N-Butanol Fraction of Curcuma Longa (Turmeric) Ameliorates Lead Acetate-Induced Altered Sensory Motor Activity, Oxidative Stress and Histopathological Changes in the Frontal Cortex of Wistar Rat Pups

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Abstract

Background: Lead acetate (Pb) exposure during frontal cortex development is associated with developmental toxicity later in life, causing both morphological and functional alterations. *Curcuma longa*, however, has been suggested to possess neuroprotective qualities that could lessen these adverse effects. ***Objective*:** Assessed the frontal cortex following treatment with *Curcuma longa*. ***Materials and Methods*:** Twenty adult female Wistar rats and ten adult male Wistar rats were matched during the proestrous phase of the estrous cycle in order to mate and create five groups of six (n=6) in a 4:2 (4 females to 2 males) ratio. Gestational day 0 was marked as the confirmation of pregnancy based on if sperm is present and a vaginal plug in the vaginal smear. Four (n=4) pregnant Wistar rats were put together. Group 1 (control) rats were given 2 milliliters per kilogram of distilled water. Pb was given at a dose of 120 mg/kg to Group 2. Group 3 rats were given 120 mg/kg of lead and 100 mg/kg of vitamin C. The animals in Group 4 received 750 mg/kg of Curcuma longa and 120 mg/kg of Pb. The animals in Group 5 rats were given 1500 mg/kg of Curcuma longa and 120 mg/kg of Pb. From gestational day 7 to day 21 (14 days), the medication was administered orally. The animals were allowed to litter naturally. At postnatal day (PND) 1, some pups were euthanized using chloroform inhalation and their brains were harvested for Oxidative stress markers, histology, histochemical assessments. While some pups were kept for Cliff avoidance test at PND 4-7. ***Results*:** The study found that lead acetate (Pb) exposure during gestation significantly decreased the mean turning latency in the cliff avoidance test and increased lipid peroxidation (MDA) levels, while decreasing antioxidant enzyme levels (SOD, CAT, GSH) compared to the control group. These neurological and oxidative changes were mitigated by co-administration of Curcuma longa, with a notable improvement in the cliff avoidance test performance and restoration of the altered histological and histochemical markers. The results suggest that *Curcuma longa*, a natural antioxidant, has neuroprotective properties that can counteract the adverse effects of lead toxicity during gestational development**.** ***Conclusion*:** *N-Butanol* Fraction of *Curcuma Longa* ameliorated lead-induced neurotoxicity in rat pups.

Keywords: *Curcuma Longa*, lead acetate, cliff avoidance, biochemical, histology, histochemistry

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Introduction

Naturally occurring elements, metals are usually found in the forms of their related compounds. They are widely used in industry and have the potential to harm people's health due to exposure to the environment and at work [1]. Heavy metals such as arsenic (As), mercury (Hg), lead (Pb) and cadmium (Cad) remain in the environment and have a variety of detrimental consequences when their specific density exceeds 5 g/cm3[2].

Lead (Pb) has been used as a heavy metal for millennia to make a variety of products, and its uses are still prevalent today. Children and developing fetuses are especially susceptible to the disastrous health effects that exposure to lead can have. Numerous industries, including coating, refining, glazing, and ceramics, use lead extensively. Furthermore, it is also employed in the production of radiation shields, cookware, building insulation, cable wrapping, water pipelines, and military applications. Lead is released into the environment by these actions, and it subsequently accumulates in many human organs, with the brain being the primary organ to target[3].

Lead poisoning, or lead toxicity, is a condition caused by elevated levels of heavy metals in the body that can influence behavior and cause biochemical alterations in the body. Cognitive and memory impairments, anxiety-related conditions, disruptions in social and sexual functioning, as well as imbalances in neurotransmitter systems are some examples of the changes that can occur. Among the symptoms of lead poisoning are headaches, anemia, irritability, convulsions, coma, and death in severe cases[4].

Lead can interfere with the formation of red blood cells and disturb numerous biological systems, including proteins, because it can produce compounds with large functional chemical groups. Therefore, if lead is swallowed or inhaled, it can be harmful to one's health. The detrimental impacts of lead exposure on children's growth and maturation continue to be a major global concern because the developing brain is most susceptible to the potentially long-term effects of lead exposure, which can cross

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Ethics committee approval: The study obtained ethical endorsement from the Ahmadu Bello University Committee on Animal Care and Use, with the approval number ABUCAUC/2022/049, ensuring the research was conducted in agreement with institutional procedures and regulations for the use and care of animals.

the placental and blood-brain barriers and be further exacerbated by maternal bone turnover during pregnancy[1].

Children absorb lead more quickly than adults do, which results in more physical harm[6]. Even at low exposures, this is detrimental to children's cognitive development[7]. Children with blood lead levels below 10 mg/dL have lower IQs, according to studies[8]. Children are susceptible to harmful consequences from even extremely low levels of lead exposure due to their rapid brain growth[9]. Although there is no safe threshold, the Centers for Disease Control (CDC) advises <5 mg/dL to prevent harm[10]. Child cognition is significantly impacted by maternal blood <6.5 mg/dL, and 24-month cognitive development is inversely associated with prenatal exposure <5 mg/dL[9]. Although some studies show the benefits of low prenatal lead exposure, the data are still mixed, necessitating additional study into the consequences of even slight prenatal lead exposure [11].

Turmeric may mitigate the damage that lead poisoning causes to the brain cortex of Wistar rats, according to studies[12]. Turmeric's primary component, curcumin, is mostly known for its health advantages. Turmeric has several positive properties, such as antioxidant activity and anti-inflammatory, anti-cancer, and anti-ulcer properties[13]. Hence, turmeric shows promise as a therapeutic agent against a number of chronic conditions, such as diabetes, cancer, allergies, rheumatoid arthritis, and Alzheimer's disease. Since turmeric has a low toxicity profile and has been used medicinally for a long time, there is growing interest in developing modern pharmaceuticals made from this spice to help treat a variety of illnesses[13].

Material and Methods

The study obtained ethical approval from the Ahmadu Bello University Committee on Animal Care and Use, with the approval number ABUCAUC/2022/049, ensuring the research was carried out in agreement with institutional procedures and regulations for the use and care of animals.

Plant extraction

The n-butanol fraction of *Curcuma longa* was prepared in Faculty of Pharmaceutical Sciences in the Department of Pharmacognosy and Drug Development, Ahmadu Bello University, Zaria. The rhizome of *Curcuma longa* was collected, cut into pieces, sun-dried, and powdered using a laboratory mortar and pestle. The powdered rhizome was macerated in ethanol for 36 hours, with occasional shaking. The resultant mixture was then filtered, and the filtered liquid was carefully evaporated to complete dryness using a water bath maintained at a temperature of 55±5 degrees Celsius. The ethanol extract was then partitioned using n-butanol under the same conditions. The n-butanol fraction, a dark-brown gummy exudate, was obtained with a yield of 5.68% and was kept in the refrigerator pending experimentation. These procedures were performed as depicted by Bulus et al. [14].

Determination of estrous cycle and pregnancy

The Wistar rats' estrous cycle was monitored using the vaginal smear/cytology method, as described by Ajayi et al. [15]. Every day vaginal lavages with normal saline were used to determine each female rat's estrous cycle stage under a light microscope. During the pro-estrous stage, marked by the presence of epithelial cells, and the estrous stage, marked by the presence of cornified cells, the female rats were retained in cages with sexually active male rats of the same strain. Sperm presence in a vaginal smear was used to check pregnancy or by the use of a vaginal plug [15].

Experimental design

Twenty (20) pregnant Wistar rats were alienated into five groups (Group I-V), n= 4; Group I (control) was given 2 ml of distilled water; Group II was given 20%/kg body weight of the LD_{50} of lead acetate (Hamza *et al*., 2017); group III were administered 100mg/kg Vitamin C + 20%mg/kg Pb; group IV were given 15% LD_{50} BFCl + 20% mg/kg Pb; group V were administered 30% LD_{50} BFCl + 20% mg/kg Pb. All dosing was carried out through the oral route and done one time daily on gestation days 6-21 (14 days) which are the critical developmental days of the frontal cortex. Some of the pups were sacrificed on postnatal day (PD1) while others were kept for behavioral analysis (PND 4-7).

Cliff avoidance reflex

The study assessed reflex and neuromotor growth in the rat pups using the method described by Olopade and Shokunbi[16]. The front paws, digits, and nose of each pup were placed on the edge of a stage that was elevated one meter from the ground beginning on postnatal days (PND) 4 and 7. With a maximum time of 40 seconds, the amount of time the pup needed to remove its nose and paws from the precipice was measured in seconds. A 40-second lag was noted if the puppy was unable to turn away from the cliff. As stated by Dubovicky et al.[17], it was also noted if the animal was capable of completing the task or not.

Animal Euthanization

On postnatal day 1 (PND1), a subset of pups (n=8) from each group were anesthetized using chloroform inhalation and then decapitated. For four of these pups from each group, the entire head was fixed in 10% formal saline for 48 hours to be used for histological studies. For the remaining four pups per group, a midsagittal incision was made to open the skull and harvest the brains. These brains were then homogenized in phosphate buffer for the analysis of oxidative stress biomarkers. The brain homogenates were collected in sample bottles, placed on ice blocks, and refrigerated for further biochemical studies. All animal sacrifices were performed in the Human Anatomy Department (Neuroscience laboratory), Ahmadu Bello University, Zaria.

Biochemical analysis

After centrifuging the homogenized brain samples, small portion of the supernatant were taken out for biochemical analysis to evaluate biomarkers of oxidative stress, such as the level of lipid peroxide (malondialdehyde, MDA), the antioxidant enzymatic activity of catalase (CAT), and glutathione (GSH), and superoxide dismutase (SOD). The Department of Human Anatomy at Ahmadu Bello University in Zaria conducted these investigations. Using ELISA kits from WKEA Med Supplies Corp., China, the concentrations of MDA and the activity of SOD, CAT, and GSH were assessed in the samples by the methodology described by Okey and Ayo[18].

Histochemical and Histological studies

The fixed heads of the pups were removed, and a midsagittal incision was made to open the skulls and harvest the brains. The fixed brains were then taken to the Histology Unit, Anatomy Department at Ahmadu Bello University, Zaria, for tissue processing and staining. Hematoxylin and Eosin staining was carried out using the methods described by Drury et al.[19], while Creysl Fast Violet staining was conducted following the method of Carson[20]. All these histological procedures were performed in the Faculty of Basic Medical Sciences of Human Anatomy Department, Ahmadu Bello University, Zaria.

Quantification of Nissl substance distribution

The staining intensity of the Creysl Fast Violet (CFV)-stained micrographs (digital microscopic images) was measured using a computer running Image J, an image analysis software from the National Institutes of Health (NIH) in the United States, by the manufacturer's instructions[21]. To limit any bias due to non-identical image quality, such as differences in image acquisition settings and exposure times, the Image J region of interest (ROI) manager tool was employed to analyze specific areas of the micrographs[22,23]. The modal gray data for three ROIs were gotten, and the means were calculated and examined [21,24].

Data analysis

The data obtained were stated as mean ± standard error of the mean (SEM). To analyze the differences between and within the groups, an analysis of variance (ANOVA) was performed, afterward the Tukey post hoc test. Data of $p<0.05$ were deemed statistically substantial. The data analysis was done using the graph pad prism software.

Results

Cliff avoidance reflex

The comparison of the initial and final turning latency showed a substantial decrease ($p<0.05$) in the mean turning latency in Group IV (750 mg/kg BFCl + 120 mg/kg Pb), suggesting an improvement in the sensory-motor maturation (Figure 1A). When the final cliff avoidance test was compared across the groups, there was a notable rise ($p<0.05$) in the mean turning latency in Group II (120 mg/kg Pb) compared to the control group (2 ml/kg H2O), which indicated a delay in sensory-motor maturation (Figure 1B).

Biochemistry of antioxidant enzyme activity and lipid peroxide levels

The malondialdehyde (MDA) assay was used to estimate the lipid peroxidation levels, while the antioxidant enzymatic activity was assessed by assaying for superoxide dismutase (SOD), catalase (CAT), and glutathione (GSH) in the brain tissue. The results showed a substantial decrease ($p<0.05$) in the SOD levels across the groups when compared to the control (Figure 2B). Additionally, there was a notable decline ($p<0.05$) in the catalase level in Group II (120 mg/kg Pb), Group III (100 mg/kg vitamin C), and Group V (1500 mg/kg BFCl) in relation to the control group. Conversely, there was a significant increase ($p<0.05$) in the catalase level in the 750 mg/kg BFCl group when compared to the 120 mg/kg Pb group (Figure 2C). Furthermore, there was a outstanding decrease ($p<0.05$) in the GSH levels across the groups in relation to the control group (Figure 2D).

Haematoxylin and Eosin (H and E) stain features

Histological examination of the frontal cortex (layer III and layer V) of the Wistar rat pups in the control group (2 ml/kg of H2O) showed a nearly normal histoarchitecture (Figure 3A). In contrast, the frontal cortex of Group II exposed to lead (120 mg/kg) demonstrated pathological changes in layer III and layer V, such as pyknosis and cytoplasmic vacuolation (Figure 3B). The frontal cortex of Group III treated with 100 mg/kg vitamin C + 120 mg/kg Pb revealed mild distortions, including pyknosis and cytoplasmic vacuolation, in layer III and layer V (Figure 3C). The frontal cortex of Group IV treated with lead (120 mg/kg) and a low dose of BFCl (750 mg/kg) showed mild distortion of the cytoarchitecture in layer III and layer V (Figure 3D). Lastly, the frontal cortex of Group V treated with 1500 mg/kg BFCl + 120 mg/kg Pb exhibited mild distortion in the histoarchitecture of the layer III and layer V, such as pyknosis and cytoplasmic vacuolation (Figure 3E).

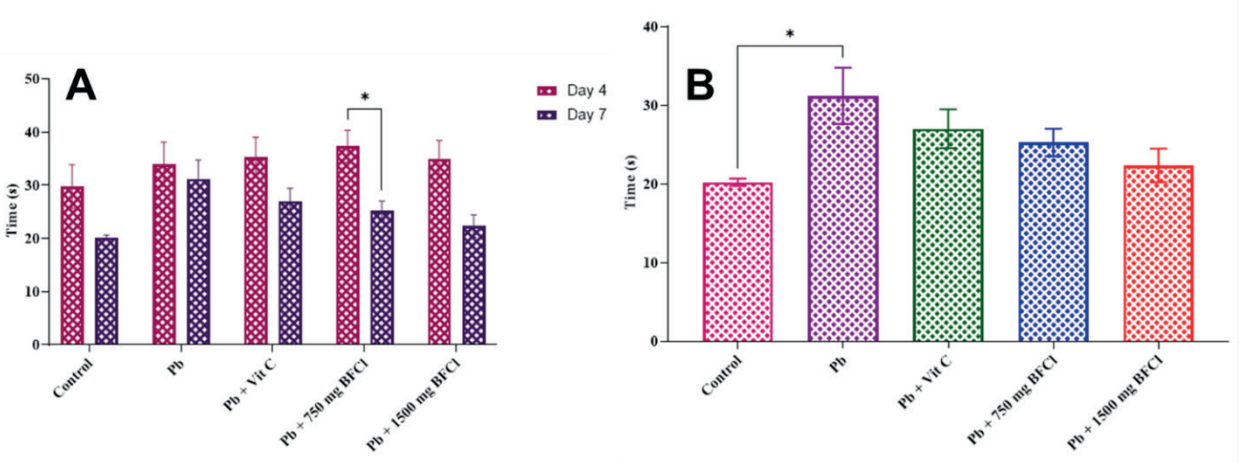

Figure 1: Cliff avoidance test. Effect of BFCl on (A) Initial and Final Cliff Avoidance test of the Wistar rat pups. (B) Final Cliff Avoidance test of the Wistar rat pups. n=7; mean ± SEM, One-way ANOVA, Tukey post hoc test, *=p<0.05 when compared to the control group. Pb= Lead acetate, Vit C= Vitamin C, BFCl=n-Butanol Fraction of *Curcuma longa*.

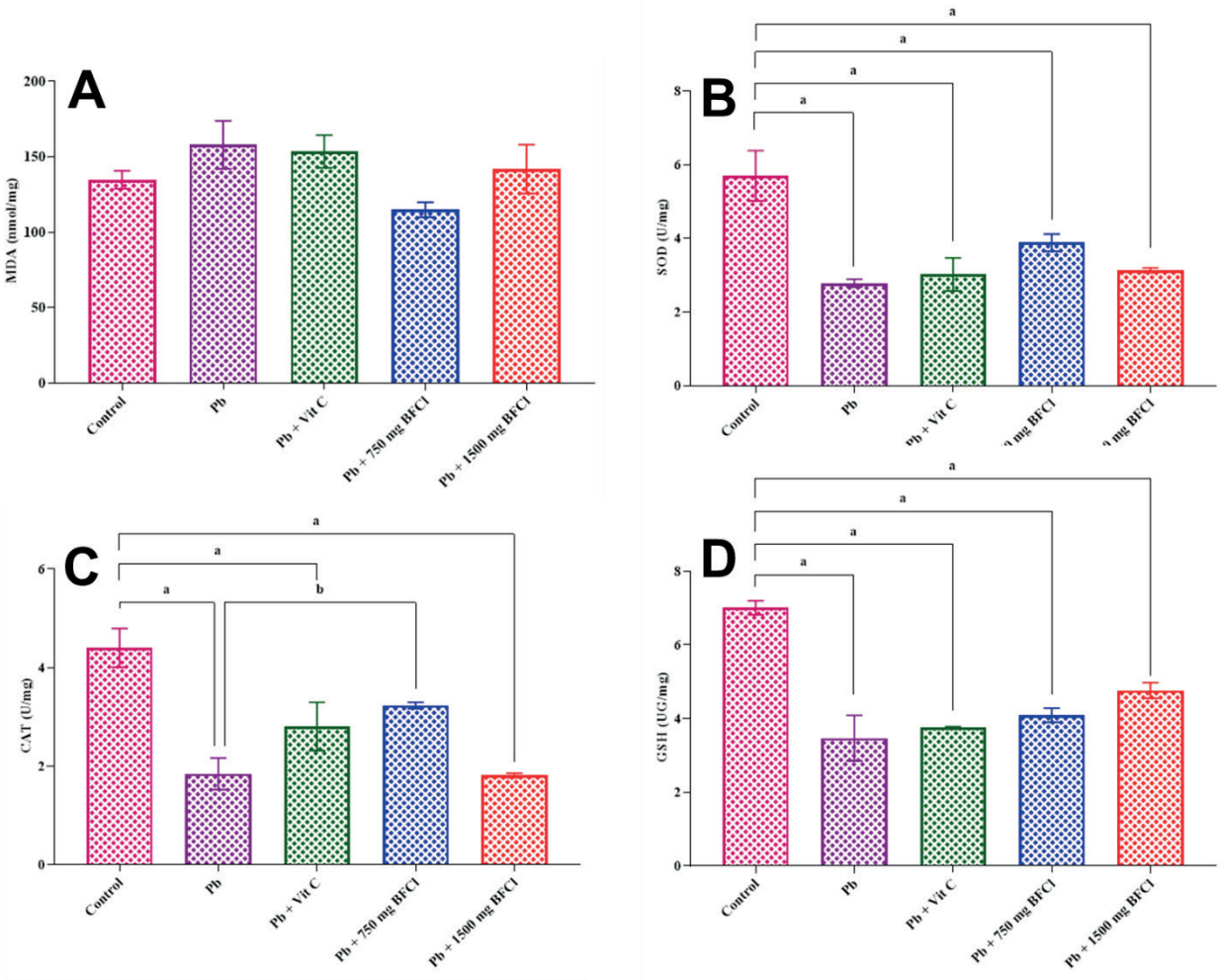

Figure 2: Bar charts of Oxidative stress parameters (A) MDA, (B) SOD, (C) CAT, and (D) GSH, of Wistar rats following administration of lead acetate and treatment with N-Butanol Fraction of Curcuma Longa prenatally. n=4; mean ± SEM, one-way ANOVA, Tukey post hoc test, a =p<0.05 when compared to the control group. Pb= Lead acetate, Vit C= Vitamin C, BFCl=n-Butanol Fraction of Curcuma longa.

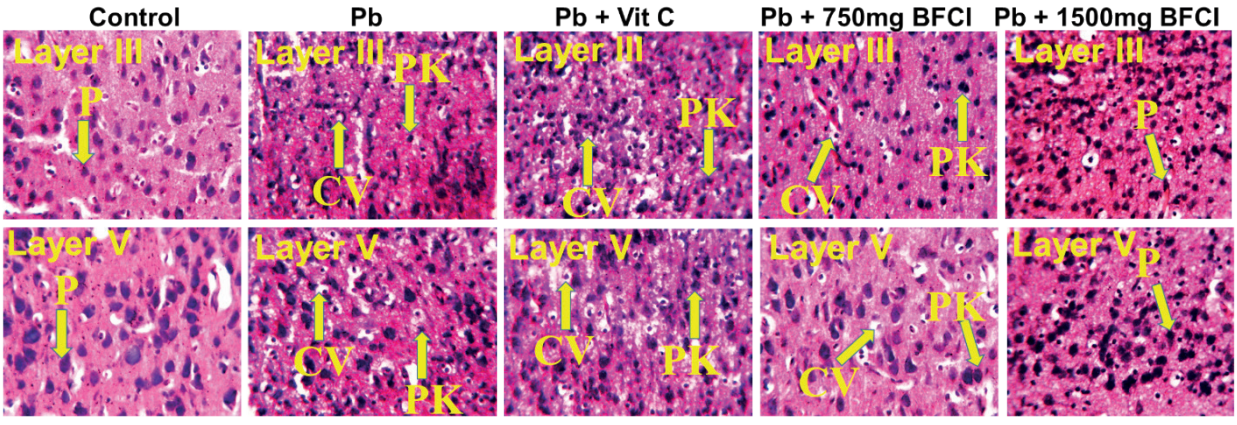

Figure 3: Composite micrographs of Wistar rat pups frontal cortex layer III and V of (A) Control group showing normal histoarchitecture. (B) Lead acetate group showing distortion in the histoarchitecture. (C) Group III showing distortion in the histoarchitecture. (D) Group IV showing mild distortion of the histoarchitecture. (E) Group V showing improvement in the histoarchitecture. H and E, Mg = x250. Pyramidal cells (P); Cytoplasmic Vacuolation (CV); Pyknosis (Pk). Pb= Lead acetate, Vit C= Vitamin C, BFCl=n-Butanol Fraction of Curcuma longa.

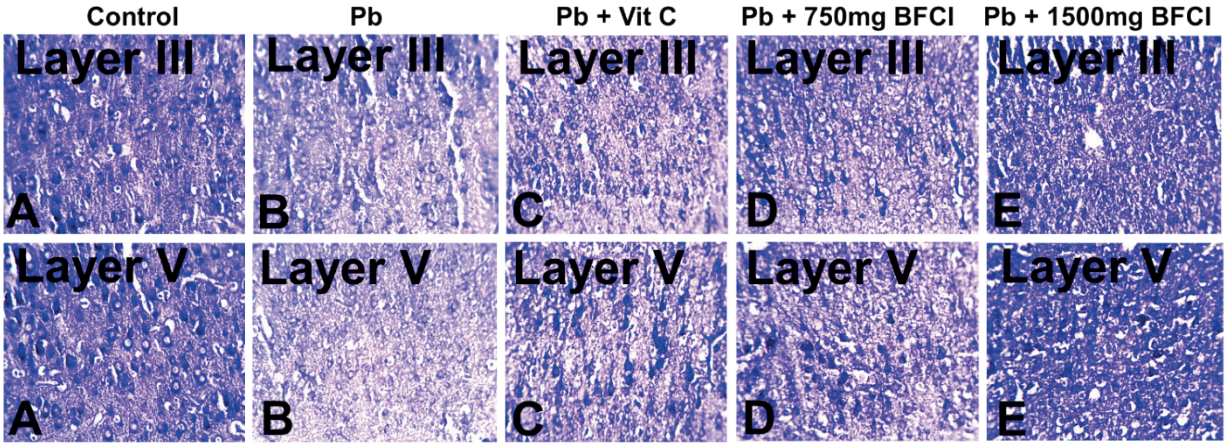

Figure 4: Photomicrograph of Wistar rat pup frontal cortex layer III and V stained by Cresyl violet, mag X250. (A) Control group (2ml/kg H20), showing staining intensity of Nissl bodies. (B) Group II (120 mg/kg Pb) showing reduced staining intensity of Nissl bodies. (C) Group III administered Vit C + 120 mg/kg Pb, showing reduced staining intensity of Nissl bodies. (D) Group IV (750 mg/kg BFCl + 120 mg/kg Pb) showing increase staining intensity of Nissl bodies. (E) Group IV (1500 mg/kg BFCl + 120 mg/kg Pb) showing increase staining intensity of Nissl bodies. Pb= Lead acetate, Vit C= Vitamin C, BFCl=n-Butanol Fraction of Curcuma longa.

Cresyl Fast Violet stain (CFV) features

The frontal cortex sections of the Wistar rat pups in the control group (2 mg/kg of distilled water) (Figure 4A), 750 mg/kg BFCl + 120 mg/kg Pb (Figure 4D), and 1500 mg/kg BFCl + 120 mg/kg Pb (Figure 4E) showed intense staining for Nissl substances in the frontal cortex, with distinctive appearance of the layer III and V regions. In contrast, Group II (120 mg/kg Pb) revealed reduced staining intensity of layer III and layer V when n relation to the control group and BFCl-treated groups, with numerous chromatolytic cells (Figure 4B). Examination of the frontal cortex of Group III (100 mg/kg vitamin C + 120 mg/kg Pb) revealed reduced staining intensity in layer III and layer V with few chromatolytic cells when compared to the BFCl-treated groups (Figure 4C).

Discussion

Studies have shown that the harm that lead poisoning does to the brain cortex of Wistar rats may be lessened by using turmeric[12]. Curcumin, the main ingredient in turmeric, is primarily responsible for its health benefits. Turmeric has several advantageous qualities, including anti-cancer, anti-inflammatory, and anti-ulcer properties in addition to its antioxidant activity[13]. Thus, turmeric has potential as a treatment for several chronic illnesses, including Alzheimer's disease, diabetes, cancer, allergies, and rheumatoid arthritis. Turmeric has been used medicinally for a long time and has a low toxicity profile, thus there is rising interest in creating contemporary medications manufactured from this spice to help treat a range of illnesses[13].

In this work, the cliff avoidance test, a measure of sensory-motor maturation in the growing frontal cortex was used to assess motor activities. Lead, one of such heavy metals that is identified to be harmful to the brain, especially in developing brains, and can induce lesions in the frontal lobes. The results of the cliff avoidance test displayed that prenatal dose of 750 mg/kg of the Curcuma longa extract (BFCl) enhanced the recorded mean turning latency, suggesting an enhancement in sensory-motor maturation. In contrast, prenatal exposure to 120 mg/kg of lead acetate destructively had an effect on the average turning expectancy, indicating a delay in sensory-motor maturation. These discoveries are consistent with the study of Usman et al. [26], who discovered similar effects of aluminum exposure during pregnancy on the cliff avoidance response in developing brains. Overall, the study demonstrated the potential neuroprotective and cognitive-enhancing effects of Curcuma longa, a plant rich in flavonoids, in animal models exposed to neurotoxicants during prenatal development. These results add to the rising body of research supporting the therapeutic potential of natural plant-based medicines to lessen the harmful effects of environmental contaminants on brain development and function.

This study also looked at the effects of *Curcuma longa* (BFCl) n-butanol fraction on oxidative stress and antioxidant enzyme activity in Wistar rat pup's frontal cortex treated with lead acetate during prenatal development. Mammalian cells are more sensitive to the redox status of both the extracellular and intracellular environments because they have developed in an oxidizing environment. Numerous cellular functions, including as signal transmission, metabolism, development, apoptosis, and detoxification systems, are influenced by the redox state of the intracellular environment. hydrogen peroxide (H2O2), hydroxyl radical (HO) and Superoxide (O2) are examples of reactive oxygen species (ROS) that have been shown to restrict the activity of a biological component.

The study found no striking variance in malondialdehyde (MDA) levels across the groups, but in the group receiving 750 mg/kg BFCl and 120 mg/kg lead acetate, the MDA level was reduced compared to the other groups. This decrease might be explained by the antioxidant qualities of *Curcuma longa*'s n-butanol fraction, which might have caused the antioxidants to be released to lessen the effects of lead acetate poisoning and lipid peroxidation in the frontal cortex. Additionally, a substantial ($p<0.05$) decline in SOD (superoxide dismutase) activity was noted in all treatment groups in relation to the control group. The discovered histological abnormalities in the frontal cortex and possible oxidative stress may have caused this decrease in SOD activity. Other possible causes include the harmful effects of lead acetate, rising oxidative activities, and lowering antioxidant activities. This outcome is consistent with studies conduct-

ed by Abu-Taweel et al.[12], who discovered that a SOD deficiency may worsen cerebral vascular hypertrophy and dysfunction. Interestingly, the group receiving 750 mg/kg BFCl and 120 mg/kg lead acetate showed an rise in SOD levels in relation to the other groups. Usman et al.[27] attributed this improvement to the antioxidant capabilities of BFCl, which may have assisted in reducing the activity of free radicals in the tissue.

The antioxidant enzyme level, catalase (CAT) was significantly reduced ($p<0.05$) in Groups II, III, and V compared to the control group. However, there was a significant increase ($p<0.05$) in CAT levels in Group IV, which received 750 mg/kg of the n-butanol fraction of Curcuma longa (BFCl) and 120 mg/kg of lead, compared to Group II, which was given only 120 mg/kg of lead. As indicated by the elevated CAT levels, a lower dose of BFCl was able to lessen the effects of lead toxicity, suggesting that the administration of BFCl is dose-dependent. This outcome is in line with the research done by Benammi et al. [28], who discovered that *Curcuma longa* is an effective neuroprotective agent against neurotoxicity triggered by lead.

Furthermore, the research found that the level of reduced glutathione (GSH) was strikingly lowered ($p<0.05$) in the treated groups in relation to the control group. It is well known that GSH's antioxidant qualities, which include directly scavenging radical species, depend on its thiol moiety[29]. This implies that the high level of GSH in the frontal cortex of the Wistar rat pups may have caused oxidative stress. Moreover, GSH is essential for cell proliferation [30].

Interestingly, the study found that the groups receiving 750 mg/kg BFCl + 120 mg/kg lead acetate and 1500 mg/kg BFCl + 120 mg/kg lead acetate were able to ameliorate the effect of lead acetate toxicity better than the group receiving 100 mg/kg vitamin C + 120 mg/kg lead acetate when in relation to the group receiving only 120 mg/kg lead acetate (Group II). This suggests that the n-butanol portion of *Curcuma longa* has higher scavenging activity than vitamin C, according to Bulus et al. [14]. Overall, the alterations in antioxidant enzyme activities and oxidative stress markers suggest that *Curcuma longa*'s n-butanol fraction possesses antioxidant properties that may be capable to mitigate the damaging effects of lead acetate exposure on the developing frontal brain.

Researches have shown that exposure to lead acetate causes histological abnormalities in the rat cerebral cortex, including an increase in apoptosis associated with oxidative stress[3]. However, a number of studies have shown that curcuma longa, often known as turmeric, has anti-inflammatory and memory-enhancing properties, suggesting that it may be helpful in the management and avoidance of neurodegenerative diseases[28]. Additionally, it has been shown that Curcuma longa reduces oxidative stress, inflammation, and apoptosis to protect the diabetic brain[31].

The present study used microscopic analysis with hematoxylin and eosin staining to examine the histoarchitecture of the frontal cortex in Wistar rat pups. The control group (2 ml/kg H2O) exhibited a nearly normal histological structure in layers III and V of the frontal cortex. In contrast, the group exposed to 120 mg/kg of lead acetate (Group II) showed pathological changes, such as neurodegenerative alterations like pyknosis and cytoplasmic vacuolation. Improvements in the histoarchitecture of the frontal cortex neuronal cells were observed in a dose-dependent manner in the groups that received vitamin C (100 mg/kg, Group III) and the n-butanol fraction of *Curcuma longa* (BFCl) at 750 mg/kg (Group IV) or 1500 mg/kg (Group V) in combination with 120 mg/kg of lead acetate. Previous studies that indicated exposure to lead acetate can alter the brain's histoarchitecture and have a deleterious effect on the brain's functional integrity [32, 33] are consistent with these findings. The antioxidant properties of BFCl have been the subject of numerous studies, which may explain the advantages shown in the groups that received it [14, 31].

Histochemical assessment of the frontal cortex using Cresyl fast violet stain revealed pathological changes, such as pyknosis, cytoplasmic vacuolation, and reduced staining intensity of Nissl bodies in the 120 mg/kg lead acetate group. Nissl bodies are a significant part of the cytoplasm of neurons and are thought to be a reliable sign of neurocyte damage[34]. The frontal cortex of Wistar rat pups treated with vitamin C and BFCl exhibited a dose-dependent rise in the staining intensity of Nissl bodies in layers III and V, indicating that BFCl had a neuroprotective effect against lead acetate-induced tissue damage. The above results have also been reported by earlier studies that examined the cerebral and cerebellar cortices of Wistar rats exposed to lead and discovered similar structures[35–37]. Anterograde and retrograde amnesia may be exacerbated by reduced neurotransmitter synthesis caused by Nissl body degeneration, which may impair impulse transmission to prefrontal cortex cells[3]. Niu et al.[34] also found that there was a striking reduction in Nissl body expression in the lead treatment group in relation to the control group in their study on the effects of lead and fluoride on adult rats' locomotor activity and Nissl body expression in their brains. Similar to this, Olatomide et al. [38] study on the influence of postnatal lead exposure on the growing hippocampal tissue of pups of Wistar rat exposed to lead acetate showed that the hippocampal tissue of exposed pups had changed cytoarchitecture and had less Nissl material staining than that of the control group.

Additionally, several studies have revealed varying degrees of alterations to the Nissl substance following the injection of lead[39.40]. These findings support the current investigation's findings about changes in Nissl body staining and neuronal degeneration associated with lead exposure.

Conclusion

The findings from this study disclosed that the *N-Butanol* Fraction of *Curcuma Longa* (Turmeric) was able to ameliorate lead acetate-induced altered sensory-motor activity, oxidative stress, and histopathological changes in the frontal cortex of Wistar rat pups.

Patient informed consent

There is no need for patient informed consent.

Ethics committee approval

The study obtained ethical endorsement from the Ahmadu Bello University Committee on Animal Care and Use, with the approval number ABUCAUC/2022/049, ensuring the research was conducted in agreement with institutional procedures and regulations for the use and care of animals.

Conflict of interest:

There is no conflict of interest to declare.

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Author Contributions subject and rate

Isaiah Israel Bakenneso (30%): Data collection, analyses and design the research.

Sunday Abraham Musa (25%): Supervision and research organization.

Abubakar Addamu Sadeeq (25%): Supervision and research organization.

Ekpo Ubong Udeme (20%): Analyses and research organization.

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