surface. This wound's surface injury is shallow but can be substantial (Khafifah, Suwendar, & Fitrianingsih, 2020; Ririn Agustina, Ajeng Dian Pertiwi, 2019). An open wound, soreness, longer damage than depth, parallel scars, and no bruising at the skin's edge are signs of a cut wound. A cut might result from scratching a rough surface. Even a shallow incision can cause a considerable skin wound. Germs easily infect cuts and can lead to systemic diseases. An infection slows wound healing and produces exudates, toxins, and regenerative cell death. To avoid infection, the wounded bodily component must heal and operate normally (Kurniawan, Pertiwi, & Lestari, 2021).

Wounds heal because of connective tissue. Cells, humoral factors, and connective tissue work together to repair wounds. The inflammatory, proliferation, and maturation or remodeling phases of the wound healing process in humans can overlap. Skin contains defensive, sensory,thermoregulatory,

metabolic, and sexual signaling roles, making wound healing crucial. After an injury, these functions are impaired. Antiseptics, antibiotics, and wound care can treat wounds. Medical and empirical wound therapy are typical. Phenotypically, poor health facilities generally use empirical treatment, while those with excellent facilities use medical care. Local herbs are employed for practical wound treatment (Afrylyani et al., 2022; Calsum, Khumaidi, & Khaerati, 2018; Khafifah et al., 2020; Weller & Sussman, 2006).

Dermatological wounds induce wound healing, which involves cell substrates and physiological processes, including hemostasis, vasoconstriction, and primary and secondary hemostasis. Healing wounds, especially incisions, is still problematic in the health sector due to the massive number of cases and treatment approaches established during globalization. Many wound healing researchers use herbal plants and fruit to make remedies. Alkaloids, flavonoids, saponins, tannins, steroids, and triterpenoids are secondary metabolites produced by plants that can treat many ailments (Syaputri, Girsang, & Chiuman, 2022). Flavonoids, saponins, and tannins are proangiogenic antioxidants that nourish wounded skin and enhance oxygen supply (Pamungkas & Wahyuningsih, 2022). Traditional medicine using plants and natural ingredients has proliferated in Indonesia, and some natural ingredients are even mass-produced because they have fewer side effects than chemical-based drugs and are easy to use, available, and affordable (Adha, Dewana, Suyono, Chiuman, & Ginting, 2022).

Moringa oleifera leaves contain flavonoids, saponins, and tannins and are used to cure wounds. Moringa leaves include quercetin, routine, kaempferol, gallic acid, catechin, chlorogenic acid, ellagic acid, epicatechin, quercitrin, and isoquercitrin. Moringa leaf extract contains tannins and saponin (Erwiyani, Haswan, Agasi, & Karminingtyas, 2020). Pteridosperm with glucosinolate four alpha-L-rhamnose silylbenzyl isothiocyanate in moringa leaves acts as an antibiotic. Moringa leaf extract has been demonstrated to heal wounds in several investigations (Nafi, Sasputra, & Rante, 2020). found that Moringa leaf extract heals mouse skin wounds. Zakiya found that 40% Moringa leaf ethanol extract heals second-degree burns in mice (Zakiya, Mulqie, & Fitrianingsih, 2019). Erwiyani found that 15% Moringa leaf ethanol extract reduced burn wounds in male white rats (Erwiyani et al., 2020). In line with the formulation of the problem above, this research was conducted to test the effectiveness of Moringa oleifera leaf extract cream on the healing process of cuts on the surface of the skin of male Wistar rats (Rattus norvegicus).

2. METHOD

The research model encompasses laboratory experimental research or real-world trials employing a pretest-posttest design with a control group. The study's objective was to evaluate the efficacy of a cream containing Moringa leaf extract in promoting the healing of incision wounds on the skin surface of male Wistar white rats. The samples in this study were adult male Wistar white rats (Rattus norvegicus) weighing 160-200 grams aged 2-3 months. The number of samples of white rats used in this study was 20 and divided into 4 (four) groups, with five rats in each group consisting of the control group (P0), treatment groups 1, 2, and 3 (P1, P2, and P3). This research comprises independent and dependent variables (Suwarno & Nugroho, 2023). The independent variable in this research is Moringa leaf extract cream. Meanwhile, the dependent variable in this research is the healing process of cuts on the skin surface of male white Wistar rats.

The method research procedures commenced by subjecting the test animals to acclimatization within the Animal House, located within the Faculty of Mathematics and Natural Sciences at the University of North Sumatra. This acclimatization phase lasted for one week. Next, the production of Moringa Leaf extract will be undertaken. Moringa leaf cream's output involves using an oil-in-water emulsion formulation. Subsequently, perform incisions on mice by carefully removing the fur surrounding the designated wound site on their dorsal region, ensuring a clean, hairless surface. The dimensions of the incision area should adhere to the specified measurements of 1×3 cm.

The therapy for incision wounds is administered by the prescribed wound care protocol, which includes specific treatment groups categorized by concentrations of 0%, 2.5%, 5%, and 10%. Subsequently, the incision site is subjected to a twice-daily treatment regimen administered in the morning and evening. Throughout this treatment period, histopathological analysis is conducted to

evaluate tissue samples using a microscope. Subsequently, the research data underwent examination utilizing the SPSS software. The normality of the data was assessed using the Kolmogorov-Smirnov test, with a significance level of $p > 0.05$. There is a statistically significant difference between the treatment groups as determined by the One-Way Analysis of Variance (ANOVA) test, with a significance level of $p < 0.05$. To ascertain the most effective treatment group, a Post Hoc Test was conducted utilizing the Least Significant Difference (LSD) technique.

3. RESULTS AND DISCUSSION

Research Result

Rats adapt to new situations and eat and drink as needed. The Moringa leaves were filtered three times and stored in bottles. Thicker Moringa leaf extract was prepared by rotary evaporating the extract at 70oC. Based on Table 3.1, distilled water is added until the contents weigh 100 grams. Following Table 1, distilled water was added to 100 grams.

Table 1. Moringa Leaf Extract Cream Formula (O/W)

Material	Cream Formula (gram)			
	F0	F1	F2	F3
Moringa Leaf Extract	**0**	**2,5**	**5**	**10**
Cetyl alcohol	4	4	4	4
Glycerin	15	15	15	15
TEA (triethanolamine)	3	3	3	3
Stearic acid	12	12	12	12
Methyl paraben	0,2	0,2	0,2	0,2
Propyl paraben	0,02	0,02	0,02	0,02
Aquades	100	100	100	100

For the required incision size (1x3 cm), the mouse's fur surrounding the wound area (back) is shaved until clean (bald). After shaving, the rats were deprived of consciousness with ketamine (80 ml/kg BW) and xylazine (5 ml/kg BW) to prevent pain and excessive movement. Mice underwent 2 cm long cuts with ± 2 mm depth to the dermis layer. The results of the phytochemical test were carried out by testing the content of flavonoids, tannins, saponins, alkaloids, and steroids, as seen in Table 2 below:

Table 2 Phytochemical Test Results of Moringa Leaf Extract (*Moringa oleifera*)

Phytochemical	Reactions	Results	Color Description
Flavonoid	Mg HCL Concentrated	Yellow	Positive
Saponin test	Aquades	Contains Foam	Positive
Tannin test	FeCl3	Blackish Green	Positive
Alkaloid	Wagner Reagent	Brown Precipitate	Positive

Table 3 shows the average wound healing rate in the treatment group given Moringa leaf extract cream at 2.5%, 5%, 10%, and the control group from the first to the 14th day.

Table 3 Average Healing of Cut Wounds (cm)

Days to -	P0	P1	P2	P3
2	1.97	1.96	1.93	1.80
4	1.74	1.72	1.73	1.69
6	1.59	1.51	1.50	1.45
8	1.32	1.22	1.19	1.15
10	1.15	0.78	0.75	0.73
12	0.87	0.50	0.47	0.33
14	0.65	0.13	0.08	0.02
Mean	1.33	1.12	1.09	1.02
SD	0.47	0.67	0.68	0.69

Based on the average healing of cut wounds in each group, group P3, or the group receiving Moringa leaf extract cream with a 10% concentration, it healed faster, followed by group P2 and then

group P1. Incision wound healing was slowest in the control group (P0) or base cream group (0% extract).

Table 4 Normality Test Results Using the Shapiro-Wilk Technique

Group Extract Dose	Statistical	Significance
Control (P0)	0,897	0,392
2,5% (P1)	0,954	0,769
5% (P2)	0,917	0,509
10% (P3)	0,902	0,423

Table 4, which was checked for normality using SPSS, shows that the control and treatment groups all have significant values for the variable % of average cut wound healing from day 1 to day 14. In the Shapiro-Wilk Test, the significance value (p) exceeds the standard margin of p>0.05: 0.392 for the control group (P0), 0.769 for the 2.5% Moringa leaf extract dose group (P1), 0.509 for the 5% Moringa leaf extract dose group (P2), and 0.423 for the 10% dose group (P3). Shapiro-Wilk normality test shows that wound healing average % data is regularly distributed (Campbell & Stanley, 2015).

Table 5 shows the ANOVA test findings (attached page) to determine if the four research or observation groups had different wound healing rates. Using table data in the "Sig." The p-value is 0.000. At the fundamental level = 0.05, Ho is rejected. Hence, the four groups have a significant variation in wound healing percentage.

Table 5. Results of the ANOVA Test of Homogeneity of Variances

Results Category	Levene Statistical	Significance
Mean	0,681	0,576
Median	0,264	0,851
Trimmed Mean	0,624	0,610

Table 6. Post Hoc Bonferroni Test Results

Test	Percentage Healed Wounds (I)	Percentage Extract Dosage (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Bonferroni	Control (P0)	2,5% (P1)	-10.58400*	.52886	.000	-12.1750	-8.9930
		5% (P2)	-11.85800*	.52886	.000	-13.4490	-10.2670
		10% (P3)	-15.24600*	.52886	.000	-16.8370	-13.6550
	Extract Dosage 2,5% (P1)	Control (P0)	10.58400*	.52886	.000	8.9930	12.1750
		5% (P2)	-1.27400	.52886	.170	-2.8650	.3170
		10% (P3)	-4.66200*	.52886	.000	-6.2530	-3.0710
	Extract Dosage 5% (P2)	Control (P0)	11.85800*	.52886	.000	10.2670	13.4490
		2,5% (P1)	1.27400	.52886	.170	-.3170	2.8650
		10% (P3)	-3.38800*	.52886	.000	-4.9790	-1.7970
	Extract Dosage 10% (P3)	Control (P0)	15.24600*	.52886	.000	13.6550	16.8370
		2,5% (P1)	4.66200*	.52886	.000	3.0710	6.2530
		5% (P2)	3.38800*	.52886	.000	1.7970	4.9790

The earlier Anova test showed that Ho was rejected (there was a difference). Hence, Post Hoc testing was needed. The Post Hoc Test will determine which groups are different (Campbell & Stanley, 2015). Further, the Post Hoc Bonferroni Test findings are in Table 6. Most comparisons across groups demonstrate a difference in the average percentage of wound healing in the Wistar strain of white rats (Rattus norvegicus), denoted by a symbol. star "*" except for P1-P2 and vice-versa comparisons. It can be concluded that the comparison between the group with 2.5% Moringa leaf extract (P1) and the group with 5% (P2) or vice versa shows no differences or values are almost close, whereas the test results showed nothing. A star "*". Group Bonferroni Post Hoc Testing was done using SPSS for Windows.

The cut wound healing process was observed by measuring how long each control and treatment group took to recover. The healing of a cut wound is measured by erythema, swelling, and

closure (Grey & Harding, 2009). Four groups of healed incision wounds were examined for 14 days for redness (erythema), edema, and wound closure.

Table 7 shows that the Control Group (P0) lost erythema (redness) on days 9–11, but experimental animals 1, 4, and 5 lost it faster. Experimental mice 1, 2, and 3 responded fastest in Treatment Group 1 (P1) on days 8–9. Treatment Group 2 (P2) had it on days 6–8, and experimental mice 1 had it fastest. Day 6–7 in Treatment Group 3 (P3), fastest in experimental mice 5. Experimental animals 1, 4, and 5 had the fastest swelling decrease compared to the Control Group (P0) on day 7. Experimental mice 1, 2, and 3 experienced the most rapid on day 6 in Treatment Group 1 (P1). In Treatment Group 2 (P2), experimental mice 1 ran quickest on day 4. In Treatment Group 3 (P3), experimental mice 5 experienced the fastest on day 4.

Cut wounds heal by inflammation, proliferation, and maturation. Fibroblasts produce collagen and other wound-healing proteins during proliferation. Vascular and cellular responses to skin tissue injury define inflammation. Collagen scar tissue reorganizes and strengthens over months. This maturation phase perfects new tissue creation into muscular, high-quality healing tissue. In this study, fibroblast cell proliferation and collagen density began on days 7-14.

As shown in Figure 1, the treatment groups given 5% Moringa leaf extract cream (P2) and 10% (P3) had more fibroblast cells and denser cells than the Control Group (P0) and the group given leaf extract cream. Moringa 2.5% (P1). However, histological findings showed thicker collagen fibers in the P3 group compared to the P2 group. The P0 control group had denser fibroblast cells, while the P1 group received Moringa leaf extract at 2.5% and had fewer sparser cells. However, group P1 collagen fibers were thicker and denser than P0.

In Figure 2, for the histopathological observation of the cut wound on the 14th day after administering 10% Moringa leaf extract cream (P3), the epithelial formation in the wound area was denser and better than the cut wound in the control group, the group given two doses of Moringa leaf extract cream, 5% (P1) and the group given Moringa leaf extract cream at a dose of 5% (P2).

Table 7. Results of Physiological Observations of Cut Wounds

Group Of Rats	to-	Condition Of the Wound on The Day													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Control (P0)	1	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open
	2	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open
	3	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open
	4	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open
	5	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close
Dosage 2,5% (P1)	1	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	2	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	3	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close
	4	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close
	5	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close
Dosage 5% (P2)	1	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close	Dry Close
	2	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	3	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	4	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close
	5	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open
Dosage 10% (P3)	1	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	2	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close
	3	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close	-
	4	Red Swoll	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close	-
	5	Red Swoll	Red Swoll	Red Swoll	Red	Red	Dry Open	Dry Open	Dry Open	Dry Open	Dry Open	Dry Close	Dry Close	-	-

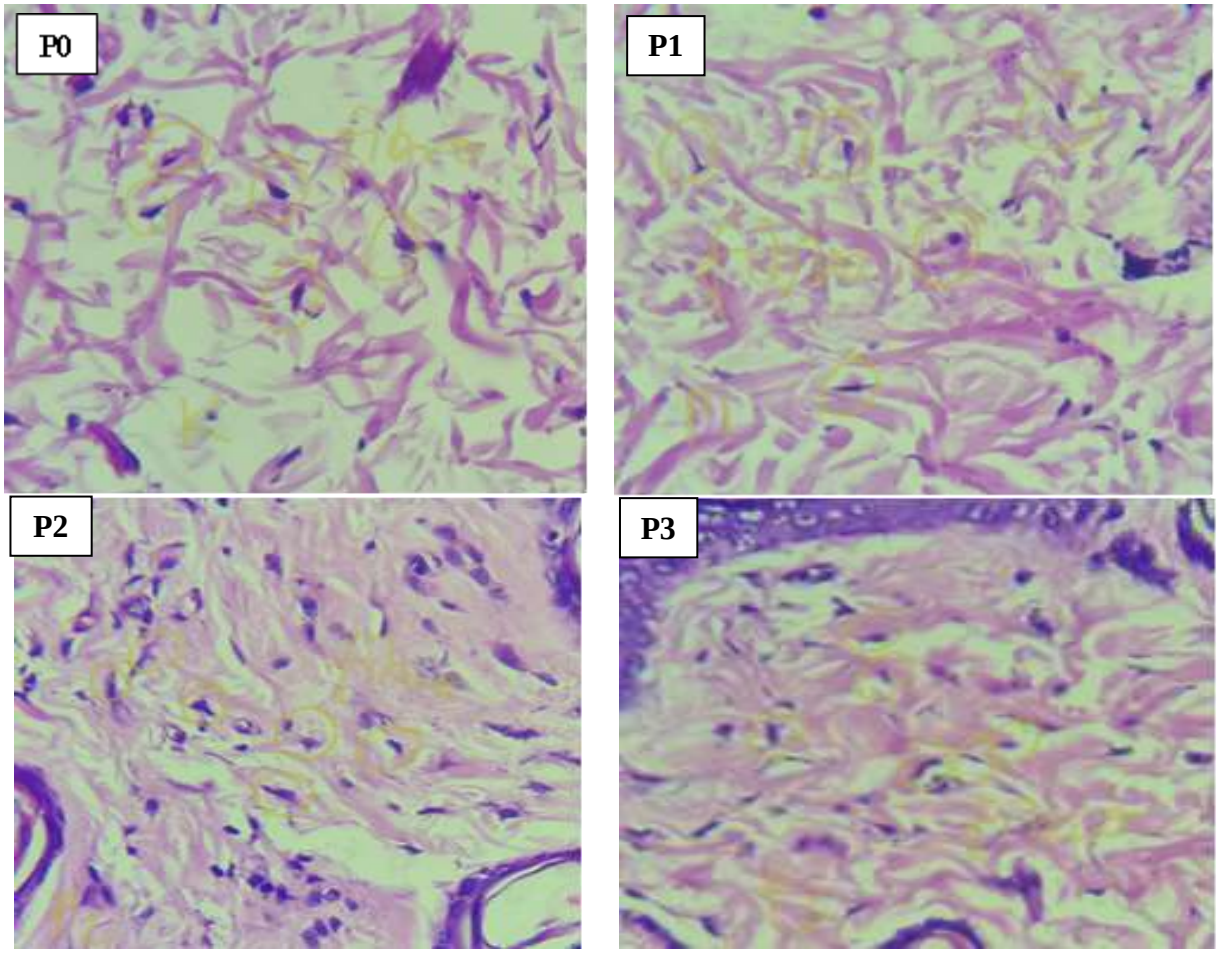

Figure 1. Fibroblast Cell Proliferation (400x Magnification)

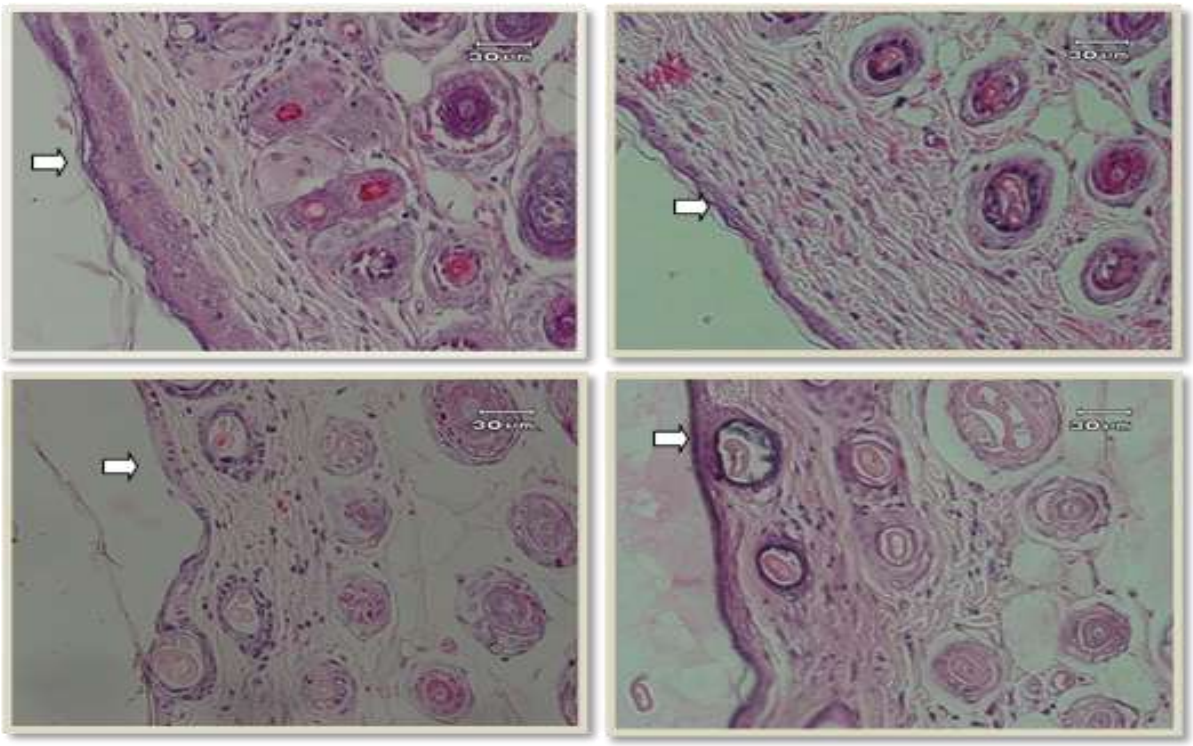

Figure 2. Image of Collagen Density on Day 14

Note: A= Control Group P0, B= Group P1, C= Group P2, D= Group P3. →Epithelial formation at the edges of the wound

Research Discussio

This study tested the healing impact of incision wounds by shortening them. Moringa oleifera leaves were extracted for this investigation. Air-dry 1500 grams of Moringa leaves after washing them with running water. After drying, Moringa leaves were crushed into powder, weighed 500 grams, and macerated for five days in a 90% ethanol solvent that had been distilled. A thick Moringa leaf extract was obtained by vacuuming the maceration results with a rotary evaporator. Ethanol meets extracting requirements. Ethanol dissolves most polar and non-polar compounds (Chakraborty, Majumder, Ghosh, Saha, & Bhattacharya, 2021; Putra et al., 2021; Srivastav, Singh, Singh, Giri, & Singh, 2021). Then, Moringa leaf extract is made into cream. The more solvents utilized, the higher the yield.

Male white rats were utilized in this study because they are easy to handle and have human-like physiology and anatomy. The average weight of the 20 mice was 108.87 grams. To adapt, mice were acclimatized for one week before treatment. Each rat was grouped into four groups: group I (P0) received cream base (0% extract), group II (P1) received 2.5% topically, group III (P2) received 5%, and group IV (P3) received 10%. Two mice were placed in a cage with a divider to minimize movement so as not to impact the healing of the cut wounds or cause issues between the animals. This study recommends plaster and gauze for cut wounds to prevent infection. Treatment of cuts was complex since the application could not attach to the rat's skin. Thus, it came off, and the rat nibbled the plaster and gauze. This researcher treated cuts without bandage and gauze. The incision wound was 2 cm long and 0.2 cm deep but widened more than 0.2 cm. Despite chloroform anesthesia, the mice moved throughout induction. During 14 days of healing, wounds were treated and measured daily using calipers. This stestimatesures erythema, edema, and wound closure.

Redness (erythema) is the first sign of inflammation. Rat wounds turn red due to inflammation. Large blood vessel releases of fibrinogen protein and activated platelets cause blood clots (Che Soh et al., 2020; Valizadeh et al., 2021; Xu et al., 2022). From ocular observations of 20 white mice, the cuts displayed erythema and swelling on the 1st to 3rd day after treatment with 2.5%, 5%, 10%, and base cream. Blood clots and stops bleeding during inflammation. On the fourth day, group P2 and P3 had a proliferative phase where tissue creation resumed and did not experience erythema, while group P1 and the control group (P0) did. Cut wounds matured fastest in the 5% extract dosage treatment group (P2) and 10% extract dose treatment group (P3), where five animals were closed and only had scars on the 10th day. Some cut wounds in group P1 and control group P0 had partially closed, forming a scab during proliferation. This shows fresh cell development by bringing the wound edges together. Scabs mark the end of the inflammatory phase and the start of the proliferation and maturation phases.

The wound-healing phase includes inflammation, proliferation, and maturation (Fam et al., 2022; Röhl, Zaharia, Rudolph, & Murray, 2015; Sorg, Tilkorn, Hager, Hauser, & Mirastschijski, 2017). The average phase of wound healing on the first to the 4th day in groups P2 (5%) and P3 (10%) given Moringa leaf extract cream was the inflammatory phase, which reduced wound length faster than groups P1 (2.5%) and P0, which took until the 6th day. Lemongrass contains flavonoids that inhibit wound bleeding and impact inflammatory cell formation during wound healing. As an astringent, tannin reduces mucosal permeability and strengthens mucosal connections, avoiding irritants. It also shrinks and kills germs by affecting their permeability. Moringa leaves phenolic acid prevents free radical-induced cell damage and inflammation. Moringa leaf extract cream at 10% (P3) was more successful than the other groups in this trial. The secondary metabolite chemicals benefit wounds at 10% Moringa leaf extract, but at low concentrations, they inhibit microbes, making them less effective. According to Baquero and Zhang, antibacterials are bacteriostatic at low concentrations but destroy microbes at high concentrations (Baquero & Levin, 2021; Zhang et al., 2021).

This research used cream preparations as extract formulations based on Djuwarno's research. They concluded that the Moringa leaf extract emulgel preparation had good physical stability when stored at room temperature for 14 days. There were no changes in organoleptic, pH, stickiness, spreadability, or viscosity, and meeting cream dosage form requirements. Additionally, cream preparations are more accessible and more desirable (Djuwarno, Hiola, & Isa, 2021). Furthermore, another factor that can also influence the results of this study is that the number of samples used is

smaller than in previous studies, where in this study, the samples used were only 20 white mice or five mice/group. The large number of samples used will influence the research because the greater the number of samples used, the smaller the chance of generalization errors (Notoatmodjo, 2018).

Stress can also influence the results within the rat's body, which cannot be ignored because it can affect the wound healing process (Cusack & Buggy, 2020; Decker, Kapila, & Wang, 2021). In references put forward by several researchers, stress can trigger an increase in cortisol, which has an impact on suppressing cellular immunity so that it can slow down wound healing.

4. CONCLUSION

The conclusion is derived from a study that examined the efficacy of a cream containing Moringa oleifera leaf extract in promoting the healing of skin cuts in male Wistar rats (Rattus norvegicus) over 14 days. The phytochemical analysis of the Moringa oleifera leaf extract revealed the presence of flavonoids, saponins, tannins, and alkaloids, known to possess medicinal properties due to their high antioxidant content.nA significant disparity was observed in the healing rates of cuts between the control group (P0) and the treatment groups (P1, P2, and P3). This is because the control group (P0) lacks active compounds that can expedite the incisions' healing process. The findings of this study indicate that the administration of a 10% dose of Moringa oleifera leaf extract cream had superior efficacy in the healing of cut wounds in white rats, as compared to the groups receiving 2.5% and 5% doses of Moringa oleifera leaf extract cream. This phenomenon is because when administered at a dosage of 10% extract, the secondary metabolite compounds present in Moringa oleifera leaf extract exhibit a discernible impact on wound healing. For further investigation with higher Moringa oleifera leaf extract concentrations and additional factors, such as comparison to the positive control group (bioplacenton). Human studies on Moringa oleifera leaf extract's wound-healing properties are safer than other Moringa oleifera leaf extract preparations that are more helpful and easier to make in large quantities, especially in North Sumatra and other growing regions. The research results should be compared to other studies to help other researchers study Moringa oleifera leaf extract administration, primarily to expedite wound healing.

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