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Morphological and Biochemical Effects of Aqueous Extract of *Moringa oleifera* Leaf on Cobalt Chloride-Induced Cerebral Damage in Adult Wistar Rats

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Cobalt induces hypoxia in the brain which leads to oxygen deprivation resulting in cognitive disturbance and decreased motor control. This study evaluated the effect of *Moringa oleifera* extract on the cobalt chloride-induced cerebral cortex of adult male wistar rats.

40 male wistar rats weighing (90 ± 120g) were used for the study and they were divided into 5 groups with each group containing 8 rats. Group A served as control which received distilled water, Group B was treated orally with Cobalt chloride at dose 45 mg/kg, Group C received cobalt chloride 45 mg/kg + low dose of *Moringa oleifera* extract 250 mg/kg for 52 days, Group D treated with cobalt chloride 45 mg/kg + high dose of *Moringa oleifera* extract 500 mg/kg and Group E treated with 500 mg/kg *Moringa oleifera* extract only and rats were sacrificed on the 53rd day by cervical dislocation. The brain of each rat was removed and weighed before half was fixed in formol calcium for histological analysis and the second half was used for oxidative stress parameters. The mean body weight of the wistar rats in group C and E increased significantly ($P < 0.05$) while it decreased significantly ($P < 0.05$) in group D. The biochemical analysis shows a significant increase ($P<0.05$) in the level of MDA in group B and a significant decrease ($P<0.05$) in group E. additionally, NO level shows a significant increase ($P<0.05$) in group B compared with control. SDH activity decreased significantly in group C, D, and E. Microscopic examination of the cerebral cortex in

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group B, C and D showed degenerative changes compared with normal histological features in A and E.
The study concluded that cobalt chloride induced cerebral cortical damage while administration of *Moringa oleifera* extract attenuated the toxic effect of cobalt chloride in wistar rats.

Keywords: Cobalt chloride; Moringa oleifera; cerebral cortex; malondialdehyde; nitric oxide; succinate dehydrogenase; degenerative changes.

1. INTRODUCTION

Cobalt is a natural occurring element present in certain ores of the earth's crust and is essential to life. Cobalt in trace amounts exists in the form of various cobalt salts. Pure cobalt is an odourless, shiny hard steel-gray metal [1]. Cobalt is a heavy metal found on the periodic table as atomic number 27 with an atomic weight of 58.933. The element was discovered by Georg Brandt, a Swedish chemist and mineralogist in 1735 (Georg 2009; Georg 2010). Cobalt compounds have been used for centuries to impart a rich blue colour to glass and ceramics. Cobalt is naturally found in many rocks, plants, soil, water, and animals typically in small amounts. (Georg 2009; Georg 2010).Cobalt possesses an allergic potential it is considered as the second of top five global allergens (Matiz et al*.,* 2009). Cobalt exposure may also occur in the construction industry, primarily through skin contact with cement. Irritant and allergic contact dermatitis are considered the most frequent occupational health hazards in cement workers [2].

Moringa oleifera is one of the best known medicinal plants that have been consumed by humans [3]. It is one of the richest plant sources of Vitamins A, B, C, D, E and K [4,5,6,7] (Caceres et al*.,* 1992). *MO* is grown for its nutritious pods, edible leaves and flowers and can be utilized as food, medicine, cosmetic oil or forage for livestock. Its height ranges from 5 to 10 m [8]. The aqueous and alcoholic extract of *M. oleifera* root-wood reduce the elevated urinary oxalate and lowers the deposition of stone forming constituents of rat kidneys subjected to ethylene glycol treatment [9]. *M. oleifera* also has nutraceutical uses in the treatment of hypercholesterolemia and hyperglycemia [10,11]. In addition, *Moringa. oleifera* leaf extract has shown potentials in protecting against liver injury induced by carbon tetrachloride [12,13]. The most commonly used parts of the plant are the leaves, which are rich in vitamins, carotenoids, polyphenols, phenolic acids, flavonoids, alkaloids, glucosinolates, isothiocyanates, tannins and saponins [14]. The leaves of *MO* are mostly used for medicinal purposes as well as for human nutrition, since they are rich in antioxidants and other nutrients, which are commonly deficient in people living in undeveloped countries [15]. *MO* leaves have been used for the treatment of various diseases from malaria and typhoid fever to hypertension and diabetes [16]. The cerebral cortex is the thin layer of the brain that covers the outer portion (1.5-5mm) of the cerebrum. i.e it is the outer covering of the grey matter over the hemisphere and it is covered by meninges. Studies have indicated cerebral cortex is the largest site of neural integration in the central nervous system [17]. It has been observed that genetic disorder of the cerebral cortex associated with decreased folding in certain areas may lead to micro gyrus, where there are four layers instead of six, is in some instances seen to be related to dyslexia [18].

In view of the reported neurotoxic properties of cobalt chloride, the presented assessed the possible ameliorative potential of *Moringa oleifera leaf* extract in wistar rats following cobalt chloride induced cortical damage

2. MATERIALS AND METHODS

2.1 Location of Study

The animal house of Anatomy department of the Faculty of Basic Medical Sciences, Ladoke Akintola University of Technology, Ogbomosho, Oyo state,Nigeria served as the location for this study.

2.2 Experimental Animals

40 adult males healthy wistar rats (90-120 g) were obtained from the animal house of the department of Human Anatomy, Faculty of Basic Medical Sciences, Ladoke Akintola University of Technology, Ogbomosho. The animals were housed in animal cages in the Animal house for two weeks to acclimatize prior to the study. The

animals were maintained strictly under standard laboratory conditions in accordance with the guide for the care and use of laboratory animals complied by the National Academy of Science and published by the National Institute of Health (1985)

2.3 Weekly Body Weight Measurement

The body weights of the experimental animals were monitored and weighed with a weighing scale and the values were recorded weekly. The body weights were taken during the acclimatization and administration periods so as to monitor the changes in view of the administration of cobalt chloride and *moringa* leaf extract to the wistar rats.

2.4 Plant Material Preparation

The fresh *moringa Oleifera* were obtained from the university environment, authenticated, cleaned and dried at room temperature. The air dried leaves were grinded into powdery form. 400 g of the powdered leaves were then taken to the Food Science and Engineering Department (Lipid Room), Ladoke Akintola University of Technology, Ogbomosho for aqueous extraction. The aqueous extract was kept in the refrigerator until the time it was used for the study.

2.5 Experimental Design and Grouping

40 adults male wistar rats weighing (110-200 g) were separated into give groups based on theirs weights range.

- Group (Control group) received distilled water
- Group B received cobalt chloride 45 mg/kg
- Group C received cobalt chloride 45 mg/kg + low dose of *Moringa* extract 250 mg/kg
- Group D received cobalt chloride 45 mg/kg + high dose of *Moringa* extract 500 mg/kg
- Group E received *Moringa Oleifera* extract only (500 mg/kg)

The administration of cobalt chloride and *moringa* extract was done orally for 52 consecutive days

2.6 Collection of Organs and Tissue Processing

The animals were sacrificed on the 53rd day of administration by cervical dislocation the brain of each rat was carefully harvested, weighed using a sensitive balance, fixed in 10%formo calcium and processed for light microscopy and stained with Hematoxylin and Eosin staining technique as described by Carleton (1967).

2.7 Lipid peroxidation (LPO) assay [19]

Lipid peroxidation was carried out by measuring the Thiobarbituric Acid – Reactive (TBAR) products. The method was based on formation of pink colored product when 2-thibarbituric acid (TBA) reacts with MDA in acidic medium for 30min to form thiobarbituric acid reactive substances (TBARS). The absorbance of the resultant pink product was measured spectrophotometrically at 534nm.

Determination of Nitric Oxide [20] (Green et al, 1982).

Under acidic condition nitrite ion (NO_2^-) reacts with sulphanilamide to form a diazonium salt, which combines with N- (1 – naphthyl) – ethylene diamine dihydrochloride (NEDD) dihydrochloride to form a bright coloured pinkish red azo dye. The colour product is directly proportional to the amount of nitrite present in the sample.

2.8 Photomicrography

The digital micrographs of the required cerebral cortical sections were obtained to show the morphological changes that occurred in the treated group as compared to the control group.

The photomicrography was done in the department of Anatomy, Ladoke Akintola university of Technology, Ogbomosho, Oyo state, using digital camera attached to photomicroscope. (MD 900).

2.9 Statistical Analysis

All data obtained in this study was analyzed using ANOVA and tested for significance using Student's t-test. $P < 0.05$, value was considered significant while value greater than 0.05 was considered insignificant.

3. RESULTS

Table 1 above revealed the body weights of Wistar rats which increased slightly from the control group (A) which increased from mean value of 148.8 ±9.342 at the beginning of the treatment to 150.8 ±5.354 at the end of the treatment.

Table 1. showing the Mean ± S.E.M of the body weights of wistar rats before and during treatment

Week	Group A	Group B	Group C	Group D	Group E
Week 0	148.8 ±9.342	156.3 ±2.631	168.8 ± 5.489	181.3 ±5.806*	178.8 ±6.105*
Week 1	136.3 ±5.324	151.3±3.504*	130.0 ± 6.172	143.8 ± 2.631	162.5 ±8.399*
Week 2	162.5 ±7.258	153.8 ±3.239	145.0 ± 7.638	145.7 ± 4.286	168.8 ± 10.21
Week 3	163.1 ±7.254	153.1 ±4.324	149.2 ± 8.604	149.3 ± 9.413	169.4 ± 13.24
Week 4	175.6 ±5.625	173.1 ±4.719	176.7 ± 8.819	183.3 ± 7.601	210.0±4.880***
Week 5	171.3 ±5.154	175.0 ±5.000	178.3 ± 9.804	185.0 ± 6.191	205.7±4.809***
Week 6	150.8 ±5.354	163.5 ±5.392	180.4±7.243**	177.7±4.232**	185.1±3.924**

Significance: P < 0.05, value was considered significant (*) while value greater than 0.05 was considered insignificant. Values were expressed as Mean ± SEM

Group B which received cobalt chloride only (45 mg/kg) shows a slight increase in body weights of the wistar rats from mean value of 156.3 ±2.631 at the beginning to 163.5 ±5.392 at the end of treatment and in comparison with the control (group A), it is statistically significant (P< 0.05).

Group C which received cobalt chloride (45 mg/kg) + a low dose of *Moringa oleifra* extract (250 mg/kg) shows a greater increase in body weight of the wistar rats from mean value of 168.8 ± 5.489 at the beginning to 180.4±7.243** at the end, this weight increase is statistically significance (P< 0.05) when compared with the control (Group A).

Group D which received cobalt chloride (45 mg/kg) + a high dose of *Moringa oleifra* extract (500 mg/kg) shows decreased in body weight of wistar rats from mean value 181.3 ±5.806* at the beginning to 177.7±4.232** at the end of treatment and this weight loss is statistically significance (P< 0.05) when compared with the control (Group A).

Group E which received a high dose of *Moringa oleifra* extract (500 mg/kg) shows a greater increase in body weight of the wistar rats from mean value 178.8 ±6.105* at the beginning to 185.1±3.924*** at the end, this weight increase is statistically significance (P< 0.05) when compared with the control (Group A).

The table showed an insignificant increase (P>0.05) in the final body weights of rats in group B, a significant increase (P<0.05) in the final body weights of rats in group C, a significant decrease (P<0.05) in the final body weights of rats in group D and a significant increase (P<0.05) in the final body weights of rats in group E when the initial and final weights of rats were compared with the control group.

Table 2. showing the initial and final body weight analysis of wistar rats

Groups	Initial Weight (g)	Final Weight (g)	% Weight Gain or Loss
A	148.8 ± 9.342	150.8 ± 5.354	2
B	156.3 ± 2.631	163.5 ± 5.392	7.2
C	168.8 ± 5.489	180.4 ± 7.243**	11.6
D	181.3 ± 5.806*	177.7 ± 4.232**	-3.6
E	178.8 ± 6.105*	185.1 ± 3.924***	6.5

Significance: P < 0.05, value was considered significant (*) while value greater than 0.05 was considered insignificant. Values were expressed as Mean ± SEM

Table 3. showing the mean ± S.E.M of brain weight of adult wistar rats after sacrifice

Groups	Brain weight (Mean ± S.E.M)	Relative weight of brain (%)
A	1.53 ± 0.02951	1.02
B	1.51 ± 0.08514	01
C	1.62 ± 0.03957	0.90
D	1.67 ± 0.03374*	0.94
E	1.60 ± 0.05101	0.90

Significance: P < 0.05, value was considered significant (*) while value greater than 0.05 was considered insignificant. Values were expressed as Mean ± SEM

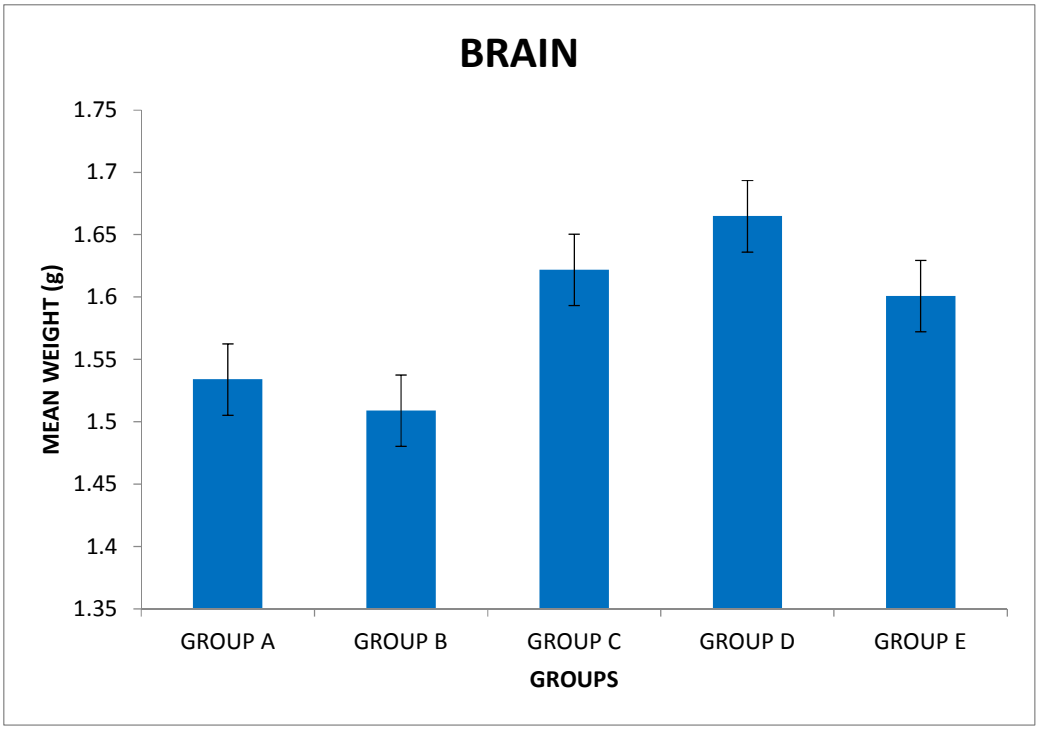


Fig. 1. Histogram showing the Mean ± S.E.M weight of BRAIN

Table 4. showing the effect of cobalt chloride and *moringa* extract on the activities of MDA, NO and SDH in the brain

Groups	MDA	NO	SDH
A	17.09 ± 0.3674	7.957 ± 0.3308	3.487 ± 0.3783
B	20.46 ± 0.5516***	9.157 ± 0.3442*	3.486 ± 0.3469
C	16.26 ± 0.7128	8.171 ± 0.1643	1.910 ± 0.4178*
D	17.51 ± 0.7507	8.100 ± 0.7381	1.720 ± 0.5399*
E	14.60 ± 0.8136*	8.171 ± 0.2447	1.739 ± 0.5377*

Significance: P < 0.05, value was considered significant (*) while value greater than 0.05 was considered insignificant. Values were expressed as Mean ± SEM; MDA: Malondialdehyde; NO: Nitric Oxide; SDH: Succinate dehydrogenase

Table 3 above shows a significant (P<0.05) decrease in the brain weight in Group B, C, D and E as compared with Group A.

The figure above shows insignificant (P>0.05) increase in brain weight in Group C, D and E as compared with Group A, while B shows an insignificant decreased (P>0.05) in brain weight.

3.1 Biochemical Evaluation

Table 4 reveals:

MDA: Group B increases significantly (P<0.05) when compared to group A.Group C decreases insignificantly (P>0.05) when compared to group A. Group D slightly increases insignificantly (P>0.05) when compared to group A. Group E decreases significantly (P<0.05) when compared to group A.

NO: Group B increases significantly (P<0.05) when compared to group A. Group C, D and E increases insignificantly (P.>0.05) when compared to group A.

SDH: Group B slightly decreases insignificantly (P>0.05) when compared to group A. Group C, D and E decreases significantly (P<0.05) when compared to group A.

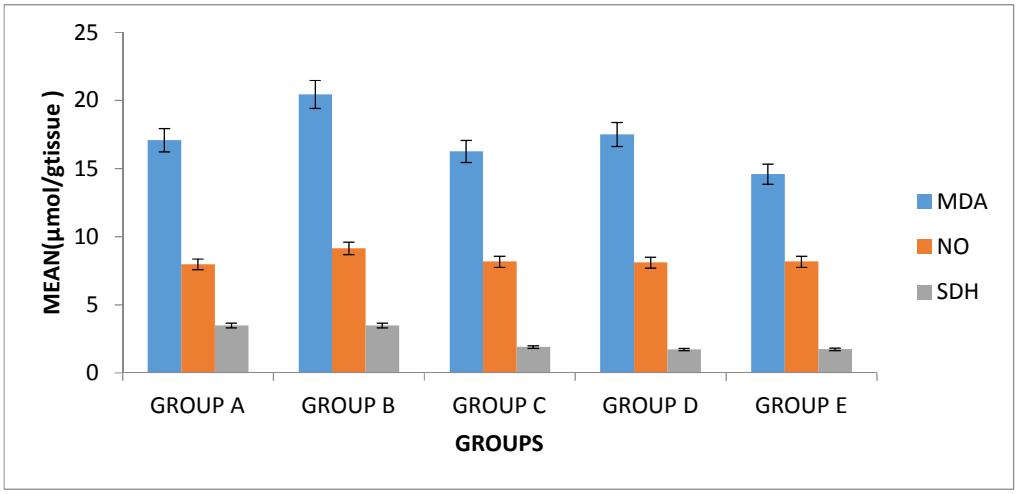


Fig. 2. Histogram showing the changes in level of MDA, NO and SDH

The figure above shows a significant increase ($P<0.05$) in the activity of MDA in group B, an insignificant decrease ($P>0.05$) in group C, insignificant increase ($P>0.05$) in group D, significant decrease ($P<0.05$) in group E.

There was a significant increase ($P<0.05$) in the activity of NO in group B, and an insignificantly increase ($P>0.05$) in group C, D, and E.

Similarly, there was an insignificant decrease ($P>0.05$) in the activity of SDH in group B, and a significant decrease ($P<0.05$) in group C, D, and E.

3.2 Histological Observation

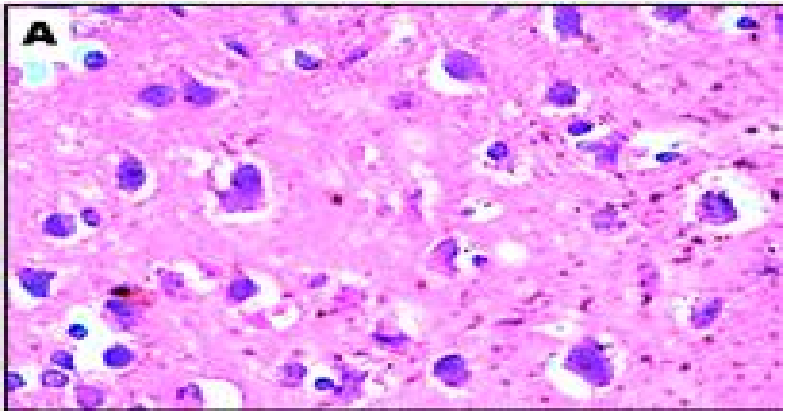
Representative micrographs of H&E staining showing the general cytoarchitecture of the cerebral cortex in Wistar rats in group A (control), Group B (Treated with cobalt chloride 45 mg/kg), Group C (Treated with cobalt chloride(45 mg/kg) and low dose of *moringa* extract(250 mg/kg)), Group D (Treated with cobalt chloride(45 mg/kg) and high dose of *moringa* extract(500 mg/kg) Group E (Treated with *moringa* extract(500 mg/kg)). Magnification: X40, X400 respectively.

Normal histological features of the cortex were observed in groups A, D and E treatment; this is characterized by large pyramidal cells as well as granule neurons, the pyramidal cells are characterized with long axons that extend well from the soma to adjacent neurons within the neuropil. Apical and basal dendrites extend from the well delineated soma of the pyramidal neurons in this group. Perineural space surrounding these cells appears intact, with intact nuclear and cytoplasmic content, both pyramidal and granular cells appeared darkly stained with no signs of diffused content with distinct layering.

Group B treatment caused conspicuous degenerative changes in the cortex that was characterized by peripheral and central degenerative changes, clustered pyknotic pyramidal and granule neurons that appear with fragmented cytoplasm and condensed nuclei. Wide Perineural spaces can be seen surrounding degenerating neurons, axons and dendrites are scarcely appreciable around neurons in this group, neuronal population appear scarcely appreciable in this group (red arrow). Group C treatment showed mild similarity with group B treatment (red arrow).

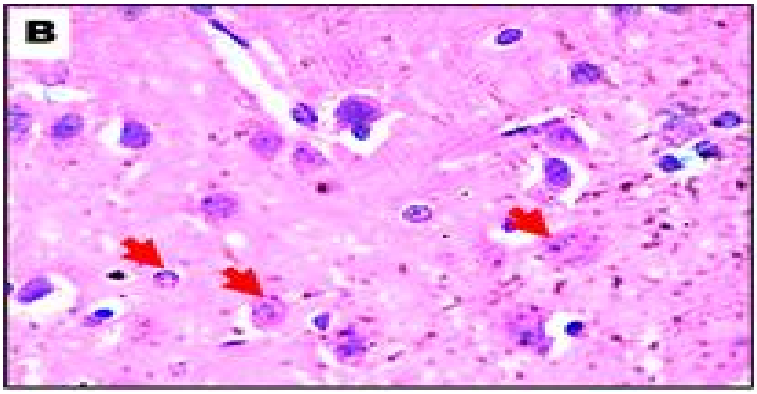
Plate A: photomicrographs showing a normal histological feature of the cerebral cortex, characterized by large pyramidal cell, with long axons that extends well from the delineated soma of the pyramidal neurons, normal molecular layers and external granular layer also appear normal (H & E X100 X400).

Plate B: photomicrographs shows conspicuous degenerative changes in the cortex that was characterized by peripheral and central degenerative changes, clustered pyknotic pyramidal and granule neurons that appear with fragmented cytoplasm and condensed nuclei. Wide Perineural spaces can be seen surrounding degenerating neurons, axons and dendrites are scarcely appreciable around neurons in this group, neuronal population appear scarcely appreciable in this group (red arrow).



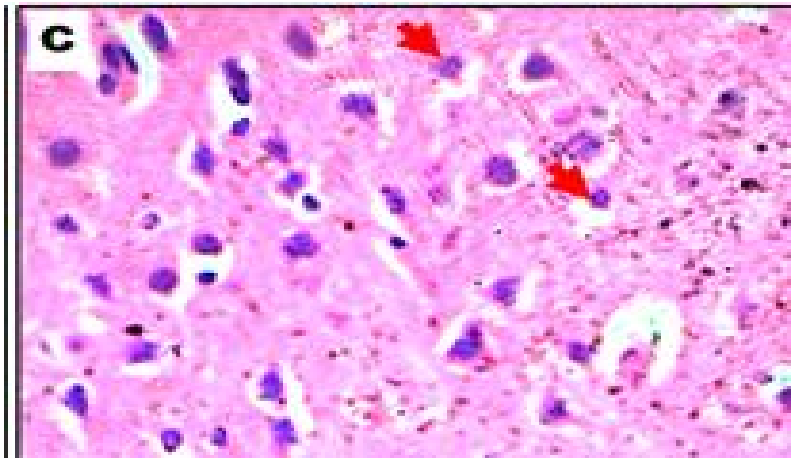
x400

Plate A. Control group x400



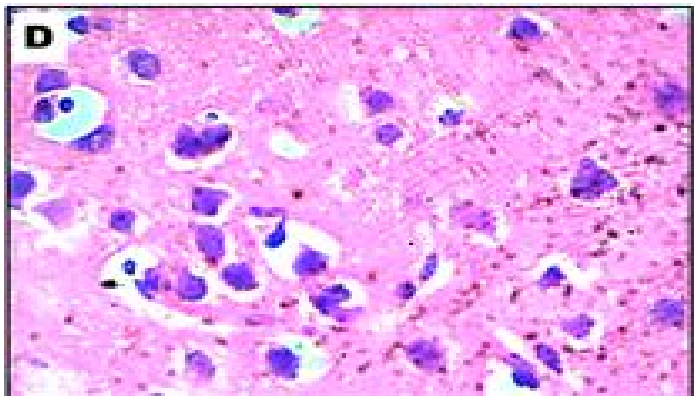
x400

Plate B. Treated with cobalt chloridE 45 MG/KG for 52days x400



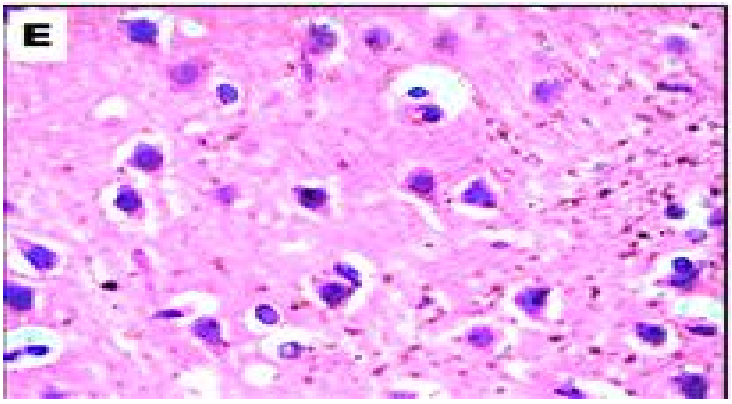
x400

Plate C. Treated with cobalt chloride (45 MG/KG) and low dose of *moringa* extract 250 MG/KG for 52days x400



x400

Plate D. Treated with cobalt chloride (45 MG/KG) and high dose of *moringa* extract (500 MG/KG) for 52days x400



x400

Plate E. Treated with *moringa* extract (500 MG/KG) for 52days x400

Plate C: photomicrographs shows Group C treatment showed mild similarity with group B treatment (red arrow).

Plate D: photomicrographs show External pyramidal layer (III), Internal granular layer (IV) are well demonstrated across study groups. Red arrow- degenerating and unhealthy cells with loss of cytoplasmic and nuclear materials.

Plate E: photomicrographs shows large pyramidal as well as granule neurons, the pyramidal cells are characterized with long axons that extend well from the soma to adjacent neurons within the neuropil. Apical and basal dendrites extend from the well delineated soma of the pyramidal neurons in this group. Perineural space surrounding these cells appears intact, with intact nuclear and cytoplasmic content, both pyramidal and granular cells appear darkly stained with no signs of diffused content with distinct layering

4. DISCUSSION

The study considered the effect of *Moringa Oleifera* extract on cobalt chloride induced cortical damage in adult wistar rats. Cobalt is an essential trace element required for normal growth development, cellular homeostasis and many enzymatic reactions [21]. *Moringa oleifera* is one of the best known medicinal plant. The *Moringa* plant has been consumed by humans [3]. It is one of the richest plant sources of Vitamins A, B, C, D, E and K [4,5,6,7] (Caceres et al*.,* 1992). The vital minerals present in *Moringa* include Calcium, Copper, Iron, Potassium, Magnesium, Manganese and Zinc. It has more than 40 natural anti-oxidants. *Moringa* has been used since 150B.C. by ancient kings

and queens in their diet for mental alertness and healthy skin. The leaves, pods, seeds, gums, bark and flowers of *Moringa* are used in more than 80 countries to relieve mineral and vitamin deficiencies, support a healthy cardiovascular system, promote normal blood-glucose levels, neutralize free radicals, provide excellent support of the body's anit-flammatory mechanisms, enrich anemic blood and support immune system. It is also used to make an efficient fuel, fertilizer and livestock feed. *Moringa* leaf has been purported to be a good source of nutrition and a naturally organic health supplement that can be used in many therapeutic ways [22,23,24].

The oral administration of cobalt chloride when compared between the first week of administration and the last week of administration with the body weight of animals in group A(control group) showed insignificant increase (P> 0.05) in group B (cobalt-treated group) which was exposed to 45 mg/kg of cobalt chloride, group C which was exposed to 45 mg/kg of cobalt chloride and 250 mg/kg of *moringa* extract (low dose) increased significantly (P<0.05) and group E which was exposed to 500 mg/kg of *moringa* extract (high dose) increased significantly (P<0.05) while group D which was exposed to 45 mg/kg of cobalt chloride and 500 mg/kg of *moringa* extract (high dose) decreased significantly (P<0.05).Group C had the highest percentage increase (11.6%) then group B(7.2%) and group E(6.5%) which shows that cobalt chloride increases the body weight and low dose of *moringa* extract act as a catalyst in body weight increase. This result is in accordance with the findings of Hoyt et al., [25] that concluded that the brain makes up only 2-4% of the body weight so cobalt chloride does not have any effect on the body weight Hoyt et al., [25]. These implies that *Moringa oleifera* extract increases feed intake which resulted in significant increase in the weight of animals in group C and E.

Comparing the relative brain weight of group B (cobalt-treated group) which was exposed to 45 mg/kg of cobalt chloride, group C which was exposed to 45 mg/kg of cobalt chloride and 250 mg/kg of *moringa* extract (low dose), group D which was exposed to 45 mg/kg of cobalt chloride and 500 mg/kg of *moringa* extract (high dose) and group E which was exposed to 500 mg/kg of *moringa* extract (high dose), insignificant decrease (P> 0.05) was observed in all groups. This result showed decrease of the brain weight in all the groups and this is similar to the previous findings Hoyt et al., [25] that cobalt chloride affected the structure and maturation of the brain suggesting its neurotoxic effects. [25].

There was a significant increase (P< 0.05) in the MDA level in group B (cobalt-treated group) from 17.09 ± 0.3674 to 20.46 ± 0.5516***when compared with group A (control group),an insignificant decrease (P> 0.05) in group C when compared with group A (control group), an insignificant increase (P> 0.05) in group D when compared with group A (control group) and a significant decrease (P< 0.05) in group E from 17.09 ± 0.3674 to 14.60 ± 0.8136* when compared with group A (control group). The groups consuming MO extract had significant decreases in malonaldehyde when compared to group B. Malondialdehyde (MDA) is an index of lipid peroxidation (Draper and Hadley, 1990). Exposure to cobalt increases the level of MDA(Lipid Peroxides).These findings are in agreement with [26] who reported that exposure to cobalt ions induced oxidative stress in investigated tissues of goldfish and [27] who reported lipid peroxidation level increase in cobalt-treated embryos at concentrations of 100 and 500ug/L.*Moringa oleifera* has an ameliorative effect against oxidative stress due to the presence of rich combination of antioxidant phytochemicals which reduces the activity of oxidative stress biomarkers in the brain [28].

There was a significant increase (P< 0.05) in the NO level in group B (cobalt-treated group) from 7.957 ± 0.3308 to 9.157 ± 0.3442* when compared with group A (control group), an insignificant increase (P> 0.05) in group C, group D and group E. There was an insignificant increase in NO level from *Moringa oleifera* co-treated groups (C , D and E) when compared to group B which shows that cobalt chloride induced oxidative stress and *M.* extract attenuated the effect of the cobalt chloride-induced toxicity. This is similar to the findings of other investigators in which the result suggest that monosodium glutamate induced oxidative stress in all the groups except the control group and *Moringa oleifera* reduces the oxidative stress caused by cobalt chloride [29].

An insignificant decrease (P> 0.05) in the SDH level from 3.487 ± 0.3783 to 3.486 ± 0.3469, in group B (cobalt-treated group) was observed. A significant decrease (P< 0.05) in group C from 3.487 ± 0.3783 to 1.910 ± 0.4178* in group D from 3.487 ± 0.3783 to 1.720 ± 0.5399* and in group E from 3.487 ± 0.3783 to 1.739 ± 0.5377*

was observed. *Moringa oleifera* has an ameliorative effect against oxidative stress due to the presence of rich combination of antioxidant phytochemicals which reduces the activity of antioxidant enzymes (SDH) in the brain [28].

Histological findings showed normal cytoarchitecture in the control group A. photomicrographs showing a normal histological feature of the cerebral cortex, characterized by large pyramidal cell, with long axons that extends well from the delineated soma of the pyramidal neurons, normal molecular layers and external granular layer also appear normal in this group. Perineural space surrounding these cells appears intact, with intact nuclear and cytoplasmic content, both pyramidal and granular cells appeared darkly stained with no signs of diffused content with distinct layering. Group B (treated with cobalt only) showed conspicuous degenerative changes in the cortex that was characterized by peripheral and central degenerative changes, clustered pyknotic pyramidal and granule neurons that appear with fragmented cytoplasm and condensed nuclei. Wide Perineural space was seen surrounding degenerating neurons, axons and dendrites are scarcely appreciable around neurons in this group, neuronal population appear scarcely appreciable in this group. The histological section of group C (treated with cobalt + low dose of *moringa*) showed a mild degenerative changes with a similar morphological features with group B (cobalt only treatment group).Treatment caused degenerative changes in the cortex in group D by showing External pyramidal layer (III), Internal granular layer (IV) which are well demonstrated across study groups. It also shows degenerating and unhealthy cells with loss of cytoplasmic and nuclear materials in this group. Histological findings in group E showed consistency with group A in histological features as.

Presented following *Morinte olenga leaf* extract administration leading to preservation of the histoarchitecture of cortical tissue in group C, D and E which prevented conspicuous loss and damage of cortical tissue. This is similar to the findings of [30] there was also loss of Purkinje cell numbers as evidenced by a decrease cellularity in the Purkinje cell layer and the external granular layer became markedly developed in the treated group which could be an indication of a delayed migration of granular cells towards the molecular layer. *Moringa oleifera* extract did not produce any observable disruptive damage on the tissue of the cerebral cortex. This finding is similar to reported positive effects of *moringa* extract on the cerebral cortex and suggested it could give protection against devastating diseases like Alzhemier's [31]. Previous findings have indicated ameliorative effects of *Moringa oleifea* (Owolabi et al*.,* 2014). The antioxidant properties of *Moringa oleifea* include polyphenols such as flavonoids, phenolic acid, tannins and saponins which potentiate the ameliorative characteristics of the extract in the following cobalt induced damage in the wistar rat after treatment

5. CONCLUSION

The present study concluded that oral administration of Cobalt chloride to male rats at a dose of 45mg/kg body weight daily for a period of 52days resulted in cortical damage on the histological and biochemical parameters on adult wistar rats. *Moringa oleifera* extract administration exhibited ameliorative effects on the cobalt chloride-induced cortical damage. This study shows that supplementation of *Moringa oleifera* extract (@ 250 mg/kg and 500 mg/kg) showed corticoprotective effect against cobalt chloride-induced toxicity.

6. LIMITATION OF THE STUDY

This study was limited to ameliorative effects of aqueous leaf extract of *Moringa oleifera* on cobalt chloride induced cortical damage in wistar rats. Further studies which could not be done in relation to this study may be necessary in association with molecular basis and immunohistochemical implication which may corroborate the findings from the present studies.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Animal Ethic committee approval has been taken to carry out this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFRENCES

1. Rengaraj S, Moon SH. Water Res. 2002;36:1783.

2. Wang BJ, Wu JD, Sheu SC. Occupational hand dermatitis among cement workers in Taiwan. J Formos Med Assoc. 2011;110(12):775-779.
3. Iqbal S, Bhanger MI. Effect of season and production location on antioxidant activity of Moringa oleifera leaves grown in Pakistan. J. Food Compos. Anal. 2006;19:544–551.
4. Dayrit FM, Alcantra AD, Villasenor IM. The antibiotic compound and its deactivation in aqueous solution. Phil. J. Sci. 1990;119:23-26.
5. Delisle H, Bakari S, et al. Provitamin A content of traditional green leaves from Niger. Cahiers Agricultures. 1997;6(6):553-560.
6. Babu SC. Rural nutrition interventions with indigenous plant foods: A case study of vitamin deficiency in Malawi. International Food Policy Research Institute, Washington, DC. Biotechnology, Agronomy Soc. Environ. 2000;4(3):169-179.
7. Anwar F, Bhanger MI. Analytical characterization of Moringa oleifera seed oil grown in temperate regions of Pakistan. J. Agric. Food Chem. 2003;51:6558-6563.
8. Padayachee A, Netzel G, Netzel M, Day L, Zabaras D, Mikkelsen D. Binding of polyphenols to plant cell wall analogues – Part 1: Anthocyanins. FoodChemistry. 2012;134(1):155–161.
9. Asare GA, Gyan B, Bugyei K. Toxicity potentials of the nutraceutical Moringa oleifera at supra supplementation levels. J Ethnopharm; 2012.
10. Ujah OF, Ujah IR, Johnson JT. Hepatoprotective property of ethanolic leaf extract of Moringa oleifera on carbon tetrachloride (CCl4) induced hepatotoxicity. J Nat Prod Plant Resour; 2013.
11. Al-Malki AL, El Rabey HA. The antidiabetic effect of low doses of Moringa oleifera Lam. seeds on streptozotocin induced diabetes and diabetic nephropathy in male rats. Biomed. Res.Int. 2015;1-13.
12. El-bakry K, Toson E, Serag M, aAboser M. Hepaprotective effect of Moringa oleifera leaves extract against carbon tetrachloride induced liver damage in rats. World Journal of Pharmacy and Pharmaceutical Sciences. 2016;5(5):76-89.
13. Okumu MO, Ochola FO, Mbaria JM. Mitigative effects of *Moringa oleifera* against liver injury induced by artesunateamodiaquine antimalarial combination in Wistar rats. Clin Phytosci; 2017.
14. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of *Moringa oleifera* leaves: An overview. Int. J. Mol. Sci. 2015;16:12791–12835
15. Popoola JO, Obembe OO. Local knowledge, use pattern and geographical distribution of Moringa oleifera Lam. (*Moringaceae*) in Nigeria. J. Ethnopharmacol. 2013;150:682–691.
16. Sivasankari B, Anandharaj M, Gunasekaran P. An ethnobotanical study of indigenous knowledge on medicinal plants used by the village peoples of Thoppampatti, Dindigul district, Tamilnadu, India. J. Ethnopharmacol. 2014;153:408–423.
17. Saladin Kenneth. Human anatomy (3rd ed.). McGraw-Hill. 2011;416–422. ISBN 9780071222075.
18. Habib M. The neurological basis of developmental dyslexia: An overview and working hypothesis. Brain. 2000;123(12):2373–2399.
19. Vashney R, Kale RF. Effect of calmodulin antagonishts on radiation induced lipid peroxidation in microsomes. international Journal Radiation Biology. 1990;58:733-743
20. Thayer JR, Huffaker RO. Determination of nitrate and nitrite by High pressure liquid chromatography: Comparison with other method for nitrite determination. Practical BioChemistry. 1980;102:110–1191.
21. Schrauzer GN, Deutsch E. Reactions of cobalt(I) supernucleophiles. The alkylation of vitamin B12s, cobaloximes(I), and related compounds. J Am Chem Soc. 1969;91:3341–3350.
22. DanMalam HU, Abubakar Z, Katsayal UA. Pharmacognostic studies on the leaves of Moringa oleifera. Nigerian Journal of Natural Product and Medicine. 2001;5:45-49.
23. McBurney RPH, Griffin C, Paul AA, Greenberg DC. The nutritionalcomposition of African wild food plants: From compilation to utilization. Journal of Food Composition and Analysis. 2004;17:277-289.
24. Fahey JW, Oleifera M. A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. Trees for Life Journal. 2005;1:5.

25. Hoyt KR, Gallagher AJ, Hastings TG, Reynolds IJ. Characterization of hydrogen peroxide toxicity in cultured rat forebrain neurons. Neurochem Res. 1997;22:333–340.
26. Olha I, Kubraka Viktor V, Husaka Bohdana M, Rovenkoa Janet M, Storeyb Kenneth B, Storeyb Volodymyr I, Lushchaka. Department of biochemistry and biotechnology, precarpathian National University named after Vassyl Stefanyk, 57 Shevchenko Str., Ivano-Frankivsk 76025, Ukraine; 2011.
27. Guiquan Cai 1, Junfeng Zhu, Chao Shen, Yimin Cui, Jiulin Du, Xiaodong Chen. Biol Trace Elem Res. Dec. 2012;150(1-3):200-207.
28. Hegazi MAM, Elebshany IAK. Ameliorative effect of Moringa oleifera on oxidative stress in male albino rat brain promoted by aluminium exposure. 2019;17(2):92-100.
29. Ayoola MB, Ejiofor NC, Ezeagu IE, Achukwu P. Organo-protective effect of *Moringa oleifera* (moringa) and *Camellia sinensis* (Green Tea) against histopathological damage in monosodium glutamate-induced oxidative-stressed rats. Adv Food Technol Nutr Sci Open J. 2019;5(1):26-37.

DOI: 10.17140/AFTN
30. Garoui E, Amara IB, Driss D. Effects of cobalt on membrane ATPASES, oxidant, and antioxidant values in the cerebrum and cerebellum of suckling rats. Biol Trace Elem Res. 2013;154: 387–395.
31. Ganguly R, Hazra R, Ray K, Guha K. Effect of *Moringa oleifera* in experimental model of alzheimer's disease: Role of antioxidants. Annals of Neurosciences. 2005;(12):36–39.

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