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The Neuroprotective Effect of Sesame Seed Oil on Cuprizone-Induced Cerebellar Damage in Male Wistar Rats

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Abstract

Cuprizone (CZ) is a copper chelator often used in laboratory research to induce demyelination in animal models. It helps to study the processes involved in demyelination and remyelination, which are relevant to multiple sclerosis research and other demyelinating diseases. This study explored the effects of Sesame seed oil (SSO) on oxidative, histomorphological and behavioral changes in CZ-damaged cerebellum. Twenty-four adult male Wistar rats were purchased and acclimatized for a week. They were, however, grouped into four and administered the following, respectively; Group A received standard rat feed (control), Group B received 2 g of CZ per 1 kg of rat/day, Group C received 5 mL SSO per 1 kg of rat/day, and Group D received 2 g of CZ per 1 kg of rat/day + 5 mL SSO per 1 kg of rat/day. This was done consecutively for 3 weeks with the use of oral cannula. The animals were assessed for exploratory and locomotor activities while the cerebellum was processed for histology, assayed for catalase chloramphenicol acetyltransferase (CAT) and superoxide dismutase (SOD) activities with immunohistochemical using ionized calcium-binding adaptor molecule 1 (IBA1). CZ treatment caused weight reduction, disruption of Purkinje cell layer, cellular degeneration, and reduction in CAT and SOD activities with IBA staining. However, these changes were ameliorated when co-administered with SSO. The results suggested that SSO contains potent anti-oxidant and anti-inflammatory characteristics that can help to alleviate the harmful effects of CZ in various regions of the body.

Keywords: Cerebellar damage, Cuprizone, Demyelination, Oxidative enzymes, Sesame seed oil

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Introduction

Multiple sclerosis (MS) is a potentially catastrophic illness affecting the brain and spinal cord (central nervous system [CNS]). In MS, the immune system damages the protective sheath (myelin) that covers nerve fibers, causing communication difficulties between the brain and the rest of the body. Over time, the condition can lead to irreversible nerve fiber loss or degeneration.[1]

MS continues to be the most common immune-mediated demyelinating disease in high-income countries. According to the Atlas of MS (2020) by the MS International Federation, the global median prevalence has increased to approximately 36/100,000 population, with the highest rates in North America (over 140/100,000) and Europe (over 130/100,000), and the lowest in Sub-Saharan Africa and East Asia (both under 5/100,000).[2]

In MS, the meninges frequently harbor B-cell-rich inflammatory infiltrates that are associated with cortical demyelination, neuronal loss, and progressive clinical disability. These ectopic lymphoid structures, particularly in secondary progressive MS, are believed to sustain chronic inflammation and neurodegeneration in adjacent cortical tissue. Due to the limited availability of human CNS tissue, researchers employ various animal models, including mice, rats, goats, and non-human primates, to replicate different pathological characteristics of MS. In addition, cell-based therapies, that is, stem cell transplantation in pigs, rabbits, and non-human primates, have been explored to examine remyelination, immune modulation, and repair mechanisms.[3]

Sesame seed oil (SSO) is an edible vegetable oil derived from the sesame plant (*Sesamum indicum* L.).[4] This plant, a member of the Pedaliaceae family, is believed to be the first oilseed used by humans.[5] Compared to many other vegetable oils, SSO contains a higher proportion of unsaturated fatty acids, particularly oleic acid (monounsaturated) and linoleic acid (polyunsaturated), making it a valuable dietary source of essential fatty acids.[6] Sesamin and sesamolin are two major lignans found in sesame seeds. Bioactive compounds in SSO-particularly sesamin, sesamol, and sesamolin exert notable lipid-lowering effects, including the reduction of total cholesterol, low-density lipoprotein-cholesterol, triglycerides, and arachidonic acid levels. These compounds also act by inhibiting cholesterol absorption and biosynthesis, and they demonstrate anti-inflammatory and immunomodulatory activities through modulation of cytokine expression and oxidative stress pathways.[7] SSO contains a wide range of bioactive compounds, including sesamin, sesamol, and tocopherols, which contribute to

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its medicinal properties. Antioxidants and anti-inflammatory agents play a crucial role in maintaining overall health by neutralizing harmful free radicals and reducing chronic inflammation. Several recent studies confirm that the natural lignans in sesame seeds, including sesamin and sesamolin, possess a wide spectrum of bioactive properties. These include anti-inflammatory, antioxidant, anticancer, antihypertensive, anti-melanogenic, otoprotective, and cholesterol-lowering effects. Furthermore, these compounds exhibit cardioprotective, hepatoprotective, and nephroprotective activities, making them promising agents for chronic disease prevention and health maintenance.[8]

Cuprizone (CZ) is a widely used copper-chelating compound that induces reversible, non-immune-mediated demyelination in the CNS of rodents, particularly targeting oligodendrocytes. This toxic demyelination model mimics features of MS, particularly white matter loss, making it a powerful experimental tool for studying remyelination and neuroinflammation.[9] Copper, an essential component of the respiratory chain complex IV-cytochrome c oxidase in oligodendrocytes – is effectively chelated by CZ.[10] Its administration leads to severe astrocytosis, microglial activation, and oligodendrocyte damage.[11]

In 1972, it was discovered that oral administration of CZ to mice causes oligodendrocyte degeneration. Since then, the CZ mouse model has become one of the most significant *in vivo* models for studying the pathology of MS and other disorders involving oligodendrocyte pathology. The mechanisms underlying CZ toxicity within the CNS are not fully understood. However, it likely disrupts mitochondrial processes and inhibits copper-dependent detoxifying enzymes, such as superoxide dismutase (SOD), by chelating copper ions. These disruptions result in increased oxidative stress, neuroinflammation, and the loss of myelin-producing oligodendrocytes.[12]

Materials and Methods

This research was conducted at the Animal House of Anatomy Departmental Laboratory, University of Ilorin, Nigeria. The study lasted from November 2022 to February 2023 and received approval from the University Ethical Review Committee.

The following materials were utilized for this project:

- CZ, SSO, formalin, hand sanitizers, oral cannula, dissecting sees, distilled water, feeding and drinking plates, towels, permanent markers, sawdust, rat cages, pellet rat feeds, cam scanners, dissecting table, hematoxylin and eosin (H&E), Morris water maze, open field box, and Y-maze box.

Experimental Design

Male Wistar rats, with an average weight of 58–117 g, were obtained from ShowGold Laboratory, Oye-Ekiti, Ekiti State, Nigeria.

The animals were divided into four groups (A, B, C, and D). The first group (Group A) was the control group and the rats in this group were given 0.5 mL of normal saline, the rats in the second group (Group B) were fed with 0.2% CZ (0.2 g of CZ/100 g of feed) daily for 3 weeks, Group C were given Sesame oil (5 mL/kg) through oral cannula, and the last group (Group D) were fed with 0.2% CZ and oral dose of Sesame oil (5 mL/kg). This treatment was carried out daily for 3 weeks.

The weights of the animals in each group were taken on the 1st day of procurement and every other day during the period of acclimatization (7 days) before the commencement of administration. After administration started, their weights were taken every day from the 1st day of administration for 3 days until they were sacrificed.

Behavioral Test

The behavioral tests were carried out at the Neurobehavioral laboratory, Faculty of Basic Medical Sciences, University of Ilorin, Kwara State, Nigeria.

Biochemical Analysis

About 24 h after the last administrations, the rats were decapitated, the cerebellum was taken, and it was weighed using a sensitive weighing scale, homogenized in a molar of cold sucrose.

Assay of SOD Activity

SOD activity was determined by its ability to inhibit the auto-oxidation of epinephrine determined by the increase in absorbance at 480 nm as described by Sun and Zigman (1978). The reaction mixture (3 mL) containing 2.95 mL 0.05M sodium buffer pH 10.2, 0.02 mL of serum sample, and 30 µL of 2 mm epinephrine reagent was used to initiate the reaction. The reference cuvette contained 2.95 mL buffer, 0.03 mL of substrate (epinephrine), and 0.02 mL of distilled water. The absorbance was read at regular intervals of 1 min for 3 min at 480 nm (Zou *et al*., 1986).

$$\text{The activity of SOD} = \frac{dA/\text{min} \times TV}{E \times Sv}$$

Where:
Tv is the total volume
Sv is the sample volume
E = molar extinction (E = 4020/m/cm)
dA = change in absorbance

Catalase Assay

Catalase activity was assayed according to the procedure reported by Sinha (1972). The reaction mixture (1.5 mL) contained 1.0 mL of 0.01 M phosphate buffer (pH 7.0), 0.1 mL of sample, and 0.02M H_2O_2. The reaction was stopped by the addition of 2.0 mL of catalase reagent. The absorbance was read at regular intervals of 1 min for 3 min at 620 nm against the reagent blank.

$$\text{Catalase activity} = \frac{dA/\text{min} \times Tv}{E \times Sv}$$

Where:
Tv is the total volume
Sv is the sample volume
E = Molar extinction (E = 4020/m/cm)
dA = Change in absorbance

Data Analysis

Data obtained were analyzed and subjected to statistical analysis using version 8 of GraphPad Prism software. Data were presented as mean ± standard error of the mean with determination of level of significance at $P < 0.05$ or 0.01. The results obtained were also presented in bar charts with error bars, using version 8 of the GraphPad application.

Research Gaps

1. Natural product-based neuroprotection: This study adds valuable evidence supporting SSO as a candidate for neuroprotection.
2. Anti-oxidant and anti-inflammatory mechanisms in neurotoxicity: By investigating sesame oil's role in modulating oxidative stress and neuroinflammation, the study helps bridge nutritional neuroscience and neuropharmacology.

Limitation of Study

1. Long-term neuroprotective effects or potential side effects of sesame oil may not be captured during duration of this study
2. Female rats may respond differently due to hormonal and genetic factors influencing neurodegeneration and repair.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to research, authorship, and/or publication of this article.

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Results

Body Weight Changes in Experimental Animals

The measurements of the experimental animals' body weight across the groups are depicted in [Table 1]. The result revealed that the body weights of the rats in the control group had the highest weight gain (35.00 ± 3.000), followed by the animals in the Sesame group (24.50 ± 2.500), the group treated with CZ had (23.00 ± 7.00) weight gain. The animals in the group treated with the group co-treated with SSO and CZ gained the least weight (17.00 ± 0.00).

Maze and Open Field Test

The result from the y-maze and open field test shows that the group of rats exposed to CZ has the lowest percentage of correct alternations compared to all the groups in the study. The group of rats that were treated with SSO has lower percentage correct alternations compared to the Control group but higher than the CZ group. The group of rats treated with both SSO and CZ had a lower percentage of correct alternation when compared to the control group [Figure 1].

Open Field Test

The rearing frequency of rats in the control group was significantly higher than that of the rats in other groups ($P < 0.05$). The group of animals treated with CZ had the least rearing frequency, the animals in the SSO group had a higher rearing frequency than the CZ group and also slightly higher than those in the SSO and CZ combined treated group [Figure 2].

The stretch attempt of the animals in the SSO group is higher than the animals in the control group, and also higher than the animals in the group of animals treated with both SSO and CZ. The stretch attempt is lower in the CZ group compared to the control and SSO-treated group [Figure 3].

The result revealed that the animals in the control group significantly crossed more lines than all the animals in the other groups ($P < 0.05$). The animals in the SSO-treated group crossed more lines than the animals in the CZ group. The group treated with both SSO and CZ crossed the least lines [Figure 4].

Biochemical Analysis

The rats in the control group showed a higher SOD activity compared to the group treated with CZ. The cerebellar cortex of rats treated with SSO had a higher SOD activity compared to the

Table 1: Measurements of body weight changes in experimental animals (mean±SEM)

Groups	*Initial weight (g) mean±SEM*	*Final weight (g) mean±SEM*	*Weight difference (g) mean±SEM*
Control	111.5±6.50	146.5±9.50	35.00±3.00
Cuprizone	117.5±0.50	140.5±6.50	23.00±7.00
Sesame	107.0±7.00	131.5±4.50	24.50±2.50
CPZ+SSO	116.0±1.00	133.0±1.00	17.00±0.00

SEM: Standard error of the mean, CPZ: Cuprizone, SSO: Sesame seed oil

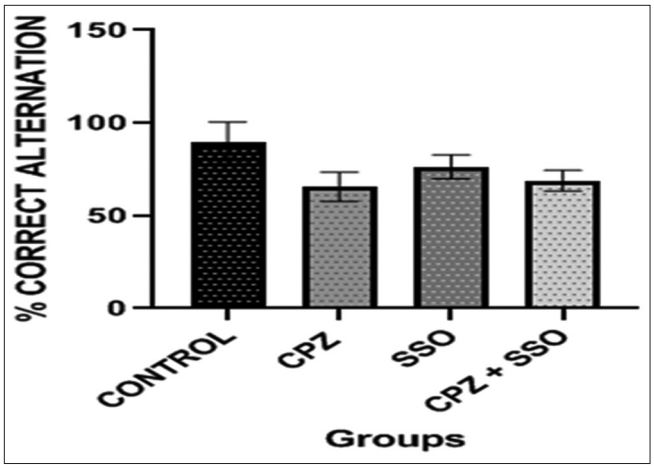

Figure 1: Comparison of the percentage of correct alternations across the groups

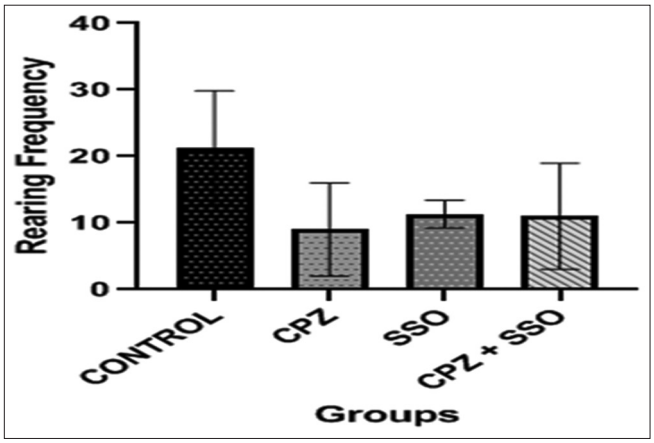

Figure 2: The rearing frequency in the open field test

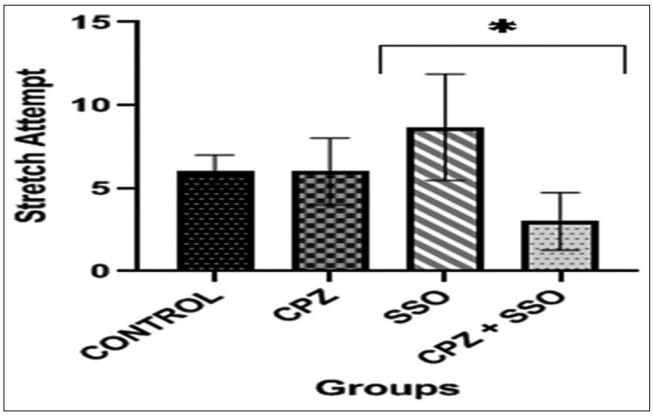

Figure 3: Stretch attempt of the animals in the open field

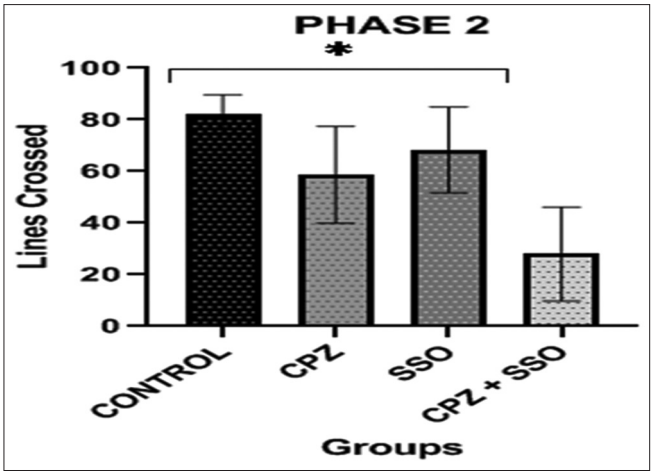

Figure 4: The number of lines crossed by the animals in the open field

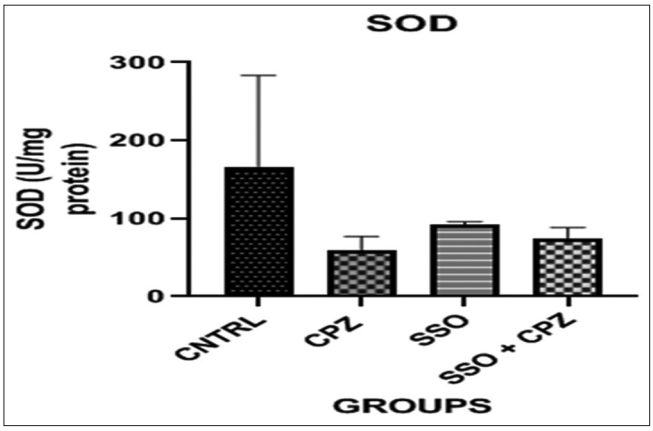

Figure 5: Biochemical analysis of superoxide dismutase activity in the cerebellum after 14 days of administration

cerebellar cortex of rats co-treated with CZ and SSO [Figure 5].

The biochemical analysis of chloramphenicol acetyltransferase (CAT) revealed that the cerebellar cortex of rats in the control group showed a higher CAT activity compared to those treated with CZ. The cerebellar cortex of rats treated with SSO had a higher

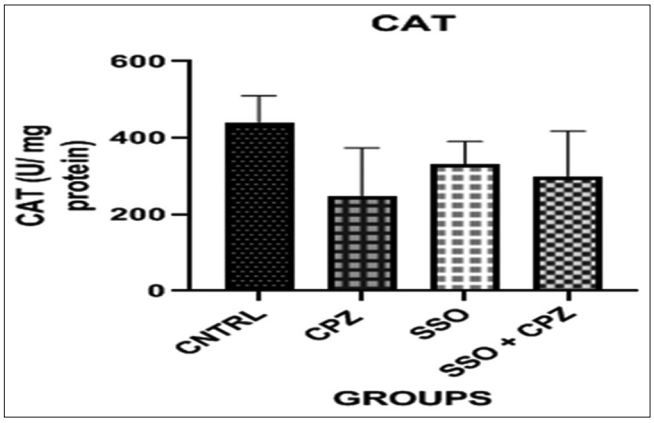

Figure 6: Biochemical analysis of chloramphenicol acetyltransferase activity in the cerebellum after 14 days of administration

CAT activity compared to the cerebellar cortex of rats co-treated with CZ and SSO [Figure 6].

Histological and Histochemical Observation

Demonstration of H&E

The cerebellar cortex of the CZ-treated rats showed degenerated Purkinje cells with pyknotic cell bodies and inconspicuous dendritic processes, along with a less dense granular layer (GL) compared to the control, as depicted in [Plate 1]. The cerebellar morphology of the CZ + Sesame treated group resembled that of the control and sesame-only groups. The animals in the control group and the animals treated with sesame oil had densely packed and intensely stained granule cells within the GL. CZ-treated groups show fragmented granule cell layers with degeneration of Purkinje cells and the presence of short dendrites. Neuronal morphology and cerebellar layers in the combined group appeared normal with the presence of neurons with the presence of healthy somas, axons, and dendrites (H & E × 100).

Demonstration of Cresyl Fast Violet

Examination of the cerebellar cortex of rats in the control group showed numerous Nissl substances with granule cells which were also intensively stained and compactly packed as depicted in [Plate 2]. The CZ-treated rats presented with extreme Purkinje neurons in the Purkinje cell layer. In comparison to the CZ -treated rats, the CZ and Sesame-treated rats had more healthy Purkinje cells and compactly packed granule cells in the granule cell layer, with staining intensities comparable to the control and sesame-treated rats.

Immunohistochemical Analysis

Ionized calcium-binding adaptor molecule 1 (IBA1) staining for the control group depicts IBA1 expression and the microglial was within baseline levels. The CZ group shows significantly increased IBA1-positive cell densities after 3 weeks of CZ induction. The SSO group indicates a minimal level of IBA1-positive cell density. The combined group shows a decreased density of IBA1-positive cells relative to the CZ group (IBA × 100).

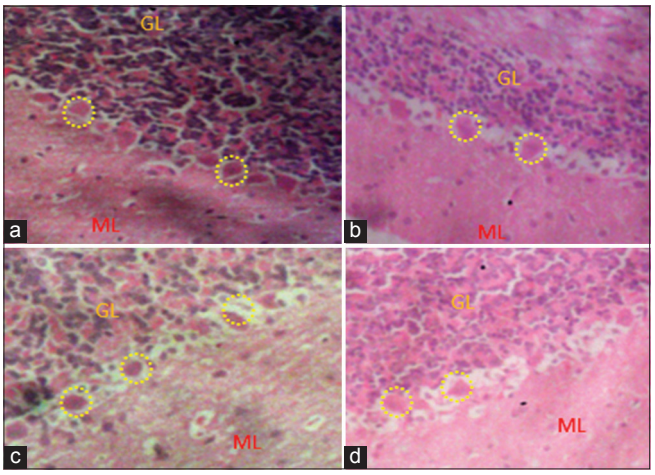

Plate 1: (a-d) Representative photomicrograph of hematoxylin and eosin stain of the cerebellum of male adult Wistar rats showing the molecular layer, granular layer, and Purkinje cells following hematoxylin and eosin staining procedure ×100

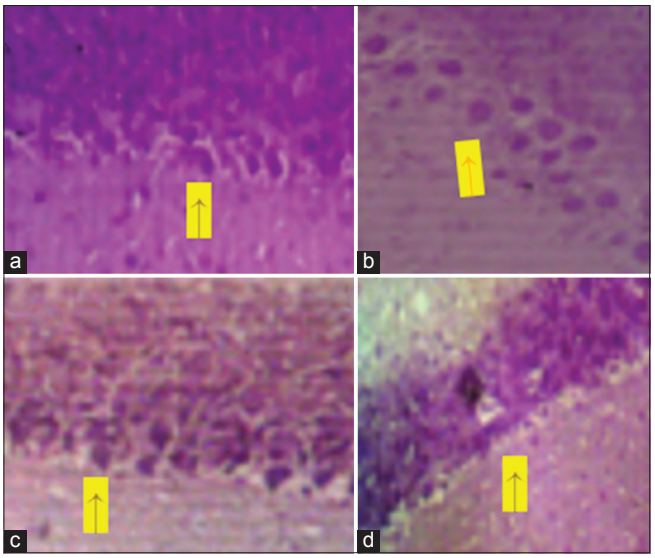

Plate 2: (a-d) Representative photomicrograph to demonstrate Nissl bodies in the cerebellar cortex of Wistar rats. The control and the sesame-treated groups presented with intensively stained nicely substance with conspicuous cell bodies of the Purkinje cells and apparent axon projecting into the molecular layer (ML). The ML is demarcated from the granular layer by a single layer of the Purkinje cells. In cuprizone-treated rats, the Purkinje layer was irregular in outline with degenerated granule cells in the granular layer. Relative to the cuprizone-treated rats, the cuprizone + sesame seed oil-treated rats presented with more healthy Purkinje cells and compactly packed granule cells with a staining intensity similar to those of the control and sesame-treated rats (CFV ×100)

Discussion

This study has shown the neurotoxic effect of CZ on the cerebellum of adult male Wistar rats following administration of CZ and the possible ameliorative effect of sesame oil on cerebellum-induced neurotoxicity. CZ (cyclohexylidene hydrazide) is a copper-chelating agent that is selective and sensitive. CZ is used to induce toxic demyelination similar to that seen in MS.[9] However, sesame oil

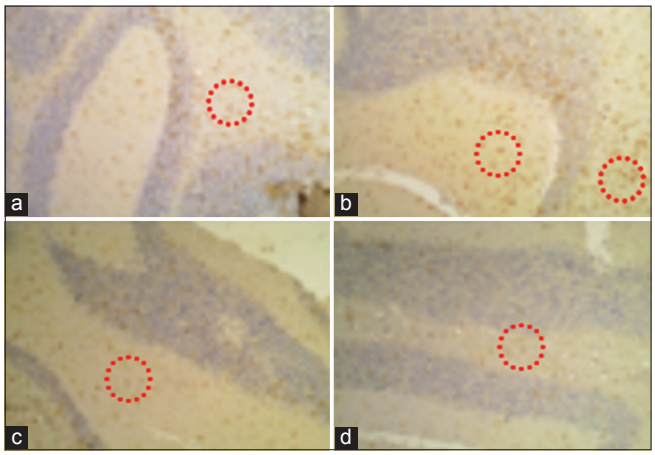

Plate 3: (a-d) Photomicrograph showing ionized calcium-binding adaptor molecule 1 immunohistochemical staining of the cerebellum. Microglia activation in the cerebellar cortex of cuprizone-induced adult male Wistar rats

is a dietary supplement with anti-inflammatory and antioxidant properties (Hsu and Parthasarathy, 2017).

In this study, observations of the body weights of rats showed that rats in the sesame group gained the highest amount of weight followed by the rats in the control group. Groups treated with CZ and Sesame + CZ shows slight increase in weight change and averagely relative to others. This indicates that SSO may have a supportive effect on general health and metabolism, mitigating the weight loss typically associated with neurotoxicity. SSO, when combined with CPZ, contributed to ameliorate CPZ's weight-lowering effect. This is consistent with the finding of a research conducted by Omotosho *et al.*, which linked CPZ consumption to weight loss.[13]

Rats in the CZ-only group showed reduced activity in the Open Field test, with lower line crossings and rearing, indicating impaired exploratory behavior and increased anxiety. In the Y-Maze test, this group displayed fewer spontaneous alternations, suggesting deficits in spatial memory and cognitive flexibility. These results are consistent with the neurotoxic effects of CZ, which impacts both motor and cognitive functions.[12] In contrast, rats treated with both CZ and SSO showed marked improvements. They exhibited more line crossings and rearing in the Open Field test, reflecting enhanced exploration and reduced anxiety. In the Y-Maze test, the CZ + SSO group demonstrated improved alternation rates, indicating better memory performance compared to the CZ-only group.

In the histoarchitectural and histochemical findings, the cerebellar cortex of the CZ-treated rats showed degenerated Purkinje cells with pyknotic cell bodies and inconspicuous dendritic processes, along with a less dense granular layer (GL) compared to the control. These findings are illustrated in Plate 1. The cerebellar morphology of the CZ + Sesame treated group resembled that of the control and sesame-only groups. The animals in the control group and those treated with sesame oil had densely packed and intensely stained granule cells within the GL. CZ-treated groups showed fragmented granule cell layers with degeneration of Purkinje cells and shortened dendrites. Neuronal morphology and cerebellar layers in the combined group appeared normal, displaying healthy somas, axons, and dendrites (Plate 1).

Further confirmation of these findings was provided through Cresyl Fast Violet (CFV) staining. The cerebellar cortex of rats in

the control group showed an abundance of Nissl substances, with intensively stained and compactly packed granule cells, as visualized in Plate 2. Rats treated with CZ displayed extreme neuronal degeneration in the Purkinje cell layer. Conversely, co-treatment with sesame oil resulted in marked preservation of cerebellar structure, evidenced by healthier Purkinje cells and densely packed granule cells. The neuroprotective role of sesame oil observed here is supported by several studies highlighting its antioxidant and anti-inflammatory components, such as sesamin and sesamolin, which are known to scavenge free radicals and modulate inflammatory pathways.[4,6,8,14] The staining intensity in this group was comparable to both the control and SSO-only groups (Plate 2).

To assess neuroinflammatory responses, immunohistochemical analysis was performed using ionized calcium-binding adaptor molecule 1 (IBA1). As shown in Plate 3, IBA1 staining in the control group indicated microglial activation within baseline physiological levels. However, the CZ group exhibited significantly increased IBA1-positive cell density, indicating pronounced microglial activation after three weeks of CZ induction. Notably, the SSO-only group showed minimal IBA1-positive cell presence, while the CZ + SSO group demonstrated substantially reduced IBA1-positive cell density in comparison to the CZ-only group, suggesting an anti-inflammatory effect of sesame oil (Plate 3).

The anti-oxidative enzymes examined in this study (catalase and SOD) have a similar pattern of effect, with CZ intoxication resulting in a significant decrease in the activity of these enzymes. Because SSO contains significant levels of powerful natural antioxidant components, the CPZ-lowering impact of anti-oxidative enzymes was neutralized when combined with CZ in this study.

Conclusion

This study highlighted SSO's potential as a therapeutic agent for neurodegenerative conditions characterized by demyelination, such as MS. Future studies should explore its efficacy in clinical settings and investigate the underlying molecular mechanisms to validate its role in neuroprotection and potential translational applications in human neurodegenerative diseases.

References

1. Oliver-Hall H, Ratschen E, Tench CR, Brooks H, Constantinescu CS, Edwards L. Pet ownership and multiple sclerosis during COVID-19. Int J Environ Res Public Health 2020;18:12683.
2. Multiple Sclerosis International Federation. Atlas of MS 3rd Edition: Mapping Multiple Sclerosis around the World. MSIF; 2020. Available from: https://www.atlasofms.org [Last accessed on 2025 Jul 31].
3. Wang S, Qu X, Zhao RC. Mesenchymal stem cell-based therapies in experimental autoimmune encephalomyelitis and MS. Stem Cell Res Ther 2023;14:21.
4. Imran M, Khan MS, Ali M, Nadeem M, Mushtaq Z, Ahmad M, *et al*. Cold pressed sesame (*Sesamum indicum*) oil. In: Cold Pressed Oils. United States: Academic Press; 2020.
5. Pal D, Chandra P, Sachan N. Sesame Seed in Controlling Human Health and Nutrition. United States: Academic Press; 2020. p. 183-210.
6. Pradhan RC, Meda V, Rout PK, Naik SN, Das LM. Composition and physico-chemical properties of oils extracted from selected oilseeds available in India. Biomass Convers Biorefin 2021;11:499-510.
7. Patergnani S, Fossati V, Bonora M, Giorgi C, Marchi S, Missiroli S, *et al*. Mitochondria in multiple sclerosis: Molecular mechanisms of pathogenesis. Int Rev Cell Mol Biol 2017;328:49-103.
8. Kumar P, Rani M. Sesame lignans in health promotion and disease prevention: Insights from chemical structure to therapeutic applications. Phytother Res 2021;35:2513-30.
9. Ghosh M, Sharma S. Sesamin and sesamolin: Nutraceutical potential and molecular insights into their therapeutic benefits. Crit Rev Food Sci Nutr 2022;62:5835-53.
10. Prajeeth CK, Singh YP. Cuprizone-induced demyelination: Mechanisms and therapeutic strategies. J Neuroimmunol 2021;354: 577525.
11. Berghoff SA, Spieth L, Sun T, Hosang L, Schlaphoff L, Depp C, *et al*. Microglia facilitate repair of demyelinated lesions via post-squalene sterol synthesis. Nat Neurosci 2021;24:47-60.
12. Duncan ID, Radcliff AB. Inherited and acquired disorders of myelin: The underlying myelin pathology. Exp Neurol 2016;283:452-75.
13. Omotoso, GO, Kadir, RE, Lewu, SF, Gbadamosi IT., Akinlolu AA., Adunmo, GO, *et al*. Moringa oleifera ameliorates cuprizone-induced cerebellar damage in adult female rats. Research J Health Sci 2018;6:13.
14. Hadipour E, Emami SA, Tayarani-Najaran N, Tayarani-Najaran Z. Effects of sesame (*Sesamum indicum* L.) and bioactive compounds (sesamin and sesamolin) on inflammation and atherosclerosis: A review. Food Sci Nutr 2023;11:3729-57.