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Effects of *Tetrapleura tetraptera* Leaves on Renal Architecture and Haematological Indices in Monosodium Glutamate-Intoxicated Rats

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ABSTRACT

Background and Objective: Medicinal plants have been widely used for the treatment of diseases and *Tetrapleura tetraptera*, a known medicinal plant is not left out. Renal failure is on the increase and calls for use of natural means for its cure and management are on the rise. This study, therefore, investigated the biochemical effects of *Tetrapleura tetraptera* leaves on renal architecture and haematological indices in Monosodium Glutamate-Intoxicated rats. **Materials and Methods:** The biochemical effects of *Tetrapleura tetraptera* leave on renal architecture and haematological indices in Monosodium Glutamate-Intoxicated rats were determined using standard protocols. The SPSS version 22 was used for the one-way ANOVA analysis. **Results:** The urea and creatinine concentration of the co-treated groups showed a significant ($p<0.05$) decrease across all and in this case was in a dose-dependent manner. The extract also showed an increase in the count of White Blood Cells, Packed Cell Volume and Haemoglobin and Red Blood Cells across the co-treated groups. The renal histopathological examination indicated normal blood flow without congestion in the normal and *Tetrapleura tetraptera* leaves ethanol extract group in contrast to full congestion of the central vein as seen in the monosodium glutamate group. Consequently, reduced congestion as seen in the co-treated groups seemingly confirmed the serum chemistry results against the monosodium glutamate group suggesting ameliorative effects. **Conclusion:** *Tetrapleura tetraptera* leaves ethanol extract, improved the haematological indices and ameliorated the effects of the renal thwack as established on monosodium glutamate-intoxicated rats.

KEYWORDS

Biochemical, haematological indices, histopathology, monosodium glutamate, renal, *Tetrapleura tetraptera*, toxicity

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INTRODUCTION

Medicinal plants have been used in the management and treatment of disease conditions as an alternative to conventional medicine due to their possession of bioactive components which are implicated in pharmaceutical properties. *Tetrapleura tetraptera*, a popularly used seasoning in parts of Nigeria is a medicinal plant and has long been used in the treatment of diseases[1] and other underlying conditions

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such as convulsion and jaundice[2]. The description of the plant includes, Kingdom: Plantae, Order: Fabales, Family: Fabaceae, Subfamily: Caesalpinioideae, Genus: *Tetrapleura* and Species: *Tetrapleura tetraptera*. Therapeutic properties of *Tetrapleura tetraptera* including anti-inflammatory, anti-bacterial, molluscicidal, anti-diabetic, antihypertensive and contraceptive properties have been widely documented in previous studies[2]. It is either cooked and taken as decoction or prepared as component of food in soups. These medicinal attributes of the plant could be a result of the antioxidant, antimicrobial and antipyretic effects of the phytochemicals in them[3].

Monosodium glutamate, the sodium salt of non-essential amino acid, is a food additive with flavour-enhancing properties and may be present in packaged food without appearing on the label[4]. High consumption of monosodium glutamate has been implicated in kidney injury[5], neuro-excitotoxicity[6], obesity[7] and liver injury[4]. The safety of monosodium glutamate (MSG) in humans is controversial. Some of the observed adverse effects following MSG consumption include, the Chinese restaurant syndrome (CRS), which is characterized by palpitation, general weakness and later flushing, dizziness[8]. Obesity and metabolic disturbances could occur due to impaired glucose tolerance, neural necrosis in the hypothalamic arcuate nucleaus and neuroimflamation[9]. Also reproductive function characterized by lowered testosterone in males and increased follicles in women[10].

The mechanism of toxicity of MSG has been a subject of the debate though many researchers seem to point to the generation of free radicals as the major mechanism through which monosodium glutamate induces toxicity in human organs including the kidney and liver[11].

The kidneys are two reddish-brown bean-shaped organs found in vertebrates. They are located on the left and right in the retroperitoneal space and in adults, humans are about 12 centimeters (4+1/2 inches) in length. They receive blood from the paired renal arteries, blood exits into the paired renal veins. Each kidney is attached to a ureter, a tube that carries excreted urine to the bladder. Infection and intoxication of the kidney by toxicants such as monosodium glutamate has been implicated in renal diseases such as diabetic nephropathy[12], glomerulonephritis[12] hydronephrosis (enlargement of one or both of the kidneys caused by obstruction of the flow of urine)[13], pyelonephritis (infection of the kidneys and is frequently caused by a complication of a urinary tract infection) and kidney failure[13].

Studies have linked high MSG with hematological disturbance implicated in White Blood Cell challenges and lowered Red Blood Cells and Haemoglobin[5]. The recent call for a switch from the use of synthetic drugs which is linked to other underlying complications to a natural remedy such as the use of the medicinal plant, *Tetrapleura tetraptera, a* known medicinal plant could readily remedy the over-dependence on the use of synthetic drugs in the management of renal assault. Thus, this study aimed at determining the biochemical effects of *Tetrapleura tetraptera* leaves on renal architecture and haematological indices in monosodium glutamate-intoxicated rats.

MATERIALS AND METHODS

Study area: This study was carried out between January, 2019 to May, 2019 at the laboratory unit of the Department of Biochemistry, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Collection of samples and preparation of extract: *Tetrapleura tetraptera* leaves were obtained from Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The plant sample was identified and authenticated by a Botanist in the Department of Plant Science and Biotechnology, College of Natural Science, Michael Okpara University of Agriculture, Umudike. The leaves were thoroughly cleansed with clean running water to avoid contamination of the plant sample and were then air-dried under shade for 28 days. The dried sample was then pulverized using Thomas Laboratory Mill (Crypto model, USA). The

resultant fine powder sample weighed 500 g and was soaked in 2.5 L of 95% methanol and extracted using filter paper. The crude methanol extract was kept in an air-tight container and stored in a refrigerator and hereafter referred to as *Tetrapleura tetraptera* leaves ethanol extract (TTLEE).

Animals: For this study, sixty adult male albino rats weighing between 110 g and 145 g were obtained from the animal house unit of the Department of Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria. They were acclimatized for 12 days and then were randomly divided into six treatment groups of 10 rats each and with each group housed an aluminium cage. All animals had access to food and water *ad libitum* and were maintained under standard laboratory conditions with light and dark cycles of 12 hrs each and room temperature.

Ethical consideration: All guidelines involving the use and care of laboratory animals were duly observed.

Determination of haematological parameter

Determination of haematological indices: Haematological indices were determined by the standard method described by Fagbohun *et al*.[14].

Determination of blood urea and creatinine concentration: The levels of urea and creatinine in the plasma were assayed using RANDOX assay (Antrim, United Kingdom) kits following the manufacturer's protocol. The method for creatinine assays was done according to the colorimetric alkaline picrate method[15]. The creatinine-picrate complex formed has a maximum absorbance at 492 nm. Plasma urea concentration was assayed by the procedure described by Zawada *et al*.[16].

Determination of PCV: The blood sample collected using capillary tubes coated with anticoagulants EDTA was sealed with plasticine and centrifuged for 5 min resulting in three suspensions, grey layer (mass of erythrocytes), thrombocytes (buffy coat) and plasma from bottom to top in a *hematocrit* reader to get the percentage of PCV.

Determination of histological parameters: The method described by Slaoui and Fiette[17] was used. The excised organs were rinsed in 0.9% saline solution and preserved in 10% formaldehyde solution. It was embedded in paraffin wax and sectioned into 4-6 microns. The sections were stained with hematoxylin and eosin and photographed.

Study design for *in vivo* antioxidant activity of *Tetrapleura tetraptera* leaves ethanol extract (TTLEE): The 6 groups of experimental animals were treated according to the protocol below:

- **Group 1:** 8000 mg kg^{-1} b.wt., of MSG and 200 mg kg^{-1} of TTLEE
- **Group 2:** 8000 mg kg^{-1} b.wt., of MSG and 400 mg kg^{-1} of TTLEE
- **Group 3:** 8000 mg kg^{-1} b.wt., of MSG and 600 mg kg^{-1} of TTLEE
- **Group 4:** Feed and water only and served as the normal control group
- **Group 5:** 200 mg kg^{-1} b.wt., of TTLEE only
- **Group 6:** 8000 mg kg^{-1} b.wt., of monosodium glutamate (MSG) only and served as the negative control

At the end of 14 days of treatment, the animals were sacrificed through cervical dislocation and blood was collected by cardiac puncture into plane bottles for the study.

Induction of toxicity: Toxicity was induced using 8000 mg kg^{-1} b.wt., of the monosodium glutamate was orally administered to the rats daily for 14 days according to Thomas *et al*.[18].

Calculation of diagnostic ratios and change relative to groups: Diagnostic ratios were calculated from the result of corresponding parameters as obtained in this study. Change relative to either control or MSG- the group was calculated using the relationship described by Egbuonu *et al*.[19]:

$$\text{Change relative to K (\%)} = \frac{V - K}{K} \times 100$$

Where:
K = Constant group hence the constant value
V = Variable group's variable values

Statistical analysis: Descriptive statistics and tests for significance in mean were carried out on the data generated by One-way Analysis of Variance (ANOVA) with the Statistical Package for Social Sciences (SPSS) version 22. The turkey's *post hoc* Test was used to identify the means that differ significantly at $p<0.05$. Results were expressed as Mean±Standard Error of Mean SEM.

RESULTS

The urea result confirmed increased urea concentration in the MSG group (37.41±0.43) but revealed reduced concentration in the extract alone (19.23±0.16). The reduction in the urea concentration of the co-treated groups was in a dose-dependent manner 33.60±0.24 (low dose), 18.63±0.33 (medium dose) and 17.80±0.11 (high dose) (Table 1). This was also further buttressed by the negative change relative to MSG across all the co-treated groups thus, suggesting improved renal function.

The result showed higher creatinine concentration in the MSG group (0.98±0.23) compared to all other groups (Table 2). However, the result of the group's co-treated extract of *Tetrapleura tetraptera* leaves showed a reduction across the co-treated groups in a dose-dependent manner of 0.82±0.12 (low dose), 0.66±0.22 (medium dose), 0.66±0.12 (high dose) This could be suggestive of improved renal creatinine clearance.

The urea:creatinine ratio showed a significant increase in the MSG group (38.17 (0.02)) compared to that of the other groups (Table 3). This deviation is further exposed by the percentage change relative to the MSG group which showed a negative percentage change and also showed a 100% change across the treatment groups (-26.04 (100)) for medium dose extract, (-29.34 (100)) for high dose extract and (-30.99 (100)) for extract only group) in the creatinine:urea ratio. This could indicate the damage done to the renal architecture by MSG and thus, the ameliorative effect of the co-treatment by TTLEE.

The percentage PCV result showed a lower percentage in the MSG group (38.80±0.10) compared to all other groups (41.80±0.00 for low extract, 41.60±0.00 for medium extract, 41.80±0.01 for high dose extract) with an improved percentage in the group's co-treated extract of *Tetrapleura tetraptera* as expressed by the % change relative to MSG (Table 4).

The result showed a lower RBC count in the MSG group (418.50±0.01) compared to the extract group and a higher RBC count in the groups co-treated extract of *Tetrapleura tetraptera* leaves 450.50±0.02, 551.50±0.02 and 549.00±0.01 for low dose, medium dose and high dose, respectively (Table 5). This could be implicative of improved RBC formation.

The result indicated lower Hb in the MSG group (12.60±0.01) compared to all other groups (Table 6). However, the Hb concentration was improved in the group co-treated extract of *Tetrapleura tetraptera*

Table 1: Effects of TTLEE on urea concentration of normal and MSG-intoxicated rats

Group	Urea (mg dL^{-1})	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	33.60±0.24	-36.90	4.42
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	18.63±0.33	-50.27	-17.70
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	17.80±0.11	-52.41	-21.24
Control (feed+water)	22.62±0.32	-39.57	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	19.23±0.16	-46.66	-15.04
MSG (8000 mg kg^{-1} b.wt., MSG)	37.41±0.43	00.00	65.49

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +Denotes higher, -: Denotes lower, MSG: Monosodium glutamate and TTLEE: *Tetrapleura tetraptera* leaves ethanol extract

Table 2: Effects of TTLEE on creatinine concentration of normal and MSG intoxicated rats

Group	Creatinine (mg dL^{-1})	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	0.82±0.12	-16.32	9.33
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	0.66±0.22	-32.65	-12.00
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	0.66±0.12	-32.65	-12.00
Control (feed+water)	0.75±0.18	-23.47	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	0.73±0.11	-25.51	-2.67
MSG (8000 mg kg^{-1} b.wt., MSG)	0.98±0.23	0.00	30.67

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate and TTLEE: *Tetrapleura tetraptera* leaves ethanol extract

Table 3: Effects of TTLEE on urea:creatinine ratio of normal and MSG intoxicated rats

Group	Urea:Creatinine (creatinine:urea) (mg dL^{-1})	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	40.98 (0.02)	-7.36 (0.00)	35.88 (-33.33)
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	28.23 (0.04)	-26.04 (100)	-6.40 (33.33)
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	26.97 (0.04)	-29.34 (100)	-10.58 (33.33)
Control (feed+water)	30.16 (0.03)	-20.99 (50)	0.00 (0.00)
TTLEE (200 mg kg^{-1} b.wt., extract)	26.34 (0.04)	-30.99 (100)	-12.67 (33.33)
MSG (8000 mg kg^{-1} b.wt., MSG)	38.17 (0.02)	0.00 (0.00)	26.56 (-33.33)

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate and TTLEE: *Tetrapleura tetraptera* leaves ethanol extract

Table 4: Effects of TTLEE on PCV of normal and MSG intoxicated rats

Group	PVC (%)	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	41.80±0.00	7.73	3.47
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	41.60±0.00	7.22	2.29
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	41.80±0.01	7.73	3.47
Control (feed+water)	40.40±0.01	4.12	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	40.80±0.00	5.15	1.00
MSG (8000 mg kg^{-1} b.wt., MSG)	38.80±0.10	0.00	3.96

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate, TTLEE: *Tetrapleura tetraptera* leaves ethanol extract and PCV: Packed cell volume

Table 5: Effects of TTLEE on RBC count of normal and MSG intoxicated rats

Group	RBC (10^9)	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	450.50±0.02	7.66	-15.41
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	551.50±0.02	31.18	3.57
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	549.00±0.01	31.34	3.20
Control (feed+water)	532.00±0.01	27.27	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	533.50±0.01	27.51	0.10
MSG (8000 mg kg^{-1} b.wt., MSG)	418.50±0.01	0.00	-2.14

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate, TTLEE: *Tetrapleura tetraptera* leaves ethanol extract and RBC: Red blood cell

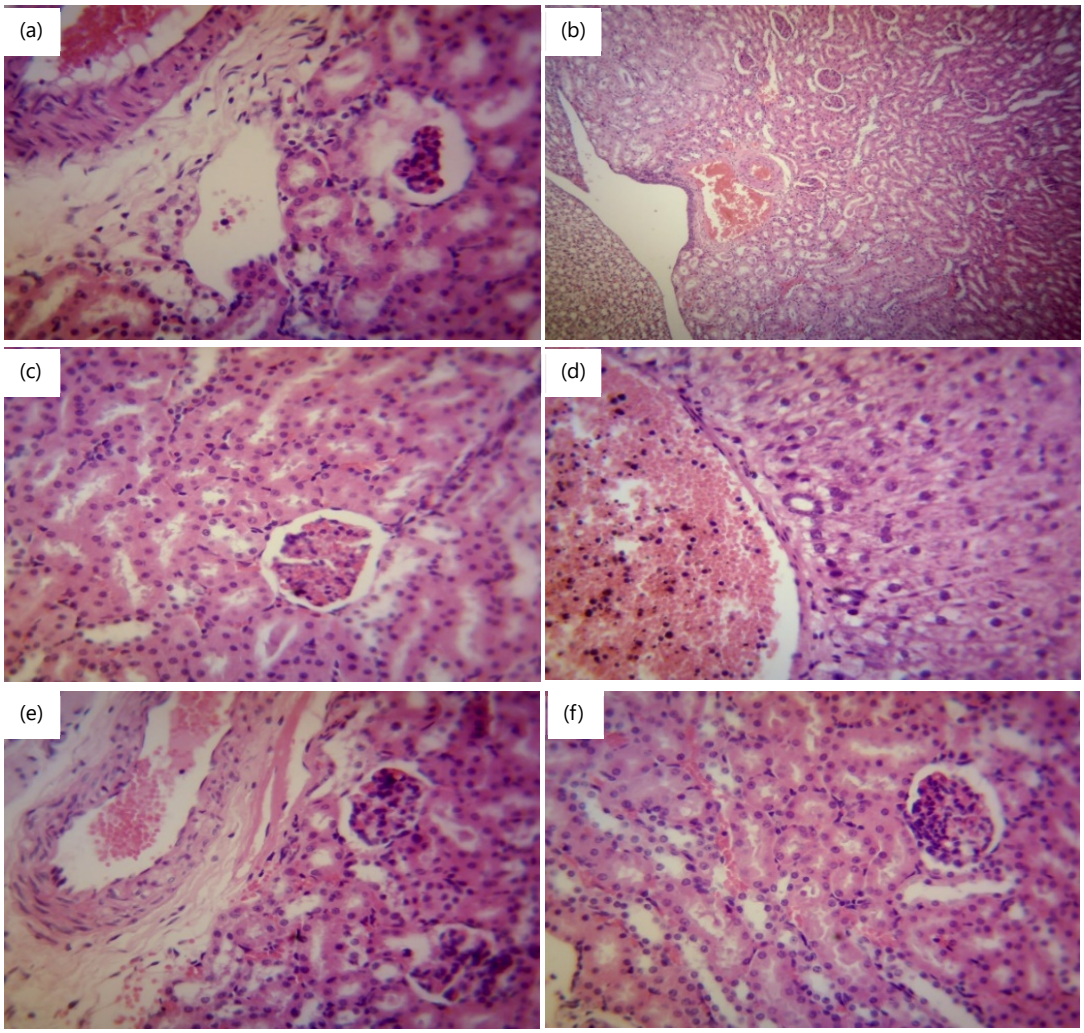

Fig. 1(a-f): Photomicrograph of kidney section (Hematoxylin and Eosin) stained ×400, (a) Kidney micrograph of rats showing the normal flow of blood with no congestion of the central vein, (b) Kidney micrograph of rats showing a normal flow of blood with no congestion of the central vein, (c) Kidney micrograph of rats showing slight congestion of the central vein, (d) Kidney micrograph of rats showing a normal flow of blood with no congestion of the central vein, (e) Kidney micrograph of rats showing a normal flow of blood with no congestion of the central vein and (f) Kidney micrograph of rats showing congestion of the central vein

(13.00±0.01, 13.92±0.01 and 13.16±0.01 for low dose, medium dose and high dose respectively). This result was equally expressed by the % change relative to MSG. This could be indicative of improved haemoglobin formation.

The result showed a lower WBC count in the MSG group (4240±210.32) compared to all other groups and an increased count in the groups co-treated (6280±200.10, 7320±230.04 and 5840±150.21 for the low dose, medium dose and high dose respectively) extract of *Tetrapleura tetraptera* as expressed by the % change relative to MSG (Table 7). This could be indicative of white blood cell challenge in the MSG group and an improved state in the co-treated groups.

The result of the micrograph of the kidney section (Hematoxylin and Eosin) stained ×400 as displayed in Fig. 1(a-f) indicated the effects of different concentrations of *Tetrapleura tetraptera* leaves ethanol extract on the kidney histomorphology of monosodium glutamate intoxicated rats.

Table 6: Effects of TTLEE on hemoglobin concentration of normal and MSG intoxicated rats

Group	Hemoglobin (g dL^{-1})	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	13.00±0.01	3.17	3.17
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	13.92±0.01	10.32	10.32
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	13.16±0.01	4.44	4.44
Control (feed+water)	12.62±0.11	0.00	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	12.84±0.14	1.90	1.90
MSG (8000 mg kg^{-1} b.wt., MSG)	12.60±0.01	0.00	0.00

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate and TTLEE: *Tetrapleura tetraptera* leaves ethanol extract

Table 7: Effects of TTLEE on WBC count of normal and MSG intoxicated rats

Group	WBC (10^3/L)	Change relative to MSG (%)	Change relative to control (%)
Low extract (MSG 8000+200 mg kg^{-1} b.wt., extract)	6280±200.10	48.11	-18.65
Medium extract (MSG 8000+400 mg kg^{-1} b.wt., extract)	7320±230.04	72.64	-5.18
High extract (MSG 8000+600 mg kg^{-1} b.wt., extract)	5840±150.21	37.74	-24.35
Control (feed+water)	7720±340.12	82.08	0.00
TTLEE (200 mg kg^{-1} b.wt., extract)	6560±150.11	54.72	-15.03
MSG (8000 mg kg^{-1} b.wt., MSG)	4240±210.32	0.00	-45.08

Values are Mean±SEM for n = 4, the difference is considered statistically significant at $p<0.05$, +: Denotes higher, -: Denotes lower, MSG: Monosodium glutamate, TTLEE: *Tetrapleura tetraptera* leaves ethanol extract and WBC: White blood cell

DISCUSSION

Tetrapleura tetraptera leaves ethanol extract (TTLEE) potently normalized the hematological indices and reversed the toxicity on the renal architecture of monosodium glutamate intoxicated rats. The result of the serum urea concentration indicated an increase in the MSG group compared to the control and a significant decrease across the co-treated groups. The increase in the concentration of Urea in the MSG groups could be an indication of renal assault and this result agreed with the work of Johnlouis and Cemaluk[5] that monosodium glutamate at high concentration could induce renal thwart. Urea and creatinine can be used in the measurement of renal function hence identifying renal assault[5] and the use of therapeutic drugs in the management and amelioration of renal and hepatic assaults have been expressed in previous assessments[4,20]. The in-depth damage, thus the ameliorative effect of *Tetrapleura tetraptera* leaves ethanol extract (TTLEE) was further clarified by the high negative percentage change of the co-treated groups relative to MSG as expressed by the results also agreeing with the result of Cemaluk *et al.*[21] that reduced serum urea could be an indication of ameliorated toxicity.

The result of the serum creatinine concentration showed a significant increase in the serum creatinine concentration and it corresponds with the result of Egbuonu *et al.*[22] that impaired renal function and architecture are proceeded by increased serum concentration. However, the dose-dependent decrease in the serum creatinine concentration of the co-treated groups showed that *Tetrapleura tetraptera* leaves ethanol extract (TTLEE) was able to improve renal function thus, improving the renal creatinine clearance which led to the decrease in the serum creatinine concentration.

There is a relationship among the haematological indices with changes in the concentration of RBC leading to changes in the Hb and PCV concentration[23]. The result of the RBC concentration indicated a reduction in the RBC concentration of the MSG group with a concomitant increase in the concentration of the cotreated groups. The decrease in the counts of RBC concentration could be an indication of inflammation and anaemia thus agreeing with the result of Kanu *et al.*[24] that RBC concentration is decreased in toxicity. The decrease could be attributed to hemolysis caused by the toxicity of the intoxicant more than the capacity of the bone marrow to produce new RBC[25]. However, the significant

increase seen in the co-treated groups indicates improved haematological indices which could be a result of *Tetrapleura tetraptera* leaves ethanol extract (TTLEE) being able to improve the rate of RBC production in the bone marrow with a concomitant reduction in the rate of destruction of the red blood cells by the intoxicant.

Reduction in haemoglobin concentration and PCV could be an indication of haematological abnormalities[26,27] and anaemia attributed to the reduction in the concentration of body iron content[18]. The result of the PCV and Hb concentration indicated a reduction in the MSG group signifying toxicity. This agrees with the result of Celik *et al.*[28] that PCV and Hb concentration drops in cases of toxicity since blood has been implicated as a physiological and pathological indicator of animal health[29]. An increase in the PCV and Hb concentration across the co-treated groups could be an indication of a reversal in the haematological abnormalities caused by the MSG. The mechanism of this reversal could be a result of the antioxidant properties of TTLEE since MSG has been previously shown to induce toxicity through the induction of oxidative stress and Wani *et al.*[30], confirmed that oxidative stress could induce anaemia by reducing the iron content of the body.

The WBC plays a major role in the defense of organisms against the attack and a reduction in WBC concentration could be indicative of the inability of an organism to defend itself against foreign body attacks[17]. The reduction in the WBC concentration seen in the MSG groups could be indicative of the reduced ability to fight infection usually implicated in hemolytic anaemia[31]. The increase in the WBC concentration seen across the co-treated groups could be suggestive of the boosted immune system by TTLEE and could also imply that the extract has an antifungal, antiviral and immunostimulatory ability.

Congestion of the central vein could lead to reduced blood flow and anorexia thus, cellular death indication altered cellular integrity. The congestion as indicated in the kidney section of the MSG group indicated toxicity thus confirming the biochemical assay results. However, the restored renal architecture as noticed in renal sections of the co-treated groups indicated that TTLEE reversed the thwart induced by MSG also confirming the serum biochemical results.

This study implies that *Tetrapleura tetraptera* leaves ethanol extract has been shown to possess haematological properties and improve renal function hence, it could be looked at as a potential ethnomedical solution to the management of haematological abnormalities and renal dysfunction. Thus, I recommend that more work be done on the identification, characterization and isolation of the basic bioactive components which would be implicated in the pharmacological bioactivity of TTLEE. However, there are no limitations in the course of this study.

CONCLUSION

Tetrapleura tetraptera leaves ethanol extract reversed the renal assault initiated by MSG thus, reversing the abnormal architectural status of the renal cells to normalcy and reversing the biochemical parameters estimated to be within range thereby confirming the ameliorative effects of TTLEE on the renal function of monosodium glutamate-intoxicated rats.

SIGNIFICANCE STATEMENT

This study discovers the reno-protective potential of TTLEE with ability to normalize haematological indices which can be beneficial for renal injuries and hematological abnormalities induced by monosodium glutamate. This study will help the researcher to uncover areas of kidney dysfunction and haematologic disorder that many ersearchers were not able to explore. Thus a new theory on pharmacological potential of *Tetrapleura tetraptera* could be arrived at.

REFERENCES

1. Jimmy, E.O. and A.J.D. Ekpo, 2016. Upgrading of lethal dose of *Tetrapleura tetraptera* extract enhances blood cell values. J. Hematol. Thromboembolic Dis., 4: 256-258.
2. Udourioh, G.A. and M.F. Etokudoh, 2014. Essential oils and fatty acids composition of dry fruits of *Tetrapleura tetraptera*. J. Appl. Sci. Environ. Manage., 18: 419-424.
3. Lahon, K. and S. Das, 2011. Hepatoprotective activity of *Ocimum sanctum* alcoholic leaf extract against paracetamol-induced liver damage in albino rats. Pharmacogn. Res., 3: 13-18.
4. Obidike, I.J. and A.C. Egbuonu, 2019. Effects of ethanol extract of cocoa (*Theobroma cacao*) pod on normal and monosodium glutamate-intoxicated rats' hepatic histo-morphology, serum bio-functional parameters and serum antioxidant activities. Int. J. Recent Res. Appl. Stud., 6: 1-13.
5. Johnlouis, O.I. and E.A. Cemaluk, 2020. Some biochemical effect of cocoa (*Theobroma cacao*) pod ethanol extract on renal histo-morphology and function in monosodium glutamate (MSG)-intoxicated rats. Int. J. Recent Res. Appl. Stud., 7: 17-28.
6. Park, C.H., S.H. Choi, Y. Piaoa, S.H. Kim and Y.J. Lee *et al*., 2000. Glutamate and aspartate impair memory retention and damage hypothalamic neurons in adult mice. Toxicol. Lett., 115: 117-125.
7. Bautista, R.J.H., A.M. Mahmoud, M. Konigsberg and N.E.L.D. Guerrero, 2019. Obesity: Pathophysiology, monosodium glutamate-induced model and anti-obesity medicinal plants. Biomed. Pharmacother., 111: 503-516.
8. Geha, R.S., A. Beisser, C. Ren, R. Patterson and P.A. Greenberger *et al*., 2000. Review of alleged reaction to monosodium glutamate and outcome of a multicenter double-blind placebo-controlled study. J. Nutr., 130: 1058S-1062S.
9. Fallarino, F., C. Volpi, F. Fazio, S. Notartomaso and C. Vacca *et al*., 2010. Metabotropic glutamate receptor-4 modulates adaptive immunity and restrains neuroinflammation. Nat. Med., 16: 897-902.
10. Das, R.S. and S.K. Ghosh, 2011. Long term effects in ovaries of the adult mice following exposure to Monosodium glutamate during neonatal life-a histological study. Nepal Med. Coll. J., 13: 77-83.
11. Johnlouis, O.I., N.C. Ifeanyi and O.P. Oluchukwu, 2022. Consequence of *Tetrapleura tetraptera* leaves on pro-oxidants, hepatic functions and histomorphology in monosodium glutamate-intoxicated rats. Res. J. Med. Plants, 16: 37-48.
12. Theunissen, M., L. Tiedt and L.H. Du Preez, 2014. The morphology and attachment of *Protopolystoma xenopodis* (Monogenea: Polystomatidae) infecting the African clawed frog *Xenopus laevis*. Parasite, Vol. 21. 10.1051/parasite/2014020.
13. Kalantar-Zadeh, K., P.A. McCullough, S.K. Agarwal, S. Beddhu and M. Boaz *et al*., 2021. Nomenclature in nephrology: Preserving 'renal' and 'nephro' in the glossary of kidney health and disease. J. Nephrol., 34: 639-648.
14. Fagbohun, O.F., P.O. Awoniran, O.O. Babalola, F.K. Agboola and T.A.M. Msagati, 2020. Changes in the biochemical, hematological and histopathological parameters in STZ-Induced diabetic rats and the ameliorative effect of *Kigelia africana* fruit extract. Heliyon, Vol. 6. 10.1016/j.heliyon.2020.e03989.
15. Francis, P.S., S.W. Lewis and K.F. Lim, 2002. Analytical methodology for the determination of urea: Current practice and future trends. TrAC Trends Anal. Chem., 21: 389-400.
16. Zawada, R.J.X., P. Kwan, K.L. Olszewski, M. Llinas and S.G. Huang, 2009. Quantitative determination of urea concentrations in cell culture medium. Biochem. Cell Biol., 87: 541-544.
17. Slaoui, M. and L. Fiette, 2011. Histopathology Procedures: From Tissue Sampling to Histopathological Evaluation. In: Drug Safety Evaluation, Gautier, J.C. (Ed.), Humana Press, Totowa, New Jersey, ISBN: 978-1-60327-186-8, pp: 69-82.
18. Thomas, M., K.S. Sujatha and S. George, 2009. Protective effect of *Piper longum* Linn. on monosodium glutamate induced oxidative stress in rats. Indian J. Exp. Biol., 47: 186-192.
19. Egbuonu, A.C.C., C.I. Opara, D. Akachukwu and U.B. Onyedikachi, 2018. Effect of ethanolic extract of avocado pear (*Persea americana*) seed on normal and monosodium glutamate-compromised rats' hepatic histo-morphology and serum bio-functional parameters. Res. J. Environ. Sci., 12: 53-62.

20. Ukpabi-Ugo, J.C., K.C. Patrick-Iwuanyanwu, F.O. Azubuike-Izah and I.J. Obidike, 2015. Effect of different solvent fractions of *Ocimum gratissimum* (OG) on some haematological indices of paracetamol-induced hepatotoxicity in Wistar albino rats. Asian J. Biochem. Pharm. Res., 5: 163-169.
21. Cemaluk, E.A.C., E.P. Madus and O.L. Nnamdi, 2010. Influence of sub-chronic oral exposure to high monosodium glutamate on some serum markers of the renal functions in male Wistar rats. Afr. J. Biochem. Res., 4: 225-228.
22. Egbuonu, A.C.C., O. Obidoa, C.A. Ezeokonkwo, P.M. Ejikeme and L.U.S. Ezeanyika, 2010. Some biochemical effects of sub-acute oral administration of L-arginine on monosodium glutamate-fed Wistar albino rats 1: Body weight changes, serum cholesterol, creatinine, and sodium ion concentrations. Toxicol. Environ. Chem., 92: 1331-1337.
23. Agiang, M.A., B.S. Dongo, I.O. Williams and A.B. Utu-Baku, 2017. Assessment of the haematological indices of albino rats fed diets supplemented with jackfruit bulb, seed or a blend of bulb and seed. Int. J. Biol. Chem. Sci., 11: 397-407.
24. Kanu, K.C., S.N. Ijioma and O. Atiata, 2016. Haematological, biochemical and antioxidant changes in Wistar rats exposed to dichlorvos based insecticide formulation used in Southeast Nigeria. Toxics, Vol. 4. 10.3390/toxics4040028.
25. Holy, B., B. Kenanagha and D.O. Onwuli, 2015. Haemato-pathological effect of dichlorvos on blood picture and liver cells of albino rats. J. Toxicol. Environ. Health Sci., 7: 18-23.
26. Enyievi, P.B., B.I.A. Mgbeje, G.M.E. Nja, B.C. Edu and R.I. Ejemot-Nwa, 2020. Effect of *Ocimum gratissimum* leaf-extract on hematological indices and lipid profile of streptozotocin-induced diabetic Wistar rats. Pak. J. Biol. Sci., 23: 1523-1529.
27. Saad, B., H. Azaizeh, G. Abu-Hijleh and S. Said, 2006. Safety of traditional Arab herbal medicine. Evidence-Based Complementary Altern. Med., 3: 433-439.
28. Celik, I., Z. Yilmaz and V. Turkoglu, 2009. Hematotoxic and hepatotoxic effects of dichlorvos at sublethal dosages in rats. Environ. Toxicol., 24: 128-132.
29. Jorum, O.H., N.M. Piero and A.K. Machocho, 2016. Haematological effects of dichloromethane-methanolic leaf extracts of *Carissa edulis* (Forssk.) Vahl in normal rat models. J. Hematol. Thromboembolic Dis., Vol. 4. 10.4172/2329-8790.1000232.
30. Wani, W.Y., S. Gudup, A. Sunkaria, A. Bal and P.P. Singh *et al*., 2011. Protective efficacy of mitochondrial targeted antioxidant MitoQ against dichlorvos induced oxidative stress and cell death in rat brain. Neuropharmacology, 61: 1193-1201.
31. Schafer, A.I., 2004. Thrombocytosis, N. Engl. J. Med., 350: 1211-1219.