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Antioxidant and Thrombopoietic Effects of *Moringa oleifera* on Cisplatin-Induced Thrombocytopenia through MDA Reduction and TPO/NF-κB Level

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Abstract

Thrombocytopenia induced by chemotherapy is a prevalent side effect of cisplatin administration, heightening the likelihood of bleeding due to bone marrow suppression and oxidative stress. Natural substances with antioxidant and anti-inflammatory attributes, like *Moringa oleifera*, are proposed as potential agents for hematoprotection. Nevertheless, the biomolecular mechanisms that clarify its impact on oxidative stress, thrombopoiesis, and inflammation pathways in thrombocytopenia have not been thoroughly investigated. This research aimed to evaluate the effects of ethanolic extract from 350 mg, 700 mg, and 1050 mg *Moringa oleifera* leaves on platelet counts, malondialdehyde (MDA), thrombopoietin (TPO), and nuclear factor kappa B (NF-κB) levels in a rat model of thrombocytopenia induced by cisplatin. A total 30 Sprague–Dawley rats were randomly categorized into 6 groups ; normal control, cisplatin control, positive control (TPO receptor agonist), and treatment groups administered cisplatin in combination with varying doses of ethanolic extract of *Moringa oleifera*. Cisplatin was given to trigger thrombocytopenia.The primary endpoint was the change in platelet count, MDA, TPO, and NF-κB levels following 14 days of treatment. Administration of *Moringa oleifera* extract markedly elevated platelet counts and TPO levels while significantly reducing MDA and NF-κB levels compared to the cisplatin group (p<0.05). The highest dosage exhibited the most favorable improvement in hematological and biomolecular parameters, indicating dose-dependent protective effects against oxidative stress and inflammation. Ethanolic extract of *Moringa oleifera* leaves shows potential as a hematoprotective agent in cisplatin-induced thrombocytopenia through antioxidant, anti-inflammatory, and thrombopoiesis-regulating mechanisms. These findings support further investigation of *Moringa oleifera* as an adjunct therapy to reduce chemotherapy-related hematological toxicity.

Keywords: *Cisplatin, Thrombocytopenia*, Moringa oleifera, *oxidative stress, anti-inflammatory.*

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INTRODUCTION

Cancer continues to represent a major global health burden, with chemotherapy remaining a cornerstone of treatment for many malignancies despite advances in precision oncology. Cisplatin is among the most widely used platinum-based chemotherapeutic agents due to its broad-spectrum antitumor activity and established clinical efficacy. However, its therapeutic benefit is frequently limited by dose-dependent toxicities, particularly chemotherapy-induced thrombocytopenia, which is associated with increased bleeding risk, treatment delay, dose reduction, and poorer oncologic outcomes. The clinical management of chemotherapy-induced thrombocytopenia remains challenging, and current therapeutic options, including thrombopoietin receptor agonists, are often limited by high cost and accessibility, particularly in low- and middle-income countries (Kuter, 2015; Romani, 2022; Sung, *et al*., 2021).

Accumulating evidence suggests that oxidative stress and inflammation are key drivers of bone marrow microenvironment dysfunction in chemotherapy-induced thrombocytopenia. Cisplatin induces excessive generation of reactive oxygen species (ROS), leading to mitochondrial damage, lipid peroxidation, and apoptosis of hematopoietic progenitor cells. Malondialdehyde (MDA), a stable end-product of lipid peroxidation, is widely accepted as a biomarker of oxidative cellular injury. In parallel, nuclear factor kappa B (NF-κB) functions as a central transcriptional regulator of inflammatory signaling and has been implicated in chemotherapy-induced bone marrow suppression. Moreover, thrombopoietin (TPO), the principal regulator of megakaryocyte proliferation and platelet production, is often dysregulated during chemotherapy exposure, contributing to impaired thrombopoiesis. Targeting oxidative stress–inflammation–thrombopoiesis axis has therefore emerged as a promising therapeutic strategy in mitigating chemotherapy-associated hematologic toxicity (Gao, *et al*., 2023; Singh, *et al*., 2014; Varghese, *et al*., 2017; Yoshida, *et al*., 2013).

Previous preclinical and clinical studies have demonstrated the antioxidant, anti-inflammatory, and hematomodulatory properties of *Moringa oleifera*. Adegbite, *et al*. (2016) reported dose-dependent increases in platelet and erythrocyte counts following *M. oleifera* supplementation in healthy humans, while Aprioku, *et al*. (2022) demonstrated improvements in hematological abnormalities in HIV-positive patients receiving HAART. Nurudhin, *et al*. (2021) further reported reductions in mean platelet volume and neutrophil-to-lymphocyte ratio in lupus patients. In animal models, Ogbu and Zigabelbari (2019) showed that aqueous *M. oleifera* leaf extract modulates immune function but paradoxically induces thrombocytopenia through platelet destruction in Sprague–Dawley rats. Most relevantly, Karale, *et al*. (2023) demonstrated neuroprotective effects of *M. oleifera* ethanolic extract in cisplatin-treated Sprague–Dawley rats via modulation of lipid peroxidation and antioxidant enzymes, yet this study focused exclusively on neurotoxicity, leaving its hematoprotective potential in cisplatin-induced thrombocytopenia unexplored. Collectively, while existing evidence supports the hematological relevance of *M. oleifera*, no study has simultaneously evaluated MDA, TPO, and NF-κB as integrated mechanistic parameters alongside platelet counts in a cisplatin-induced thrombocytopenia model, nor established a dose-response profile for its optimal therapeutic use in this context.

From a translational perspective, exploring evidence-based phytotherapeutics is particularly relevant in Indonesia, where traditional herbal medicine is widely utilized and accessibility to high-cost biologic agents remains limited. Identification of locally available, cost-effective adjunct therapies could substantially improve supportive cancer care and reduce treatment-related morbidity. Therefore, this study aimed to investigate the hematoprotective effects of ethanolic extract of *Moringa oleifera*

leaves in a cisplatin-induced thrombocytopenia Sprague–Dawley rat model by evaluating platelet count, MDA, TPO, and NF-κB levels. We hypothesized that *Moringa oleifera* exerts protective effects through modulation of oxidative stress, inflammatory signaling, and thrombopoiesis regulation, thereby providing mechanistic insights into phytochemical-based supportive therapy for chemotherapy-induced hematological toxicity.

METHODS

This study was a randomized true experimental *in vivo* laboratory study employing a post-test only control group design. The experiment was conducted at the Center for Food and Nutrition Studies Laboratory, Universitas Gadjah Mada, Yogyakarta, Indonesia. The total experimental period was 21 days, comprising 7 days of acclimatization followed by 14 days of treatment. Male Sprague–Dawley rats (Rattus norvegicus), aged 8–12 weeks and weighing 150–200 g, were acclimatized under controlled conditions with standard pellet diet and water ad libitum. Sample size was determined using the Federer formula, yielding a minimum of 4 animals per group; 5 animals per group were used to account for potential attrition, giving a total of 30 rats in six groups. The study design and reporting followed ARRIVE guidelines. Rats were randomly allocated into six experimental groups: (K1) normal control; (K2) cisplatin-induced negative control; (K3–K5) cisplatin + M. oleifera extract at 350, 700, and 1,050 mg/kgBW/day, respectively; and (K6) cisplatin + eltrombopag 1 mg/day (positive control). Thrombocytopenia was induced by a single intraperitoneal injection of cisplatin at 8 mg/kgBW. Eltrombopag, a small-molecule TPO receptor agonist that stimulates megakaryocyte proliferation via JAK-STAT signaling, was dosed at 1 mg/day, equivalent to the human therapeutic dose of 50 mg/day following rat conversion factor (×0.018).

Ethanolic extract of *Moringa oleifera* leaves was administered orally at graded doses equivalent to approximately 350 mg/kgBW, 700 mg/kgBW, and 1,050 mg/kgBW. *Moringa oleifera* leaves (Batu, East Java, Indonesia) were dried at 40°C for 24 h, ground, and sieved through a 50-mesh sieve. Maceration was performed in 70% ethanol at a 1:6 (w/v) ratio for 72 h, followed by re-maceration and filtration until a colorless filtrate was obtained. The filtrate was concentrated via vacuum rotary evaporation at 70°C and suspended in 0.5% CMC-Na. Phytochemical analysis yielded a total flavonoid content of 30.6 mg/g, predominantly quercetin and kaempferol. Doses were selected based on established effective ranges from previous studies (Saleem, *et al*., 2020; Ouedraogo, *et al*., 2025), corresponding to flavonoid doses of 10.7, 21.4, and 32.5 mg/kgBW — within the anti-inflammatory quercetin dose range (10–50 mg/kgBW).

Blood samples were collected via retroorbital puncture on day 15 post-treatment into EDTA tubes for platelet count and plain tubes for serum preparation. Serum was obtained by centrifugation at 3,000 rpm for 10–15 minutes and stored at −20°C until analysis. Platelet counts were measured using an automated hematology analyzer (electrical impedance and flow cytometry), expressed as $\times 10^3/\mu L$. Serum MDA was quantified by the TBARS method, measuring the MDA-TBA complex absorbance at 532 nm by spectrophotometer, with concentrations calculated from a 1,1,3,3-tetramethoxypropane standard curve (nmol/mL). Serum TPO and NF-κB levels were measured by sandwich ELISA using DiaSys kits (Diagnostic Systems, Holzheim, Germany) and read on a microplate reader (pg/mL).

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corp., USA). Data normality was assessed using the Shapiro–Wilk test and homogeneity of variance was evaluated using the Levene test. Normally distributed data with homo-

geneous variance were analyzed using one-way ANOVA with Tukey HSD post hoc test. Data with heterogeneous variance were analyzed using Welch ANOVA with Games-Howell post hoc test. Statistical significance was defined as $p<0.05$.

Ethical Approval

All experimental procedures were conducted in accordance with institutional and international ethical guidelines for animal research. Ethical approval was obtained from the Health Research Ethics Committee of RSUD Dr. Moewardi, Surakarta, Indonesia (Approval No. 1.152/V/HREC/2025). Animal handling and experimental procedures complied with institutional animal welfare standards and ethical laboratory animal use principles.

RESULTS

All variables demonstrated normal distribution across all groups as assessed by the Shapiro–Wilk test ($p>0.05$). Homogeneity of variance was confirmed for platelet count and NF-κB (Levene test: $p=0.054$ and $p=0.382$, respectively), which were analyzed using one-way ANOVA with Tukey HSD post hoc test. MDA and TPO showed heterogeneous variance ($p=0.038$ and $p=0.016$, respectively) and were therefore analyzed using Welch ANOVA with Games-Howell post hoc test. Comparison of biomarker levels among experimental groups is shown in Table 1.

Table 1. Comparison of biomarker levels among experimental groups.

Variable	K1	K2	K3	K4	K5	K6	*P-value*
MDA	1.81 ±0.03	12.40 ±0.16	2.86 ±0.04	2.32 ±0.04	2.04 ±0.02	2.45 ±0.04	<.001*
TPO	102.88 ±2.04	11.99 ±0.28	49.57 ±0.41	54.09 ±0.23	58.33 ±0.39	52.07 ±0.38	<.001*
NF-κB	33.06 ±2.14	367.23 ±2.99	77.05 ±1.84	44.18 ±1.71	33.64 ±1.57	55.58 ±1.22	<.001*
Platelet	313.53 ±2.37	119.63 ±0.60	278.92 ±3.69	281.95 ±0.35	298.39 ±1.34	286.76 ±1.75	<.001*

Note: K1 = Negative Control; K2 = CIS 8mg/kg; K3 = CIS 8mg/kg + Extract M.oleifera 350mg/kg BW; K4 = CIS 8mg/kg + Extract *M.oleifera* 700mg/kg BW; K5 = CIS 8mg/kg + Extract M.oleifera 1050mg/kg BW; and K6 = CIS 8mg/kg + TPO-RA 1mg/day. Data are presented as mean ± standard deviation. One-way ANOVA test was used to see the difference in NFkB and platelets between groups. Welch ANOVA test was used to see the difference in MDA and TPO. *There is a statistically significant difference ($p<0,05$). MDA = Malondialdehyde; TPO = Thrombopoietin; NF-κß= Nuclear Factor Kappa B.

Post hoc analysis revealed that cisplatin administration (K2) significantly increased MDA and NF-κB levels while decreasing TPO and platelet counts compared to normal control (K1), confirming effective thrombocytopenia induction ($p<0.001$). Among the *M. oleifera* dose groups, a dose-dependent pattern was observed: MDA levels followed K1<K5<K4<K3<K6<K2, TPO levels followed K1>K5>K4>K6>K3>K2, platelet counts followed K1>K5>K6>K4 = K3>K2 with no significant difference between K3 and K4 ($p=0.207$), and NF-κB levels followed K1<K5<K4<K3<K6<K2 with no significant difference between K1 and K6 ($p=0.997$). Collectively, these results indicate that *M. oleifera* extract at 1,050 mg/kgBW (K5) produced the most optimal hematoprotective response across all measured parameters.

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DISCUSSION

This study showed that ethanolic extract of *Moringa oleifera* significantly improved platelet counts, reduced MDA and NF-κB levels, and increased TPO levels in a cisplatin-induced thrombocytopenia rat model, supporting its hematoprotective potential through antioxidant, anti-inflammatory, and thrombopoiesis-modulating mechanisms. These results are consistent with previous evidence indicating that *M. oleifera* possesses strong antioxidant and immunomodulatory activity capable of improving hematologic abnormalities (Adam, *et al*., 2023; Adegbite, *et al*., 2016; Prabowo, *et al*., 2021).

The dose-dependent response observed, with the 1,050 mg/kgBW dose demonstrating the most optimal effect, suggests a pharmacological relationship between phytochemical concentration and biological activity. However, it is important to acknowledge that no safety or toxicity assessment was conducted in this study. While *M. oleifera* has generally been regarded as safe in previous studies, the relatively high doses administered, particularly 1,050 mg/kgBW, warrant caution in interpretation, as potential adverse effects on hepatic and renal function were not evaluated. Future studies should incorporate acute and subacute toxicity profiling alongside efficacy assessment to establish a comprehensive safety-efficacy profile.

Cisplatin-induced thrombocytopenia is primarily associated with oxidative stress, bone marrow suppression, and apoptosis of hematopoietic progenitor cells. Cisplatin increases reactive oxygen species (ROS) production, resulting in lipid peroxidation and cellular damage in hematopoietic tissues. Increased oxidative stress subsequently disrupts megakaryopoiesis and reduces platelet production. The observed reduction of MDA levels following *M. oleifera* administration indicates attenuation of lipid peroxidation and oxidative injury. Similar findings have been reported in experimental studies showing that antioxidant compounds can protect hematopoietic cells from chemotherapy-induced toxicity (Abd Rashid, *et al*., 2021; Perše, 2021; Romani, 2022).

The significant reduction of MDA levels in treatment groups suggests that *M. oleifera* may stabilize cellular membranes and prevent ROS-mediated platelet destruction. Flavonoids, polyphenols, and vitamins present in *M. oleifera* leaves have been reported to scavenge free radicals and enhance endogenous antioxidant defense systems. By reducing oxidative stress, these compounds may protect bone marrow microenvironment integrity and maintain hematopoietic stem cell viability. This mechanism may explain the restoration of platelet production observed in this study (Adam, *et al*., 2023; Adebayo, *et al*., 2018; Akbayram, *et al*., 2010).

Another important finding of this study is the significant increase in TPO levels following *M. oleifera* administration. TPO is the primary regulator of megakaryocyte proliferation and platelet production through activation of JAK-STAT signaling pathways. Increased TPO levels indicate improved stimulation of megakaryopoiesis and enhanced platelet production. Previous studies have demonstrated that natural antioxidant compounds can enhance thrombopoiesis by protecting hematopoietic progenitor cells and supporting TPO signaling pathways (Varghese, *et al*., 2017; Xu, *et al*., 2025; Zhang and Zehnder, 2013).

The reduction of NF-κB levels observed in this study further supports the anti-inflammatory properties of *M. oleifera*. NF-κB is a key transcription factor involved in inflammatory signaling, immune activation, and thrombosis regulation. Cisplatin-induced oxidative stress can activate NF-κB pathways, leading to inflammatory cytokine production and platelet dysfunction. Suppression of NF-κB signaling by *M. oleifera* may reduce inflammatory injury to bone marrow and circulating platelets. Critically, this finding is consistent with and extends previous reports on the hematoprotective

effects of *M. oleifera*. Adegbite, *et al*. (2016) reported dose-dependent increases in platelet counts in humans, while Aprioku, *et al*. (2022) demonstrated hematological improvements in HAART-treated patients; however, neither study evaluated NF-κB or oxidative stress markers.

Ogbu and Zigabelbari (2019) reported paradoxical thrombocytopenia with aqueous extract in healthy rats, suggesting that extract type, solvent polarity, and baseline hematological status may critically influence outcomes, a finding that underscores the importance of the ethanolic extraction method employed in the present study. Most relevantly, Karale, *et al*. (2023) demonstrated neuroprotective effects of *M. oleifera* ethanolic extract in cisplatin-treated rats via lipid peroxidation modulation, paralleling the MDA reduction observed here, yet without evaluating thrombopoietic parameters. Collectively, the present study advances existing evidence by simultaneously integrating oxidative stress, inflammatory, and thrombopoietic endpoints in a cisplatin-induced thrombocytopenia model, a mechanistic framework not previously reported (Kojok, *et al*., 2019; Saleem, *et al*., 2020).

These findings are further supported by Sidharta, *et al*. (2025), who demonstrated that ethanolic extract of *M. oleifera* at 1,200 mg/kgBW exerted the most optimal hepatoprotective effects against cisplatin-induced liver damage through attenuation of oxidative stress and inflammatory responses in a Sprague-Dawley rat model. Both studies share a comparable cisplatin-induced model, ethanolic extraction method, and dose-dependent response pattern, suggesting a consistent mechanistic basis for *M. oleifera* cytoprotective activity across different organ systems. However, while Sidharta, *et al*. focused on hepatotoxicity endpoints including histological assessment of liver cell damage, the present study extended this mechanistic framework to thrombocytopenia by simultaneously evaluating MDA, TPO, NF-κB, and platelet counts, parameters not assessed in the hepatotoxicity study.

M. oleifera leaves are rich in bioactive compounds including flavonoids, quercetin, kaempferol, isoquercetin, rutin, β-carotene, and ascorbic acid (Cajuday and Pocsidio, 2010), which collectively possess free radical scavenging and anti-inflammatory properties. It is plausible that these compounds attenuate ROS-mediated lipid peroxidation, thereby reducing MDA levels and protecting hematopoietic progenitor cells from oxidative injury. Reduced oxidative stress may in turn suppress NF-κB activation, potentially mitigating inflammatory signaling that otherwise impairs megakaryopoiesis and platelet production. The concurrent increase in TPO levels suggests that restoration of the bone marrow microenvironment may have enhanced thrombopoietic signaling, facilitating megakaryocyte proliferation and platelet recovery. However, it must be emphasized that these mechanistic interpretations are inferential, as direct assessment of molecular signaling pathways, gene expression, or bone marrow histology was not performed in this study. Phytochemical-rich extracts may simultaneously modulate multiple pathways, which may explain the broad hematoprotective response observed across all parameters (Abd Rashid, *et al*., 2021; Xu, *et al*., 2025).

Despite these promising findings, this study has several limitations. First, the study was conducted in an animal model, and translation to human clinical settings requires further investigation. Second, the molecular signaling pathways were evaluated using biomarker analysis rather than direct gene expression or proteomic approaches. Third, pharmacokinetic profiles of the extract were not assessed. Future studies should include clinical trials, molecular pathway analysis, and dose-optimization studies to establish therapeutic safety and efficacy in humans (Perše, 2021; Romani, 2022).

CONCLUSION

This study demonstrated that ethanolic extract of *Moringa oleifera* was associated with significant improvements in platelet counts and favorable modulation of MDA, TPO, and NF-κB levels in a cisplatin-induced thrombocytopenia rat model. A dose-dependent response was observed, with the 1,050 mg/kgBW dose showing the most pronounced effect across all measured parameters. These findings suggest that *M. oleifera* extract may exert hematoprotective effects through mechanisms related to oxidative stress attenuation, inflammatory signaling modulation, and thrombopoietic support; however, causal and mechanistic conclusions cannot be definitively drawn from the current experimental design. Further studies incorporating bone marrow histology, molecular pathway analysis, toxicity profiling, and clinical trials are warranted to validate these findings and establish the therapeutic potential of *M. oleifera* as an adjunctive agent in chemotherapy-induced hematotoxicity.

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REFERENCES

Abd Rashid, N., Abd Halim, S.A.S., Teoh, S.L., Budin, S.B., Hussan, F., Adib Ridzuan, N.R., *et al.*, 2021, The role of natural antioxidants in cisplatin-induced hepatotoxicity, *Biomed. Pharmacother.*, **144**, 112328.

Adam, D., Yansen, I.A., Fahria, Budhy, T.I., and Nugraha, A.P., 2023, Potential of *Moringa oleifera* as anti-cancer agents in oral cancer: a review, *Malays. J. Med. Health Sci.*, **19**, 140–143.

Adebayo, I.A., Arsad, H., and Samian, M.R., 2018, Total phenolics, total flavonoids, antioxidant capacities, and volatile compounds gas chromatography-mass spectrometry profiling of *Moringa oleifera* ripe seed polar fractions, *Pharmacognosy Mag.*, **14**(54), 191–194.

Adegbite, O.A., Omolaso, B., Seriki, S.A., and Shatima, C., 2016, Effects of *Moringa oleifera* leaves on hematological indices in humans, *Ann. Hematol. Oncol.*, **3**(8), 1107.

Akbayram, S., Doğan, M., Akgün, C., Mukul, Y., Peker, E., Bay, A., *et al.*, 2010, The association of oxidant status and antioxidant capacity in children with acute and chronic ITP, *J. Pediatr. Hematol. Oncol.*, **32**(4), 277–281.

Aprioku, J.S., Robinson, O., Obianime, A.W., and Tamuno, I., 2022, Moringa supplementation improves immunological indices and hematological abnormalities in seropositive patients receiving HAARTs, *Afr. Health Sci.*, **22**(2), 1–11.

Cajuday, L.A. and Pocsidio, G.L., 2010, Effects of *Moringa oleifera* Lam. (Moringaceae) on the reproduction of male mice (Mus musculus), *J. Med. Plants Res.*, **4**(12), 1115–1121.

Gao, A., Zhang, L., and Zhong, D., 2023, Chemotherapy-induced thrombocytopenia: literature review, *Discov. Oncol.*, **14**(1), 10.

Karale, S., Farshad, M.P., and Kamath, J.V., 2023, *Moringa oleifera* leaf extract ameliorates cisplatin evoked neurotoxicity in male Sprague-Dawley rats, *IP Int. J. Compr. Adv. Pharmacol.*, **8**, 54–58.

Kojok, K., El-Kadiry, A.E.-H., and Merhi, Y., 2019, Role of NF-κB in platelet function, Int. *J. Mol. Sci.*, **20**(17), 4185.

Kuter, D.J., 2015, Managing thrombocytopenia associated with cancer chemotherapy, *Oncology,* **29**(4), 282–294.

Mittal, A., Sharma, M., David, A., Vishwakarma, P.,

Saini, M., Goel, M., *et al.*, 2017, An experimental study to evaluate the anti-inflammatory effect of *Moringa oleifera* leaves in animal models, *Int. J. Basic Clin. Pharmacol.*, **6**(2), 452–457.

Nurudhin, A., Widyastuti, R., Prabowo, N.A., Adnan, Z.A., and Werdiningsih, Y., 2021, The effect of *Moringa oleifera* leaf extract on mean platelet volume and neutrophil to lymphocyte ratio in lupus, *Bangladesh J. Med. Sci.*, **20**(1), 68–73.

Ogbu, O.S. and Zigabelbari, Z.V., 2019, The immuno-modulatory and thrombocytopaenic effects of the varying concentrations of the aqueous leaf extract of Moringa oleifera in male albino wistar rats, *J. Adv. Med. Pharm. Sci.*, **21**(4), 1–8.

Ouedraogo, M., Coulibaly, A., Paul, A.J., and Mathieu, B.N., 2025, *Moringa oleifera* total leaf extract on anthropometric and hematological parameters in anemic rats, *Haya Saudi J. Life Sci.*, **10**(1), 1–7.

Persě, M., 2021, Cisplatin mouse models: treatment, toxicity and translatability, *Biomedicines*, **9**(10), 1406.

Prabowo, N.A., Nurudhin, A., and Buanantri, A.C., 2021, The effect of *Moringa oleifera* leaf extract on mean platelet volume and neutrophil-to-lymphocyte ratio in autoimmune patients, Proceeding, 4th International Conference on Sustainable Innovation 2020–Health Science and Nursing (ICoSIHSN 2020), Atlantis Press, pp. 625–629.

Romani, A.M.P., 2022, Cisplatin in cancer treatment, *Biochem. Pharmacol.*, **206**, 115323.

Saleem, A., Saleem, M., Akhtar, M.F., Shahzad, M., and Jahan, S., 2020, *Moringa oleifera* leaf extracts attenuate complete Freund's adjuvant-induced arthritis in Wistar rats via modulation of inflammatory and oxidative stress biomarkers, *Inflammopharmacology*, **28**(1), 139–151.

Sidharta, B.R.A., Purwanto, B., Wasita, B., Widyaningsih, V., Soetrisno, S., Cilmiaty, R., *et al.*, 2025, The effect of *Moringa oleifera* ethanol extract on improving cisplatin induced liver cells damages, *Asian Pac. J. Cancer Prev.*, **26**(6), 2175–2183.

Singh, Z., Karthigesu, I.P., Singh, P., and Kaur, R., 2014, Use of malondialdehyde as a biomarker for assessing oxidative stress in different disease pathologies: a review, *Iran. J. Public Health*, **43**(Suppl 3), 7–16.

Sung, H., Ferlay, J., Siegel, R.L., Laversanne, M., Soerjomataram, I., Jemal, A., *et al.*, 2021, Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries, *CA Cancer J. Clin.*, **71**(3), 209–249.

Varghese, L.N., Defour, J.P., Pecquet, C., and Constantinescu, S.N., 2017, The thrombopoietin receptor: structural basis of traffic and activation by ligand, mutations, agonists, and mutated calreticulin, *Front. Endocrinol.*, **8**, 59.

Xu, H., Lei, S., Li, J., Xianyu, D., Li, D., Lei, M., *et al.*, 2025, Protective effects and potential mechanisms of *Pyracantha fortuneana* fruit extract on chemotherapy-induced thrombocy-topenia revealed by transcriptomic analysis, *J. Funct. Foods*, **128**, 106838.

Yoshida, Y., Umeno, A., and Shichiri, M., 2013, Lipid peroxidation biomarkers for evaluating oxidative stress and assessing antioxidant capacity *in vivo*, *J. Clin. Biochem. Nutr.*, **52**(1), 9–16.

Zhang, B. and Zehnder, J.L., 2013, Oxidative stress and immune thrombocytopenia, *Semin. Hematol.*, **50**(3), e1–e4.