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Ameliorative effects of *Ocimum gratissimum* on aluminium-induced hepatotoxicity in adult wistar rats

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Abstract

Background of study: *Ocimum gratissimum* has been reported to be rich in natural antioxidants such as flavonoids. This study aims to investigate the potential ameliorative effects of *Ocimum gratissimum* extract against aluminium-induced hepatotoxicity in rat model. **Methods:** Thirty female wistar rats (240 g) were randomly assigned to seven groups (1, 2A, 2B, 3, 4, 5 and 6). Group 1 served as the control group and received feed and water ad libitum. Groups 2A and 2B received a single dose of 32.5 mg/kg b.w of aluminium nitrate. Groups 3 and 4 received 200 mg/kg and 300 mg/kg b.w of *Ocimum gratissimum* respectively after 24 hours of administration of a single dose of 32.5 mg/kg of aluminium nitrate. Both groups 5 and 6 received 400 mg/kg b.w of *Ocimum gratissimum* after 24 hours of administration of a single dose of 32.5 mg/kg of aluminium nitrate. **Results:** Histological studies show degenerative changes in the liver cytoarchitecture of groups treated with aluminium. Relative to the control group, treatment with aluminium significantly raised the bilirubin levels and serum activities of ALT, AST and ALP. Regenerative changes were observed after the extract administration. **Conclusion:** From this study, it appears that *Ocimum gratissimum* extract is capable of ameliorating the hepatotoxic effects of aluminium.

Keywords: *Ocimum gratissimum extract, Aluminium, Oxidative stress, Antioxidant enzymes, Hepatotoxicity, Liver*

1. Introduction

The Global use of herbal products for medicinal benefits has been recognized as an essential building block for primary healthcare and has an important role in nearly every culture on earth (Balkrishna *et al*., 2024). According

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to the World Health Organization (WHO), more than 80% of the world's population still rely on herbal medicines as their prime source of health care (Pant, 2014). Over 50% of all modern clinical drugs are of natural product origin and natural products play an important role in drug development programs (Chaachouay and Zidane, 2024).

The impact of aluminium on human health has been increasingly alarming in recent years (Ighodaro *et al.*, 2012). Widely distributed and extensively used in daily life resulting in exposure (Rahimzadeh *et al.*, 2022). It is present in many cooking utensils, manufactured foods, medicines, cheese, tea, and cosmetics and is also added to drinking water during the purification process. However, it has been reported in several studies to be hepatotoxic, cardiotoxic, neurotoxic, and nephrotoxic and also induces testicular damage in animals and humans (Pasha and Oglu, 2017). Aluminium inhibits antioxidant enzymes and other components of the antioxidant system in a variety of organs including the liver, testis, kidney, lungs and brain imposing oxidative stress on these organs (Rahimzadeh *et al.*, 2022).

Many plants known to possess antioxidant properties have been proposed in the treatment and prevention of different pathologies induced by oxidative stress. An example of such is a vegetable plant called *Ocimum gratissimum* which has an important dietary and therapeutic medicinal role in Nigeria and other parts of the world (Akara *et al.*, 2021). It has been reported to be rich in natural antioxidants such as flavonoids (a polyphenolic compound), and other vital bioactive substances including tannins, oligosaccharides, phenols, and alkaloids thus, it possesses the ability to scavenge free radicals and Reactive Oxygen Species (ROS) (Irondi *et al.*, 2016). It is usually used in the treatment of diseases, such as diarrhoea, upper respiratory tract infection, conjunctivitis, pneumonia, headache, cough, conjunctivitis, fever, tooth disorders, abdominal, oral and gynaecological disorders, ophthalmic and skin diseases (Akara *et al.*, 2021). It has been reported to have antibacterial, antidiabetic, anti-inflammatory, neuroprotective, anticarcinogenic, antioxidant and chemo-preventive properties (Arun *et al.*, 2022; Jahanger *et al.*, 2023).

The liver is the key to metabolism, secretion and excretion and it is continuously and variedly exposed to xenobiotics, environmental pollutants and chemotherapeutic agents because of its strategic location in the body (Kalra *et al.*, 2023). It is a critical organ which contains most of the accumulated metals and where toxic effects can be expected (Kurutas *et al.*, 2009). Liver diseases are a worldwide problem. Conventional drugs used in the treatment of liver diseases are sometimes inadequate and can have serious adverse effects (Hayward and Weersink, 2020). Many natural products possessing anti-oxidative properties have been proposed to prevent and treat hepatopathies induced by oxidative stress. There is increasing evidence for the hepatoprotective role of hydroxyl and polyhydroxy-organic compounds, particularly from vegetables, fruits and some herbs (Kumar *et al.*, 2024). It is therefore necessary to search for alternative drugs for the treatment of liver diseases to replace currently used drugs of doubtful efficacy and safety (Ozbek *et al.*, 2004). The aim of this study is to evaluate the ameliorative effects of aqueous leaf extracts of *Ocimum gratissimum* on aluminium-induced liver damage in rats.

2. Material and methods

2.1. Collection and identification of materials

Fresh leaves of *Ocimum gratissimum* were plucked from Beulah Baptist Garden, Sunsun area, Ogbomoso on 7th of April, 2016. The leaves were identified as *Ocimum gratissimum* leaves by Dr. Akintola, of the Department of Pure and Applied Biology, Faculty of Pure and Applied Sciences, Ladoke Akintola University of Technology, Ogbomoso, Oyo State on 8th of April, 2016. Aluminium Nitrate crystal (nona hydrate) was procured from a reputable supplier at Denis chemical Nigeria Company, Ilorin, Nigeria. All experimental rats were fed with standard rat pellet feeds and drinking water ad libitum. The yield of aqueous extract of leaves of *Ocimum gratissimum* was found to be 6.72% w/w (Gupta *et al.*, 2011). LD50 of Aluminium Nitrate was found to be 65mg/kg (Shrivastava, 2013).

2.2. Preparation of Ocimum gratissimum extract and aluminium nitrate solution

Fresh leaves of *Ocimum gratissimium* were air-dried for two weeks and converted into light powdered form using pestle, mortar and sieve. About 320 g of the powdered leaves were dissolved in 8 litres of distilled water inside a closed container for 2 days. The mixture was then sieved using a muslin bag and the filtrate was heated in a reflux apparatus at a temperature of 50 °C which extracted the scent leaf concentrate. The concentration of the final extract was calculated to be 40 mg/ml. 5 g of Aluminium Nitrate crystal (nona hydrate) was dissolved in 1000mls of distilled water and the concentration was calculated to be 5 mg/ml.

2.3. Experimental animals

Thirty female Wistar rats (mean weight of 240 g) were procured from Adewole Farm Animal House in Ibadan. They were kept in plastic cages in the animal house nearest to the Anatomy Department, Ladoke Akintola University of Technology, Ogbomoso, Oyo State. They were allowed to acclimatize for two weeks and allowed free access to air, food and water. All animals were weighed on a weekly basis during the acclimatisation and experimental period. The experimental protocols were performed in compliance with the Animal Ethics Committee's guidelines of Ladoke Akintola University of Technology, Nigeria in accordance with the standard Guidelines of Animal Care and Use for laboratory investigations. Administration of aluminum nitrate solution and aqueous leaf extract of *Ocimum gratissimum* was carried out orally by the use of syringes and a cannula. Some animals received their doses of leaf extract daily for a period of 15 days and others 30 days and 24 hours after the experiment, the rats were sacrificed by cervical dislocation after which an incision was made on the midline of the ventral surface of the rats, blood sample was collected and the liver harvested, labelled and fixed in Bouin's fluid for further tissue processing. Collected blood samples were put and labelled in an Ethylenediaminetetraacetic acid (EDTA) bottle.

2.4. Experimental design

A total of forty-two (42) female wistar rats were randomly assigned into seven groups (1, 2A, 2B, 3, 4, 5 and 6) with 6 rats in each group. Group 1 serve as control, each of the rats in groups 2A, 2B, 3, 4, 5 and 6 received a single dose of 32.5 mg/kg of aluminium nitrate (1/2 LD50 of Al (NO3)3) orally. Groups 2A and 2B received 32.5 mg/kg of aluminium nitrate only. Different doses of aqueous leaf extract of *Ocimum gratissimum* (300 and 400 mg/kg) were also administered orally for fifteen days in some rats (Group 3 and 5) and thirty days in others (Group 4 and 6) according to their body weight after 24 hours of aluminium exposure. Groups 2A, 3 and 5 were sacrificed after fifteen days while Group 1, 2B, 4 and 6 were sacrificed after thirty days (Table 1).

Table 1: Showing experimental design and grouping. LD50 of Aluminium nitrate = 65 mg/kg

Groups	Dose of aluminium nitrate	Dose of *Ocimum gratissimum*
1	…………….	…………….
2A	32.5 mg/kg	…………….
2B	32.5 mg/kg	……………..
3	32.5 mg/kg	300 mg/kg
4	32.5 mg/kg	300 mg/kg
5	32.5 mg/kg	400 mg/kg
6	32.5 mg/kg	400 mg/kg

2.5. Tissue processing

The harvested livers were fixed in Bouin's fluid. The tissue samples were first dehydrated in graded ethanol. This was followed by tissue embedding in paraffin wax. Sections of 5- 6μ thickness were cut and stained with Hematoxylin and Eosin. Images were captured using a digital microscope attached to a computer (Isaac *et al.*, 2023).

2.6. Determination of liver enzymatic activities

The serum activities of bilirubin, Alanine transaminase (ALT), Aspartate transaminase and alkaline phosphatase were determined by the method described by Belfield and Goldberg (1971).

2.7. Method of statistical analysis

Statistical analysis for weights of the experimental animals and liver enzymes and bilirubin levels in the serum were carried out using the one-way analysis of variance (ANOVA) method with Tukey post hoc test. The level of significance was set at $p<0.05$ by Tukey post hoc test. The results were presented as the mean ± S.D (Standard Deviation). The statistical package used was SPSS version 20, graph pad prism version 5.

3. Results

3.1. Histological observations

Group 1 rats (the control group) showed intact liver histoarchitecture with normal distribution of the hepatocytes. There is normal presentation of hepatic vein, hepatic artery, bile duct and cords of hepatocytes. There are no evidences of hemorrhage and degenerative changes (Plate 1). Group 2A rats treated with aluminium nitrate (32.5 mg/kg) once only and sacrificed after 15 days showed mild degenerative changes, mild hemorrhage, infiltration of inflammatory cells, distorted hepatic artery, congested hepatic vein, some fibrosis (F) and disturbed cords of hepatocytes (Plate 2). Group 2B rats treated with aluminium nitrate (32.5 mg/kg) once only and

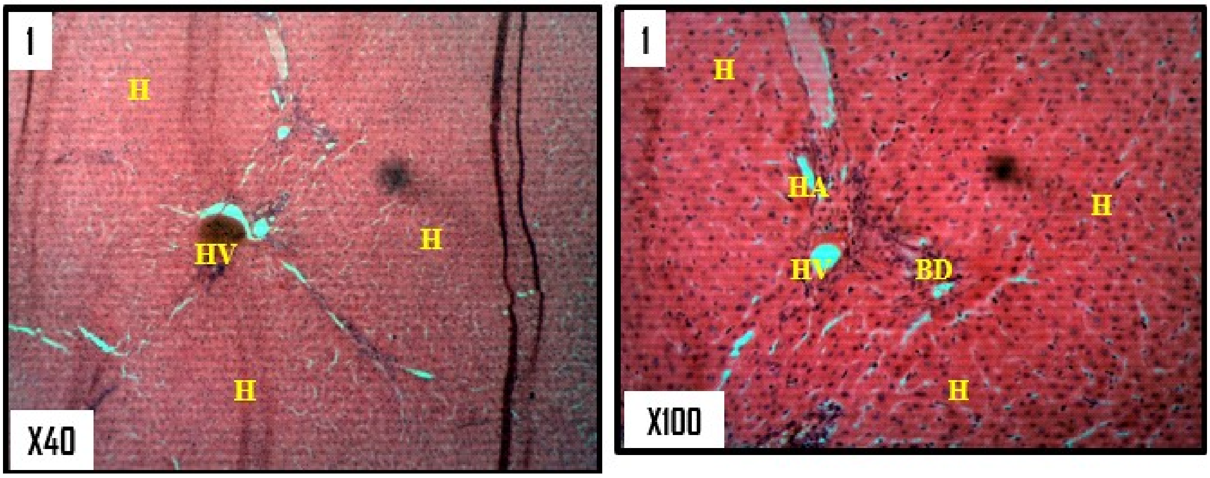

Plate 1: Liver section showing: intact cytoarchitecture with normal hepatocyte (H) and hepatic vein (HV) (MGX40: H&E stain); intact cytoarchitecture with normal hepatocyte (H), hepatic artery (HA), hepatic vein (HV) and bile duct (BD) (MGX100: H&E stain)

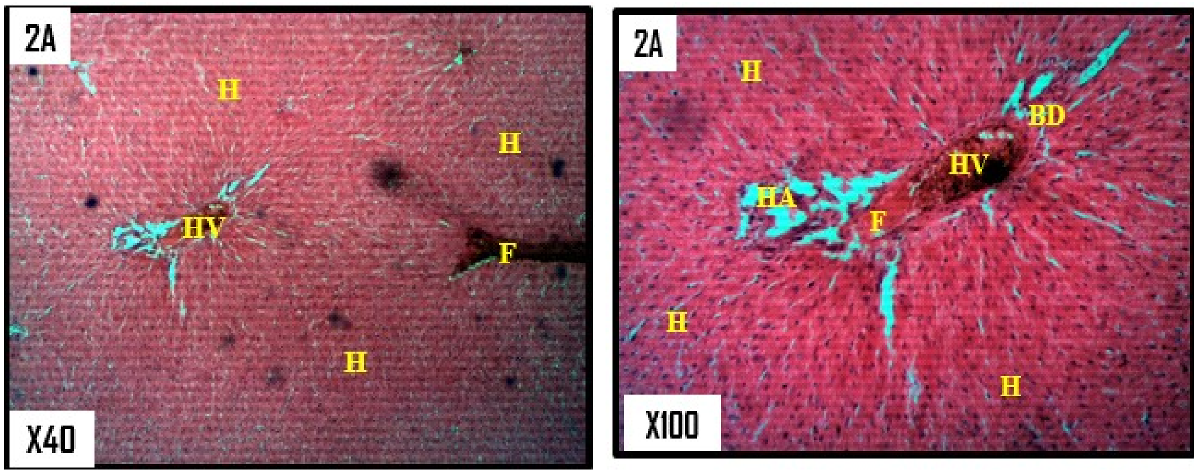

Plate 2: Liver section showing: disturbed cords of hepatocytes (H), infiltration of inflammatory cells, hepatic vein (HV) and fibrosis (F) (MGX40: H&E stain);disturbed cords of hepatocytes (H), infiltration of inflammatory cells, distorted hepatic artery (HA), congested hepatic vein (HV) and fibrosis (F) (MGX100: H&E stain)

sacrificed after 30 days showed severe degenerative changes, severe hemorrhage, infiltration of inflammatory cells, disturbed cords of hepatocytes, more pronounced fibrosis (F) and distorted central vein (Plate 3). Group 3 rats treated with aluminium nitrate (32.5 mg/kg) once after which low dose (300 mg/kg body wt.) of aqueous leaf extract of *ocimum gratissimum* was administered for 15 days showed congested hepatic vein, slight regenerative changes in hepatic artery and rearrangement in cords of hepatocytes (Plate 4). Group 4 rats treated with aluminium nitrate (32.5 mg/kg) once after which medium dose (300 mg/kg body wt.) of aqueous leaf extract of *ocimum gratissimum* was administered for 30 days showed some fibrosis, congested hepatic vein, normal cords of hepatocytes and some regenerative changes in hepatic artery and central vein (Plate 5). Group 5 rats treated with aluminium nitrate (32.5 mg/kg) once after which high dose (400 mg/kg body wt.) of aqueous leaf extract of *ocimum gratissimum* was administered for 15 days showed normal liver cyto-architecture with some evidences of hemorrhage. There is normal presentation of hepatic vein, hepatic artery, bile duct and cords of hepatocytes (Plate 6). Group 6 rats treated with aluminium nitrate (32.5 mg/kg) once after which high dose (400 mg/kg body wt.) of aqueous leaf extract of *ocimum gratissimum* was administered for 30 days showed normal liver cytoarchitecture with normal distribution of the hepatocytes. There is normal presentation of hepatic vein, hepatic artery, bile duct and cords of hepatocytes (Plate 7).

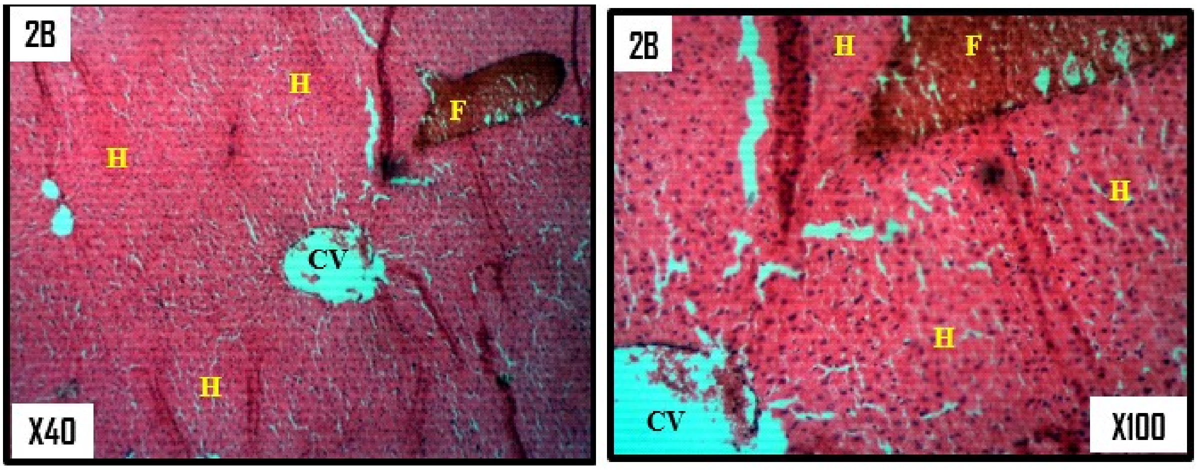

Plate 3: Liver section showing: disturbed cords of hepatocytes (H), fibrosis (F), inflammation of inflammatory cells and distorted central vein (CV) (MGX40: H&E stain); disturbed cords of hepatocytes (H), fibrosis (F), inflammation of inflammatory cells and distorted central vein (CV) (MGX100: H&E stain)

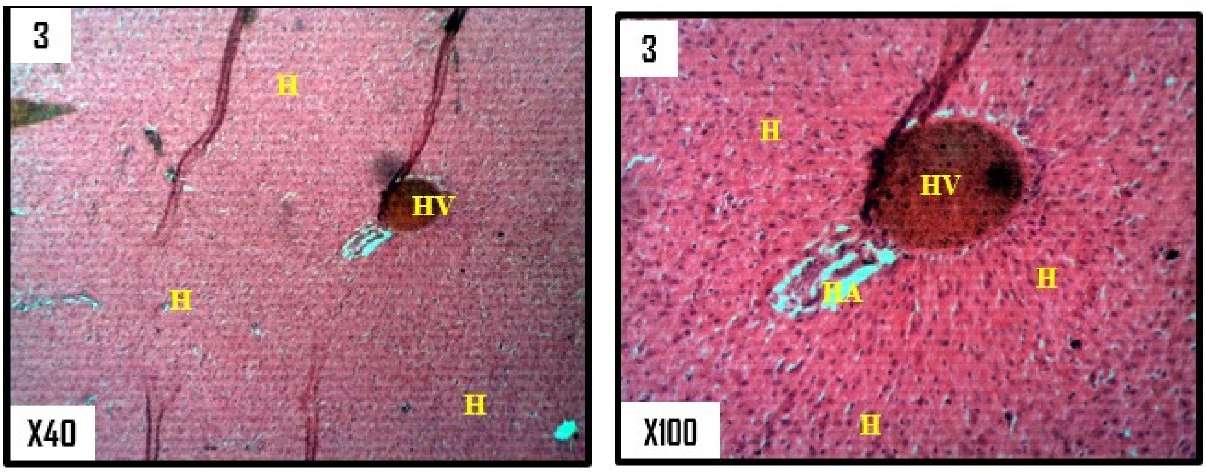

Plate 4: Liver section showing: congested hepatic vein (HV) and slight regenerative changes in rearrangement in cords of hepatocytes (H) (MGX40: H&E stain); congested hepatic vein (HV) and slight regenerative changes in hepatic artery (HA) and rearrangement in cords of hepatocytes (H) (MGX100: H&E stain)

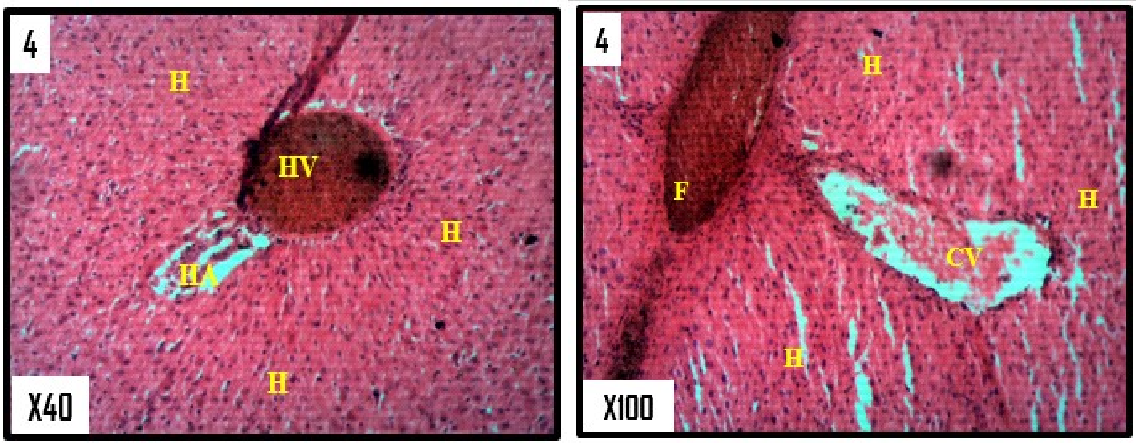

Plate 5: Liver section showing: congested hepatic vein (HV), normal cords of hepatocytes (H) and some regenerative changes in hepatic artery (HA) (MGX40: H&E stain); fibrosis (F), normal cords of hepatocytes (H) and some regenerative changes in central vein (CV)(MGX100: H&E stain)

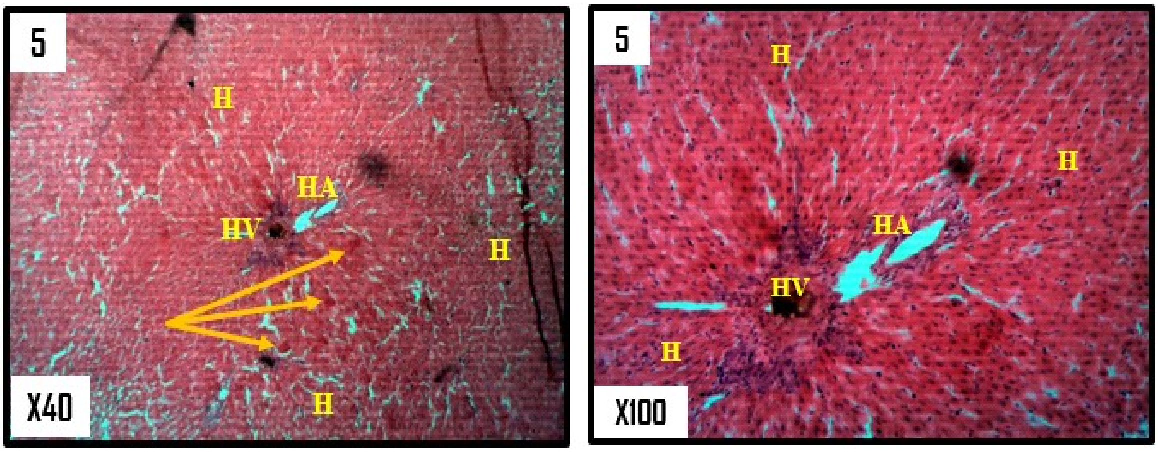

Plate 6: Liver section showing: normal liver cytoarchitecture with evidences of hemorrhage (yellow arrow), normal presentation of hepatic vein (HV) and cords of hepatocytes (H) (MGX40: H&E stain); normal liver cytoarchitecture with normal presentation of hepatic artery (HA), hepatic vein (HV) and cords of hepatocytes (H) (MGX100: H&E stain)

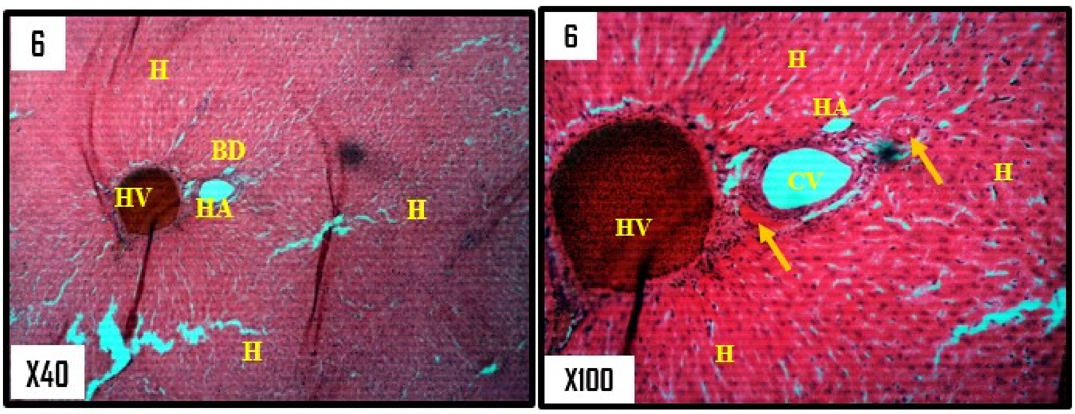

Plate 7: Liver section showing: normal liver cytoarchitecture with normal distribution of hepatocytes (H) and normal presentation of hepatic vein (HV), hepatic artery (HA) and bile duct (BD) (MGX40: H&E stain); normal liver cytoarchitecture with normal distribution of hepatocytes (H), congested hepatic vein (HV), mild hemorrhage (yellow arrow) and normal presentation of central vein (CV) and hepatic artery (HA) (MGX100: H&E stain)

3.2. Effects of Occimum gratissimum on serum levels of bilirubin of aluminum treated rats

Group 1 (control group) shows normal bilirubin level. After administration of a single dose of aluminium nitrate, there is higher increase in bilirubin level in group 2A while group 2B shows much higher bilirubin level as compared to the control group. After administration of a single dose of aluminium nitrate and daily doses of *ocimum gratissimum*; group 3 shows decrease in bilirubin level to normal, there is decrease in bilirubin level of group 4 rats but slightly higher than that of group 3 and control group, group 5 rats shows much decrease in bilirubin level as compared to control group, the bilirubin level in group 6 rats was decreased to normal. Thus, Aluminium increased serum bilirubin levels but was decreased after treatment with *ocimum gratissimum* extract (Figure 1).

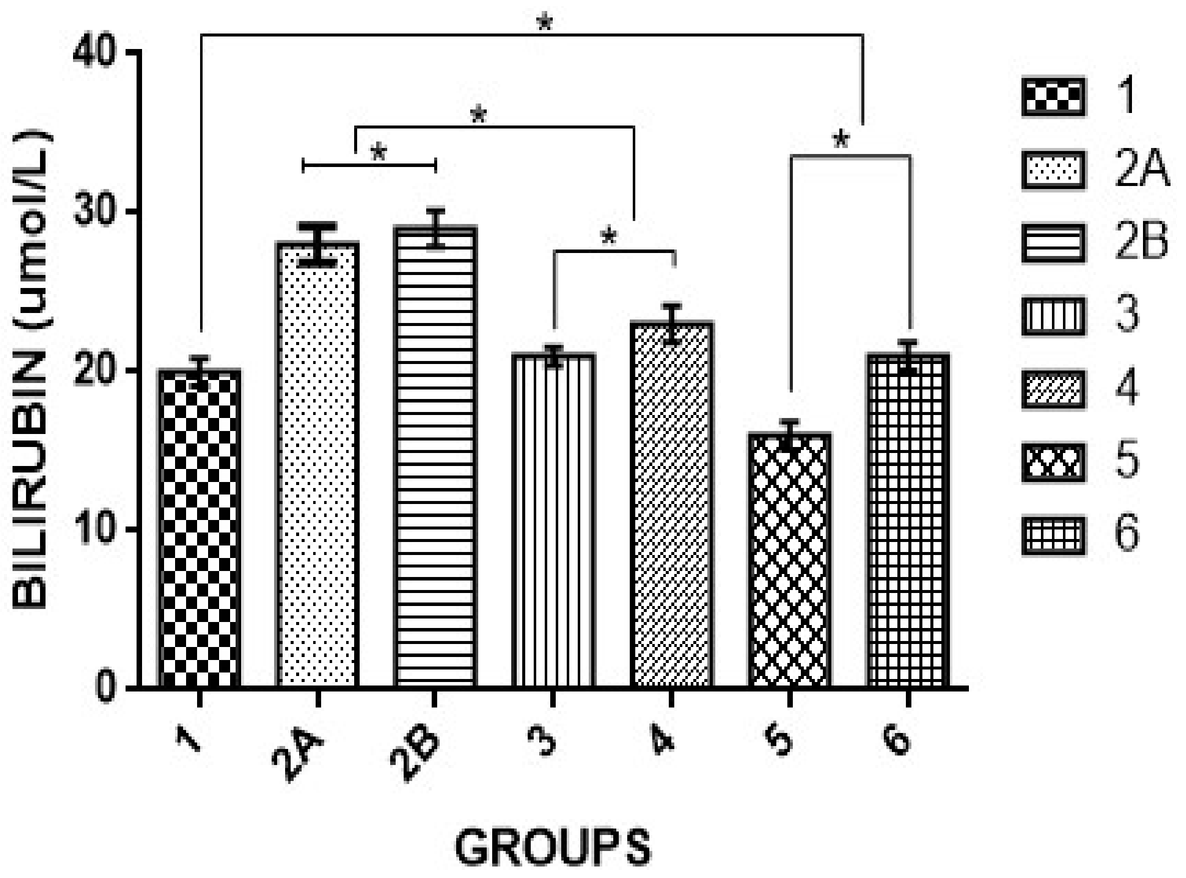

Figure 1: The effects of *Occimum gratissimum* on bilirubin in aluminium treated rats

Note: 1: Control (placebo only), 2A: 32.5 mg/kg aluminium nitrate only $_{15\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 15 day), 2B: 32.5 mg/kg aluminium nitrate only $_{30\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 30 days), 3: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 15 days), 4: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 30 days), 5: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 15 days), 6: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 30 days). Graph represent mean values ± SEM. (* $p < 0.05$).

3.3. Effects of Occimum gratissimum and alumimium nitrate on serum levels of alkaline phosphatase of aluminum treated rats

Group 1 (control group) shows normal level of alkaline phosphatase. After administration of a single dose of aluminium nitrate, there was an increase in the ALP level of group 2A rats while group 2B rats showed a much higher increase in ALP level as compared to the control group. After administration of a single dose of aluminium nitrate and daily doses of *Ocimum gratissimum*; group 3 shows a decrease in ALP level, there is much higher decrease in ALP level of group 4 rats, group 5 shows much higher decrease in ALP level, ALP level of group 6 rats was decreased to normal (Figure 2).

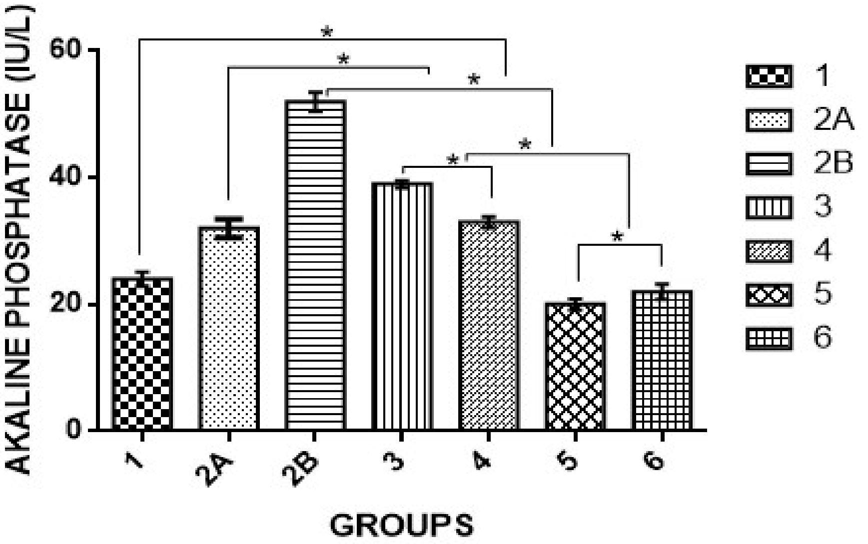

Figure 2: The effects of *Occimum gratissimum* on alkaline phospahtase in aluminium treated rats

Note: 1: Control (placebo only), 2A: 32.5 mg/kg aluminium nitrate only $_{15\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 15 day), 2B: 32.5 mg/kg aluminium nitrate only $_{30\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 30 days), 3: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 15 days), 4: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 30 days), 5: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 15 days), 6: 32.5 mg/kg aluminium + 400 *Occimum gratissiumum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 30 days). Graph represent mean values ± SEM. (* $p < 0.05$).

3.4. Effects of Occimum gratissimum on serum levels of alanine transaminase of alumiunium treated rats

Group 1 (control group) shows normal ALT level. After administration of a single dose of aluminium nitrate,

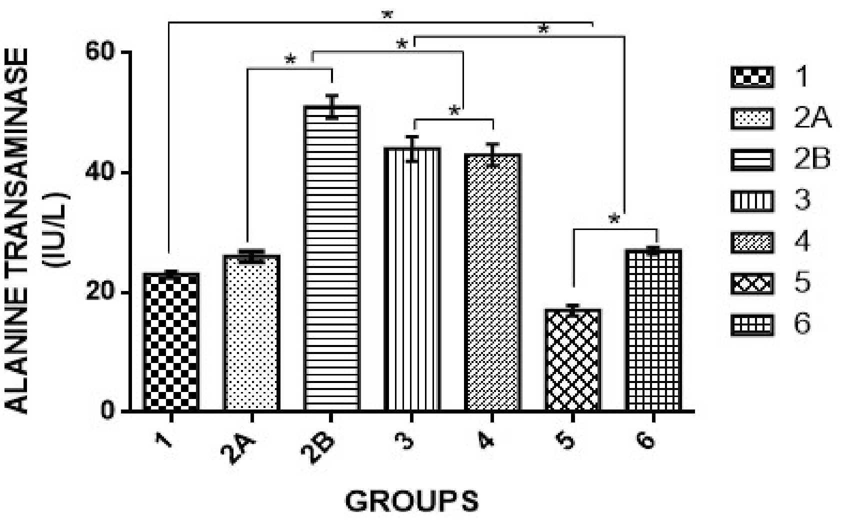

Figure 3: The effects of *Occimum gratissimum* on alanine transaminase in aluminium treated rats

Note: 1: Control (placebo only), 2A: 32.5 mg/kg aluminium nitrate only $_{15\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 15 day), 2B: 32.5 mg/kg aluminium nitrate only $_{30\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 30 days), 3: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 15 days), 4: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 30 days), 5: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 15 days), 6: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 30 days). Graph represent mean values ± SEM. (* $p < 0.05$).

there is a slight increase in the ALT level of group 2A rats while group 2B rats showed much higher increase in ALT level as compared to the control group. After administration of a single dose of aluminium nitrate and daily doses of *Ocimum gratissimum;* group 3 showed a decrease in ALT level but higher than that of the control group, there is another decrease in ALT level of group 4 rats but higher than that of control group, group 5 shows much higher decrease in ALT level as compared to control group, group 6 rats showed decrease in ALT level to normal but slightly higher than that of control group.

3.5. Effects of Occimum gratissimum and alumimium nitrate on serum levels of aspartate transaminase in control and experimental animals

Group 1 (control group) shows normal AST level. After administration of a single dose of aluminium nitrate, there is an increase in AST level in group 2A rats while group 2B shows a much higher increase in AST level. After administration of a single dose of aluminium nitrate and daily doses of *Ocimum gratissimum*; group 3 showed a decrease in AST level but higher than that of the control group, group 4 also showed a decrease in AST level but higher than that of group 3 and control group, there is much decrease in AST level of group 5 rats as compared to control group, group 6 rats showed decrease in AST level but higher than that of control group (Figure 4).

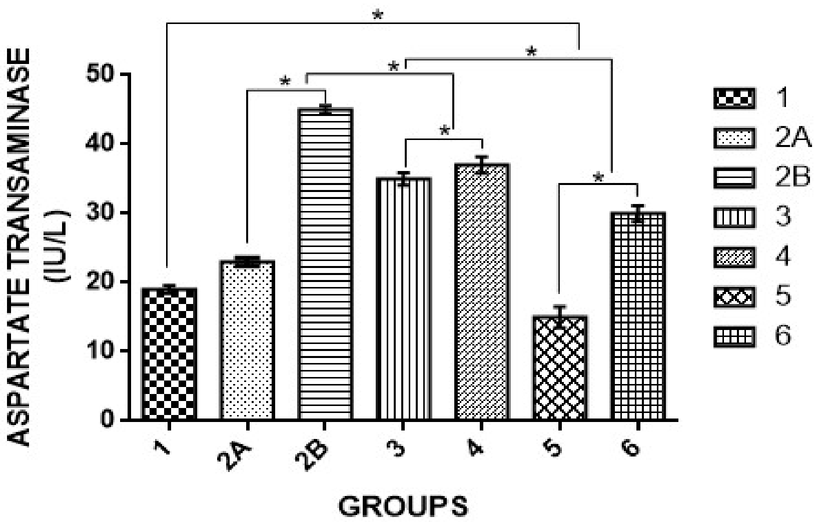

Figure 4: The effects of *Occimum gratissimum* on Aspartate Transaminase in aluminium treated rats

Note: 1: Control (placebo only), 2A: 32.5 mg/kg aluminium nitrate only $_{15\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 15 day), 2B: 32.5 mg/kg aluminium nitrate only $_{30\ days}$ (32.5 mg/kg single dose of alumium nitrate then sacrificed after 30 days), 3: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 15 days), 4: 32.5 mg/kg aluminium + 300 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 300 mg/kg *Occimum gratissimum* for 30 days), 5: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{15\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 15 days), 6: 32.5 mg/kg aluminium + 400 *Occimum gratissimum* $_{30\ days}$ (32.5 mg/kg single dose of aluminium nitrate then treated with 400 mg/kg *Occimum gratissimum* for 30 days). Graph represent mean values ± SEM. (* $p < 0.05$).

4. Discussion

Many agents possessing anti-oxidative properties have been proposed to prevent and treat hepatopathies induced by oxidative stress (Chaudhary *et al.*, 2023). An example of such is a vegetable plant called *Ocimum gratissimum* which has an important dietary and therapeutic medicinal role in Nigeria and other parts of the world.

Histopathological studies after Aluminium exposure suggest strong pro-oxidant activity despite its non-redox status (Exley, 2024). Aluminium toxicity may be mediated by free radical generation (Tabaldi *et al.*, 2009), which causes hepatotoxicity (Kutlubay *et al.*, 2007; Abubakar *et al.*, 2004). Upon administration of aluminium, histological observation showed mild to severe degenerative changes, mild haemorrhage, infiltration of inflammatory cells, distorted hepatic artery, congested hepatic vein, some fibrosis (F) and disturbed cords of hepatocytes which are shreds of evidence of distorted hepatic architecture as reported in previous study by

Shrivastava (2013). Histological observations in the treated groups showed some degenerative changes occurring to some of the hepatocytes coupled with mild hemorrhagic cells, infiltration of inflammatory cells and some little fibrosis after the administration of *occimum gratissimum.*

Serum liver function enzymes including bilirubin, AST, ALT and ASP showed increased activities after long-term administration of alumiunum. These results are in accordance with Yusuf *et al.* (2023) which reported an increase in the serum levels of bilirubin, AST, ALT and ASP due to exposure to aluminium. The rise in the serum levels of these liver functions enzymes (ALT, ASP and ALP) may be attributed to the damaged structural integrity of the liver as a result of aluminium exposure, which results in the leakage of these enzymes from the cytosol into the blood circulation (Giannini *et al*., 2005). This observation agrees with the report by Giannini *et al*. (2005) that ALT, AST, GGT and ALP normally located in the cytoplasm are released into circulation after cellular damage. The administration of *occimum gratissimum* showed a significant increase in the serum activities of bilirubin, AST, ALT and ASP in the experimental groups which is in line with a previous study by Chaudhary *et al.* (2018) who reported that *occimum gratissimum* exhibited scavenging effects on free radicals thus increasing the levels of AST, ALP and ASP following aluminium exposure. This is hinged on the presence of biologically active phytochemicals such as phenolic acid and flavonoid *ocimum gratissimum* which enabled it to protect the liver against the disastrous effects of free radicals and Reactive Oxygen Species (ROS) generated by aluminium (Ogundipe *et al*., 2021).

5. Conclusion

In conclusion, Aluminium possesses hepatotoxic properties and its damage on the liver results in the oxidative stress, reduction in the level of liver antioxidant enzymes and destruction of the normal histoarchitecture of the liver tissue. On the other hand, the leaves of *ocimum gratissimum* possess antioxidant and hepatoprotective properties and potentiate the activities of liver antioxidant enzymes. This is achieved through the scavenging of free radicals generated by aluminium. Thus, *ocimum gratissimum* is therapeutically effective in treating aluminium-induced liver damage.

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