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Research Article

Potential Therapeutic Implications of *Securidaca longipedunculata* Root Bark Ethanolic Extract in a Rat Model of Traumatic Brain Injury

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ABSTRACT

This study explores the neuroprotective potential of *Securidaca longipedunculata* (Violet tree) used in traditional African medicine for treating traumatic brain injury (TBI). Fifteen albino rats were divided into three groups: a control group without TBI or treatment, a TBI group treated with *S. longipedunculata* (400 mg/kg body weight for 21 days), and a TBI group without treatment. TBI was induced using the weight drop method. Neurological responses were assessed using a revised neurological severity score, and haematological parameters (WBC, RBC, HB, PCV, neutrophils, lymphocytes, and monocytes) were measured, including the neutrophil to lymphocyte ratio. Plasma glucose levels were monitored hourly for three hours post-TBI and daily for three days. Histological analysis of brain tissues was performed. Results indicated that rats treated with *S. longipedunculata* exhibited significantly lower neurological severity scores and better responsiveness compared to untreated TBI rats during the first two weeks of treatment. Treated rats also showed higher PCV, HB, and RBC levels, and lower WBC, neutrophil, and lymphocyte counts. Plasma glucose levels in treated rats steadily decreased, a trend not seen in untreated TBI rats. Histology revealed less severe brain lesions in treated rats. The study concludes that *S. longipedunculata* may reduce inflammatory responses and enhance hematopoietic activity in TBI rats, suggesting its potential for developing new neuroprotective pharmaceuticals.

Keywords: Traumatic brain injury, Securidaca, Haematology, Electrolytes

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INTRODUCTION

Traumatic brain injury (TBI) is an important contributor of fatalities and permanent impairments and a major threat to global health, with an approximately 64–74 million people suffering from a (TBI) annually (Dewan *et al.,* 2018). Traditionally, the Glasgow Coma Scale (GCS) is used to classify traumatic brain injury (TBI) as mild, moderate, or severe at the time of trauma. TBIs are

linked to several different ways to trigger damage, such as falls, injuries sustained in cars or other forms of transportation, injuries sustained in sports, and physical or other forms of violence against another person (such as gunshot and blast injuries).

Age, sex, socioeconomic status, and geographic location all affect these damage processes considerably (Saadi *et al*., 2021) The proportion of traumatic brain injury (TBI) cases in low- and middle-income countries (like Nigeria) is almost three times higher than in high-income countries. This is explained by the prevalence of risk factors for TBI causes (like car accidents) and the disparities in the healthcare systems that affect patients' ability to seek treatment and manage related health effects (Naik *et al*., 2022).

Electrolytes play a major role in cell metabolism because they are crucial cofactors or coenzymes required for appropriate cell activity (Cecchi *et al*., 2024). There are important therapeutic implications for the changes in acid-base balance and haematological parameters seen in TBI (Romero *et al.,* 2018). Electrolytes can function as prognostic indicators for patient outcomes and markers of the severity of injuries. Furthermore, if these disruptions are not treated, they may make medical care more difficult and hasten the degeneration of the nervous system (Okediran *et al.,* 2021). To prevent further neuronal damage, prompt and effective treatment, including fluid resuscitation and control of electrolyte abnormalities is crucial in the initial minutes to days following traumatic brain injury. Because TBI is a complex condition requiring an intricate equilibrium between preventing secondary brain injury and sustaining sufficient blood flow to the brain, fluid therapy poses several challenges for patients with TBI, including avoiding cerebral fluid retention, preserving cerebral perfusion pressure, as well as controlling the risk of acute respiratory distress syndrome (ART) (Kishen, 2023).

Considering there isn't a reliable conventional therapy for traumatic brain injury (TBI) at the moment, it's important to find plants that can mitigate the negative effects of TBI on health.

In the Hausa language of Northern Nigeria, the plant S longipedunculata Fresen, often known as the violet tree, is considered the mother of all remedies. It is a member of the Polygalaceae family. In African nations, Traditional Medicine Practitioners (TMPs) employ its extract to treat a variety of illnesses, including brain abnormalities. In Northeastern Nigeria, it is the plant that TMPs utilize the most commonly to treat cancer (Ngulde *et al.,* 2019). Studies carried out on the extract showed antiproliferative activities on Ehrlich ascites carcinoma invitro and in vivo, lowering vascular development and triggering fragmentation of DNA (Lawal *et al.,* 2012) The root bark extract of *S. longipedunculata* was also reported to have potentials in the treatment of brain tumor (Ngulde *et al.,* 2019). This study investigates the potential of *S. longipedunculata* on traumatic brain injury-induced haematological and neurological alterations in albino rats.

MATERIALS AND METHODS

Experimental Animals

Fifteen (15) healthy albino rats (Wister strain) weighing between 200-250g were obtained from the faculty of Veterinary Medicine, University of Maiduguri, Nigeria for this study. The rats were allowed to acclimatize to the research laboratory conditions for two weeks. The rats were fed with a grower's mash of vital® feed *ad-libitum* and were also given water

Plant Collection and Extraction

Securidaca longipedunculata was collected from Ngulde district in Borno State, Nigeria. The root of the plant was collected, cleaned, and the bark removed, crushed and then air-dried at room temperature for one week.It was pulverized using a mortar and pestle and the ground herb was soaked overnight in petroleum ether at 1:5. The residue from defatted samples was extracted in 95% ethanol at 1:5 for 24hr. The sample was filtered using Whatman filter paper No. 1 and evaporated to dryness under reduced pressure using a rotary evaporator.

Experimental Design

A total of Fifteen (15) seemingly healthy albino rats weighing (200-250g), were randomly divided into three groups I, II and III of five albino rats each.

Group I: Normal rats [Non-traumatized non-treated (NTNT)]

Group II: Traumatize – plus treatment

Group III: TBI-induced rats but not treated (TNT)

Treatment was given daily for twenty-one days at the dose of 400mg/kg body weight of the *S. longipedunculata* root bark ethanolic extract to group II.

Induction of Traumatic Brain Injury

Head injury was induced in the entire group of the experimental animals by means of weight drop method using an acceleration impact device of Marmaru *et al*., (1994) except in group I. The experimental rats were properly restrained and anaesthetized using Xylazine and Ketamine at the dose of 5mg/kg and 80mg/kg body weight respectively. Once the rats are unconscious, the head was shaved using a razor blade and cleaned with an antiseptic (Dettol). The skull was exposed by midline incision (1cm) using a scalpel blade and a blade holder and a stainless steel disc measuring 10mm in diameter and 3mm in depth was cemented centrally along the frontal bone. The experimental animals were secured in

the prone position on a 10cm deep foam bed. The injury was induced by dropping a one-hundred and twenty gram (120g) brass weight from a distance of 1m. The stainless steel disc was immediately removed from the skull; the incised skin was sutured using nylon size 3.0 in a simple interrupted pattern. The animals were allowed to recover in the cage.

Neurological severity score

The score was done as described by Yarnell *et al.* (2016). Two vacant containers were positioned with approximately 25cm between them, a linear balance beam was positioned on top of the containers. Subsequently, a rat was positioned at the initial point of the beam to carry out a series of neurobehavioral assessments while accounting for the element of time. These assessments encompassed various tests, namely the general balance test, landing test, sound reflex, tail raise test, drag test, righting reflex, ear reflex, eye reflex, and paw flexion reflex. The findings are documented in the following manner.

0 = rat was able to do each of the above tests successfully without any hindrance.

1 = the rat had some difficulties while undergoing those tests.

2= rats did not respond. The scale has a total of 0 to 20 scores with higher scores indicating an increase in severity.

Sample collection

At the end of the 21 days treatment period, blood was collected via cardiac puncture after anaesthesia with ketamine and xylazine. The samples were immediately transferred to plane and EDTA sample bottles for heamatology and serum electrolytes determination. Brain tissues were extracted out from the skull and fixed in 10% neutral buffered formalin for histology

Determination of Packed Cell Volume, Erythrocyte Count, Haemoglobin concentration, Total white blood cell count and Differential leukocyte count

Using micro-haematocrit and haematocytometric techniques, packed cell volume (PCV), erythrocyte (RBC), and leukocyte counts (WBC) were individually determined for each blood sample (Weiss and Wardrop,2011). The cyanmethemoglobin technique was used for the determination of hemoglobin concentration (Gheldof *et al.,* 2002).

Evaluation of Glucose and Plasma Proteins

Using digital glucometer and glucometer strip (ACCU CHECK?), the blood glucose level was determined. Briefly, a drop of blood from the tail vain was made onto the glucometer strip appropriately placed in a glucometer and the reading was recorded

Serum electrolytes and total protein determination

O-cresol Phthalein complexion colorimetric method (Kessler *et al.,* 1964) was use for Ca ion determination, Colorimetric method was used for the determination of Na and bicarbonate ions, method of (Tierz Berger, 1976). K ion was determined using Turbidimetric tetraphenylborate (Tierz Berger, 1976) Total protein was determined using the calibration method (*K*oller *et al., 1984*).

Histology

Samples of the brain tissue extracted from all the experimental animals were fixed in 10% buffered formalin for 48hrs. The fixed tissues were dehydrated in graded concentrations of alcohol (70%, 80%, 90% and 100%). The tissues were cleared using xylene. Wax-embedded tissues were sectioned at 0.5µm using a microtome knife attached to a microtome the sectioned tissues were mounted on a grease-free, clean glass slide, dried at room temperature and stained with haematoxylin and eosin (H and E) stain. The slides were viewed under a microscope at different magnifications (x10, x20, x40). The Lumpers technique of ordinal method of scoring was used in scoring the lesions observed in the different groups (Gibson-Corley *et al.,* 2013).

Data Analyses

Data obtained were summarized as means ± standard deviations (SD). Differences between means were analyzed using analysis of variance (ANOVA; One way) followed by Tukey's posthoc test and $p< 0.05$ was considered as statistically significant. Statistical analyses were done using computer software, GraphPad InStat® (2018).

Ethical Statement

All animals were handled according to the ethical procedure approved by the faculty of veterinary medicine committee on animal use and experiment protocol (AUP No: AUP – R001/222)

RESULTS

The effects of *Securidaca* root bark Administration on neurological score in TBI rats

The effects of securidaca root bark administration on neurological score of TBI rats is illustrated in Figure 1. We observed that, securidaca treatment significantly ($p<0.05$) decreased the neurological severity score and improve neurological response of the rats when compared with the TNT rats in the first week of treatment. Furthermore, the decrease in the score continues for the second week, where rats treated with securidaca showed lower score ($p<0.05$) and improved neurological response when compared with the TNT group.

The effects of Securidaca root bark administration on glucose concentrations in TBI rats

Figure 2 depicts the effects of securidaca root bark administration and TBI on glucose concentration in mg/dl from 1st hr to the 3rd hr We observed that the glucose concentration decreased steadily from the 1st hr to the 3rd hr on the first day (Fig 2a) and from day 2 to day 4 (fig2b) in the treated group. However, we observed no steady decrease in glucose concentrations between the hours and days in the TNT rats.

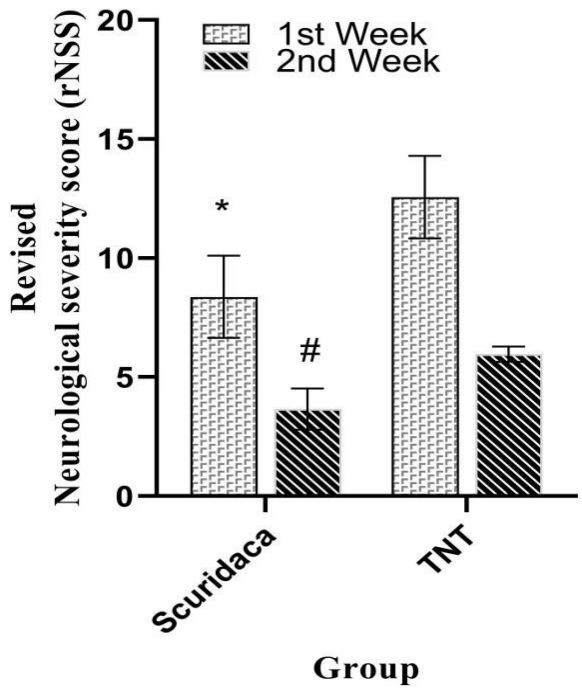

Figure 1: Effects of Securidaca root bark on neurological score in TBI rats

Each bar colour represents a different week. *p<0.05 when compared to TNT in the first week, #p<0.05 when compared to TNT in the second week for ANOVA analysis and Tukey's test.

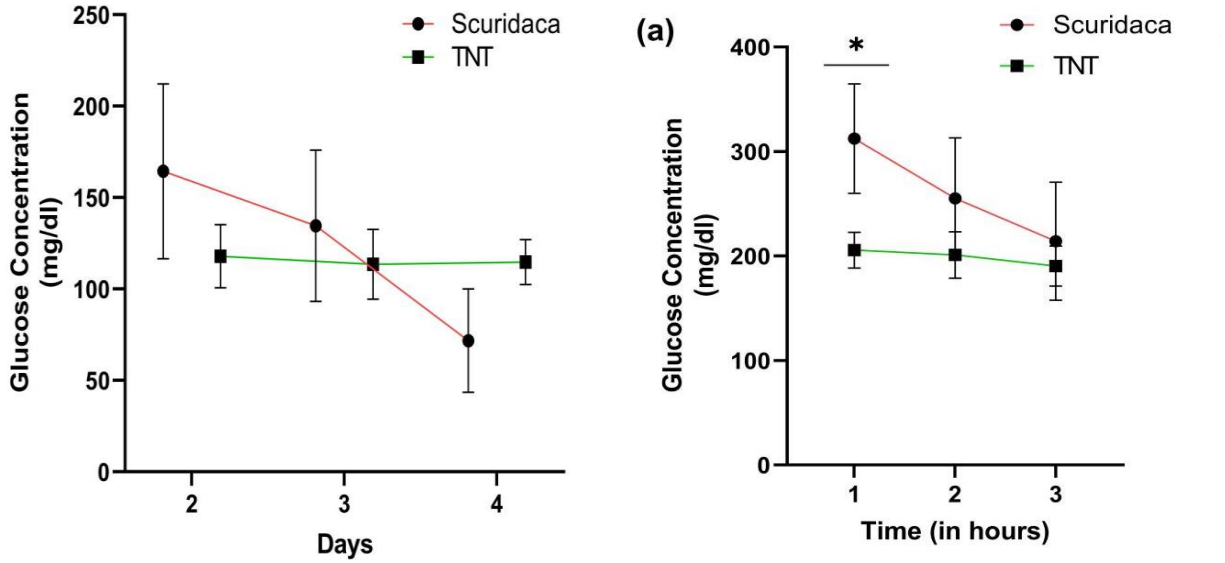

Figure 2a&b: Effects of Securidaca root bark administration on glucose concentration in TBI rats

Effects of Securidaca root bark on RBC, Hb, and PCV in TBI rats

Figure 3 depicts the effects of securidaca root bark administration on red blood cells (RBC), haemoglobin (Hb), and packed cell volume (PCV) in TBI rats post injury. TBI significantly (p<0.0001) decreased RBC level in TNT rats when compared to NTNT rats. However, after treatment with securidaca, RBC level was

significantly (p<0.001) increased when compared with TNT rats (Figure 3a). TBI significantly (p<0.0001) decreased Hb level of TNT rats when compared to the NTNT rats. Subsequently, after treatment with securidaca, the Hb level increased but not statistically significant when compared to the TNT rats (Figure 3b). Furthermore, TBI significantly (p<0.0001) decreased PCV volume of TNT rats when compared to the NTNT rats. Subsequently, after treatment with securidaca, the PCV significantly increased (p<0.05) when compared to the TNT rats (Figure 3a).

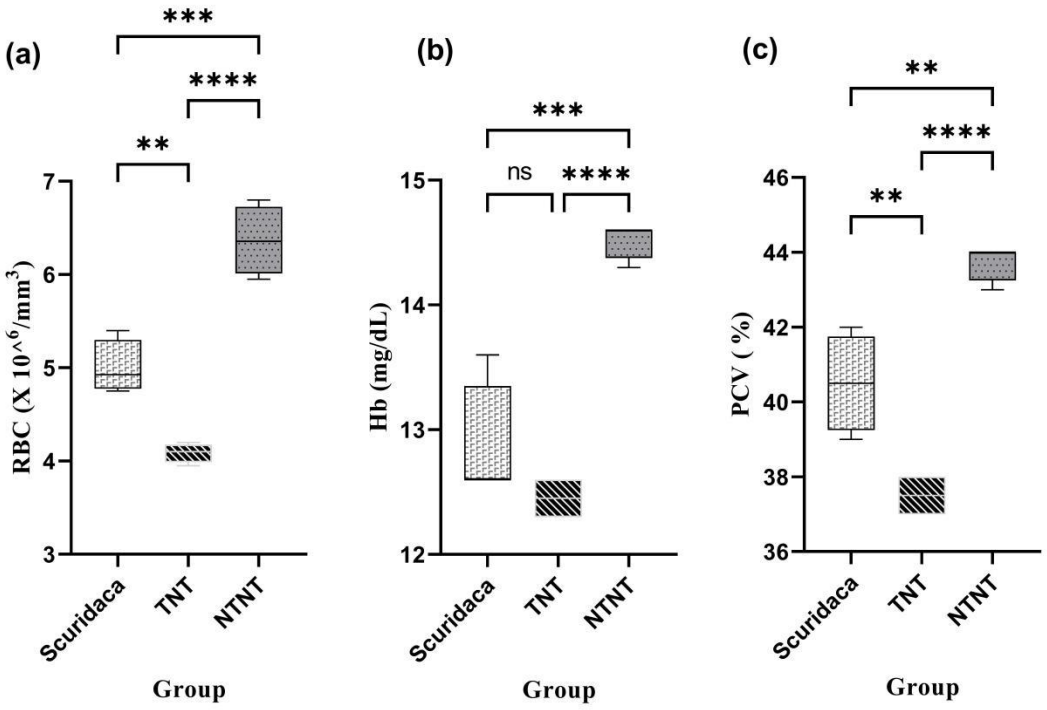

Figure 3: Effects of Securidaca root bark on red blood cells, hemoglobin, and packed cell volume in TBI rats. TNT – Traumatized non-treated, NTNT – Non-traumatized non-treated, ns – not significant, *p<0.05, **p<0.01, ***p<0.001, ****p<0.0001 for ANOVA analysis and Tukey's multiple comparison test

The effects of Securidaca root bark Administration on WBC, neutrophil counts, lymphocyte counts, and neutrophil-lymphocyte ratio in TBI rats

Figure 4 showed significantly (p<0.0001) elevated WBC (Fig 4a), neutrophils (Figure 4b), and lymphocytes (Figure 4c) counts in TNT rats when compared to the NTNT rats. while these levels were significantly (p<0.05) reduced in the securidaca treated groups when compared to TNT group (Figure 4a, 4b & 4c). It was observed that NLR was significantly (p<0.0001) elevated in the TNT rats when compared to NTNT rats. However, NLR was significantly (p<0.001) decreased after treatment with securidaca when compared with TNT rats (Figure 4d).

Effects of Securidaca root bark on Total proteins (TP), sodium (Na), and potassium (K) levels in TBI rats

Figure 5 shows the effects of securidaca root bark administration on total proteins (TP), sodium (Na), and potassium (K) levels in TBI rats. After injury, TBI significantly (p<0.05) elevated the levels of TP in TNT rats when compared to the NTNT rats. However, securidaca treatment significantly (p<0.05) decreased TP levels when compared to TNT rats (Figure 5a). Also, TBI significantly (p<0.05) increased Na level in the TNT rats when compared to NTNT rats. When treated with securidaca, the level of Na significantly (p<0.001) decreased when compared to the TNT rats (Figure 5b). Further analysis revealed that, TBI significantly (p<0.001) increased K level of TNT rats when compared with NTNT rats. However, after treatment, securidaca significantly (p<0.05) decreased K level when compared to TNT rats (Figure 5c).

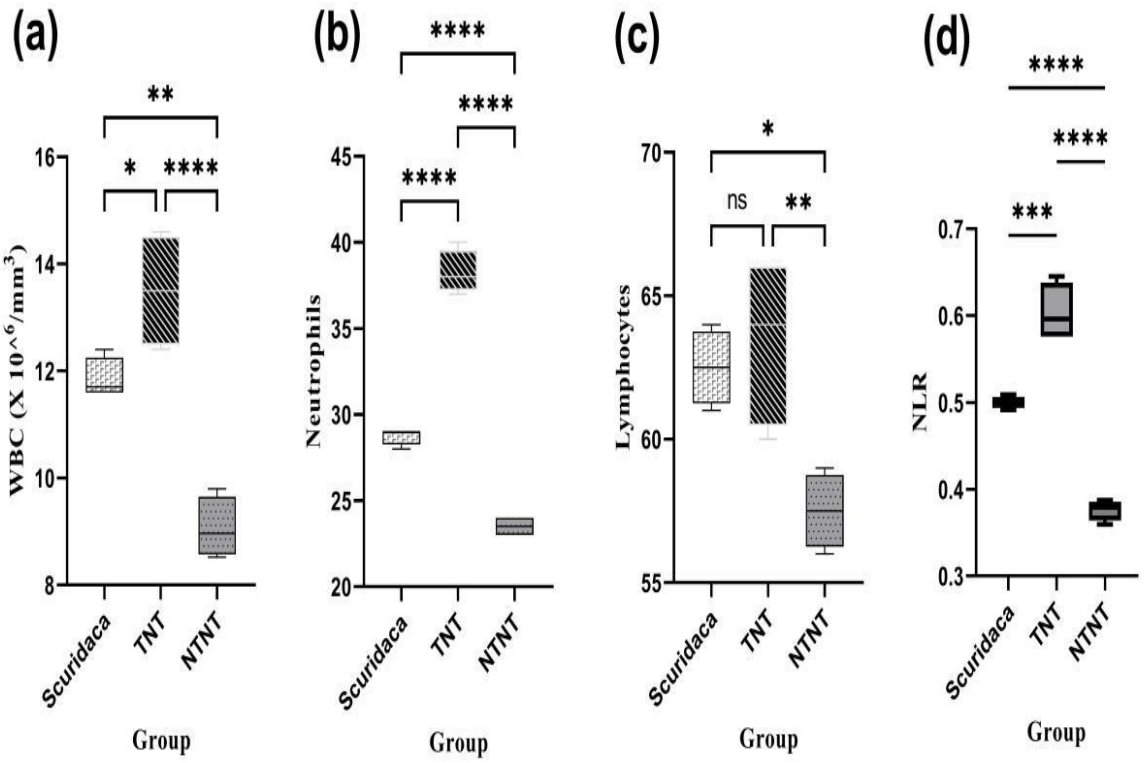

Figure 4: Effects of Securidaca root bark on neutrophil counts, lymphocyte counts, and neutrophil-lymphocyte (NLR) ratio in TBI rats. TNT – Traumatized non-treated, NTNT – Non-traumatized non-treated, ns – not significant, *p<0.05, **p<0.01, ***p<0.001, ****p<0.0001 for ANOVA analysis and Tukey's multiple comparison test

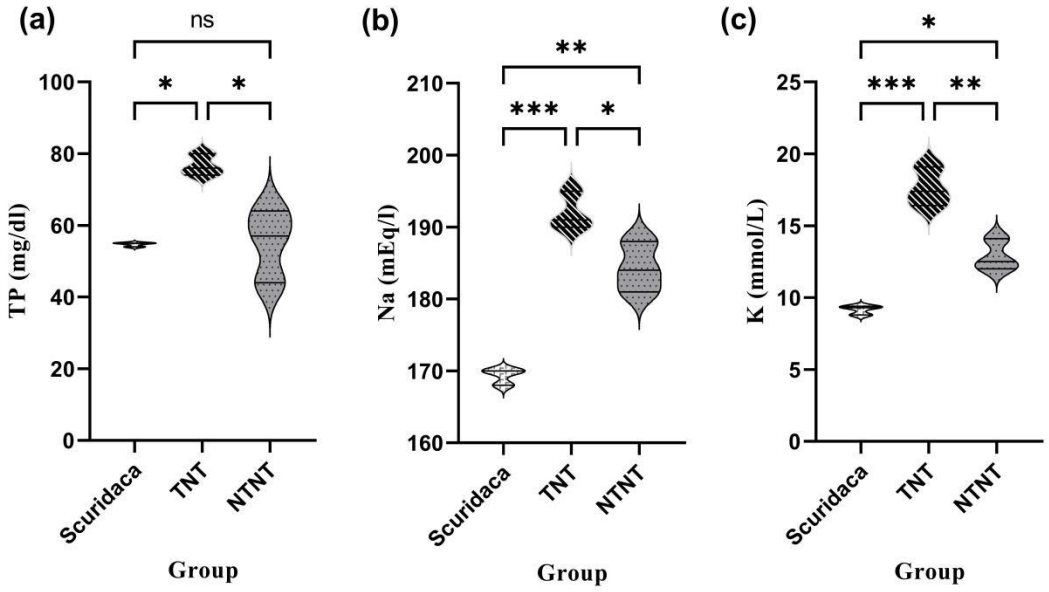

Figure 5: Effects of Securidaca root bark on Total proteins, sodium, and potassium levels in TBI rats. TNT – Traumatized non-treated, NTNT – Non-traumatized non-treated, ns – not significant, *p<0.05, **p<0.01, ***p<0.001, ****p<0.0001 for ANOVA analysis and Tukey's multiple comparison tests

The effects of Securidaca root bark Administration on calcium (Ca) and bicarbonate (HCO_3) levels in TBI rats

The effects of securidaca administration on calcium (Ca) and bicarbonate (HCO_3) levels in TBI rats is illustrated in Figure 6. After injury induction, TBI was observed to have significantly increased Ca level in the TNT rats when compared with NTNT rats. However, after securidaca treatment, Ca levels significantly ($p<0.05$) decreased when compared to TNT rats (Figure 6a). After further analysis, TBI significantly ($p<0.05$) decreased HCO_3 level when compared with NTNT rats. However, after treatment with securidaca, the HCO_3 level increased significantly ($p<0.05$) when compared with TNT rats (Figure 6b).

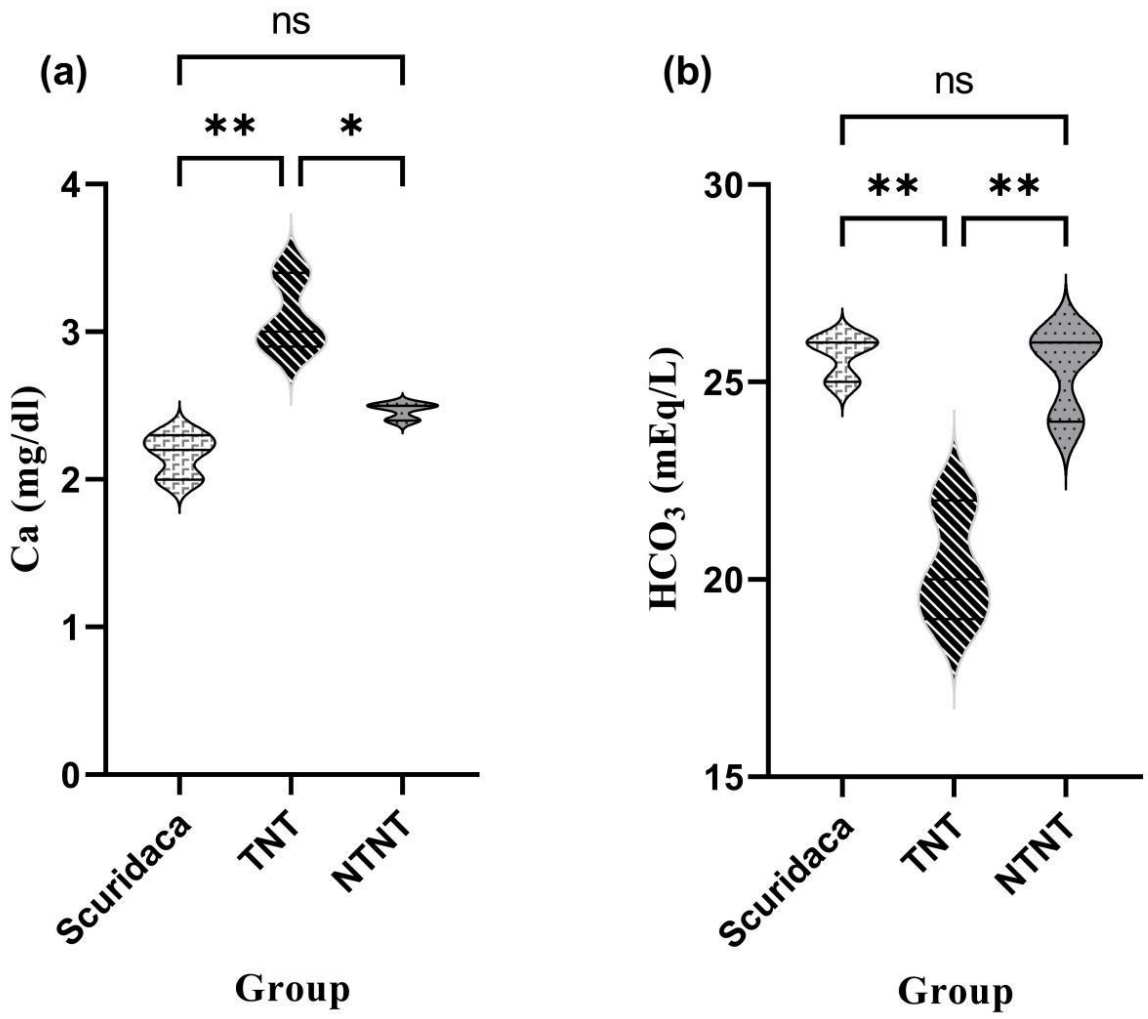

Figure 6: Effects of Securidaca root bark on calcium and bicarbonate levels in TBI rats. TNT – Traumatized non-treated, NTNT – Non-traumatized non-treated. ns – not significant, *p<0.05, **p<0.01, ***p<0.001, ****p<0.0001 for ANOVA analysis and Tukey's multiple comparison tests

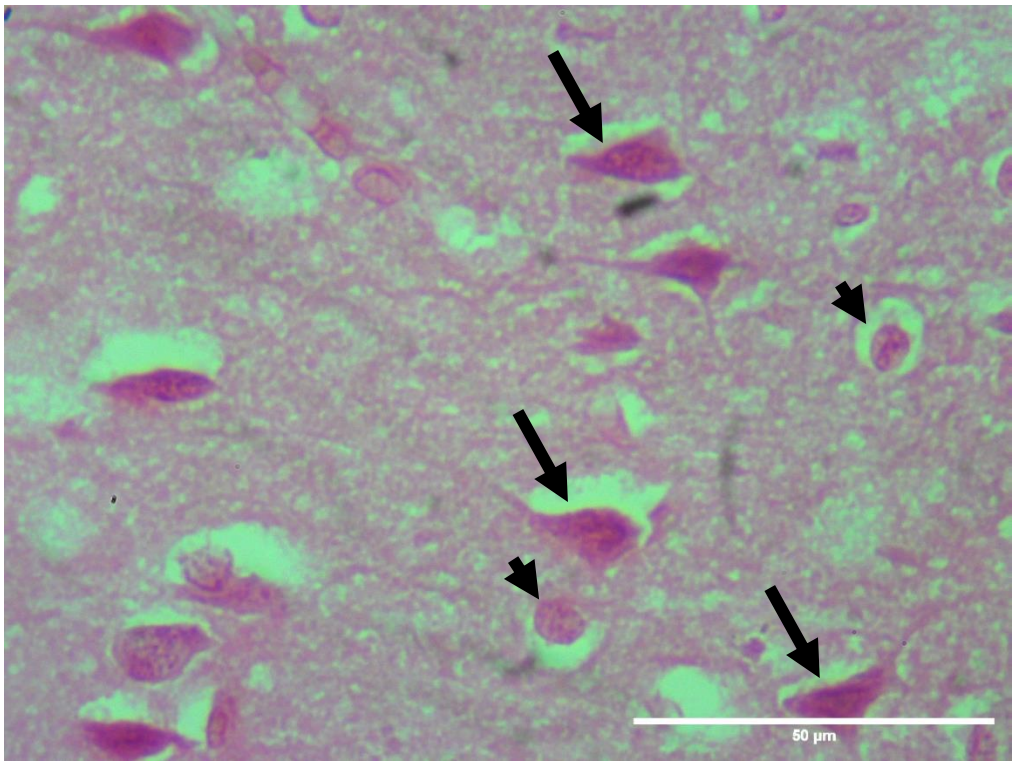

Fig 7;Photomicrograph of brain (cerebrum) of rat of normal control group showing apparently normal oligodendroglial cells (arrowheads) and a shrunken intensely eosinophilic neurons (red neurons) with undiscernible nucleolus (arrows), H & E, X400

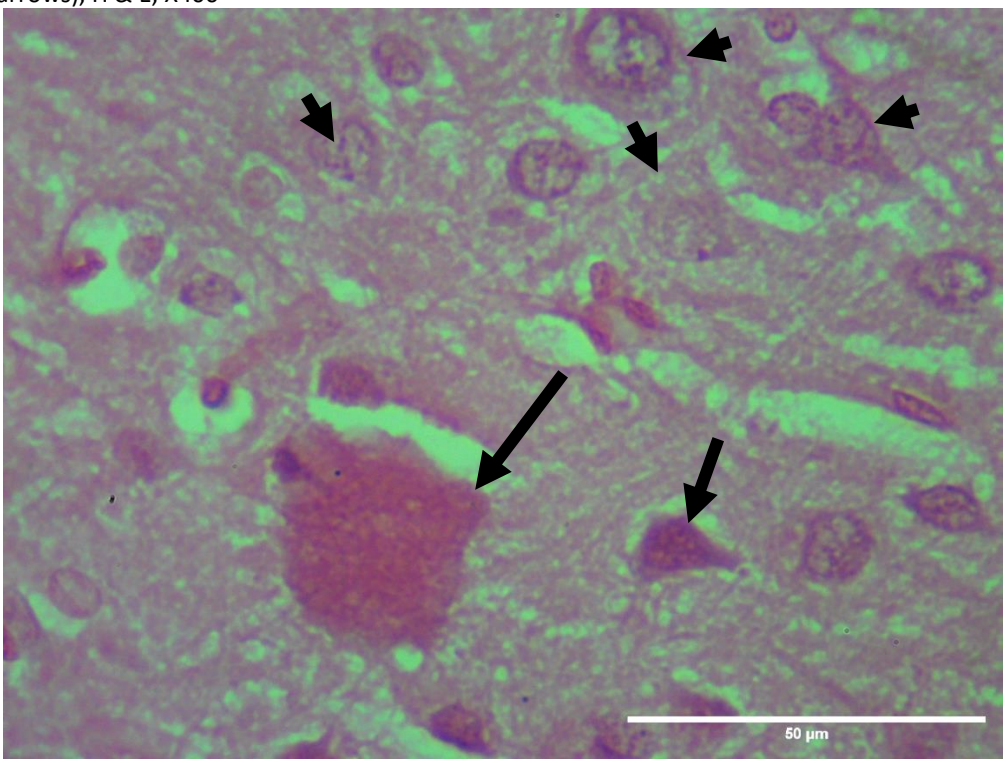

Fig.8;Photomicrograph of brain (cerebrum) of rat of induced non-treated group showing central chromatolysis (arrow) and a shrunken intensely eosinophilic neurons, red meuron (short arrow) with its nucleus shifted to the periphery. other neurons are undergoing degeneration (arrowheads) with undiscernible nucleolus (arrows), H & E, X400

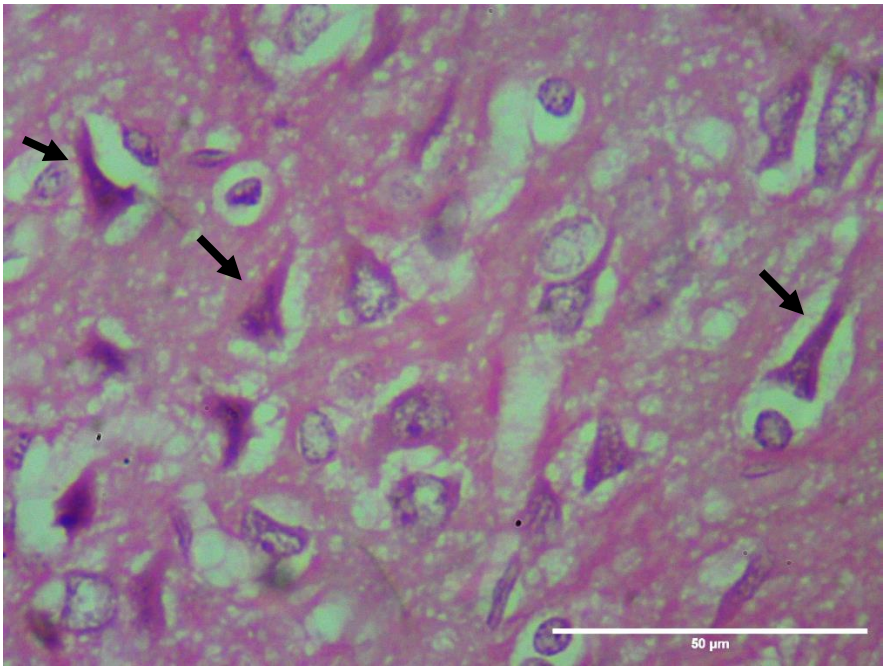

Fig.9;Photomicrograph of brain (cerebrum) of rat of treatment group showing intensely eosinophilic neurons, red neurons (arrows), H & E, X400

DISCUSSION

This study investigated the effects of treating Albino rats with an ethanolic extract from the root bark of *Securidaca longipedunculata* after they experienced traumatic brain damage (TBI). Both the TBI and *Securidaca* root therapy produced different responses in every hematological parameter in the TBI-induced rats. The TNT group showed significant elevations in inflammatory mediators, including differential leukocyte count and total white blood cell count, and significant decreases in red blood cell count, HB, and packed cell volume values. Total protein and electrolytes were elevated. The neutrophil-lymphocyte ratio (NLR), a later measure of inflammation, was similarly higher in the same group after three weeks. After brain damage, *Securidaca* root lessened inflammatory reactions, electrolyte imbalances, and anemia.

Result indicated that rats treated with *Securidaca* root bark have significant improvements in neurological responses and function from the first to the third week, according to the revised neurological severity score. Its neuroprotective, anti-inflammatory and antioxidant properties are responsible for this improvement. It has been demonstrated that antioxidants increase neurological function in brain injuries and neurodegenerative disorders. Anti-inflammatory compounds have also shown this (Bulama *et al.,* 2022). The mechanisms may involve mitochondrial damage, oxidative cell damage caused by free radicals, and inflammation-induced cell damage prevention. By limiting oxidative damage to mitochondrial DNA, proteins, and lipids, antioxidants safeguard mitochondrial function and promote effective energy production and cell survival (Chidambaram *et al.,* 2020). Consequently, neurological response was enhanced by *Securidaca* root bark therapy possibly by inhibiting neuroinflammation and oxidative damage.

Following traumatic brain injury, the brain experiences dynamic alterations in the metabolism of glucose (Demers-Marcil and Coles, 2022). Traumatic brain injury frequently triggers a stress response that is marked by the production of stress hormones such as cortisol, adrenaline, and glucagon. These hormones raise blood glucose levels by promoting glycogenolysis and gluconeogenesis (Dungan *et al.,* 2009). This could be the cause of the elevated plasma glucose level in the first hour following TBI as opposed to the second (when comparing within the same group). Since the extract was administered one hour after induction, the hypoglycemic action of *Securidaca* root may have contributed to the decline in glucose levels observed in the second and third hours. The subsequent glucose reading from day 2 to day 4 confirms *Securidaca*'s hypoglycemic action as the results showed steady decrease in the treated group while the TNT group had inconsistent plasma glucose levels from day 2 to 4

The findings showed that the TNT rats' packed cell volume, hemoglobin, and red blood cell count were significantly lower than those of the NTNT rats. This suggests anemia, perhaps driven by ongoing processes of damage. Reactive oxygen species produced during

traumatic brain injury (TBI) can cause red blood cell loss and consequent anemia, and inflammatory mediators can inhibit erythropoiesis (Bissinger *et al.,* 2018). Anemia in TBI patients and animal models has also been documented in earlier research (Salim *et al.,* 2008; Tango *et al.,* 2009). However, compared to TNT rats, *Securidaca*-treated rats exhibited significant increase in packed cell volume, hemoglobin, and red blood cell count. This rise may have been caused by *Securidaca*'s growing effect on PCV, as reported by Bashir *et al.,* (2015). Increased suppression of erythropoiesis may result from *Securidaca*'s inhibitory action on inflammatory mediators.

When comparing TNT rats to NTNT rats, the white blood cell count increased significantly, suggesting an inflammatory response due to leucocytosis. Similarly, leucocytosis following experimental TBI was observed by Kumar (2012). *Securidaca* root treatment prevented this leucocytosis by dramatically lowering the treated rats' white blood cell count. *Securidaca* has an anti-inflammatory impact; this is supported by the fact that the neutrophil count significantly increased in TNT-treated rats and decreased in rats treated with *Securidaca* roots. Serum cortisol and catecholamine levels may be the cause of leukocytosis in TBI, while *Securidaca*'s inhibitory action on inflammatory mediators seems to offset this. Numerous studies have demonstrated the anti-inflammatory properties of *Securidaca* (Dermane *et al.,* 2024). Suppression of cytokines such as TNF-α, IL-1β, and IL-6, suppression of enzymes like COX2, and enhanced nitric oxide production have all been suggested as potential anti-inflammatory strategies.

According to Dimo *et al.* (2002) and Ezeja *et al.* (2011), there have been reports that suggest potential anti-inflammatory mechanisms such as the suppression of cytokines like TNF-α, IL-1β, and IL-6, the inhibition of enzymes like COX2, and induced nitric oxide synthase (iNOS), which play a role in the production of pro-inflammatory substances.

T cells may not be important in the early stages of TBI pathogenesis, according to available evidence, but since they release pro-inflammatory cytokines, their number may be an indicator of continued tissue damage. Because *Securidaca* inhibits the synthesis of cytokines, it has a therapeutic effect that explains why it suppresses lymphocytes.

Securidaca has anti-inflammatory and neuroprotective properties, as evidenced by the increase in neutrophil-lymphocyte ratio (NLR) in TNT-treated rats and the reduction in NLR in rats treated with *Securidaca* root. NLR may have prognostic significance as demonstrated by its correlation with TBI patient outcomes. Low NLR has consistently been associated with adverse results for TBI patients (Swicker-Gieroba *et al*., 2019).

The brain plays a crucial role in controlling the body's acid-base balance and electrolyte balance. However, its regulatory function may be compromised by brain injury. In line with results from hospital studies (Kocik *et al.,* 2024; Mwachaka *et al.,* 2020), our investigation revealed that TNT rats had low HCO_3 levels, hypernatremia, hypercalcemia, and hyperkalemia in comparison to normal rats. These imbalances worsen secondary damage processes. TBI may result in pituitary or hypothalamic dysfunction, which may lead to insufficient release of ADH and water loss, ultimately culminating in hypernatremia (Pin-on *et al.,* 2018). In addition, fluid loss via fever, perspiration, or osmotic diuresis connected to hyperglycemia in the stress reaction after traumatic brain injury can also result in hypernatremia (Maas *et al.,* 2017). Reduced bone resorption as a result of TBI-induced immobility and increased calcium levels as a stress reaction to injury can both cause calcium release from bone storage.

Furthermore, parathyroid hormone (PTH) secretion may be disrupted by TBI-related hypothalamic dysfunction, which could impact calcium homeostasis (Bakaeva *et al.,* 2022). Potassium is released into the extracellular space by damaged cells, such as neurons and glial cells, which causes hyperkalemia. Low HCO_3 levels and hyperkalemia can result from metabolic acidosis, a secondary cause of traumatic brain injury (TBI) brought on by reduced cerebral perfusion and tissue hypoxia. Remarkably, compared to normal rats, rats treated with *Securidaca* root exhibited rectified electrolyte abnormalities. Its selective actions on the different electrolytes may be the cause of this. After being administered to rats, *Securidaca* significantly lowered the levels of potassium and sodium ions, according to a study by Owoyele *et al.* (2007). Additionally, hypocholeramic effects have been demonstrated (Anuka *et al.,* 2006). In the treated group, the antioxidant properties of *Securidaca* may lessen the oxidative stress and cell damage linked to hypercalcemia and hypernatremia.

Changes in tissue perfusion, disruption of the blood-brain barrier, and systemic inflammatory responses are some of the mechanisms by which TBI can result in fluctuations in plasma protein levels (Wang *et al.,* 2014). TBI causes the release of pro-inflammatory cytokines and the activation of immune cells, which in turn set off a systemic inflammatory response. Through a variety of pathways, such as altered hepatic protein synthesis, increased vascular permeability in peripheral organs, and altered protein turnover rates, this inflammatory cascade can impact plasma protein levels (Wang *et al.,* 2014). Hemorrhage and fluid shifts are linked to TBI, and

these can alter plasma volume and protein content. Elevated plasma protein levels and hemoconcentration can be caused by hypovolemia or hemorrhagic shock.

Similar to this, Timaru-Kast *et al.,* (2012) found that patients with traumatic brain injury (TBI) have altered plasma protein profiles, including variations in inflammatory mediators and different acute-phase proteins. In this investigation, we found that the TNT rats' serum total protein level was significantly higher than the NTNT rats'. The treated rats exhibited a significant decrease in this elevated level of total protein. This may be explained by *Securidaca*'s anti-inflammatory properties, which include its ability to prevent the production and release of inflammatory mediators such as acute phase proteins.

As reported by Andre *et al.* (2014), the TNT group displayed symptoms of neurodegeneration and necrosis in the cerebrum, including dead neurons, diffuse spongiosis, red shrunken neurons (eosinophilic), and central chromatolysis. These findings pointed to diffuse brain damage. According to Anderson *et al.,* (1998), eosinophilic neurons were found in surviving instances within an hour after injury, indicating that many of these lesions are suggestive of the commencement of adverse effects. Similarly, as early as 30 minutes after injury, shrinkage and pyknosis of dead neurons have been observed, and this phenomenon can last for up to a day (Rahaman and Delbigio, 2018).

In this study, three weeks after the lesion, shrinking neurons were seen indicating persistent neurodegeneration, most likely brought on by ongoing free radical production. The group that received treatment with *Securidaca* root bark extract, however, did not have as severe lesions. This could be due to the extract's therapeutic or stabilizing properties, which are linked to its ability to block cytokines and free radicals that facilitate damage processes.

CONCLUSION

In conclusion, traumatic brain injury can cause anemia, neuro-inflammation, tissue destruction, disruption of the delicate electrolyte balance, and acid-base equilibrium. Comprehending the fundamental processes that underlie these alterations is crucial for efficient handling and enhanced results for patients. Healthcare personnel can minimize secondary brain injury and enhance the recovery process for persons with traumatic brain injury (TBI) by rapidly managing electrolyte imbalances, anemia, acid-base abnormalities, and neuroinflammation.

Our results point to the potential neurotherapeutic ability of *Securidaca* root bark by demonstrating that intervention with the bark can ameliorate these alterations. To precisely pinpoint the mechanism(s) of action and isolate the bioactive components in charge of its neurotherapeutic actions, more research is needed.

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CONFLICT OF INTEREST

The authors assert that there are no conflicts of interest in the current study.

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