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Efficacy of Kremah (*Alternanthera* sp.) Leaf Extract in Reducing Methomyl-Induced Effects on Leukocyte Response in Nile Tilapia (*Oreochromis niloticus*)

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ABSTRACT

Intensification of tilapia (*Oreochromis niloticus*) farming around agricultural land increases the risk of contamination by the toxic and genotoxic pesticide methomyl, which can trigger oxidative stress, and immune system disorders. The use of natural materials with antioxidant potential, such as kremah (*Alternanthera* sp.) leaf extract, is an alternative to mitigate these effects. This study was conducted to evaluate the effect of immersion in kremah leaf extract on the leukocyte differential of tilapia exposed to methomyl. A completely randomized design was applied, consisting of four treatments with three replications, namely control, and doses of 20, 30, and 40 ppm. The fish were exposed to 3.2 ppm methomyl for 96 hours and then immersed in the extract for 14 days. The observed parameters comprised leukocyte differential, clinical signs, and water quality, all of which were analyzed using one-way ANOVA followed by an LSD test ($p < 0.05$). The findings indicated that methomyl exposure led to an increase in monocytes while reducing lymphocyte levels. Immersed in 40 ppm extract for 14 days provided the best results by decreasing monocytes (4.00%), as well as increasing lymphocytes (82.00%) and hemoglobin levels to near normal. It was concluded that kremah leaf extract effectively mitigates oxidative stress and genetic damage caused by methomyl, with an optimal dose of 40 ppm for 14 days.

INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a freshwater aquaculture species of significant economic importance, widely farmed because of its fast growth rate, adaptability to diverse environmental conditions, and consistent market demand (Aziz & Barades, 2021). However, intensive cultivation in close proximity to agricultural land increases the risk of water pollution

from pesticide residues through water runoff. This condition can reduce the quality of the cultivation environment and disrupt fish health (Nurhalisa *et al*., 2022).

One commonly used pesticide is methomyl, a carbamate insecticide that works by inhibiting the enzyme acetylcholinesterase. Exposure to methomyl in aquatic organisms can trigger physiological stress and increase the formation of Reactive Oxygen Species (ROS), causing oxidative stress and cell damage (Lin *et al*., 2020). These effects can be observed through changes in hematological parameters, particularly leukocyte differential and clinical symptoms. Changes in leukocyte proportions reflect the immune response to stress or toxic exposure (Ginting *et al*., 2021).

To minimize the effects of oxidative stress, the use of natural ingredients as antioxidants is a potential alternative. Kremah leaves (*Alternanthera* sp.) are recognized for containing bioactive compounds, including flavonoids and phenolics, which exhibit antioxidant properties. These compounds work by neutralizing free radicals and inhibiting the formation of ROS, thereby maintaining cell stability and supporting immune system function (Kristina & Kristiani, 2021). Based on this rationale, the present study aims to evaluate the effect of Kremah leaf extract administration on the modulation of differential leukocytes in tilapia exposed to methomyl. It is anticipated that the findings will offer a scientific foundation for the use of Kremah leaf extract as a natural antioxidant to alleviate oxidative and genotoxic stress in tilapia aquaculture systems.

METHODS

Time and Place

The study was carried out between September 15 and November 13, 2025, at the Fish Reproduction and Disease Laboratories, Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang.

Tools and Materials

The equipment utilized in this study included aquaria, aerators, air stones, aeration hoses, plastic cups, brushes, digital scales, sieves, rulers, thermometers, pH meters, dissolved oxygen (DO) meters, UV–Vis spectrophotometer, rotary evaporator, oven, blender, microscope, glass slides, microtubes, 1 mL syringes, pipettes, analytical balance, and writing tools.

The materials used in this research were freshwater, Kremah leaves (*Alternanthera* sp.), ethanol 96%, methanol p.a., DPPH (2,2-diphenyl-1-picrylhydrazyl), methomyl pesticide, EDTA solution, Giemsa stain, distilled water, fish (*Oreochromis niloticus*), commercial fish feed, sponge, and tissue.

Research Design

The study employed an experimental approach using a completely randomized design, consisting of four treatments with three replications. The treatments consisted of different concentrations of Kremah leaf extract (*Alternanthera* sp.), namely control (0 ppm), 20 ppm, 30 ppm, and 40 ppm. The experimental fish were subjected to methomyl exposure to assess the protective effect of the extract.

The observed parameters included differential leukocyte counts, clinical symptoms, and water quality variables (temperature, pH, and dissolved oxygen). This experimental design was implemented to evaluate the effectiveness of Kremah leaf extract in mitigating the toxic effects of methomyl on fish health. The selection of extract concentrations refers to preliminary toxicity testing (LC_{50}) and previous studies indicating the potential of plant

extracts as antioxidants and protective agents against pesticide exposure.

Research Procedure

Production of Kremah Leaf Extract

Kremah leaves are first sorted to separate impurities and parts of the plant other than the leaves. After that, the leaves are dried in an oven at 45°C for 24 hours until the water content is reduced. The dried leaves are then ground into powder and stored in a closed container (Rumahombar *et al*., 2025). A total of 254 g of ground Kremah leaves are weighed, then extracted with 2 L of 96% ethanol using the maceration method. The leaves are soaked for 6 hours while being stirred occasionally, then left to stand for 18 hours. The filter residue was re-macerated once using 1 L of solvent to optimize the yield of active compounds. All macerates were subsequently pooled and concentrated using a rotary evaporator to yield a thick Kremah leaf extract.

Blood Sampling

Blood samples were collected from the caudal vein using a 1 mL syringe pre-rinsed with EDTA solution as an anticoagulant to prevent clotting. After the blood is collected, it is transferred to a microtube containing EDTA. The sample is then gently homogenized to mix evenly with the anticoagulant (Ambarwati *et al*., 2022). Blood sampling is performed periodically on days 7, 11, 18, and 25 to observe changes in hematological parameters during the study period.

Research Parameters

Differential Leukocyte Count

Leukocyte differential count is performed by observing blood smears. Blood smears are made on glass slides and dried at room temperature, then fixed using 70% methanol for 5 minutes to preserve cell structure and increase dye absorption. After re-drying, the preparations were stained with Giemsa solution for 20 minutes, then rinsed and allowed to dry. The smear is then observed under a microscope at 400× magnification (Irwanti *et al*., 2022). The count is performed until 100 leukocyte cells are reached, then the percentage of each cell type is calculated using the following formula (Widyaningrum *et al*., 2017):

$$\text{Leukocyt D } (\%) = \frac{\text{leukocyte components (cells)}}{\text{100 leukocyte cells}} \text{x } 100$$

Clinical Symptoms

Clinical symptoms were carried out by visually monitoring fish behavior before, during, and after exposure to the pollutant. Parameters such as movement patterns, feeding response, body color, eye, fin, and scale condition, and mucus production were recorded to assess physiological stress and early signs of toxic effects (Jamin & Erlangga, 2016).

Water Quality

Water quality parameters, including temperature, dissolved oxygen (DO), and pH, were measured in accordance with SNI standards. Temperature is measured by immersing a thermometer in the water for 2–5 minutes until the reading stabilizes. DO is measured after initial calibration by immersing the probe in water until the reading stabilizes, then the results are recorded and the device is rinsed again. The pH value is determined using a pH meter that has been calibrated with a buffer solution, then the electrode is immersed in the sample until it shows a stable reading before being recorded, and the device is cleaned after use (Marsaude *et al*., 2023).

Data Analysis

The data obtained were statistically analyzed using a one-way analysis of variance (ANOVA) test to determine the effect of treatment on the observed parameters. If there was

a significant difference ($p < 0.05$), The Least Significant Difference (LSD) test was applied to identify differences among treatments. Statistical analyses were conducted using SPSS software, and the data are presented as mean ± standard deviation.

RESULTS

Leukocyte Differential

Lymphocytes

The percentage of lymphocytes before treatment, 96 hours after methomyl exposure and 7th and 14th day after extract administration can be seen in Figure 1 below.

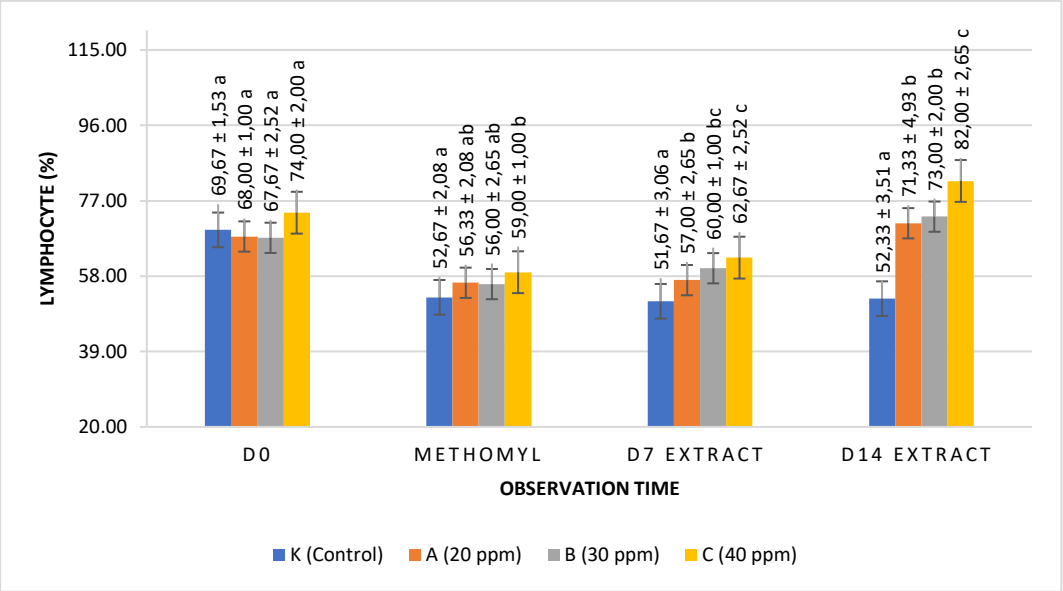


Figure 1. The Percentage of Lymphocytes

Monocytes

The percentage of monocytes before treatment, 96 hours after methomyl exposure and 7th and 14th day after extract administration can be seen in Figure 2 below.

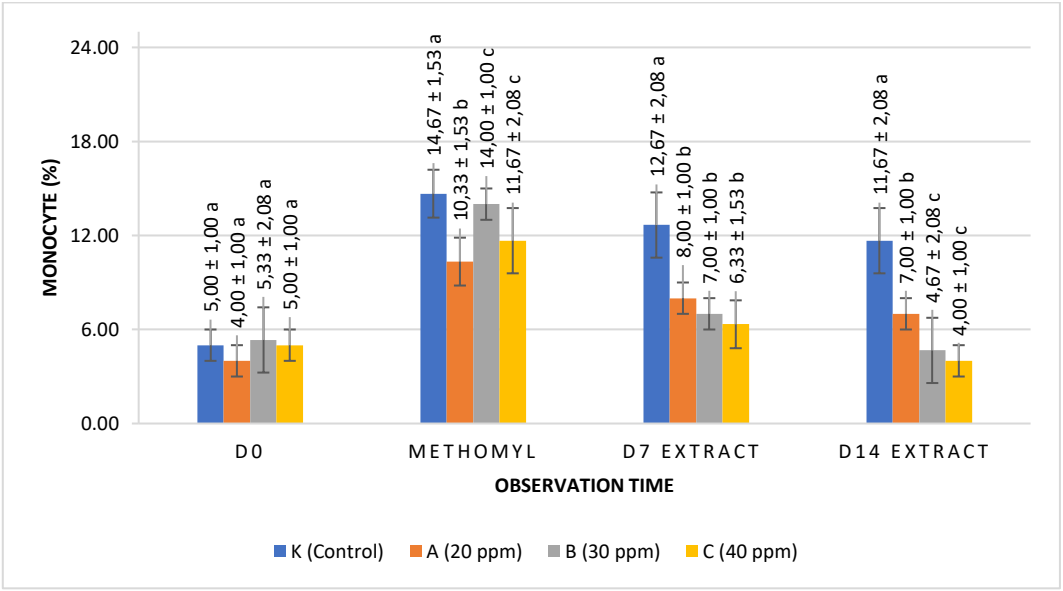
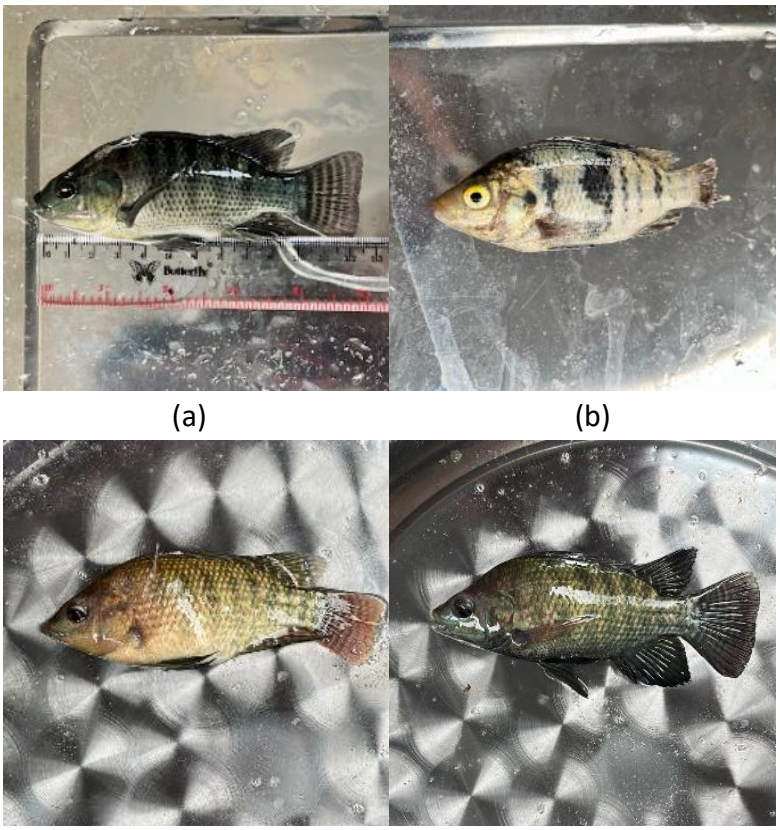


Figure 2. The Percentage of Monocytes

Clinical Symptoms

Clinical symptoms of Oreochromis niloticus during the study included normal fish, 96 hours exposure to methomyl, 7 days immersion in extract, and 14 days immersion in extract are showed in Figure 3.



(a) (b)

(c) (d)

Figure 3. Clinical Symptoms of *Oreochromis niloticus* During the Study: (A) Normal Fish, (B) 48 Hours Exposure to Methomyl, (C) 96 Hours Exposure to Methomyl, (D) 7 Days Immersion in Extract, and (E) 14 Days Immersion in Extract

Water Quality

The results of the water quality measurements are shown in Figure 4, encompassing the assessed parameters of temperature, pH, and dissolved oxygen (DO).

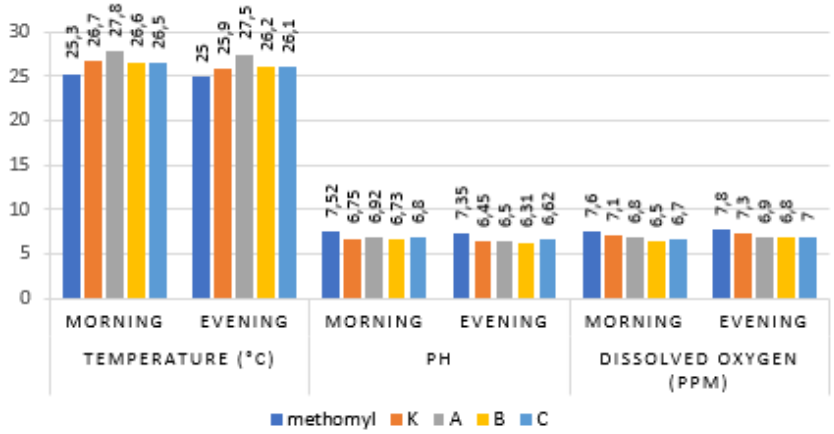


Figure 4. Variations in Temperature, pH, and DO of Water in Each Treatment of Kremah Leaf Extract

DISCUSSION

Lymphocytes

In the initial phase (D0) (Figure 1), the lymphocyte percentage in tilapia ranged from 67.67% to 74.00%, remaining within the normal range of 60–86% (Hastuti et al., 2024), with no significant differences observed among groups ($p > 0.05$). This condition indicates that the fish's immune system was stable and homogeneous before treatment, so that changes in the next phase can be directly attributed to exposure to methomyl or administration of kremah leaf extract. Lymphocytes comprise B cells and T cells that function in adaptive immunity; B cells are responsible for producing antibodies to neutralize antigens, while T cells coordinate immune responses and inhibit the proliferation of infected or damaged cells (Darwin *et al*., 2021). After 96 hours of methomyl exposure, the percentage of lymphocytes decreased to 52.67–59.00% and differed significantly between groups ($p<0.05$), indicating a toxic stress response. This decrease occurred because lymphocytes migrated to inflamed tissues, where T cells and B cells worked to recognize antigens, regulate cellular responses, and produce antibodies as part of the body's defense mechanism (Nurprilinda, 2024).

On day 7 (D7) after administration of the kremah leaf extract, the percentage of lymphocytes increased in treatments A, B, and C to 57.00–62.67%, while the control remained low at 51.67%, with a significant difference ($p<0.05$). This increase indicates stimulation of the adaptive immune system, where flavonoids, saponins, and phenolic compounds in the extract promote lymphocyte proliferation, enhance T cell activity in coordinating immune responses, and B cell activity in producing antibodies to counter toxins (Sipayung *et al*., 2023). On day 14 (D14), The lymphocyte percentage increased further to 71.33–82.00% in treatments A, B, and C, returning to the normal range, whereas the control group remained low at 53.33%, showing a significant difference ($p < 0.05$). This indicates the recovery and strengthening of the adaptive immune system, where the bioactive compounds in the extract suppress oxidative stress caused by methomyl, support lymphocyte proliferation, and enhance T cell coordination and antibody production by B cells, thereby restoring immune system homeostasis (Hastuti *et al*., 2024; Yuliana *et al*., 2021).

The linear regression results show a relationship between the treatment dose variable and the percentage of tilapia lymphocytes, with the equation $y = 4.117x + 55.54$ and a coefficient of determination $R^2 = 0.9275$. This means that an increase in the dose of kremah leaf extract is followed by an increase in the percentage of lymphocytes. This is in line with the increased antioxidant activity of the extract at higher concentrations, neutralizing free radicals and suppressing the formation of Reactive Oxygen Species (ROS) due to methomyl exposure, thereby reducing oxidative stress and stabilizing the physiological condition of the fish. Under these conditions, lymphocytes as specific immune cells are more active, while the role of nonspecific immune cells decreases. After maturing into immunocompetent cells, lymphocytes are able to carry out optimal immunological responses (Darwin *et al*., 2021).

Monocytes

In the initial phase (D0) (Figure 2), the percentage of monocytes in tilapia ranged from 4.00% to 5.33%, remaining within the normal range of 3.9–5.9% (Hastuti *et al*., 2024), with no significant differences observed among groups ($p > 0.05$). This condition indicates that the fish's immune system was stable and homogeneous before treatment, so that subsequent changes can be directly attributed to methomyl exposure or the administration of kremah leaf extract. Monocytes act as phagocytic cells that are ready to migrate to tissues to deal with foreign objects or damage, so their stability in the initial phase indicates the absence of

significant immune stimulation (Wulandari *et al*., 2018). After 96 hours of methomyl exposure, the percentage of monocytes increased to 14.67% and differed significantly between groups ($p<0.05$), reflecting the activation of the nonspecific immune system. This increase occurred because monocytes migrated from the blood to tissues experiencing stress or inflammation, differentiated into macrophages, and performed phagocytosis as an initial defense response to tissue damage caused by toxins (Toolingo *et al*., 2025; Yanuhar *et al*., 2022).

On day 7 (D7) after administration of the kremah leaf extract, the percentage of monocytes in treatments A, B, and C decreased to 6.33–8.00%, while the control remained high at 12.67%, with a significant difference ($p<0.05$). This decrease indicates the adaptation and recovery process of the immune system, in which flavonoids and saponins in the extract suppress oxidative stress and regulate cytokine activation, so that more monocytes migrate to the tissue to perform phagocytic and regenerative functions. On day 14 (D14), monocyte percentages in treatments A, B, and C decreased to 4.00–7.00%, approaching the normal range, whereas the control group remained elevated at 11.67%, with significant differences observed among groups ($p < 0.05$). This indicates a phase of recovery and adaptation of the immune system, in which circulating monocytes in the blood are reduced because some have migrated to repair tissues and perform defense functions, and kremah leaf extract through its bioactive compounds supports the regulation of the distribution and activity of nonspecific immune cells (Hastuti *et al*., 2024; Ginting *et al*., 2021).

The linear regression results show a relationship between the treatment dose and the percentage of monocytes in tilapia, with the equation $Y = –1.075x + 9.75$ and a coefficient of determination $R^2 = 0.757$. This indicates that increasing doses of kremah leaf extract are associated with a reduction in the percentage of circulating monocytes. Reduced oxidative stress decreases tissue damage and inflammatory stimulation, thereby reducing the need for monocyte mobilization into the blood. Physiologically, monocytes that migrate to tissues differentiate into macrophages and perform phagocytosis, but in more stable tissue conditions, the inflammatory response is not as intense, resulting in a decrease in the number of monocytes in the blood. This decrease reflects the effectiveness of the extract's antioxidant activity in reducing oxidative stress and stabilizing the immune system of tilapia (Darwin *et al*., 2021).

Clinical Symptoms

In initial observations (Figure 3), the fish showed stable physiological conditions with normal swimming activity, good feeding response, bright body color, clear eyes, and intact fins and scales, indicating that the fish were healthy before treatment. After exposure to methomyl for 48–96 hours, there were noticeable clinical changes due to toxic stress. Methomyl, as a carbamate insecticide, inhibits the enzyme acetylcholinesterase, causing an accumulation of acetylcholine, which disrupts nerve impulse transmission (Wispriyono *et al*., 2013). Fish exhibited symptoms such as decreased activity, slow swimming at the bottom, loss of response to feed, darkening of body color, fin damage, lesions, and increased mucus secretion; excess mucus serves a protective function to minimize toxin contact and protect tissues (Adharini *et al*., 2017).

After immersed in kremah leaf extract for 7 days, the fish began to show recovery with more stable swimming movements, increased appetite, brighter body color, and fin regrowth indicating regeneration (Iza *et al*., 2017). By day 14, the fish had almost fully recovered, with normal activity, restored body color, and more complete fin repair. This recovery is related to the phenolic content, such as flavonoids and alkaloids, in the extract, which has anti-

inflammatory effects, helping to reduce inflammation and support tissue regeneration (Nirmala *et al*., 2022).

Water Quality

Based on measurements during the study (Figure 4), the water temperature ranged from 25.0 to 27.8°C. During the 96-hour methomyl exposure phase, the temperature was relatively stable at 25.0–25.3°C, while during the Kremah leaf extract immersion phase, there was a slight increase, especially in treatment A, which reached 27.8°C. Treatments K, B, and C tended to be in the range of 26.1–26.7°C. These slight temperature fluctuations were still within the SNI 7550:2009 standard range of 25–32°C and were considered optimal for supporting the metabolism, digestion, and physiological recovery of fish after methomyl exposure (Koniyo, 2020). Prolonged low temperatures can reduce digestive enzyme activity and blood flow, causing physiological stress in fish, but the research conditions showed stability that supported recovery.

The pH value of the water was in the range of 6.31–7.52, relatively stable without extreme fluctuations. During the 96-hour methomyl exposure phase, the pH was recorded at 7.35–7.52, while treatment K was at 6.45–6.75, A and C at 6.5–6.9, and B was the lowest at 6.31. Although one value was slightly below the optimal range, all parameters still supported freshwater fish life according to SNI 7550:2009 (6.5–8.5) (Koniyo, 2020). pH stability is important for maintaining metabolism, ion balance, and gill function; extreme fluctuations can reduce growth, increase stress, and decrease survival (Sukendar *et al*., 2025). Overall, water quality during the study remained supportive of fish physiological conditions and recovery processes after treatment.

Dissolved oxygen (DO) values were recorded between 6.5–7.8 ppm, with the methomyl exposure phase showing the highest values of 7.6–7.8 ppm. Treatment K had a DO of 7.1–7.3 ppm, A and C 6.7–7.0 ppm, and B the lowest at 6.5 ppm, but all values remained above the safe threshold of >5 ppm according to SNI 7550:2009 (Indriati & Hafiludin, 2022). Stable DO supports normal fish respiration, accelerates tissue recovery, and maintains immune response during immersion in kremah leaf extract (Andriani & Nurinsani, 2025). Adequate DO values prevent growth disorders and death due to oxygen deficiency (Astuti & Lismining, 2018).

CONCLUSION

Immersion in cream leaf extract affects differential white blood cells and clinical symptoms in tilapia exposed to methomyl. The optimal dose of 40 ppm on day 14 reduced monocytes (4.00%), but increased lymphocytes (82.00%), indicating physiological recovery and optimal blood cell protection. These results indicate that the leaf extract at this concentration effectively reduces oxidative stress caused by methomyl exposure, enhances the antioxidant defense system, and supports the modulation of the tilapia's immune response.

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REFERENCES

Adharini, R. I., Suharno, S., & Hartiko, H. (2017). Contamination Effect of Profenofos Insecticide on Physiology of Red Nila (*Oreochromis* Sp.). *Jurnal Manusia dan Lingkungan*, 23(3), 365-373. DOI: 10.22146/jml.18808

Ambarwati, N., Hidayati, S., & Mujthidah, T. (2022). Hematological Analysis of Tilapia (*Oreochromis niloticus*) Infected with Ectoparasites in Floating Net Cages in Rawa Pening. *Asian Journal of Aquatic Sciences*, 5 (1), 55-61. DOI: https://doi.org/10.31258/

Andriani, Y., & Nurinsani, R. A. (2025). Sistem Budidaya Ikan Lele (*Clarias* Sp.) Dalam Kolam Terpal Dengan Teknologi Nano Bubble. *Journal Of Fish Nutrition*, 5(1), 55-67. DOI: https://doi.org/10.29303/jfn.v5i1.7534

Astuti, Y. S. D. L. P., & Lismining, P. (2018). Respon Oksigen Terlarut Terhadap Pencemaran dan Pengaruhnya Terhadap Keberadaan Sumber Daya Ikan di Sungai Citarum Dissolved Oxygen Response Againts Pollution and The Influence of Fish Resources Existence in Citarum River. *Jurnal Teknologi Lingkungan*, 19(2), 203. DOI: 10.29122/jtl.v19i2.2488

Aziz, R., & Barades, E. (2021). Adaptation of Tilapia Juvenile (*Oreochromis niloticus*) on Different Salinity Increases. *Jurnal Perikanan Unram*, 11(2), 251-258. DOI: https://doi.org/10.29303/jp.v11i2.262

Darwin, E., Elvira, D., & Elfi, E. F. (2021). *Imunologi dan Infeksi*. Padang: Andalas University Press. URL: http://repository.stikesbcm.ac.id/id/eprint/593

Ginting, K. D., Riauwaty, M., & Syawal, H. (2021). Leukocyte Differentiation in Dumbo Catfish (*Clarias gariepinus*) Fed a Diet Containing Turmeric (*Curcuma domestica* Val.) and Infected with *Aeromonas hydrophila* Bacteria. *Journal of Aquatic Science*, 9(2), 116-125. DOI: https://doi.org/10.31258/jipas.9.2.p.116-125

Hastuti, S. D., Zubaidah, A., & Fatimah, S. (2024). Respons Kekebalan Bawaan Ikan Nila (*Oreochromis niloticus*) yang Diberi Pakan dengan Suplementasi Daun Alpukat (*Parsea americana* Mill). *Jurnal Riset Akuakultur*, 19(1), 15-29. DOI: http://dx.doi.org/10.15578/jra.19.1.2024.15-29

Indriati, P. A., & Hafiludin, H. (2022). Manajemen Kualitas Air pada Pembenihan Ikan Nila (*Oreochromis niloticus*) di Balai Benih Ikan Teja Timur Pamekasan. *Juvenil: Jurnal Ilmiah Kelautan Dan Perikanan*, 3(2), 27-31. DOI: https://doi.org/10.21107/juvenil.v3i2.15812

Irwanti, N. G., Susatyo, P., & Wibowo, E. S. (2022). Diferensial Leukosit Beberapa Spesies Ikan Tangkapan dari Familia Cyprinidae di Sungai Banjaran, Kabupaten Banyumas. *Bioeksakta: Jurnal Ilmiah Biologi Unsoed*, 4, 152-159. DOI: http://10.20884/1.bioe.2022.4.2.4703.

Iza, N., Listyorini, D., & Gofur, A. (2017). Regenerasi Sirip Kaudal Ikan Gatul (*Poecilia* sp.) yang Mengalami Malformasi. *Edubiotik: Jurnal Pendidikan, Biologi dan Terapan*, 1(01), 42-47. DOI: https://doi.org/10.33503/ebio.v1i01.100

Jamin, J., & Erlangga, E. (2016). Pengaruh Insektisida Golongan Organofosfat Terhadap Benih Ikan Nila Gift (*Oreochromis niloticus*, Bleeker): Analisis Histologi Hati dan Insang. *Acta Aquatica: Aquatic Sciences Journal*, 3(2), 46-53. DOI: https://doi.org/10.29103/aa.v3i2.324

Koniyo, Y. (2020). Analisis Kualitas Air pada Lokasi Budidaya Ikan Air Tawar di Kecamatan Suwawa Tengah. *Jurnal Technopreneur (Jtech)*, 8(1), 52-58. DOI: https://10.30869/jtech.v8i1.527

Kristina, L., & Kristiani, E. B. E. (2021). The Effect of Salt Stress on the Antioxidant Content of *Alternanthera* Sp. Leaves. In Sinasis (National Science Seminar) (Vol. 2, No. 1).

Lin, Z., Zhang, W., Pang, S., Huang, Y., Mishra, S., Bhatt, P., & Chen, S. (2020). Current Approaches to and Future Perspectives on Methomyl Degradation in Contaminated Soil/Water Environments. *Molecules*, 25(3), 738. https://doi.org/10.3390/molecules25030738

Marsaude, A., & Sukainah, A. Patang. (2023). Kajian Kualitas Perairan Pada Lahan Budidaya Rumput Laut (*Eucheuma cottoni*) di Kecamatan Mandalle Kabupaten Pangkep. *Jurnal Review Pendidikan Dan Pengajaran (Jrpp)*, 6(4), 1325-1332. DOI: https://doi.org/10.31004/jrpp.v6i4.20934

Nirmala, A., Hardiatma, A., Nurhikmah, N., & Saleh, L. (2022). Penggunaan Batang Pepaya dalam Pengendalian Penyakit Infeksi Bakteri pada Pembesaran Ikan Nila. In Prosiding Seminar Nasional Politeknik Pertanian Negeri Pangkajene Kepulauan, Vol. 3, 154-162. DOI: https://doi.org/10.51978/proppnp.v3i1.259

Nurhalisa., Arfianti, D., Andayani, S., Kartikaningsih, H., (2022). *Methomyl Active Substance in the Process of Cell Degradation*. Publisher: Media Nusa Creative. ISBN: 978-623-175-055-6.

Nurprilinda, M. (2024). Mekanisme inflamasi peradangan. Universitas Kristen Indonesia Repository. URl: http://repository.uki.ac.id/id/eprint/14852

Rumahombar, V. G., Setyowati, E., & Rawar, E. A. (2025). Analysis of Total Phenolic and Flavonoid Content in Green Tea (*Camellia sinensis*) Dried Using an Oven, Solar Dryer, and Traditional Drying Methods. *Journal of Pharmacy Science and Practice*, 12(1), 25-33. https://doi.org/10.3390/life12111929

Sipayung, B. R., Prakasita, V. C., & Madyaningrana, K. (2023). Efek Ekstrak Daun Bayam Brasil (*Alternanthera sissoo* Hort) Terhadap Jumlah Limfosit dan Indeks Organ Limfoid Mencit Terinduksi Cfa. *Biowallacea: Jurnal Penelitian Biologi (Journal of Biological Research)*, 10(2), 135-150. DOI:https://doi.org/10.24843/metamorfosa.2022.v09.i02.p19

Sukendar, W., Diniarti, N., Laheng, S., Rasyid, A., Redha, S., Dwiyanti, S., Lestari, D. P., Kania Mardika, H. P., & Affandi, R. I. (2025). *Manajemen Kualitas Air Budidaya Ikan Air Tawar*. Pt. Penerbit Qriset Indonesia.

Toolingo, F., Lamadi, A., & Mulis, M. (2025). Pengaruh Penambahan Serbuk Daun Binahong Dalam Pakan untuk Meningkatkan Total Leukosit dan Diferensiasi Leukosit Ikan Mas (*Cyprinus carpio*) yang Diinfesi Bakteri *Aeromonas hydrophila*. *Journal of Fisheries Agribusiness*, 1(2), 103-109. DOI: https://10.56190/jfa.v1i2.20

Widyaningrum, H., Sorta, B. I. S., & Priyo, S. (2017). Diferensial Leukosit Ikan Gurami (*Osphronemus gouramy* Lac.) Dengan Perbedaan Level Suplementasi Spirulina Platensis Dalam Pakan. *Scripta Biologica*, 4(1), 37-40. DOI: https://doi.org/ 10.20884/1.sb.2017.4.1.383

Wispriyono, B., Yanuar, A., & Fitria, L. (2013). Tingkat Keamanan Konsumsi Residu Karbamat dalam Buah dan Sayur Menurut Analisis Pascakolom Kromatografi Cair Kinerja Tinggi. *Kesmas*, 7(7), 317-323. DOI: https://doi.org/10.21109/kesmas.v7i7.30

Wulandari, S., Jumadi, R., & Rahmawati, F. F. (2018). Efektivitas Serbuk Daun Tanaman Kayu Manis (*Cinnamomum burmanii*) Terhadap Diferensial Leukosit dan Aktivitas Fagositosis Ikan Nila (*Oreochoromis niloticus*) Yang Diinfeksi *Streptococcus agalactiae*. *Jurnal Perikanan Pantura* (Jpp), 1(1), 40-49. DOI: DOI:10.30587/jpp.v1i1.293

Yanuhar, U., & Caesar, N. R. (2022). *Imunologi Molekuler Untuk Ikan*. Malang: Universitas Brawijaya Press.

Yuliana, A., Wulandari, R., & Zahra, A. (2021). Pemberian Ekstrak *Sargassum* sp. Melalui Pakan Komersil Terhadap Nilai Hematokrit dan Diferensial Leukosit pada Ikan Bawal Bintang. *Intek Akuakultur*, 5(2), 36-49. DOI: 10.31629/intek.v5i2.3092