

Pengaruh Ekstrak Bawang Putih terhadap Kadar Malondialdehid pada Tikus yang Terpapar Asap Rokok dalam Jangka Panjang

The Effect of Garlic Extract on Malondialdehyde Levels in Rats Exposed to Prolonged Cigarette Smoke

Syarinta Adenina¹, Masayu Nabila Hanifah^{2*}, Legiran³, Tri Suciati⁴, Indri Seta Septadina⁵

¹Medicine Faculty, Universitas Sriwijaya, Palembang, Indonesia

²Departement of Pharmacology, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia

^{3,4,5}Departement of Anatomy, Faculty of Medicine, Universitas Sriwijaya, Palembang, Indonesia
Email: masayunabilahanifah@gmail.com

Abstrak

Latar belakang: Paparan asap rokok dalam jangka panjang dapat meningkatkan pembentukan *spesies oksigen reaktif* (ROS), yang memicu stres oksidatif dan peroksidasi lipid pada jaringan paru-paru. Salah satu biomarker yang sering digunakan untuk menilai kerusakan oksidatif adalah malondialdehid (MDA). Bawang putih (*Allium sativum* L.) mengandung senyawa organosulfur yang dilaporkan memiliki aktivitas antioksidan dan antiinflamasi. Namun, efektivitas ekstrak bawang putih dalam kondisi paparan asap rokok dalam jangka panjang masih terbatas. **Tujuan:** Penelitian ini bertujuan untuk mengevaluasi pengaruh pemberian ekstrak bawang putih terhadap kadar MDA serum pada tikus Wistar jantan yang terpapar asap rokok dalam jangka panjang. **Metode:** Penelitian ini menggunakan desain eksperimental sejati dengan kelompok kontrol posttest-only, melibatkan 30 tikus jantan Wistar yang dibagi menjadi kelompok normal, kelompok paparan asap rokok, kelompok vitamin C, kelompok ekstrak bawang putih 50 mg/kg berat badan, kelompok ekstrak bawang putih 100 mg/kg berat badan, dan kelompok kombinasi ekstrak bawang putih-vitamin C. **Hasil:** Paparan asap rokok dilakukan selama 21 hari berturut-turut. Kadar MDA serum dianalisis menggunakan metode *Thiobarbituric Acid Reactive Substances* (TBARS). Studi ini menunjukkan bahwa paparan asap rokok meningkatkan kadar MDA serum. Sementara itu, pemberian vitamin C secara signifikan menurunkan kadar MDA tersebut. **Kesimpulan:** ekstrak bawang putih belum terbukti memiliki efek antioksidan terhadap stres oksidatif yang disebabkan oleh paparan asap rokok dalam jangka waktu lama.

Kata kunci: Paparan asap rokok; *Allium sativum* L.; Malondialdehid; Stres Oksidatif; Antioksidan.

Abstract

Background: Prolonged exposure to cigarette smoke can increase the formation of reactive oxygen species (ROS), which trigger oxidative stress and lipid peroxidation in lung tissue. One biomarker frequently used to assess oxidative damage is malondialdehyde (MDA). Garlic (*Allium sativum* L.) contains organosulfur compounds that have been reported to possess antioxidant and anti-inflammatory activities. However, the effectiveness of garlic extract in conditions of prolonged cigarette smoke exposure remains limited. **Aim:** This study aims to evaluate the effect of garlic extract administration on serum MDA levels in male Wistar rats exposed to prolonged cigarette smoke. **Methods:** This study used a true experimental posttest-only control group design with 30 male Wistar rats divided into the normal group, the cigarette smoke exposure group, the vitamin C group, the 50 mg/kg body weight garlic extract group, the 100 mg/kg body weight garlic extract group, and the garlic extract-vitamin C combination group. Cigarette smoke exposure was conducted for 21 consecutive days. Serum MDA levels were analyzed using the Thiobarbituric Acid Reactive Substances (TBARS) method. **Result:** This study showed that cigarette smoke exposure increased serum MDA levels. Meanwhile, vitamin C administration significantly reduced these MDA levels. However, administration of garlic extract at doses of 50 mg/kg body weight or 100 mg/kg body weight, either alone or in combination with vitamin C, did not result in a reduction in serum MDA levels. **Conclusion:** garlic extract has not yet been shown to provide an antioxidant effect against oxidative stress caused by prolonged exposure to cigarette smoke.

Keywords: Cigarette Smoke Exposure; *Allium sativum* L.; Malondialdehyde; Oxidative Stress; Antioxidant.

*Corresponding author: Masayu Nabila Hanifah, Medicine Faculty, Universitas Sriwijaya, Palembang, Indonesia.

E-mail : masayunabilahanifah@gmail.com

Doi : 10.35451/jfm.v9i1.3947

Received : September 23, 2026, Accepted: October 27, 2026, Published: October 30, 2026

Copyright: © 2026 Masayu Nabila Hanifah (s). Creative Commons License This work is licensed under a Creative Commons Attribution 4.0 International License.

1. INTRODUCTION

Exposure to cigarette smoke is significantly linked to the onset of chronic diseases affecting several organ systems, especially the respiratory system. Tobacco exposure significantly impacts global morbidity and mortality, with the World Health Organization documenting over 8 million annual deaths attributable to tobacco consumption and secondhand smoke exposure [1]. The prevalence of smoking-related diseases is particularly severe in low- and middle-income nations, where restricted access to healthcare may exacerbate disease development and outcomes.

The detrimental consequences of cigarette smoke are mostly associated with its intricate chemical composition. Cigarette smoke has thousands of molecules, including hazardous gases, oxidants, and substances that generate free radicals, which can disturb normal cellular homeostasis [2,3]. Prolonged contact to these materials can result in the overproduction of reactive oxygen species (ROS) and subsequent oxidative imbalance in biological tissues. Elevated levels of reactive oxygen species (ROS) damage lipids, proteins and nucleic acids and simultaneously activate inflammatory pathways that result in tissue deterioration. Oxidative stress in pulmonary tissues is associated with inflammatory cell infiltration, epithelial degradation, and progressive structural alterations that are often found in chronic obstructive pulmonary disease (COPD) and other smoking-related respiratory diseases. One often utilised biomarker for assessing oxidative stress is malondialdehyde (MDA), a byproduct of lipid peroxidation produced during oxidative damage to cellular membranes. Elevated MDA levels have often been documented after exposure to cigarette smoke and are regarded as a marker of increased oxidative damage. Experimental studies indicate that exposure to cigarette smoke may elevate reactive oxygen species (ROS) production beyond the limits of innate antioxidant defence mechanisms, thereby hastening inflammatory and oxidative processes [8].

The interest in natural products as potential modulators of oxidative stress has significantly risen in recent years. Numerous medicinal plants possess bioactive chemicals that can provide antioxidant and anti-inflammatory properties with comparatively less side effects than synthetic medicines. Garlic (*Allium sativum* L.) is a medicinal plant extensively studied for its substantial concentration of organosulfur compounds, such as allicin, diallyl sulphide, diallyl disulphide, and diallyl trisulfide. These chemicals are thought to exhibit antioxidative effects via scavenging free radicals and modulating inflammatory signalling pathways. Previous research have shown that garlic extract may diminish oxidative stress indicators, such as MDA levels, in experimental models subjected to cigarette smoke [11,12].

While numerous research have assessed the antioxidative capacity of garlic extract, the majority concentrated on short-term smoke exposure models lasting around 14 days [13, 14]. There is insufficient evidence concerning the impact of garlic extract administration during extended exposure to cigarette smoke, which may more accurately reflect persistent oxidative stress and initial pathological alterations linked to chronic lung damage [15,16]. This study aimed to assess the impact of garlic extract on blood malondialdehyde (MDA) concentrations in male Wistar rats subjected to prolonged exposure to cigarette smoke.

2. METHODS

Experimental design

This study employed an in vivo experimental design using a true experimental posttest-only control group method. A total of 30 male Wistar rats (*Rattus norvegicus*) were randomly divided into six groups: Normal group (A), Cigarette smoke exposure group as a negative control (B), Vitamin C group as a positive control (C), Garlic extract group at a dose of 50 mg/kg body weight (D), Garlic extract group at a dose of 100 mg/kg body weight (E), and Combination group of garlic extract and vitamin C at a dose of 100 mg/kg body weight (F).

Preparation of garlic extract

Fresh garlic bulbs were obtained from the traditional market in Jakabaring, South Sumatra. The garlic was cleaned and dried in an oven at 40°C for five days. Once dry, the material was ground into a crude powder using a blender. Extraction was performed using the maceration method with 70% ethanol at a 1:5 ratio for 48 hours. The extraction mixture was stirred periodically, and the solvent was replaced every 24 hours. After the maceration process, the solution was filtered to separate the filtrate from the residue, and the extraction process

was repeated twice. The filtrate was then concentrated and dried until all the ethanol had evaporated, yielding a powdered garlic extract [17, 18].

Phytochemical analysis

Phytochemical analysis was conducted to identify secondary metabolites associated with antioxidant activity, including flavonoids, alkaloids, saponins, steroids, triterpenoids, quinones, and tannins [19].

Acclimatisation of experimental animals

Prior to the intervention, all animals were acclimatized for seven days under controlled laboratory conditions. Mice were housed in stainless steel cages at a temperature of $22 \pm 1^\circ\text{C}$, with good ventilation and maintained cage sanitation. Food was provided ad libitum, and drinking water was provided twice daily [20].

Cigarette smoke exposure and treatment administration

After acclimatization, rats in the intervention group were exposed to cigarette smoke for 21 consecutive days using unfiltered kretek cigarettes containing 39 grams of tar and 2.3 grams of nicotine. Exposure was conducted using a smoking chamber measuring 54 cm $\times$ 36.5 cm $\times$ 28.5 cm with six mice per session. A total of 23 cigarettes were smoked in the chamber over the course of one hour to produce consistent smoke exposure. Following cigarette smoke exposure, garlic extract and vitamin C were administered orally via a gastric tube according to the treatment group.

Venipuncture and serum isolation

At the conclusion of the intervention period, about 2 ml of blood was extracted from the ocular vein utilising microhematocrit tubes. Blood samples were maintained at room temperature for one hour to facilitate clot formation, followed by centrifugation at 3,000 rpm for 10 minutes to isolate serum samples [21].

Quantification of serum malondialdehyde (MDA)

Serum malondialdehyde (MDA) levels were measured using the thiobarbituric acid reactive substances (TBARS) assay. The serum was initially mixed with 1 ml of 0.9% nacl solution, then 100 μl of that mixture was centrifuged at 8,000 rpm for 20 min. Then, 550 μl distilled water and 100 μl 20 % trichloroacetic acid (TCA) were added to the mixture. Homogenisation was performed with vortex mixer and 400 μl of 1% thiobarbituric acid (TBA) solution was added and centrifuged at 500 rpm for 15 minutes. The supernatant containing the tba–mda complex was then transferred to a new microtube and heated in a water bath at 100°C for 30min. The absorbance readings were recorded at 535 nm by means of a uv-visible spectrophotometer [22].

Statistical analysis

Data analysis was performed using statistical program for the social sciences (SPSS) version 27 for windows. Data normality was tested using the shapiro-wilk test and variance homogeneity was evaluated using levene's test. Comparative studies were conducted using parametric or nonparametric statistics tests depending on the parameters of distribution of data. One-way analysis of variance (ANOVA), independent t test and kruskal–wallis test were applied with post hoc analysis to differentiate differences between group.

Ethical Consideration

All research procedures were conducted in accordance with biomedical research ethics standards and approved by the Health Research Ethics Committee of the Faculty of Medicine at Sriwijaya University (Protocol No.321-2025).

3. RESULT

Phytochemical analysis of garlic extract (Table 1) identified six types of secondary metabolites: flavonoids, alkaloids, saponins, triterpenoids, steroids, and quinones; tannins were not detected.

Table 1. Phytochemical Constituents of Garlic Extract

Phytochemical compound	Result
Flavonoids	+
Alkaloids	+
Saponins	+
Triterpenoids	+
Steroids	+
Quinones	+
Tannins	-

Based on this study, it was found that there were differences in serum MDA levels among the treatment groups ($p=0.0001$, Table 2). The normal group had the lowest mean serum MDA level, while the cigarette smoke-exposed group showed an increase in MDA levels to 21.48 ± 1.15 . Post hoc analysis showed that there was a significant difference in serum MDA levels between the normal group and the cigarette smoke-exposed group ($p=0.009$, Table 3). These results indicate that cigarette smoke exposure increases oxidative stress in Wistar rats.

Vitamin C supplementation was found to significantly reduce the mean serum MDA level compared to the cigarette smoke-exposed group ($p = 0.009$; Table 3). This indicates that vitamin C supplementation can reduce serum MDA levels caused by cigarette smoke exposure. However, the group administered garlic extract still showed persistently high mean MDA levels (Table 2). The same was observed with the combination of garlic extract and vitamin C. Although the mean MDA levels in the garlic extract group (both single and combination) appeared higher, the difference was not statistically significant (Table 3). In addition, the vitamin C group showed significant differences compared to all garlic extract groups, including the 50 mg/kg body weight dose, the 100 mg/kg body weight dose, and the combination with vitamin C ($p = 0.008$, $p = 0.009$, and $p = 0.009$, respectively; Table 3). These findings indicate that vitamin C exhibits superior antioxidant activity compared to garlic extract under conditions of prolonged exposure to cigarette smoke.

Table 2. Serum MDA Levels Across Experimental Groups

Group	Mean $\pm$ SD	Median	P-value
A	9.85 ± 6.02	9.16	0.001
B	21.48 ± 1.15	21.82	
C	12.55 ± 4.32	12.68	
D	21.60 ± 0.23	21.76	
E	22.33 ± 1.46	22.01	
F	21.90 ± 3.30	19.93	

Notes: A: Normal; B: Cigarette smoke-induced (negative control); C: Vitamin C (positive control); D: Garlic extract 50 mg/kg BW; E: Garlic extract 100 mg/kg BW; F: Garlic extract + vitamin C 100 mg/kg BW.

Table 3. Post Hoc Mann–Whitney U Test for Serum MDA Levels

Group	A	B	C	D	E	F
A		0.009*	0.347	0.008*	0.009*	0.009*
B			0.009*	0.597	0.465	0.0917
C				0.008*	0.009*	0.009*
D					0.459	0.597
E						0.602

Notes: A: Normal; B: Cigarette smoke-induced (negative control); C: Vitamin C (positive control); D: Garlic extract 50 mg/kg BW; E: Garlic extract 100 mg/kg BW; F: Garlic extract + vitamin C 100 mg/kg BW.

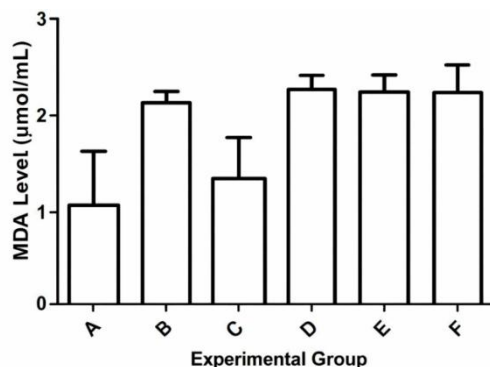


Figure 1. Comparison of Serum MDA Levels in Wistar Rats

Notes: A: Normal; B: Cigarette smoke-induced (negative control); C: Vitamin C (positive control); D: Garlic extract 50 mg/kg BW; E: Garlic extract 100 mg/kg BW; F: Garlic extract + vitamin C 100 mg/kg BW.

4. DISCUSSION

Garlic contains various bioactive compounds that have the potential to exert antioxidant and anti-inflammatory effects. This study confirmed the presence of flavonoids, alkaloids, saponins, steroids, triterpenoids, and quinones in garlic ethanol extract through phytochemical analysis. El-Khamissi et al. reported that garlic extract contains flavonoids, phenols, saponins, terpenoids, and steroids associated with free radical scavenging activity. Meanwhile, Deepa et al. reported that garlic contains organosulfur compounds, flavonoids, and phenols. Flavonoids and phenolic compounds are known to donate electrons to stabilize free radicals and inhibit lipid peroxidation, whereas organosulfur compounds such as allicin, diallyl sulfide, and diallyl disulfide play a role in modulating inflammatory pathways and oxidative stress. The combination of these various bioactive compounds is thought to contribute to garlic's antioxidant activity in reducing oxidative damage caused by ROS [23, 24].

In this study, exposure to cigarette smoke was found to increase serum MDA levels, indicating increased oxidative stress and lipid peroxidation. These findings are consistent with previous research showing that cigarette smoke stimulates excessive ROS production, thereby exceeding the capacity of the endogenous antioxidant system. Exposure to cigarette smoke can activate oxidative and inflammatory pathways through mitochondrial dysfunction and redox-sensitive signaling pathways, ultimately leading to cellular damage. The accumulation of ROS can also trigger the activation of inflammatory cells and NADPH oxidase (NOX) activity, thereby exacerbating superoxide formation and oxidative damage in lung tissue [7, 26].

In this study, vitamin C administration reduced serum MDA levels following repeated exposure to cigarette smoke by donating electrons to stabilize reactive molecules and inhibit the oxidative chain reaction that causes lipid membrane damage [27, 28]. This is consistent with previous studies showing a reduction in MDA levels following vitamin C administration under conditions of oxidative stress. Meanwhile, administration of garlic extract at doses of 50 mg/kg body weight and 100 mg/kg body weight failed to reduce MDA levels in mice exposed to cigarette smoke. This may be because the prolonged cigarette smoke exposure in this study exceeded the antioxidant capacity of the administered garlic extract. Another possible explanation is the dual biological activity of certain organosulfur compounds in garlic. Under specific conditions, compounds such as diallyl sulfide (DAS), diallyl disulfide (DADS), and diallyl trisulfide (DATS) can act as pro-oxidants through redox-related reactions that actually increase ROS formation [29, 30].

The administration of a combination of garlic extract and vitamin C in this study also did not result in a decrease in MDA levels. This is because the interaction between vitamin C and garlic derivatives may affect antioxidant activity, thereby reducing the effectiveness of the combination. Khaira et al. (2019) also reported similar results, indicating that the combination of garlic extract and vitamin C did not exert a biological effect on *Candida albicans* [30][31].

A limitation of this study is the lack of quantitative measurement of active garlic compounds such as allicin and alliin, so the relationship between active compound levels and antioxidant activity cannot yet be confirmed [32].

Other markers of oxidative stress and endogenous antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase were also not measured. Evaluation of these parameters could provide a more comprehensive understanding of the mechanisms of oxidative stress and the antioxidant response following exposure to cigarette smoke.

5. CONCLUSIONS

The results of this study indicate that prolonged exposure to cigarette smoke can increase oxidative stress in Wistar rats. Administration of antioxidants such as vitamin C can reduce this oxidative stress, particularly under conditions of excessive cigarette smoke exposure. However, administration of garlic extract, either alone or in combination with vitamin C, has not yet been shown to reduce serum MDA levels.

REFERENCES

1. World Health Organization. Tobacco [Internet]. World Health Organization. [cited 2025 Mar 18]. Available from: <https://www.who.int/health-topics/tobacco>
2. World Health Organization. Chronic obstructive pulmonary disease (COPD) [Internet]. World Health Organization. [cited 2025 Mar 20]. Available from: [https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-\(copd\)](https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd))
3. Zuo L, Wijegunawardana D. Redox Role of ROS and Inflammation in Pulmonary Diseases. In: Wang YX, editor. Lung Inflammation in Health and Disease, Volume II [Internet]. Cham: Springer International Publishing; 2021 [cited 2025 Mar 20]. p. 187–204. Available from: https://doi.org/10.1007/978-3-030-68748-9_11
4. Soleimani F, Dobaradaran S, De-la-Torre GE, Schmidt TC, Saeedi R. Content of toxic components of cigarettes, cigarette smoke vs cigarette butts: A comprehensive systematic review. *Science of The Total Environment*. 2022 Mar 20;813:152667.
5. Sharma A, Tewari D, Nabavi SF, Nabavi SM, Habtemariam S. Reactive oxygen species modulators in pulmonary medicine. *Current Opinion in Pharmacology*. 2021 Apr 1;57:157–64.
6. Zhou S yuan, Du J min, Li W jing, Liu Q yun, Zhang Q ye, Su G hai, et al. The roles and regulatory mechanisms of cigarette smoke constituents in vascular remodeling. *International Immunopharmacology*. 2024 Oct;140:112784.
7. Kellner M, Noonepalle S, Lu Q, Srivastava A, Zemskov E, Black SM. ROS Signaling in the Pathogenesis of Acute Lung Injury (ALI) and Acute Respiratory Distress Syndrome (ARDS). *Pulmonary Vasculature Redox Signaling in Health and Disease*. 2017 Oct 18;967:105–37.
8. Dean M. Green Medicine: Exploring the Role of Herbal Treatments in Disease Therapy. *Golden Ratio of Data in Summary*. 2024 Apr 30;4(1):01–10.
9. El-Saber Batiha G, Magdy Beshbishy A, G. Wasef L, Elewa YHA, A. Al-Sagan A, Abd El-Hack ME, et al. Chemical Constituents and Pharmacological Activities of Garlic (*Allium sativum* L.): A Review. *Nutrients*. 2020 Mar 24;12(3):872.
10. Adhiva Berlian Febryanti, Danang Raharjo, Septian Maulid Wicahyo. Analisis Kadar Vitamin C Bawang Putih Majemuk Bawang Hitam dan Bawang Putih Tunggal Serta Aktivitas Antioksidan dengan Metode ABTS. *JKA*. 2025 Oct 6;9(2):495–505.
11. Kinasih DSS, Meliana A, Safitri I. Effect of Solo Garlic Extract (*Allium Sativum*) on Malondialdehyde (MDA) in Rats (*Rattus Norvegicus*) Exposed to Cigarette Smoke. *Jurnal Kesehatan Prima*. 2024 Feb 1;18(1):20–7.
12. Duwairoh AM, Wirjatmadi B, Adriani M. Pengaruh Ekstrak Bawang Putih Tunggal dalam Penurunan Kadar Malondialdehid (MDA) akibat Pemaparan Rokok Elektronik. 2018;
13. Seo YS, Park KH, Park JM, Jeong H, Kim B, Jeon JS, et al. Short-term inhalation exposure to cigarette smoke induces oxidative stress and inflammation in the lungs without systemic oxidative stress in mice. *Toxicol Res*. 2024 Feb 16;40(2):273–83.
14. Tsikas D. Assessment of lipid peroxidation by measuring malondialdehyde (MDA) and relatives in biological samples: Analytical and biological challenges. *Analytical Biochemistry*. 2017 May 1;524:13–30.
15. Wahyuni R, Guswandi G, Rivai H. Pengaruh Cara Pengeringan Dengan Oven, Kering Angin Dan Cahaya Matahari Langsung Terhadap Mutu Simplisia Herba Sambiloto. *Jurnal Farmasi Higea*. 2017 Feb 22;6(2):126–32.
16. Athaillah. Uji Aktivitas Antibakteri *Staphylococcus Epidermidis* Menggunakan Ekstrak Etanol Dari Simplisia Kering Bawang Putih (*Allium Sativum* L.). 2020;8.
17. Prastiwi R, Marlita N. Parameter Fisikokimia dan Analisis Kadar Allyl Disulfide dalam Ekstrak Etanol 70% Bawang Putih (*Allium sativum* L.) dengan Perbandingan Daerah Tempat Tumbuh Parameter. 2017;

18. Wahyuni S, Yunita I, Yolla Sundari U, Bunga Pagalla D, Yolana Kalalinggi S, Alpian. Ekstraksi Bahan Alam. 2024th ed. CV. Gita Lentera Redaksi; 2024.
19. Hidayah N, Mussa ORPA, Solfaine R, Utomo YS. Perbandingan Paparan Asap Rokok Konvensional Dan Rokok Herbal Pada Mencit (*Mus Musculus*) Terhadap Perbandingan Gambaran Histologi Paru. *VITEK : Bidang Kedokteran Hewan*. 2020 Nov 10;10:25–32.
20. Liu X, Wang Z, Li T, Ni L, Zeng R, Liu C. A simplified device for exposing rats to cigarette smoke. *International Journal of Clinical and Experimental Medicine*. 2016 Oct 30;9(10):19213–21.
21. Jaggi S, Yadav AS. Increased serum malondialdehyde levels among cigarette smokers. *The Pharma Innovation*. 2015;1:94–6.
22. Vera B, Dasrul D, Azhar A, Karmil TF, Riady G, Sabri M. Pengaruh Pemberian Vitamin E Terhadap Kadar Malondialdehid (MDA) Serum Tikus Putih (*Rattus norvegicus*) Diabetes Melitus. *JURNAL ILMIAH MAHASISWA VETERINER*. 2018 Feb 15;2(2):70–6.
23. El-khamissi H, Saad Z, Rozan H. Phytochemicals Screening, Antioxidant and Anticancer Activities of Garlic (*Allium sativum*) Extracts. *Journal of Agricultural Chemistry and Biotechnology*. 2019 Apr 1;10(4):79–82.
24. Balasubramaniam D, Thirumal S. Screening of Phytochemicals and in vitro studies of Garlic: An Updated Review. *international journal of engineering technology and management sciences*. 2023 Jan 6;Volume: 7:6–11.
25. Sampurna S, Masyhudi M, Pritasari AMS, Zulaikhah ST, Pratama AAP. Peningkatan Kadar Malondialdehid (MDA) Akibat Paparan Asap Rokok. *Jurnal Penelitian Kesehatan “SUARA FORIKES” (Journal of Health Research “Forikes Voice”)*. 2023 Nov 13;14(4):780–3.
26. Lugg ST, Scott A, Parekh D, Naidu B, Thickett DR. Cigarette smoke exposure and alveolar macrophages: mechanisms for lung disease. *Thorax*. 2022 Jan;77(1):94–101.
27. Sinaga R, Sinaga F. Pengaruh pemberian vitamin C terhadap kadar malondialdehid dan hemoglobin atlet pada aktivitas fisik maksimal. *J Unimed*. 2015;14–24.
28. Villagran M, Ferreira J, Martorell M, Mardones L. The Role of Vitamin C in Cancer Prevention and Therapy: A Literature Review. *Antioxidants*. 2021 Nov 26;10(12):1894.
29. Ni'mah I, Hapsari RAF, Wulandari E. Efek Ekstrak Bawang Putih (*Allium sativum* L.) Terhadap Kadar Malondialdehid Hepar Tikus. *Jurnal Fakultas Kedokteran dan Ilmu Kesehatan UIN Syarif Hidayatullah Jakarta*. 2017;
30. Khaira N, Misrahanum M, Idroes R, Bahi M, Khairan K. Pengaruh kombinasi ekstrak petroleum eter bawang putih (*Allium sativum* Linn.) dengan vitamin C terhadap aktivitas *Candida albicans*. *Journal Natural Unsyiah*. 2016;16(1):116153.
31. Octora, D. D., Situmorang, Y., & Marbun, R. A. T. (2020). Formulasi sediaan sabun mandi padat ekstrak etanol bonggol nanas (*Ananas cosmosus* L.) untuk kelembapan kulit. *Jurnal Farmasimed (Jfm)*, 2(2), 77-84.
32. Situmorang, N. B., & Febriady, A. (2025). Optimization of the Preventive Potential of Andaliman (*Zanthoxylum acanthopodium* DC) as a Natural Biofilter Against Cigarette Smoke Exposure Through TNF- α Expression. *JURNAL FARMASIMED (JFM)*, 8(1), 228-235.