ISSN: 2536-7153 SJMLS

Sokoto Journal of Medical Laboratory Science 2024; 9(1): 68 - 77

SJMLS - 9(1) - 007

Antioxidant Effects of Aqueous Leaves Extracts of *Launaea Taraxacifolia* in Benzene-Induced Haematotoxicity in Albino Wistar Rats

Progress Arhenrhen OBAZELU*[1] and Abieyuwa Peace OMOREGIE[2]
Department of Medical Laboratory Science, School of Basic Medical Sciences, University of Benin [1], Institute of Child Health, University of Benin [2].
Author of Correspondence*: progress.obazelu@uniben.edu/ +234-805-673-3255/ 0000-0002-4492-5684. DOI: 10.4314/sokjmls.v9i1.7

Abstract

Launaea taraxacifolia, a plant renowned in diverse traditional medicines for its health-enhancing qualities, has garnered interest owing to its documented antioxidant attributes. Given the potential anti-oxidative and cytoprotective properties of *Launaea taraxacifolia* extracts, there is a growing interest in investigating their effects on cellular pathways such as nuclear factor erythroid 2-related factor 2 (NRF-2) and heme oxygenase 1 (HO-1) in the context of benzene-induced haematotoxicity. Understanding the interactions between these extracts and the cellular defense mechanisms could provide valuable insights into their potential as therapeutic agents. The aim of this study was to determine the antioxidant effects of aqueous leaf extracts of *Launaea taraxacifolia* in benzene induced haematotoxicity in albino Wistar rats. A total of sixty (60) adult male albino Wistar rats were divided into six groups namely groups A, B, C, D, E and F, representing control, benzene group, cyclophosphamide group, benzene + 100mg/kg *Launaea taraxacifolia*, benzene + 200mg/kg *Launaea taraxacifolia* and benzene + 400mg/kg *Launaea taraxacifolia* respectively. mRNA expression of NRF-2 and HO-1 were determined using polymerase chain reaction. Data obtained was analyzed by the Statistical Package for Social Science (SPSS) software. Comparison amongst the study groups showed that mRNA expression of NRF-2 was significantly higher in group E when compared to group B ($p<0.05$).The mRNA expression of NRF-2 was significantly lower in group F than group A ($p<0.05$). The mRNA expression of HO-1 in group B, C, D, E and F was significantly lower than group A ($p<0.05$). The mRNA expression of HO-1 in group C, D and F was significantly lower than group B ($p<0.05$). This study concludes that benzene induced a reduction in NRF-2 and HO-1 mRNA expression. *Launaea taraxacifolia* reversed the observed effects of benzene on NRF-2 but not on HO-1.

Keywords: *Launaea taraxacifolia,* Nuclear Factor Erythroid 2-Related Factor -2, Heme Oxygenase-1, Benzene.

Introduction

Launaea taraxacifolia, commonly known as African lettuce or wild lettuce, is a plant primarily found in the western, central, and eastern regions of the continent, including countries such as Nigeria (Dansi *et al*., 2012). In Nigeria, Hausa tribe call it '*Namijin dayii*, *Nomen barewa* and *Nonan Barya'* while Yoruba tribe call it '*Efo Yanrin* and *Odundun Odo'* (Bello *et al*., 2017). Antioxidants are compounds that help protect the body against oxidative stress caused by free radicals (Hamid *et al*., 2010). Oxidative stress is the imbalance between the occurrence of reactive oxygen/nitrogen species (ROS/RNS) and cellular antioxidant defenses (Waterman *et al*., 2002). Oxidative stress is a result of excess ROS/RNS, which occurs due to a lack of counteraction by cellular antioxidant systems. Increased oxidative stress can have severe consequences in biological systems, including molecular damage, which can severely impact health (Carocho and Ferreira, 2013).

Nuclear factor erythroid 2-related factor 2 (NRF-2) is a transcription factor that plays a crucial role in the body's antioxidant defense system (Pajares

et al., 2016). When the body is exposed to oxidative stress, NRF-2 is activated and translocate into the cell nucleus. Once in the nucleus, NRF-2 binds to specific DNA sequences called antioxidant response elements (AREs) in the promoter region of target genes. This binding triggers the transcription of genes involved in antioxidant defense, detoxification, and anti-inflammatory processes (Lee *et al*., 2018). NRF-2 activation leads to the increased production of enzymes, such as glutathione peroxidase, superoxide dismutase, and catalase, which help neutralize reactive oxygen species (ROS) and prevent oxidative damage to cells and tissues that can lead to various diseases like cancer (Aboonabi and Singh, 2015). Heme oxygenase 1 (HO-1) is an inducible isoform of heme oxygenase; its expression can be increased in response to stimuli such as oxidative stress (Munoz-Sanchez *et al*., 2014). One of the products of heme breakdown by HO-1 is biliverdin, which is rapidly converted to bilirubin. Bilirubin is a potent endogenous antioxidant that scavenges free radicals and inhibits lipid peroxidation. It helps protect cells and tissues from oxidative damage caused by reactive oxygen species (ROS) (Sedlak and Snyder, 2004). Benzene is a volatile organic compound and chronic exposure to benzene has been associated with several health risks, including its potential to induce oxidative stress in blood cells (Abd El-Shakour *et al*., 2015). Nuclear factor erythroid 2-related factor 2 (NRF-2) is a transcription factor that plays a pivotal role in the cellular defense against oxidative stress. Activation of NRF-2 leads to the upregulation of a variety of antioxidant enzymes including Heme oxygenase 1 (HO-1). NRF-2 and HO-1 both possesses antioxidant properties. In light of the potential therapeutic properties of *Launaea taraxacifolia* and the growing concern over benzene-induced haematotoxicity, there is a need to investigate the antioxidant effect of *Launaea taraxacifolia* leaf extracts in benzene-induced haematotoxicity in albino Wistar rats.

Materials and Methods

Study Population

In this study, animal (rats) model was used. A total of sixty (60) of the Albino Wistar strain were purchased from the animal holdings of the Department of Anatomy, University of Benin, Benin City, Nigeria. The rats were housed at the animal housing wing of the Department of Anatomy, University of Benin (Obazelu and Faluyi, 2023).

Identification of the *Launaea taraxacifolia* leaves

Launaea taraxacifolia leaves were harvested from Faculty of Agriculture (in the month of February, 2023) in the University of Benin, Nigeria. The leaves were then identified and authenticated by Dr. A.O. Akinnibosun of the Department of Plant Biology and Biotechnology, Faculty of Life Sciences, University of Benin, Benin City (Obazelu *et al*., 2021).

Preparation of Plant Extract

About 3.65kg leaves were pulverized (after drying) by a commercial blender and (665g of powder obtained), soaked in distilled water using 1g of powder to 5ml of distilled water and allowed to stand at room temperature for 72 hours at room temperature. The extract was filtered using Whatman's (Nitro cellulose 45; 0.45µm pore size) filter paper and the filtrates were concentrated to dryness at 100ºC in a water bath. Thereafter, it was put in an airtight container and refrigerated until use (Obazelu *et al*., 2021).

Animal Care

Animals were housed in a cross ventilated room in the animal holdings of the department of anatomy, University of Benin, Benin City. Animals were exposed to 12 hours of dark and light cycles with access to feed and water *ad libitum*. The rats were acclimatized for a period of two (2) weeks before commencement of the experiment (Obazelu *et al*., 2021).

Ethical Consideration

Ethical approval was obtained from Research Ethics Committee on animal subjects from Edo State Ministry of Health, Benin City (Ref Number: HA/737/23/B/200600143 issued on 30th June, 2023).

Preparation of Benzene and Cyclo-phosphamide Drug Solution

Benzene Solution

Benzene solution was made by mixing benzene (Manufactured by Loba Chemie Laboratory Reagents and Fine Chemicals LTD, Batch

Number: L246641711), distilled water v/v and 2-propanol in the ratio of 1:5:5. That is, 1 part of benzene was mixed with 5 part of distilled water v/v and 5 parts of 2-propanol. 0.2ml of this benzene solution was administered to each animal in the various test groups with an average weight of 150g every 48 hours for 28 days (Obazelu and Faluyi, 2023).

Cyclophosphamide Drug Solution

Cyclophosphamide drug solution was made by mixing 500mg of the powdered drug in 25ml of distilled water. 0.3ml of this drug solution was administered orally to each animal in group C of an average weight of 150g every 48 hours for 28 days (Akanni et al., 2014).

Research Design

Grouping of Animals: Sixty (60) adult Wistar rats weighing 150-200g were randomly selected and divided into six groups (n = 10 per group). The Groups were Group A, Group B, Group C, Group D, Group E and Group F.

Group A: This was the control group. Animals in this group received only standardized feed (Manufactured by Karma Agric Feeds and Food Limited, Oyo State) and clean water ad libitum.

Group B: This group received only benzene intraperitoneally.

Group C: Animals in this group were administered benzene solution and treated with the standard drug solution (cyclophosphamide) intraperitoneally.

Group D: Animals in this group were administered benzene solution intraperitoneally and treated with low dose of Launaea taraxacifolia leaves extract orally.

Group E: Animals in this group were administered benzene solution intraperitoneally and treated with a higher dose of Launaea taraxacifolia leaves extract orally.

Group F: Animals in this group were administered benzene solution intraperitoneally and treated with the highest dose of Launaea taraxacifolia leaves extract orally (Obazelu and Faluyi, 2023).

Dosage of Cyclophosphamide Administered (Akanni et al., 2014).

Administered Doses of Launaea taraxacifolia Extract

Group A (control) received only standardized feed and clean water ad libitum. Group B (benzene treated group) were administered 0.2ml of benzene solution intraperitoneally every 48 hours for 28 days. Group C (cyclophosphamide drug solution treated group) were administered 0.2ml of benzene solution intraperitoneally every 48 hours for 28 days and treated with 0.3ml of 6mg/ml of cyclophosphamide 48 hourly for 28 days. Group D were administered with 0.2ml of benzene solution intraperitoneally every 48 hours for 28 days and treated with 0.15ml of 100mg/kg body weight of Launaea taraxacifolia leaves extract orally using a gavage tube every 24 hours for 28 days. Group E were administered with 0.2ml of benzene solution intraperitoneally every 48 hours for 28 days and treated with 0.3ml of 200mg/kg body weight of Launaea taraxacifolia leaves extract orally using a gavage tube every 24 hours for 28 days. Group F were administered with 0.2ml of benzene solution intraperitoneally every 48 hours for 28 days and treated with 0.6ml of 400mg/kg body weight of Launaea taraxacifolia leaves extract orally using a gavage tube every 24 hours for 28 days (Obazelu and Faluyi, 2023).

Physical Examination of Animals

Animals were weighed to check for any increase or decrease in body weight throughout the experiment.

Measurement of Body Weight

The body weights of the animals were measured three times during the experiment. This was done at day 0, 14 and 28. A weighing scale was used to measure the individual weight of each animal. This was done by removing the animals from the cage and placing them on the scale. The weights were read and recorded while the animals were resting on the scale.

Sacrifice of Animals and Collection of Samples

At the end of the experimental period, the animals were grossly observed for general physical characteristics. A midline incision was made through the ventral wall of the rats after anaesthetizing (using chloroform) and cervical

dislocation. Five milliliters (5ml) of blood were collected from each rat using a sterile syringe and placed in an Ethylene Diamine Tetra-acetic Acid (EDTA) container for full blood count analysis and peripheral blood film preparation. Bone marrow samples were also obtained from the rats by opening the femur longitudinally and exposing the marrow cavity. A sterile forceps was used to obtain the bone marrow from the cavity and placed in an Eppendorf container containing Trizol for molecular analysis (Obazelu and Faluyi, 2023).

Laboratory Analysis
Nuclear Factor Erythroid 2-Related Factor -2 (NRF-2) and Heme Oxygenase-1 (HO-1) mRNA Assay

Isolation of Total RNA
Total RNA was isolated from tissue samples with Quick-RNA MiniPrep™ Kit (Zymo Research). The DNA contaminant was removed following DNAse I (NEB, Cat: M0303S) treatment. The RNA was quantified at 260 nm and the purity confirmed at 260 nm and 280 nm using A&E Spectrophotometer (A&E Lab. UK).

cDNA Conversion
One (1 µg) of DNA-free RNA was converted to cDNA by reverse transcriptase reaction with the aid of cDNA synthesis kit based on ProtoScript II first-strand technology (New England BioLabs) in a condition of 3-step reaction: 65 °C for 5 min, 42 °C for 1 h, and 80 °C for 5 min (Elekofehinti et al., 2020).

PCR Amplification and Agarose Gel Electrophoresis
Polymerase chain reaction (PCR) for the amplification of NRF-2 and HO-1 gene was carried out with OneTaqR2X Master Mix (NEB) using the following primers (Inqaba Biotec, Hatfield, South Africa). PCR amplification was performed in a total of 25µl volume reaction mixture containing cDNA, primer (forward and reverse SEE BELOW) and Ready Mix Taq PCR master mix. Under the following condition: Initial denaturation at 95ºC for 5 min, followed by 30 cycles of amplification (denaturation at 95ºC for 30 seconds, annealing for 30 seconds and extension at 72ºC for 60 seconds) and ending with final extension at 72ºC for 10 min. The amplicons were resolved on 1.0% agarose gel. The Glyceraldehyde-3-Phosphate Dehydrogenase (GAPDH) gene was used to normalize the relative level of expression of each gene, and quantification of band intensity was done using "image J" software (Elekofehinti et al., 2020).

Primer Sequences
NRF2
Forward: CACATCCAGACAGACAC CAGT
Reverse: CTACAAATGGGAATGTCTC TGC

HO-1
Forward ACCCCACCAAGTTCAAA CAG
Reverse GAGCAGGAAGGCGGTCTTAG

GAPDH
CTCCCTGGAGAAGAGCTATGA
AGGAAGGAAGGCTGGAAGA

Statistical Analysis
Data obtained from this research was presented and analyzed using statistical package for social sciences (SPSS) version 21.0 (IBM Inc. USA). Bar charts were used to represent the mRNA gene expression patterns. A p value of ≤ 0.05 was considered statistically significant.

Results
The results obtained in this study are shown in Figures 1- 3.
The body weight of groups A, B, C, D, E and F, representing control, benzene group, cyclophosphamide group, benzene + 100mg/kg Launaea taraxacifolia, benzene + 200mg/kg Launaea taraxacifolia and benzene + 400mg/kg Launaea taraxacifolia respectively measured at day 0, 14 and 28. The weight gain of groups A and B increased at day 14 and day 28 when compared to day 0. Group C showed a slight increase in body weight from day 0 to day 14 but decreased significantly between day 14 and day 28. Group D showed a significant increase at days 14 and 28 when compared to day 0. Also, at day 28, group D showed a slight increase when compared to day 14. Group E and F showed significant weight gain at days 14 and 28 when compared to day 0. Also, there was a slight weight gain in group E and F between days 14 and 28 (figure 1).

Figure 2 shows the expression of genes as represented by gel electrophoresis picture and internal control (Glycealdehyde-3-Phosphate Dehydrogenase {GADPH}) of mRNA expression of NRF-2 of groups A, B, C, D, E and F, representing control, benzene group, cyclophosphamide group, benzene + 100mg/kg Launaea taraxacifolia, benzene + 200mg/kg Launaea taraxacifolia and benzene + 400mg/kg Launaea taraxacifolia respectively, represented on different bars on the bar chart. There was a significant decrease in the expression of NRF-2 in group B when compared to A ($p<0.05$). Groups C expression of NRF-2 was significantly lower ($p<0.05$) when compared to the group A but showed no significant difference when compared to group B. Group D showed no significant difference when compared to both groups A and B ($p<0.05$). Group E expression of NRF-2 was significantly higher when compared group B ($p<0.05$). Group F expression of NRF-2 was significantly lower than group A, but showed no significant difference with group B ($p<0.05$).

Figure 3 shows the expression of genes as represented by gel electrophoresis picture and internal control (Glycealdehyde-3-Phosphate Dehydrogenase {GADPH}) of mRNA expression of HO-1 of groups A, B, C, D, E and F, representing control, benzene group, cyclophosphamide group, benzene + 100mg/kg Launaea taraxacifolia, benzene + 200mg/kg Launaea taraxacifolia and benzene + 400mg/kg Launaea taraxacifolia respectively, represented on different bars on the bar chart. There was a significant decrease in the expression of HO-1 in group B when compared to group A ($p<0.05$). Groups C and D had a statistically significantly lower expression of HO-1 when compared to groups A and B. Group E expression of HO-1 was significantly lower when compared to group A ($p<0.05$) but showed no significant difference with group B. Group F expression of HO-1 was significantly lower than groups A and B ($p<0.05$).

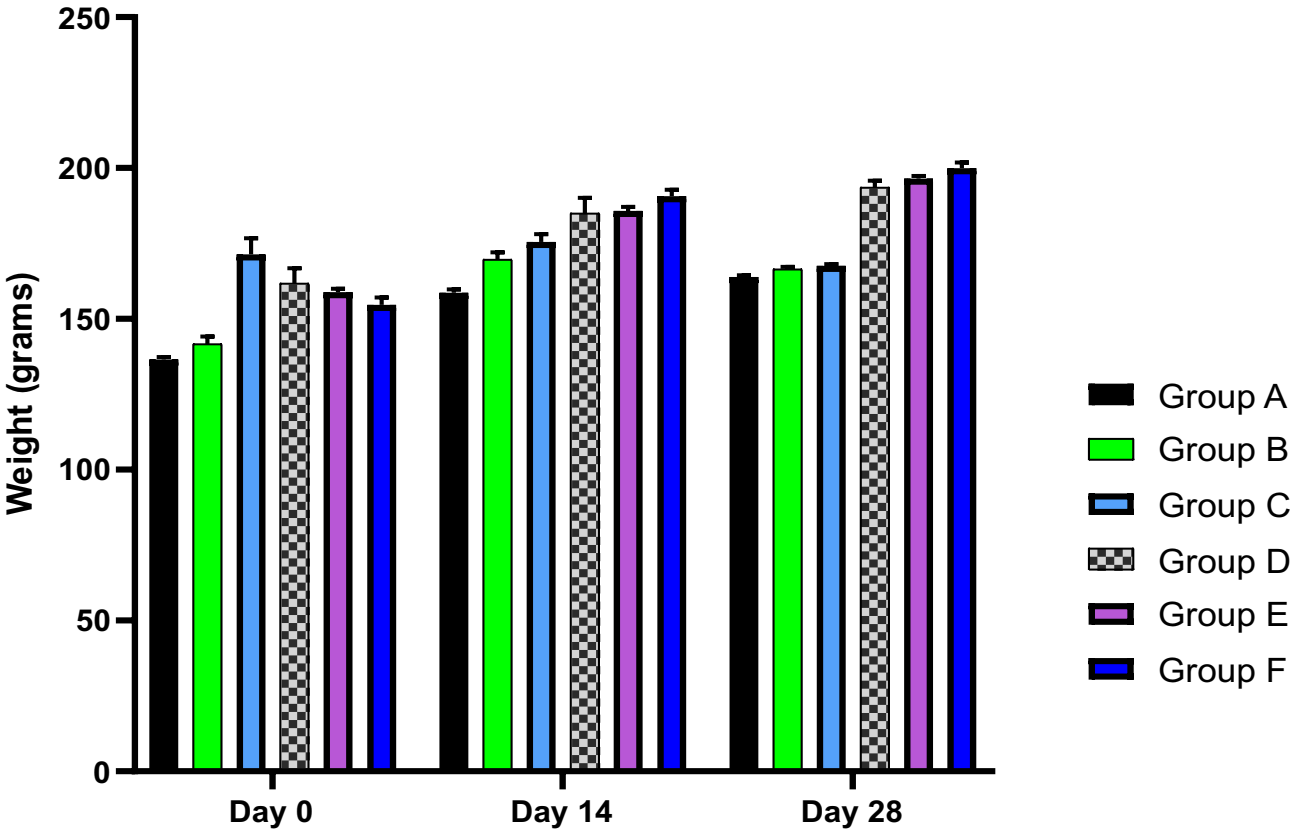
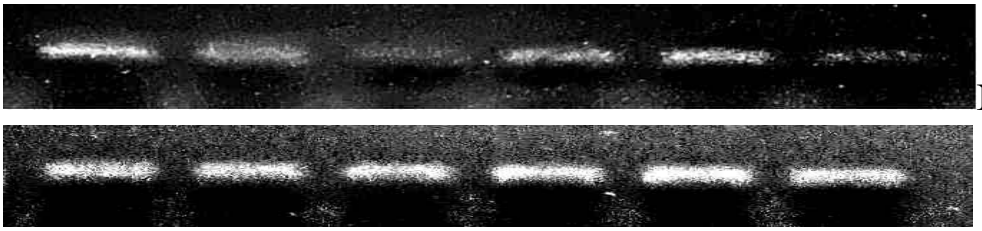


Figure 1: Body Weights of Groups A, B, C, D, E and F measured at Day 0, Day 14 and Day 28.
Key: Group A=control, Group B=benzene group, Group C=cyclophosphamide group, Group D=benzene + 100mg/kg *Launaea taraxacifolia*, Group E=benzene + 200mg/kg *Launaea taraxacifolia* and Group F=benzene + 400mg/kg *Launaea taraxacifolia*



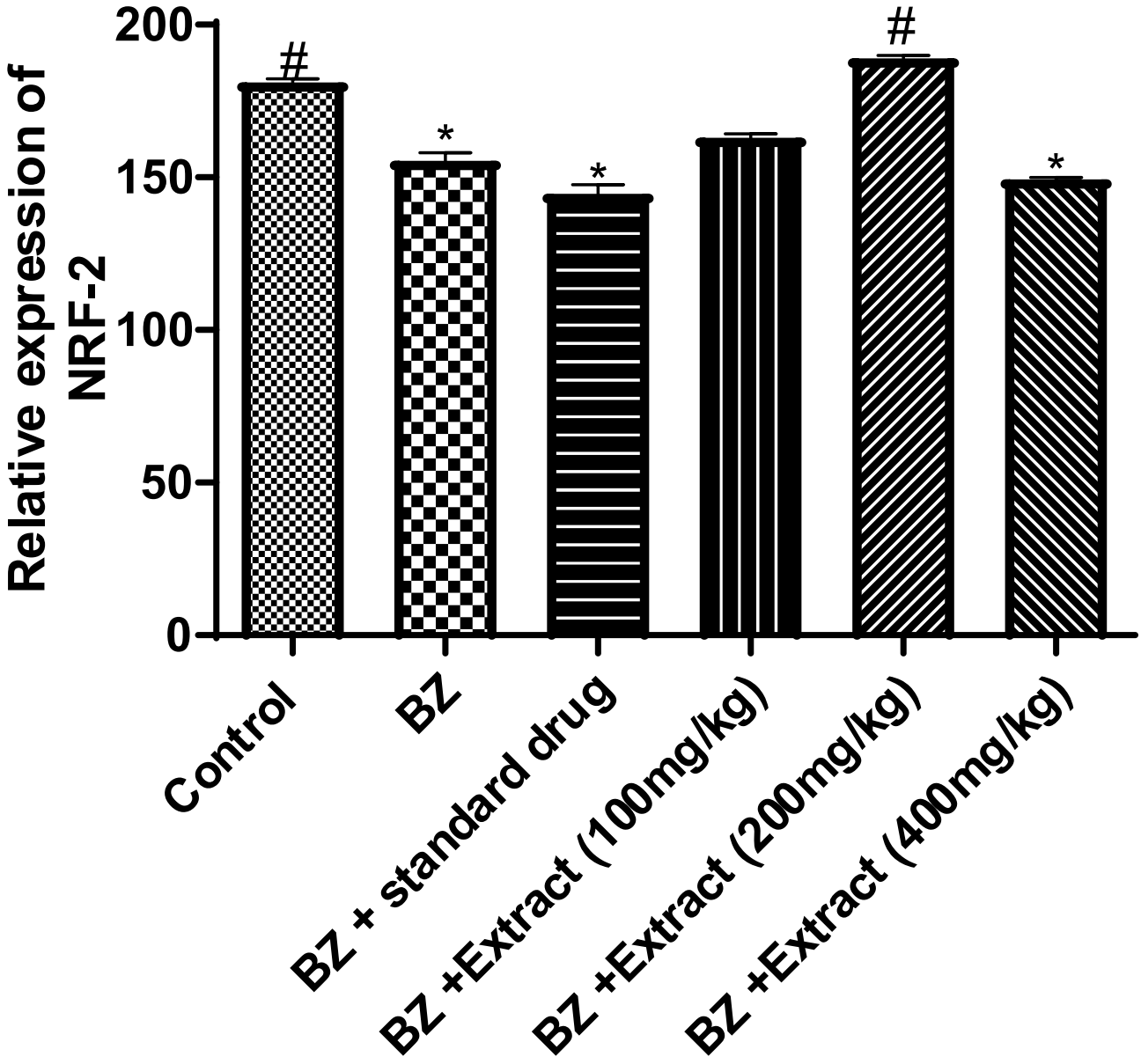


Figure 2: mRNA Expression of NRF-2 of the Studied Groups.
* Represents statistical difference to control. # Represents statistical difference to benzene induced group at $p<0.05$.
Key: BZ=Benzene, GADPH=Glyceraldehyde-3-Phosphate Dehydrogenase

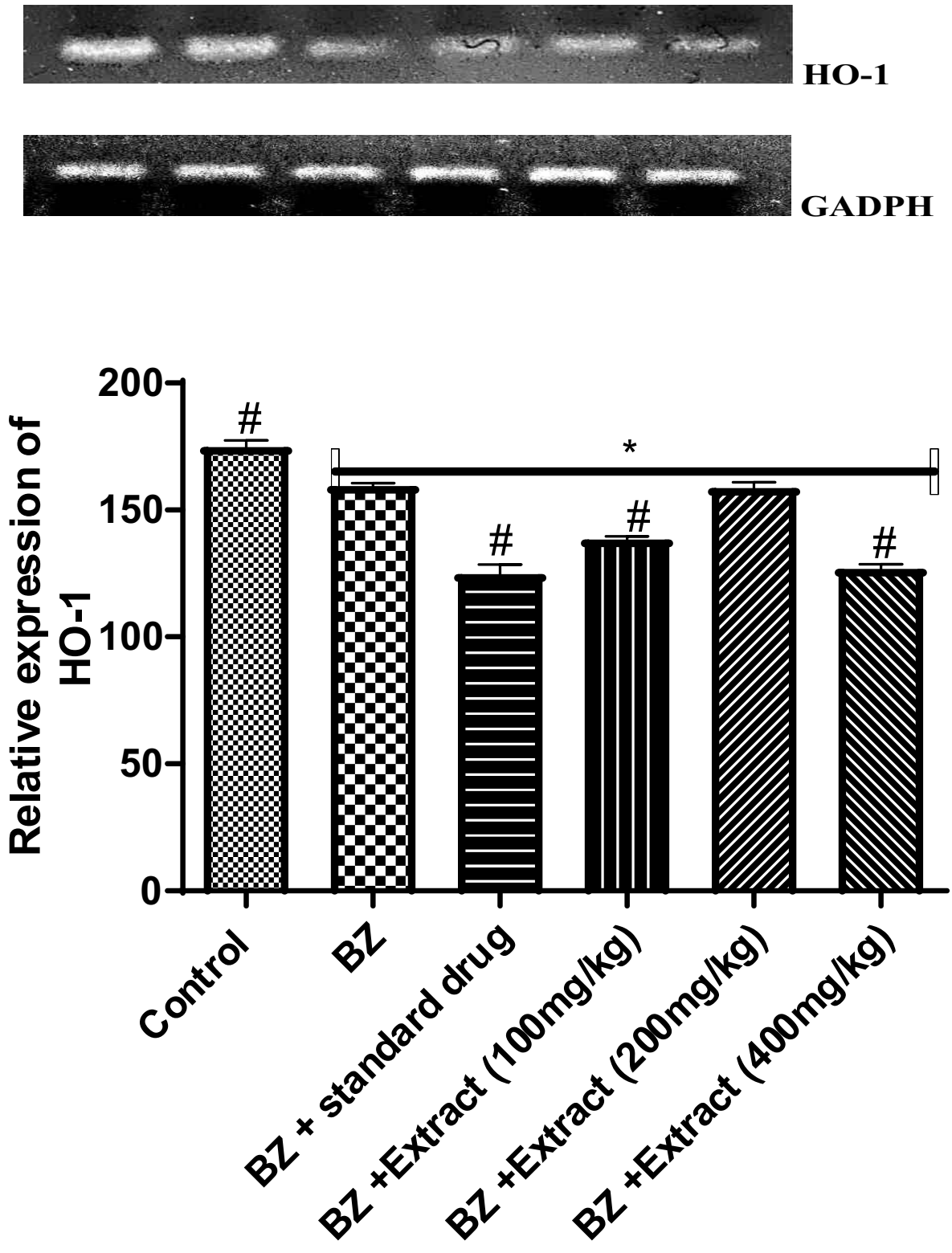


Figure 3: mRNA Expression of HO-1 of the Studied Groups.
* Represents statistical difference to control. # Represents statistical difference to benzene induced group at $p<0.05$.
Key: BZ=Benzene, GADPH=Glyceraldehyde-3-Phosphate Dehydrogenase

Discussion

Body weight holds great importance in research, serving as a crucial parameter with multiple dimensions. It offers valuable insights into various aspects of health, biology, and experimental results. This study noted a distinct pattern in body weight variations among different experimental groups. Specifically, there was a gradual increase in body weight observed among the groups that were administered benzene, cyclophosphamide, and a combination of benzene with varying concentrations of *Launaea taraxacifolia* from day 0 to day 14. This initial upward trend in body weight suggests a potential phase of adaptation to the experimental conditions. During this time, the organisms likely underwent compensatory adjustments to maintain physiological balance in response to the introduced stressors. However, a significant change took place between day 14 and day 28, characterized by a decrease in body weight among the groups exposed to benzene and cyclophosphamide. This reduction indicates the adverse impact of these substances on overall health and well-being, leading to compromised growth or potentially altered metabolic processes.

Nuclear factor erythroid 2-related factor-2 (NRF-2) plays a crucial role in regulating the antioxidant response in the body. It is a key component of the cellular defense system against oxidative stress and inflammation (Pajares *et al*., 2016). The reduction in the expression of NRF-2, which is a key transcription factor that regulates antioxidant response elements in this study, suggests that benzene impairs the cells' ability to provide a proper defense against oxidative stress. This finding is consistent with the idea that benzene can disrupt the balance between oxidative stress and antioxidant defense mechanisms (Ziech *et al*., 2010). Cyclophosphamide, a chemotherapeutic agent, further reduces NRF-2 expression. This is likely due to its well-documented immunosuppressive effects, which could lead to reduced NRF-2 activation and subsequent antioxidant response. The reduction of NRF-2 by cyclophosphamide in this study is in agreement with the study of Siracusa *et al*. (2022) who also noted a reduction in NRF-2 expression after administration of cyclophosphamide. The increase in NRF-2 expression following co-administration of 100mg/kg, 200mg/kg and 400mg/kg of *Launaea taraxacifolia* with benzene is important. It suggests that the plant extract might stimulate NRF-2 activation as a response to oxidative stress. However, the reduction in NRF-2 expression at the highest concentration of the extract suggests a potential biphasic response, where excessively high doses could have different effects on NRF-2 regulation.

Heme oxygenase-1 (HO-1) is an inducible enzyme, and its expression is upregulated in response to various stimuli. It can be induced by oxidative stress (Munoz-Sanchez *et al*., 2014). In this study, the decrease in Heme oxygenase 1 (HO-1) expression after benzene and cyclophosphamide administration aligns with their known toxic effects (Emadi *et al*., 2009). HO-1 is an enzyme that plays a crucial role in the degradation of heme and has cytoprotective effects (Kikuchi *et al*., 2005). The reduction in HO-1 expression could indicate an impairment of cellular defense mechanisms against oxidative stress. The reduction of HO-1 by cyclophosphamide in this study agrees with the study of Siracusa *et al*. (2022) who also noted a reduction in HO-1 expression after administration of cyclophosphamide. The further reduction in HO-1 expression following co-administration of 100mg/kg, 200mg/kg and 400mg/kg of *Launaea taraxacifolia* with benzene suggests a potential interplay between the plant extract and the cellular response to benzene-induced oxidative stress. It's possible that the extract's compounds interact with pathways related to HO-1 expression, potentially increasing the reduction of this cytoprotective enzyme.

Conclusion

Data from this study showed that benzene exposure induced a reduction in NRF-2 and HO-1 mRNA expression. Co-administration of benzene and varying *Launaea taraxacifolia* concentrations caused an increase in NRF-2 expression when compared to benzene group. However, HO-1 expression was further reduced following co-administration of benzene and varying *Launaea taraxacifolia* concentrations.

Acknowledgements

I want to specially thank Mr. Joshua Oziegbe Osaghae of the Department of Medical Laboratory Science, University of Benin for helping out in the laboratory analysis of this study.

References

Abd El-Shakour, A., El-Ebiarie, A. S., Ibrahim, Y. H., Moneim, A. E. A. and El-Mekawy, A. M. (2015). Effect of Benzene on Oxidative Stress and the Functions of Liver and Kidney in Rats. *Journal of Environmental and Occupational Health*; **4(1)**: 34-39.

Aboonabi, A., and Singh, I. (2015). Chemo Preventive Role of Anthocyanins in Atherosclerosis via Activation of NRF-2–ARE as an Indicator and Modulator of Redox. *Biomedicine and Pharmacotherapy*; **72(1)**: 30-36.

Akanni, E. O., Adedeji, A. L., Adedosu, O. T., Olaniran, O. I. and Oloke, J. K. (2014). Chemopreventive and Anti-Leukemic Effects of Ethanol Extracts of Moringa Oleifera Leaves on Wistar Rats Bearing Benzene Induced Leukemia. *Current Pharmaceutical Biotechnology*; **15(6)**: 563-568.

Bello, O. M., Zaki, A. A., Khan, S. I., Fasinu, P. S., Ali, Z., Khan, I. A. and Oguntoye, O. S. (2017). Assessment of Selected Medicinal Plants Indigenous to West Africa for Antiprotozoal Activity. *South African Journal of Botany*; **113(1)**: 200-211.

Carocho, M. and Ferreira, I. C. (2013). A Review on Antioxidants, prooxidants and Related Controversy: Natural and Synthetic Compounds, Screening and Analysis Methodologies and Future Perspectives. *Food and Chemical Toxicology*; **51(1)**: 15-25.

Dansi, A., Vodouhè, R., Azokpota, P., Yedomonhan, H., Assogba, P., Adjatin, A. and Akpagana, K. J. T. S. W. J. (2012). Diversity of the Neglected and Underutilized Crop Species of Importance in Benin. *The Scientific World Journal*; **2(1)**: 3-10.

Elekofehinti, O. O., Lawal, A. O., Ejelonu, O. C., Molehin, O. R. and Famusiwa, C. D. (2020). Involvement of Fat Mass and Obesity Gene (FTO) in the Anti-obesity Action of Annona *Muricata annonaceae*: in silico and in vivo studies. *Journal of Diabetes and Metabolic Disorders*; **19(1)**: 197-204.

Emadi, A., Jones, R. J. and Brodsky, R. A. (2009). Cyclophosphamide and Cancer: golden anniversary. *Nature Reviews Clinical Oncology*; **6(11)**: 638-647.

Hamid, A. A., Aiyelaagbe, O. O., Usman, L. A., Ameen, O. M. and Lawal, A. (2010). Antioxidants: Its Medicinal and Pharmacological Applications. *African Journal of Pure and Applied Chemistry*; **4(8)**: 142-151.

Kikuchi, G., Yoshida, T. and Noguchi, M. (2005). Heme Oxygenase and Heme Degradation. *Biochemical and Biophysical Research Communications*; **338(1)**: 558-567.

Lee, H. J., Pyo, M. C., Shin, H. S., Ryu, D. and Lee, K. W. (2018). Renal Toxicity Through AhR, PXR, and NRF-2 Signaling Pathway Activation of Ochratoxin A-Induced Oxidative Stress in Kidney Cells. *Food and Chemical Toxicology*; **122(1)**: 59-68.

Muñoz-Sánchez, J. and Chánez-Cárdenas, M. E. (2014). A review on Hemeoxygenase-2: Focus on Cellular Protection and Oxygen Response. *Oxidative medicine and Cellular Longevity*; **2(1)**: 36-40.

Obazelu, P. A., Aruomaren, A. I. and Ugboaja, E. E. (2021). 'Phytochemical Analysis, Nutrients and Mineral Composition of *Combretum platypterum* Aqueous Leaf Extract'. *Journal of Applied Science and Environmental Manage*ment; **25(9)**: 1625-1630.

Obazelu, P. A. and Faluyi, O. (2023). Effect of *Launaea taraxacifolia* Aqueous Leaves Extracts on ICAM-1 and VCAM-1 Gene Expressions in Benzene-Induced Haematotoxicity in Albino Wistar Rats. *Journal of Applied Science and Environmental Manage*ment; **27(12)**: 2845-2852.

Pajares, M., Jiménez-Moreno, N., García-Yagüe, Á. J., Escoll, M., de Ceballos, M. L., Van Leuven, F. and Cuadrado, A. (2016). Transcription factor NFE2L2/NRF-2 is a Regulator of Macroautophagy Genes. *Autophagy*; **12(10)**: 1902-1916.

Sedlak, T. W. and Snyder, S. H. (2004). Bilirubin Benefits: Cellular Protection by a Biliverdin Reductase Antioxidant Cycle. *Pediatrics*; **113(6)**: 1776-1782.

Siracusa, R., D'Amico, R., Fusco, R., Impellizzeri, D., Peritore, A. F., Gugliandolo, E. and Di Paola, R. (2022). Açai Berry Attenuates Cyclophosphamide-Induced Damage in Genitourinary Axis-Modulating Nrf-2/HO-1 Pathways. *Antioxidants*; **11(12)**: 2355.

Waterman, K. C., Adami, R. C., Alsante, K. M., Hong, J., Landis, M. S., Lombardo, F. and

Roberts, C. J. (2002). Stabilization of Pharmaceuticals to Oxidative Degradation. *Pharmaceutical Development and Technology*; **7(1)**: 1-32.

Ziech, D., Franco, R., Georgakilas, A. G., Georgakila, S., Malamou-Mitsi, V., Schoneveld, O. and Panayiotidis, M. I. (2010). The Role of Reactive Oxygen Species and Oxidative Stress in Environmental Carcinogenesis and Biomarker Development. *Chemico-Biological Interactions*; **188(2)**: 334-339.

Citation: Progress Arhenrhen OBAZELU and Abieyuwa Peace OMOREGIE Antioxidant Effects of Aqueous Leaves Extracts of *Launaea Taraxacifolia* in Benzene-Induced Haematotoxicity in Albino Wistar Rats. ***Sokoto Journal of Medical Laboratory Science*; 9(1): 68 - 77.** DOI: 10.4314/sokjmls.v9i1.7