ZIBELINE INTERNATIONAL™ PUBLISHING

Acta Scientifica Malaysia (ASM)

DOI: http://doi.org/10.26480/asm.01.2026.31.35

ISSN: 2521-5051 (Print)
ISSN: 2521-506X (Online)
CODEN: ASMCCQ

CrossMark

RESEARCH ARTICLE

Haematoprotective Effects of *Artocarpus heterophyllus* against Mercuric Chloride Toxicity

Edobor Obayuwana., Joseph Raymond Enoghase*
[a] ***Department of Anatomy, University of Benin.***
Corresponding Author : joseph.enoghase@bmedsci.uniben.edu

ARTICLE DETAILS

Article History:

Received 20 January 2026
Revised 26 January 2026
Accepted 18 March 2026
Available online 19 April 2026

ABSTRACT

Mercuric Chloride ($HgCl_2$) is a very toxic heavy metal which induces oxidative stress-mediated Haematological disturbances. Jackfruit (*Artocarpus heterophyllus* (Lam.)) is a tropical fruit rich in bioactive and phytochemical antioxidants. This study evaluated the haematoprotective effects of *Artocarpus heterophyllus* fruit extract on $HgCl_2$-induced Haematological toxicity in Wistar rats. Thirty adult Wistar rats weighing 150–200 g were assigned randomly to five groups (n = 6): control, $HgCl_2$ only (3 mg/kg), extract-only group (1000 mg/kg *Artocarpus heterophyllus*), extract + $HgCl_2$ (extract administered 30 min before $HgCl_2$) and vitamin E + $HgCl_2$ (200 mg/kg, administered 30 min before $HgCl_2$). Doses were administered orally for 28 days. Analysis of Body weight changes and Haematological parameters (erythrocytic indices, leukocyte profile and platelet indices) was conducted. The data were expressed as mean ± SEM and analyzed with one-way ANOVA followed by Tukey's post hoc test; $P < 0.05$ was considered significant. Histological analysis of the blood was done using peripheral blood film and viewed in a microscope at 400x magnification. The administration of $HgCl_2$ significantly reduced weight gain, as evidenced by a significant decrease in body weight change when compared to controls ($p = 0.0005$). Compared to the $HgCl_2$-only group, weight gain was considerably increased by co-treatment with *Artocarpus heterophyllus* extract. Significant haematological toxicity was caused by $HgCl_2$ exposure, as shown by decreased haemoglobin concentration ($p = 0.0002$), red blood cell count ($p = 0.0003$), platelet count ($p = 0.0004$), plateletcrit ($p < 0.0001$), and changed red cell distribution width-SD ($p = 0.0013$). There were also differences in the number of leukocytes, such as a higher proportion of granulocytes ($p = 0.0039$) and a lower number of lymphocytes ($p = 0.0187$). Co-treatment with *Artocarpus heterophyllus* significant improved the alterations caused by the administration of $HgCl_2$-only. Histologically, $HgCl_2$ caused a reduction in the erythrocyte population and reduced the vacuole of the blood, this alterations where prevented by the co-administration of *Artocarpus heterophyllus.* Toxicity induced by $HgCl_2$ was prevented by the co-administration of *Artocarpus heterophyllus* confirming the protective properties of *Artocarpus heterophyllus* against heavy metal induced toxicity.

KEYWORDS

Artocarpus heterophyllus, Mercuric Chloride, haematology, Histology, Wistar rats

1. Introduction

Mercury is one of the most toxic heavy metals. Exposure to it can severely impact the environment and public health. Mercuric chloride (HgCl2), which is present in most types of inorganic mercury, often causes immune dysfunction, oxidative stress, and blood disorders (1,2). The haematopoietic system, which keeps blood balanced, is especially sensitive to oxidative damage. This can result in abnormalities in white blood cells and anemia (3,4).

The potential of natural plant-based compounds rich in antioxidants to combat heavy metal toxicity has drawn attention. Jackfruit, or *Artocarpus heterophyllus* Lam, is a tropical fruit that has high levels of flavonoids, polyphenols, vitamins, and other bioactive phytochemicals. It is widely consumed in Africa and Asia (5, 6, 7). These components are thought to have antioxidant, anti-inflammatory, and blood-forming properties (8, 9).

Despite earlier studies showing that *Artocarpus heterophyllus* can reduce oxidative damage and improve blood parameters in affected models, its protective effect against blood disturbances caused by mercuric chloride has not been fully examined. A comparison of these two organisms is now possible.

The study aims to evaluate the haematoprotective effects of *Artocarpus heterophyllus* fruit extract on Wistar rats administered with Mercuric Chloride.

2. Materials and Methods

2.1 Plant Material and Extract Preparation

The University of Benin's Department of Plant Biology and Biotechnology identified and validated *Artocarpus heterophyllus* fruits. The fruits were sliced into small pieces and then air dried, followed by grounding to obtain powdered form, which was then soaked in ethanol for extraction. Using a rotary evaporator, the solvent was evaporated and the extract residue was left behind. The residue was stored in a refrigerator at 4°C until it was needed.

2.2 Experimental Animals

Thirty adult Wistar rats (150–200 g) were obtained from the University of Benin animal facility. Animals lived in a normal lab setting (12 hours of light and 12 hours of dark, 25±2°C) and had free access to food and water. All experimental procedures adhered to NIH guidelines for the care and use of laboratory animals (1985).

2.3 Experimental Design

Quick Response Code	Access this article online	
	Website: www.actascientificamalaysia.com	**DOI:** 10.26480/asm.01.2026.31.35

The rats were randomly assigned into five groups (n=6):

a) Group I (Control): Received distilled water only.

b) Group II ($HgCl_2$ only): Administered 3 mg/kg $HgCl_2$ orally.

c) Group III (Extract only): 1000 mg/kg *Artocarpus heterophyllus* extract.

d) Group IV (Extract + $HgCl_2$ after 30 minutes): Administered 1000 mg/kg extract + 3 3mg/kg $HgCl_2$ after 30 minutess.

e) Group V (Vitamin E + $HgCl_2$ after 30 minutes): Administered 200mg/kg of Vitamin E + 3 mg/kg $HgCl_2$ after 30 minutess.

Treatments lasted for 28 days, after which animals were sacrificed and blood samples collected by cardiac puncture.

2.4 Haematological Analysis

Blood samples were analyzed for red blood cell (RBC) count, white blood cell (WBC) count, hemoglobin concentration (Hb), and packed cell volume (PCV) using an automated haematology analyzer.

2.5 Statistical Analysis

Data were expressed as mean ± SEM. Statistical differences were determined using one-way ANOVA followed by Tukey's post hoc test. A value of $p<0.05$ was considered statistically significant.

3.Results

3.1 Effect on Hemoglobin and Red Blood Cell Count

$HgCl_2$ significantly reduced Hb concentration and RBC count compared to the control group ($p<0.05$). Treatment with *Artocarpus heterophyllus* extract reversed these effects in a dose-dependent manner, with the high-dose group showing near-complete restoration to control levels (Table 2).

3.2 Effect on Packed Cell Volume

A significant reduction in PCV was observed in the $HgCl_2$-only group compared with control ($p<0.05$). Administration of *Artocarpus heterophyllus* extract significantly increased PCV values, particularly in the medium- and high-dose groups (Table 2).

3.3 Effect on White Blood Cell Count

$HgCl_2$ exposure significantly increased WBC count compared with control ($p<0.05$), suggesting immune activation. Co-treatment with *Artocarpus heterophyllus* extract significantly reduced WBC counts toward normal values in a dose-dependent manner (Table 2).

Table 1: showing initial weight, final weight and weight change after 28 days of administration

Groups /Test	Control	3mg/kg of $Hgcl_2$	1000mg/kg of *Artocarpus heterophyllus*	1000mg/kg of *Artocarpus heterophyllus* + 3mg/kg of Hgc_2 after 30 mins	Vit. E + 3mg/kg of $Hgcl_2$ after 30 mins	p-value
Initial Weight	128.7±58.51	147.0±25.84	142.7±53.84	151.0±44.51	157.0±38.84	0.1105
Final Weight	162.3±8.83*	148.0±23.84	171.7±4.16*	170.7±5.17	171.0±10.81	0.0262
Weight Change	33.7±2.91	1.00±2.65$^{\alpha}$	29.0±5.03	19.7±3.71$^{\gamma}$	14.0±2.65$^{\gamma}$	0.0005

Values are given as mean ± SEM. $^{\alpha}$ $p<0.05$ compared with the control group; $^{\gamma}$ $p<0.05$ compared with the Mercuric Chloride-alone group.

Table 2: Showing % Granulocyte, Lymphocyte, Red Blood Cell, Haemoglobin, Red Cell Distribution Width-SD (RDW-SD), Platelet, Platelet Distribution Width, Plateletcrit and Platelet Large Cell Ratio after 28 Days of Administration

Groups/ Test	Control	3mg/kg of $Hgcl_2$	1000mg /kg of *Artocarpus heterophyllus*	1000mg /kg of *Artocarpus heterophyllus* + 3mg/kg of Hgc_2 after 30 mins	Vit. E + 3mg/kg of $Hgcl_2$ after 30 mins	p-value
% Granulocyte	2.3±0.33	6.0±0.82$^{\alpha}$	2.4±0.23	3.0±0.55$^{\gamma}$	3.0±0.56$^{\gamma}$	0.0039
Lymphocyte	5.6±0.99	3.0±0.42$^{\alpha}$	5.3±0.18	3.7±0.38	5.3±0.23$^{\gamma}$	0.0187
Granulocyte	0.13±0.03	0.23±0.03$^{\alpha}$	0.13±0.03	0.13±0.03$^{\gamma}$	0.13±0.03$^{\gamma}$	0.2055
Red Blood Cell	7.3±0.24	5.0±0.09$^{\alpha}$	7.2±0.48	5.8±0.11	7.1±0.14$^{\gamma}$	0.0003
Haemoglobin	14±0.48	11±0.32$^{\alpha}$	14±0.31	12±0.15	14±0.20$^{\gamma}$	0.0002
RDW-SD	41±0.87	36±0.70$^{\alpha}$	40±0.70	39±0.49$^{\gamma}$	42±0.89$^{\gamma}$	0.0013
Platelet	381±7.2	224±20$^{\alpha}$	314±23	380±55$^{\gamma}$	664±76$^{\gamma}$	0.0004
Platelet Distribution width	12±1.10	8.4±0.29$^{\alpha}$	11±0.73	10±0.20$^{\gamma}$	11±0.64$^{\gamma}$	0.0231
Platelet crit	0.32±0.01	0.12±0.03$^{\alpha}$	0.22±0.03	0.38±0.01$^{\gamma}$	0.61±0.08$^{\gamma}$	<0.0001
Platelet Large Cell Ratio	17±0.56	9.9±0.44$^{\alpha}$	16±1.40	16±1.40$^{\gamma}$	17±1.60$^{\gamma}$	0.0179

Values are given as mean ± SEM. $^{\alpha}$ $p<0.05$ compared with the control group; $^{\gamma}$ $p<0.05$ compared with the Mercuric Chloride-alone group.

Table 3: Showing White Blood Cell, % Lymphocyte, % Mid Inhibitory Dilution, Mid Inhibitory Dilution, Mean Corpuscular Volume, Mean Corpuscular Haemoglobin, Mean Corpuscular Haemoglobin Concentration, Red Cell Distribution Width-CV (RDW-CV) and Mean Platelet Volume after 28 days of administration

Groups/ Test	Control	3mg/kg of $Hgcl_2$	1000mg /kg of *Artocarpus heterophyllus*	1000mg /kg of *Artocarpus heterophyllus* + 3mg/kg of Hgc_2 after 30 mins	Vit. E + 3mg/kg of $Hgcl_2$ after 30 mins	p-value

Table 3 (Cont): Showing White Blood Cell, % Lymphocyte, % Mid Inhibitory Dilution, Mid Inhibitory Dilution, Mean Corpuscular Volume, Mean Corpuscular Haemoglobin, Mean Corpuscular Haemoglobin Concentration, Red Cell Distribution Width-CV (RDW-CV) and Mean Platelet Volume after 28 days of administration

White Blood Cell	5.9±1.00	3.3±0.40	3.6±0.85	3.9±0.38	5.5±0.18	0.0562
% Lymphocyte	94±0.72	90±2.10	93±1.90	94±1.10	94±0.035	0.2339
% Mid Inhibitory Dilution	3.9±0.61	4.6±0.61	3.3±0.73	2.9±0.60	2.7±0.55	0.2769
Mid Inhibitory Dilution	0.23±0.07	0.13±0.03	0.13±0.03	0.13±0.03	0.23±0.03	0.2287
Haematocrit	40±1.20	38±2.50	39±1.70	36±0.73	38±0.29	0.3553
Mean Corpuscular Volume	55±0.92	55±1.50	54±1.50	53±0.90	54±1.10	0.7628
Mean Corpuscular Haemoglobin	19±0.43	19±0.15	18±0.15	18±0.09	18±0.15	0.7718
Mean Corpuscular Haemoglobin Concentration	34±0.26	34±0.75	34±0.67	34±0.32	34±0.23	0.9516
RDW-CV	14±0.47	16±0.03	12±0.67	14±0.45	14±0.64	0.0175
Mean Platelet Volume	8.5±0.03	7.7±0.41	8.0±0.32	7.9±0.15	8.4±0.35	0.3114

4.Histology

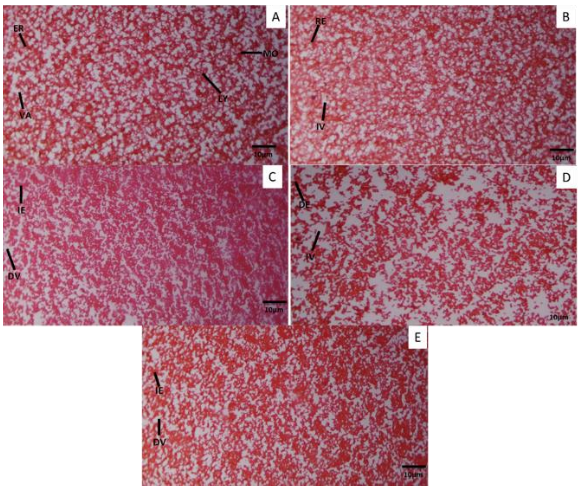

Figure 1: Histological representation of the blood using peripheral blood film: Normal rat blood (A) shows stacked erythrocytes (ER), lymphocytes (LY), microcytes (MO), and vacuoles (VA). HgCl2 exposure (B) reduces erythrocytes (RE) and increases vacuoles (IV). Extract treatment alone (C) increases erythrocytes (IE) and decreases vacuoles (DV). Co-administration of extract + HgCl2 (D) increased erythrocytes (IE) and decreased vacuoles (DV), whereas Vit. E + HgCl2 (E) increases erythrocytes (IE) and decreases vacuoles (DV). H&E 100x

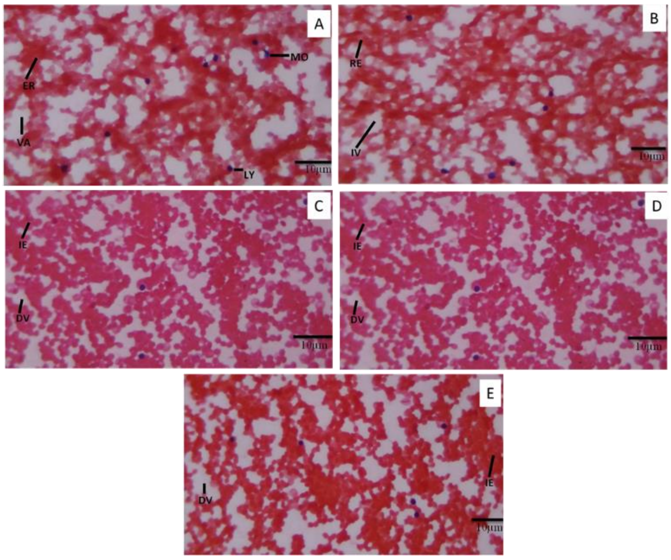

Figure 2: Histological representation of the blood using peripheral blood film: Normal rat blood (A) shows stacked erythrocytes (ER), lymphocytes (LY), microcytes (MO), and vacuoles (VA). HgCl2 exposure (B) reduces erythrocytes (RE) and increases vacuoles (IV). Extract treatment alone (C) increases erythrocytes (IE) and decreases vacuoles (DV). Co-administration of extract + HgCl2 (D) increased erythrocytes (IE) and decreased vacuoles (DV), whereas Vit. E + HgCl2 (E) increases erythrocytes (IE) and decreases vacuoles (DV). H&E 400x

5.Discussion

In this study, administration of Mercuric Chloride led to major changes in the blood. There was a significant increase in granulocytes count, and a decreased number of lymphocytes, hemoglobin, and red blood cells. These findings match earlier research showing that exposure to heavy metals can weaken the immune system and change blood morphology. Vianna et al (10) reported that exposure to mercury vapor leads increased levels of neutrophils, which shows that heavy metal poisoning often causes an inflammatory reaction in the body. Liu et al (11) also found that rats exposed to mercury had higher levels of white blood cells, particularly granulocytes, which suggest the body is responding with inflammation throughout the system.

On the other hand, administration jackfruit at a dose of 1,000 mg/kg and vitamin E significantly reduced the effects of Mercuric Chloride, by preventing mercuric chloride-induced blood-related alterations. Jackfruit is considered healthy because it contains many antioxidants, which can help reduce oxidative stress and inflammation that occur due to heavy metal toxicity (12).

Vitamin E, a known antioxidant has been recorded to possess the ability to mitigate harmful substances like heavy metals, which can cause damage to the body (13). Administration of jackfruit and vitamin E helped reduce the number of granulocytes, while also increasing the number of lymphocytes and hemoglobin levels. This shows that red blood cell production and the body's immune response improved significantly compared to Mercuric chloride only group. This agrees by El-Demerdash et al (13) who reported that vitamin E can support the growth of lymphocytes and reduce inflammation.

The decrease in average platelet size in Vitamin E and Jackfruit co-administration groups with mercuric chloride may be an indication of the antioxidants ability to better manage how platelets are reused and functions in the body. The results, which demonstrate the obvious changes in blood-related indicators following the administration of jackfruit and vitamin E, support the theory that natural antioxidants can lessen the detrimental effects of heavy metals.

Administration of Mercuric Chloride led to a significant reduction in red blood cells count, as well an increase in the vacoule. Mercury exposure has the potential to harm red blood cells and bone marrow, which can negatively impact the blood system (14).

Mercury compounds can lead to oxidative stress, which harms cells by damaging DNA and destroying red blood cells (14). Oxidative stress occurs when the body produces an excess amount of reactive oxygen species and is unable to remove them quickly enough. This causes damage to fats, changes proteins, and affects how cells work (15). Being around mercury for a long time can cause several health issues in people, like problems with the nervous system, damage to the blood, and difficulties with the immune system (16).

Co-administration of Jackfruit extract appeared to increased red blood cells count and reduce central pallor and intercellular vacuoles, which might suggest it offers certain kind of protection. Previous studies have highlighted the strong antioxidant properties of Jackfruit, which come from a variety of plant chemicals like flavonoids and phenolic compounds (17). These antioxidants might help reduce some harm caused by oxidative stress; However, the study indicates that jackfruit extract may not offer very strong protection against blood cell damage caused by mercury.

Vitamin E, like other antioxidants, proved excellent in preventing red blood cells from the damaging effects of mercuric chloride. This ensured that red blood cells maintained their typical shape and quantity. There were less vacant gaps between the red blood cells and less center paleness. One kind of antioxidant that dissolves in fat is vitamin E. It is essential for protecting cell membranes from damage brought on by dangerous chemicals known as free radicals. It accomplishes this by halting the lipid peroxidation process (18). This is consistent with earlier studies' findings that vitamin E can reduce oxidative stress, particularly in the presence of environmental pollutants such heavy metals like mercury (19).

The study's conclusions go beyond animal testing and recommend that treatment regimens for individuals with mercury toxicity include preventive dietary antioxidants like vitamin E. Understanding how dietary antioxidants can help protect against mercury exposure is crucial since people are becoming more concerned about it from things like industrial pollution and eating fish that contains mercury (16).

Limitations

Haematological characteristics were the main focus of this investigation. The results would be more trustworthy if further oxidative stress marker tests were conducted, the bone marrow was examined under a microscope, and it was determined which particular plant compounds were protective.

Conclusion

The extract from the *Artocarpus heterophyllus* fruit helped protect the blood cells of Wistar rats from harmful effects caused by Mercuric Chloride.

Author Contributions

E.O. conceived the study and participated in experimental design and data acquisition.
J.R.E. supervised the study, performed data analysis, interpreted results, and drafted the manuscript.
Both authors reviewed and approved the final manuscript.

Ethical Approval

All experimental procedures involving animals were conducted in compliance with the European Commission Directive 86/609/EEC and ARRIVE 2.0 guidelines and were approved by the Research Ethics Committee, College of Medical Sciences, University of Benin (Approval No. CMS/REC/2024/793).

Funding

This research received no external funding

Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Use of Artificial Intelligence (AI)

The authors declare that no artificial intelligence was used in the preparation of this manuscript.

References

Jarup, L. 2003. Hazards of heavy metal contamination. *British Medical Bulletin*, 68(1), Pp. 167–182. https://doi.org/10.1093/bmb/ldg032

dos Santos Chemelo, V., Bittencourt, L. O., Aragão, W. A., Dos Santos, S. M., Souza-Rodrigues, R. D., Ribeiro, C. H., Monteiro, M. C., and Lima, R. R. 2021. Long-term exposure to inorganic mercury leads to oxidative stress in peripheral blood of adult rats. *Biological Trace Element Research*, 199(8), Pp. 2992–3000. https://doi.org/10.1007/s12011-020-02411-5

Bissinger, R., Bhuyan, A. A., Qadri, S. M., and Lang, F. 2019. Oxidative stress, eryptosis and anemia: a pivotal mechanistic nexus in systemic diseases. *The FEBS Journal*, 286(5), Pp. 826–854. https://doi.org/10.1111/febs.14606

Orrico, F., Laurance, S., Lopez, C. A., Lefevre, S. D., Thomson, L., Möller, M. N., and Ostuni, M. A. 2023. Oxidative stress in healthy and pathological red blood cells. *Biomolecules*, 13(8), 1262. https://doi.org/10.3390/biom13081262

Anvar Hussain, N. A., Hoque, M., Agarwal, S., Syed, I., and Raihan, M. 2020. Jackfruit (*Artocarpus heterophyllus*). In *Antioxidants in Fruits: Properties and Health Benefits* (Pp. 461–477). Springer Singapore. https://doi.org/10.1007/978-981-15-7285-2_24

Ranasinghe, R. A., Maduwanthi, S. D., and Marapana, R. A. 2019. Nutritional and health benefits of jackfruit (*Artocarpus heterophyllus* Lam.): a review. *International Journal of Food Science*, 2019, 4327183. https://doi.org/10.1155/2019/4327183

Van, C. K., Hoang, Q. B., Nguyen, T. V., Pham, C. H., Bich Le, C. N., Nguyen, T. L., and Truong, T. N. 2023. A review of nutrition, phytochemical compounds and biological activities of jackfruit (*Artocarpus heterophyllus* Lam.). *AIP Conference Proceedings*, 2907(1), 020004. https://doi.org/10.1063/5.0171413

Kumar, A., Mishra, A., and Singh, A. 2022. Phytochemistry, pharmacological, medicinal significance of *Artocarpus heterophyllus* Lam. (Jackfruit). *International Journal of Health Sciences*, 6(S5), Pp. 6578–6590. https://doi.org/10.53730/ijhs.v6nS5.10134

Gupta, A., Marquess, A. R., Pandey, A. K., and Bishayee, A. 2023. Jackfruit (*Artocarpus heterophyllus* Lam.) in health and disease: a critical review. *Critical Reviews in Food Science and Nutrition*, 63(23), Pp. 6344–6378. https://doi.org/10.1080/10408398.2022.2031094

Vianna, A. D., Matos, E. P., Jesus, I. M., Asmus, C. I., and Câmara, V. D. 2019. Human exposure to mercury and its haematological effects: a systematic review. *Cadernos de Saúde Pública*, 35(2), e00091618. https://doi.org/10.1590/0102-311X00091618

Liu, W., Xu, Z., Li, H., Guo, M., Yang, T., Feng, S., Xu, B., and Deng, Y. 2017. Protective effects of curcumin against mercury-induced hepatic injuries in rats, involvement of oxidative stress antagonism, and Nrf2-ARE pathway activation. *Human & Experimental Toxicology*, 36(9), Pp. 949–966. https://doi.org/10.1177/0960327116677355

Chavez-Santiago, J. O., Rodríguez-Castillejos, G. C., Montenegro, G., Bridi, R., Valdes-Gomez, H., Alvarado-Reyna, S., Castillo-Ruiz, O., and Santiago-Adame, R. 2021. Phenolic content, antioxidant and antifungal activity of jackfruit extracts (*Artocarpus heterophyllus* Lam.). *Food Science and Technology*, 42, e02221. https://doi.org/10.1590/fst.02221

El-Demerdash, F. M., Yousef, I. M., Kedwany, F. S., and Baghdadi, H. H. 2004. Cadmium-induced changes in lipid peroxidation, blood hematology, biochemical parameters and semen quality of male rats: protective role of vitamin E and β-carotene. *Food and Chemical Toxicology*, 42(10), Pp. 1563–1571. https://doi.org/10.1016/j.fct.2004.05.001

Wieloch, M., Kamiński, P., Ossowska, A., Koim-Puchowska, B., Stuczyński, T., Kuligowska-Prusińska, M., Dymek, G., Mańkowska, A., and Odrowąż-Sypniewska, G. 2012. Do toxic heavy metals affect antioxidant defense mechanisms in humans? *Ecotoxicology and Environmental Safety*, 78, Pp. 195–205. https://doi.org/10.1016/j.ecoenv.2011.11.023

Halliwell, B., and Gutteridge, J. M. 2015. *Free radicals in biology and medicine* (5th ed.). Oxford University Press.

Grandjean, P., and Landrigan, P. J. 2006. Developmental neurotoxicity of industrial chemicals. *The Lancet*, 368(9553), Pp. 2167–2178. https://doi.org/10.1016/S0140-6736(06)69665-7

Sreeja Devi, P. S., Kumar, N. S., and Sabu, K. K. 2021. Phytochemical profiling and antioxidant activities of different parts of *Artocarpus heterophyllus* Lam. (Moraceae): A review on current status of knowledge. *Future Journal of Pharmaceutical Sciences*, 7(1), 30. https://doi.org/10.1186/s43094-021-00178-7

Abdelqader, A., Obeidat, M. D., Al-Rawashdeh, M. S., and Alrazak, A. A. 2023. The role of vitamin E as an antioxidant and preventing damage caused by free radicals. *Journal of Life Science and Applied Research*, 4(2), Pp. 88–95. https://doi.org/10.59807/jlsar.v4i2.89

Halliwell, B. 2007. Dietary polyphenols: good, bad, or indifferent for your health? *Cardiovascular Research*, 73(2), Pp. 341–347. https://doi.org/10.1016/j.cardiores.2006.10.004