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NEUROPROTECTIVE EFFECT OF AQUEOUS EXTRACT OF ALOE VERA ON THE MALE ADULT WISTAR RATS WITH NICOTINE INDUCED OXIDATIVE STRESS AND HIPPOCAMPAL INJURY

Ezugwu Ndubuisi Samuel[1], Ozoemena Chiadikaobi Lawrence[1], Ugbor Ekene Valentine[1]

[1]Department of Anatomy, Faculty of Basic Medical Sciences,
Enugu State University College of Medicine, Parklane, Enugu, Enugu State, Nigeria.

ABSTRACT

Background of the study: The study investigated the neuroprotective effect of aqueous extract of aloe vera on the male adult wistar rats with nicotine induced oxidative stress and hippocampal injury.**Methodology:** Thirty adult wistar rats (185 - 222g) were divided into six experimental groups, (n=5). Group I (normal control) received food only, Group II received 1.5mg/kg nicotine, Group III was treated with 120mg/kg Aloe-Vera , Group IV was treated with 60mg/kg of Aloe-Vera and 1.5mg/kg nicotine, Group V was treated with 120mg/kg of Aloe-vera and 1.5mg/kg nicotine, while Group VI (standard group) was treated with 25mg/kg of Imipramine and 1.5mg/kg nicotine. After the experiment, the rats were sacrificed and both blood samples and brain tissues were obtained for biochemical and histological analysis respectively. **Result:** There is a statistically significant increase ($p < 0.05$) in the serum level of MDA with decreased SOD and Catalase in the nicotine treated animals without aloe vera pretreatment when compared with aloe vera and imipramine pretreatment before inducing oxidative stress. Pretreatment with aloe vera significantly ($p < 0.05$) decreased the serum level of MDA, but increased ($p < 0.05$) SOD and Catalase. This biochemical fact is supported by the histological results that present normal histoarchitecture of the hippocampus on the aloe vera treated rats when compared to untreated rats. **Conclusion:** There were comparable degrees of abatement as evidenced by the biochemical results, normal appearance of the neuroglial cells, and no signs of degeneration in the histology. Therefore, aloe vera has justified in this study that well-protected hippocampus may be the indication of its antioxidative properties. Meanwhile, it is worthwhile to consider this aspect at a deeper level of investigation using different animal models and methods.

Key Words: Protective, Aloe Vera , Wistar rat, Nicotine, Hippocampus

1.0 INTRODUCTION

1.1 Background of the study

Aloe vera is a short-stemmed succulent plant, that is generally presumed to be originated from Saudi Arabia, Somalia and Sudan, (Manvitha and Bidya, 2014; Chatterjee et al., 2012). Aloe vera has a wide range of medicinal application in diabetes, soothes burns, eases intestinal problems, reduces arthritic swelling, ulcer curative effect, stimulates immunes response against cancer, antimicrobial and anti-inflammatory properties, (Gopinathan and Rameela, 2014; Chatterjee et al., 2012). Aloe vera gel has been shown to exhibit some wound healing effects including encouragement of granulation tissue, and aloe polysaccharides have demonstrated some positive effects in studies preventing radiation burns in animals (Wang et al., 2010; Cervantes-Martínez et al., 2014; Zodape et al., 2016). Aloe gel contains glycoproteins and polysaccharides which helps to speed up healing and stimulate skin growth and repair respectively (Deora et al., 2021; Akinloye et al., 2021; Maan et al., 2018).Certain food products for instance, berries, nuts, pomegranate, chocolate etc. are known to improve cognitive function, memory skills, learning capacity and to maintain good brain health, (Conrad, 2008; Consiglio et al., 2010). Such plant supplements address only certain concerns like oxidative stress or inflammation but aloe has the unique advantage of being therapeutically effective in reducing oxidative damage, inflammation, increasing vasodilatation, treating tumors and neurodegenerative disorders, as well as an effective drug in maintaining general brain health and memory (Christen , 2000; Butterfield, 2002; Ceriello, 2008). Aloe has also been proven to possess cholinergic and cognitive enhancing capabilities (Cui et al., 2017; Cui et al., 2014). It has been observed through research that taking Aloe vera in food or drink has reduced the glucose level in the blood which has been useful in controlling diabetes. Most of the people who suffered from diabetes consumed aloe vera mixed with yoghurt or in the form of herbal tea. It has also been used in antiaging and antiwrinkle creams and moisturizers (Minjares-Fuentes et al., 2016). The moisturizer or the cream is preferred as it is not oily or sticky but dries up quickly as it is easily absorbed by the skin and does not have any type of odor. It can be applied to get relief from sunburn or other kind of burn as it reduces the pain and the inflammation and gives relief from the burning sensation and heals the wound very quickly. The sap from inside the leaf can be used directly or the product that is made of pure Aloe vera extract can be used for application on the burn or the wound. The extract from Aloe vera can also be used for treating ulcer (Seyyed et al, 2015). Aloe vera has been used from time immemorial to aid in smooth functioning of the gastrointestinal tract, mainly because of its properties of soothing, cleansing and helping the body to maintain healthy tissues. Aloe vera gel is famous for facilitating digestion, aiding blood and lymphatic circulation, as well as improving kidney, liver and gall bladder functions (Atik et al., 2020). Aloe

vera has a minimum of three anti-inflammatory fatty acids, which help in smooth functioning of the stomach, small intestines and colon (Zodape, 2011; Wu et al., 2006; Al-Shinnawy et al., 2014). It has a natural property to alkalize digestive juices and prevents over-acidity, which is one of the common causes of digestive ailments. Aloe vera juice concentrates are high in essential enzymes, which stimulate digestion and liver functions (Shirali et al., 2018; Sholehvar et al., 2016). The synergistic effect of Aloe vera juice used in combination with a few other herbs does wonders as a liver-cleansing agent (Yos Adi, 2018). Aloe vera supplements also contain a rare natural ingredient called Saponins, which is provided by nature to cleanse and flush out waste products and toxins (Shelton, 1991; Sampath, 2010). Aloe vera could be used to reduce the burning sensation of burns and blisters. Applying the pure gel of Aloe vera would quell the sting of herpes (Yongchaiyudha et al., 1996; Boudreau and Beland, 2006). Juice or gel of Aloe vera is used to reduce warts, psoriasis and eczema, (Chithra et al., 1998; Chithra et al., 1999).

Nicotine is a chemical that contains nitrogen, which is made by several types of plants, including the tobacco plant (Oyeyipo et al., 2013). It is also produced synthetically. Chewing or snorting tobacco products usually releases more nicotine into the body than smoking. Nicotine is at least as difficult to give up as heroin. The side effects of nicotine can affect the Brain (Hippocampus), heart, hormones, and gastrointestinal system. Nicotiana tabacum, the type of nicotine found in tobacco plants, comes from the nightshade family. Tobacco has been used as a medicine and stimulant for at least 2,000 years in America but It is not known how tobacco first reached Europe (Beck ER et al., 1986). However, Christopher Columbus is often thought to have discovered tobacco while exploring the Americas for the first time. The smoking of pipes and cigars spread quickly throughout the 1600s. The plant had divided opinion when it was introduced to Europe. Some saw tobacco as medicinal, while others saw it as toxic and habit-forming. The tobacco industry grew throughout the 1700s, and exploded in 1880 when a machine was first patented to mass-produce paper cigarettes (Chattopadhyay, 2008). From then on, cigarettes became much easier to produce, and this saw in the dawn of the major tobacco coporations, (Weizenecker and Deal, 1970).

The nicotine in any tobacco product readily absorbs into the blood when a person uses it. Upon entering the blood, nicotine immediately stimulates the adrenal glands to release the hormone epinephrine (adrenaline). Epinephrine stimulates the central nervous system and increases blood pressure, breathing, and heart rate. As with drugs such as cocaine and heroin, nicotine activates the brain's reward circuits and also increases levels of the chemical messenger dopamine, which reinforces rewarding behaviors. Studies suggest that other chemicals in tobacco smoke, such as acetaldehyde, may enhance nicotine's effects on the brain (Jin and Roomans, 2007). Nicotine is naturally found in the plants belonging to

the Solanaceae family. Concentrations high enough to have a pharmacological effect are seen only in the tobacco sub-family, approximately 2% of dry weight and in Duboisia Hopwoodii that has been used by Australian aborigin, (Jana et al., 2010). It is also present in the range of 2–7 microgram per kg of various edible plants. Nicotine in the vehicle of tobacco has been used by humans for thousands of years (Hritcu et al., 2009). Nicotine is a natural ingredient acting as a botanical insecticide in tobacco leaves. It is the principal tobacco alkaloid, occurring to the extent of about 1.5% by weight in commercial cigarette tobacco and comprising about 95% of the total alkaloid content. Oral snuff and pipe tobacco contain concentrations of nicotine similar to cigarette tobacco, whereas cigar and chewing tobacco have only about half the nicotine concentration of cigarette tobacco. An average tobacco rod contains 10–14 mg of nicotine, (Jana et al., 2010), and on average about 1–1.5 mg of nicotine is absorbed systemically during smoking, (Jin and Roomans, 2007). Nicotine in tobacco is largely the levorotary (S)-isomer; only 0.1–0.6% of total nicotine content is (R)-nicotine, (Hritcu et al., 2009). Chemical reagents and pharmaceutical formulations of (S)-nicotine have a similar content of (R)-nicotine (0.1–1.2%) as impurity since plant-derived nicotine is used for their manufacture.

In most tobacco strains, nornicotine and anatabine are the most abundant of minor alkaloids, followed by anabasine . This order of abundance is the same in cigarette tobacco and oral snuff, chewing, pipe, and cigar tobacco (Beck ER et al., 1986). However, nornicotine levels are highest in cigar tobacco, anatabine levels are lowest in chewing tobacco and oral snuff, and anabasine levels are lowest in chewing tobacco, (Chattopadhyay, 2008). Small amounts of the N′-methyl derivatives of anabasine and anatabine are found in tobacco and tobacco smoke. Several of the minor alkaloids are thought to arise by bacterial action or oxidation during tobacco processing rather than by biosynthetic processes in the living plant, (Jin and Roomans, 2007). These include myosmine, N′-methylmyosmine, cotinine, nicotyrine, nornicotyrine, nicotine N′-oxide, 2, 3′-bipyridyl, and metanicotine . Myosmine is found not only in tobacco but also in a variety of foods including nuts, cereals, milk, and potatoes, (). Also, nicotine is found in low levels in vegetables such as potatoes, tomatoes, and eggplants (Yarahmadi et al., 2017).

Nicotine is one of the widely used substance to get a relief and often very addictive, many drugs used for oxidative stress treatment are synthetic and have shown a lot of negative effects to body organs. Therefore, this study was designed to find out more natural remedies to oxidative stress with mild or no side effects.

This study aimed to determine the protective effect of aloe vera gel on the wistar with nicotine induced hippocampal injury and oxidative stress following nicotine administration.

2.0 MATERIAL AND METHODS

2.1 Experimental Animals

Thirty adult male wistar rats (185-222g) were procured from the animal house of the Department of Veterinary Medicine, University of Nigeria, Nsukka. The rats were handled according to the guideline of the committee for the purpose of control and supervision of experiments on animals.

2.2 Chemicals and drugs

Nicotine was procured from Dani Chemicals^{R}, Enugu, Nigeria. Imipramine tablet (Batch number 201441) was supplied by Care Root Pharmaceuticals Enugu, Nigeria.

2.3 Preparation of extract

Mature and healthy aloe vera plants were harvested from aloe vera garden in Nsukka, Enugu state, Nigeria. A taxonomist in the Department of Plant Science and Technology, University of Nigeria Nsukka, identified the plant and a voucher specimen (Ref No: 1543) was deposited in the herbarium for reference. The plants were washed in water, and the thick epidermis was peeled off. The gel was then scooped with a spatula and blended in a blender. The homogenate was concentrated and freeze-dried with a lyophilizer. The yield was put in a desiccator, and later refrigerated, and ready for the use in the experiment.

2.4 Experimental Protocol

Thirty (30) adult male wistar rats were divided into six experimental groups, (n=5). Group I (normal control) received normal saline only, Group II received 1.5mg/kg nicotine, Group III was treated with 120mg/kg Aloe-Vera , Group IV was treated with 60mg/kg of aloe vera and 1.5mg/kg nicotine, Group V was treated with 120mg/kg of aloe vera and 1.5mg/kg nicotine, while Group VI was treated with 25mg/kg of Imipramine and 1.5mg/kg nicotine. After the experiment, the rats were sacrificed, and both blood samples and brain tissues were gotten for biochemical and histological analysis respectively.

Table 2.1: **Drug administration**

GROUPS	ADMINISTRATION
I	Normal saline
II	1.5mg/kg nicotine daily from 15th day to 21st day (1 week)
III	120mg/kg Aloe vera daily from 1st day to 14th day (2 weeks)
IV	60mg/kg Aloe vera daily from 1st day to 14th day (2 weeks) + 1.5mg/kg nicotine daily from 15th day to 21st day (1 week)
V	120mg/kg Aloe vera daily from 1st day to 14th day (2 weeks) + 1.5mg/kg nicotine daily from 15th day to 21st day (1 week)
VI	25mg/kg of Imipramine daily from 1st day to 14th day (2 weeks) + 1.5mg/kg nicotine daily from 15th day to 21st day (1 week)

2.5: SACRIFICE OF EXPERIMENTAL ANIMALS

After twenty four hours of the last administration for various groups, the rats were sacrificed via cervical dislocation. Blood samples were collected with capillary tube via orbital puncture into plain specimen bottle, and taken to a laboratory for test on the oxidative and anti-oxidativw stress activities. Perfusion was done, and the 'whole' brain tissues were removed from the skull, and fixed in 10% formal saline for histological studies on the prefrontal cortex. Superoxide dismutase (SOD) and Catalase (CAT) was estimated by (Bancroft and Gamble, 2008) method and Malondialdehyde (MDA) was estimated by Thiobarbituric acid reaction method (Bancroft and Gamble, 2008).

2.6 Oxidative Stress Markers

Determination of superoxide dismutase activity

Superoxide Dismutase (SOD) activity was determined by Colorimetry a method, (Fridovich, 1989; Ezugwu et al., 2022; Kakkar, et al., 1984).

Determination of catalase activity

Potassium heptaoxochromate (VI) K2Cr2O7 is mixed with glacial acetic acid in the ratio 1:3, and stored in brown bottle at room temperature, after which 0.9 ml of distilled water was added to 0.1 ml of sera and mixed thoroughly (Sinha, 1972; Ezugwu et al., 2022).

Determination of Malondialdehyde (MDA) activity

Malondialdehyde (MDA) is one of the final products of polyunsaturated fatty acid peroxidation in cells and is commonly known as a biomarker of oxidative stress.

2.7 Histological Studies

The harvested brain (hippocampus) was fixed in a freshly prepared 10% formal saline solution. The tissue was subsequently trimmed, dehydrated in 4 grades of alcohol (70%,80%,90% and absolute alcohol), cleared in 3 grades of xylene and embedded in molten wax (Bancroft and Gamble, 2008). On solidifying, the tissue-containing wax blocks were cut into 5µm thick sections were with a rotary microtome, floated in water bathe and incubated at 60°C for 30 minutes. The sectioned tissues were cleared in 3 grades of xylene and rehydrated in 3 grades of alcohol (70%, 80% and 90%). The sections were then stained with Hematoxylin for 15 minutes. Bluing was done with ammonium chloride. Differentiation was done with 1% acid alcohol before counterstaining with Eosin. Permanent mounts were made on degreased glass slides using a mountant (DPX). The prepared slides were examined with a compound light microscope using x4, x10 and x40 lenses. The photomicrographs were taken using a 5.0MP microscope camera at x100 magnifications.

2.8 Data Analysis

Data obtained were expressed as mean ± SEM (standard error of mean). One-way analysis of variance (ANOVA) was used to compare the mean differences. Tukey's post hoc test was done where the result was significant. P-value less than to 0.05 was considered statistically significant. All results were analyzed using the Statistical Package for Social Sciences (SPSS version 22).

3.0 RESULTS

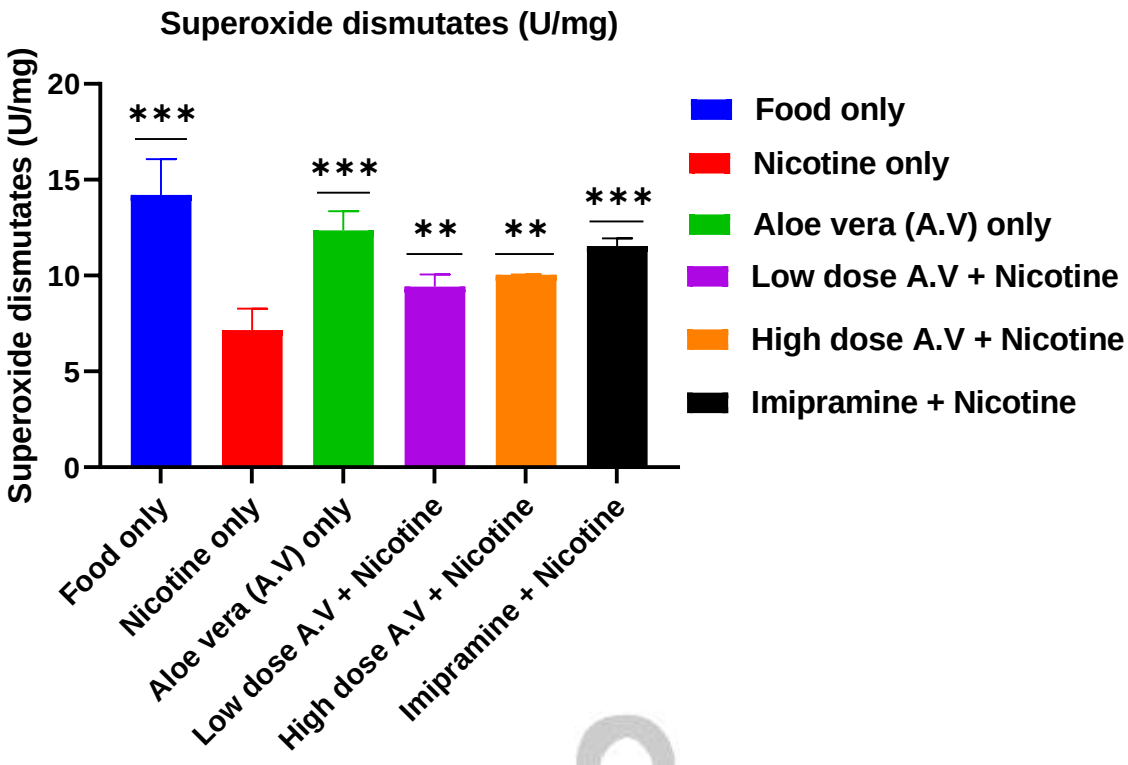
3.1 Biochemical Results

Table 2.1: SOD and MDA level

GROUP	TREATMENT	SOD(U/mg)	CAT (U/mg)	MDA(mg/)
1	Feed only	14.215 ±1.8650***	12.520 ±0.3100**	5.8200 ±0.6500***
2	Nicotine only	7.1550 ±1.1250	9.0610 ±0.0150	10.0450 ±1.2350
3	Aloe Vera	12.3600 ±1.0000***	14.4300 ±0.5000***	6.9450 ±0.7350**
4	Low dose Aloe Vera + Nicotine	9.4300 ±0.6200**	10.107 ±1.1150*	9.7600 ±0.4100
5	High dose Aloe Vera + Nicotine	10.0450 ±0.0130**	14.1270 ±1.1930***	6.0600 ±2.1200**
6	Imipramine + Nicotine	11.5400 ±0.4000***	13.3600 ±1.1200***	5.0450 ±1.1950***

Values are mean ± SD; n=2 in each group; ($p<0.05$)=Statistically significant

a= Significant when compared with the normal control **(A), b**= Significant when compared with the Negative control **(B), d**= Significant when compared with the standard drug **(F), A=** Not significant when compared to the normal control **(A), B**= Not significant when compared to the negative control **(B), D**= Not significant when compared to the standard drug **(F).**



Values are mean ± SEM; n = 5 in each group, (P < 0.05) = Statistically significant.

* Significant when compared to the control at P < 0.05

** Significant when compared to the control at P < 0.01

*** Significant when compared to the control at P < 0.001

Figure 2.1: Shows the mean level of the Superoxide dismutase

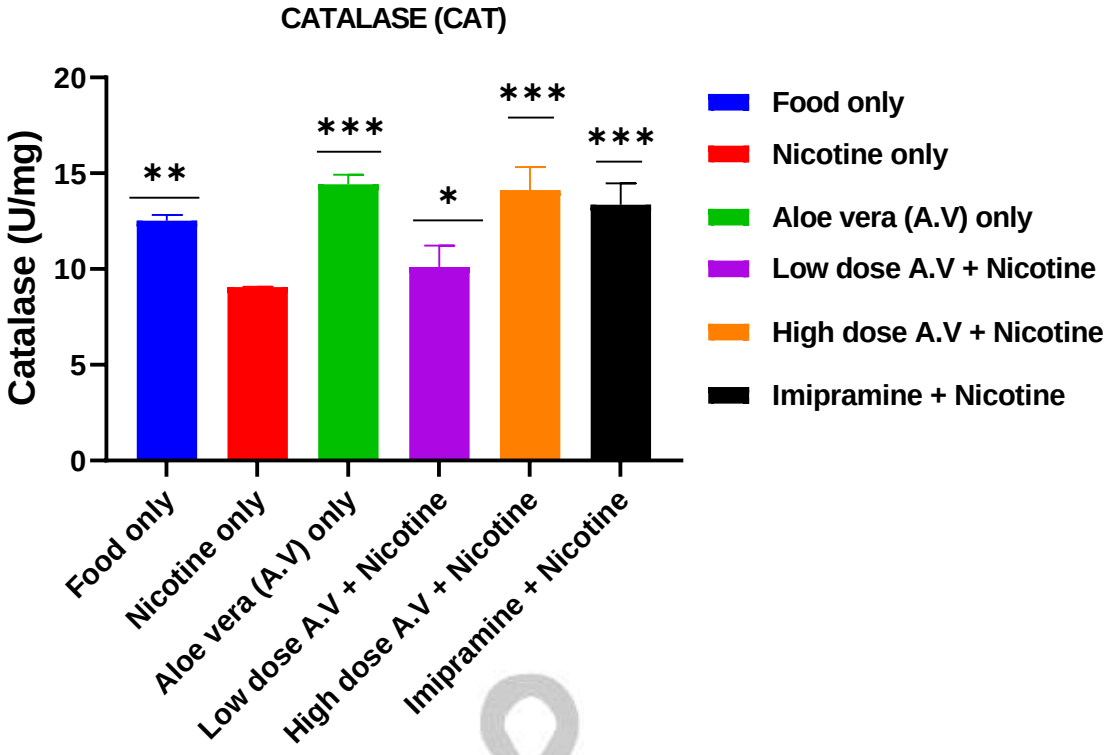


Figure 2.2: Shows the mean level of the Catalase

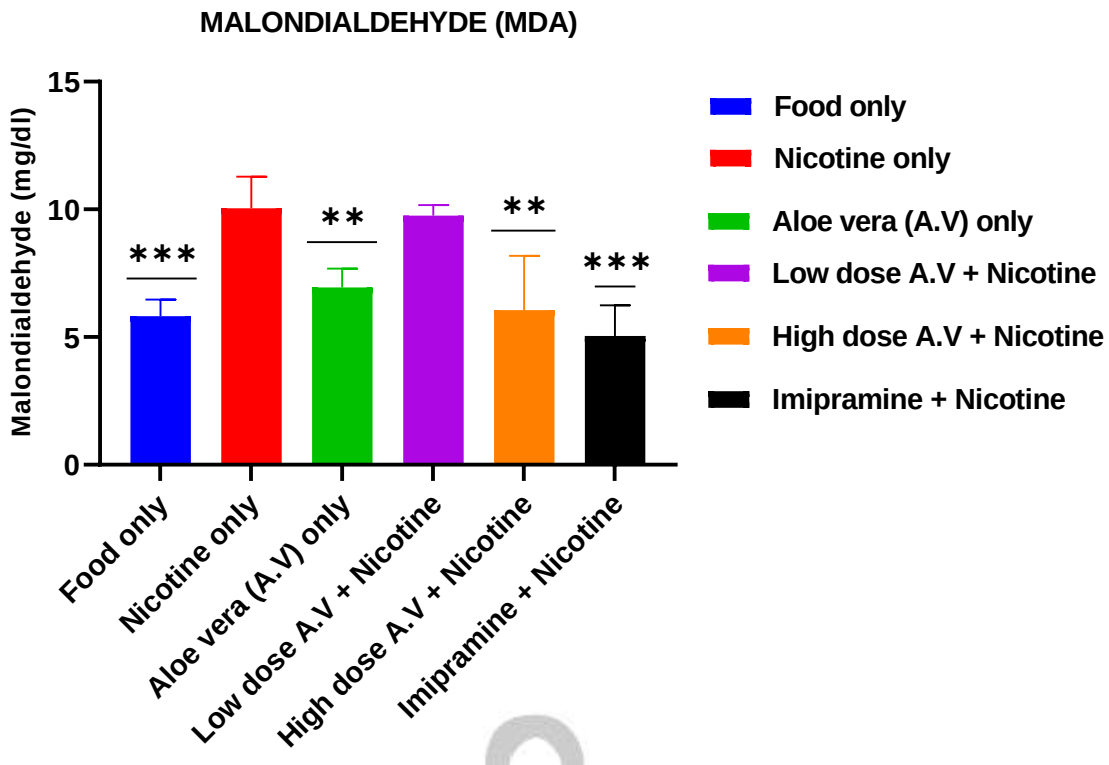


Figure 2.3**:** Shows the mean level of the Malondialdehyde

2.2 Micrograph

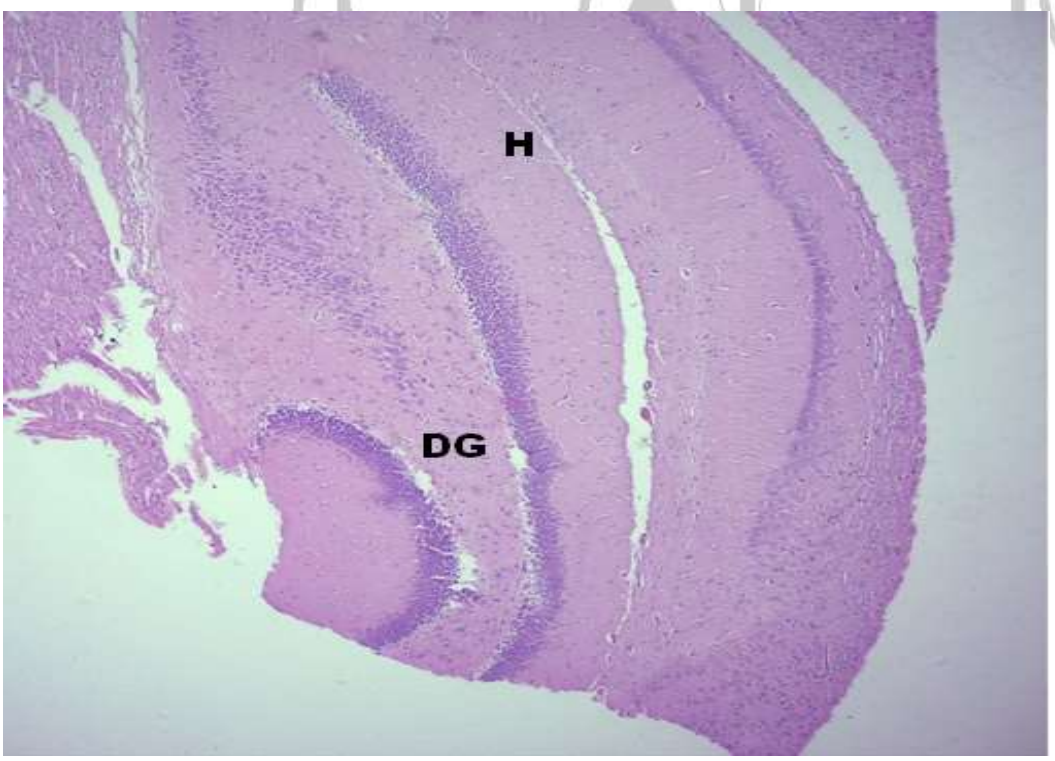


PLATE IA: Photomicrograph of the hippocampus of a laboratory rodent administered normal saline only showing a hippocampal formation (H) with normal cyto-architecture of the hippocampal neurons. The CA1 and CA3 regions revealed compact granular cells of the granular layer (GL) and the dentate gyrus (DG), large pyramidal cells of the pyramidal cell layer (PCL) and normal glial cells and neurons observed on the molecular layer (ML). H&E. X100

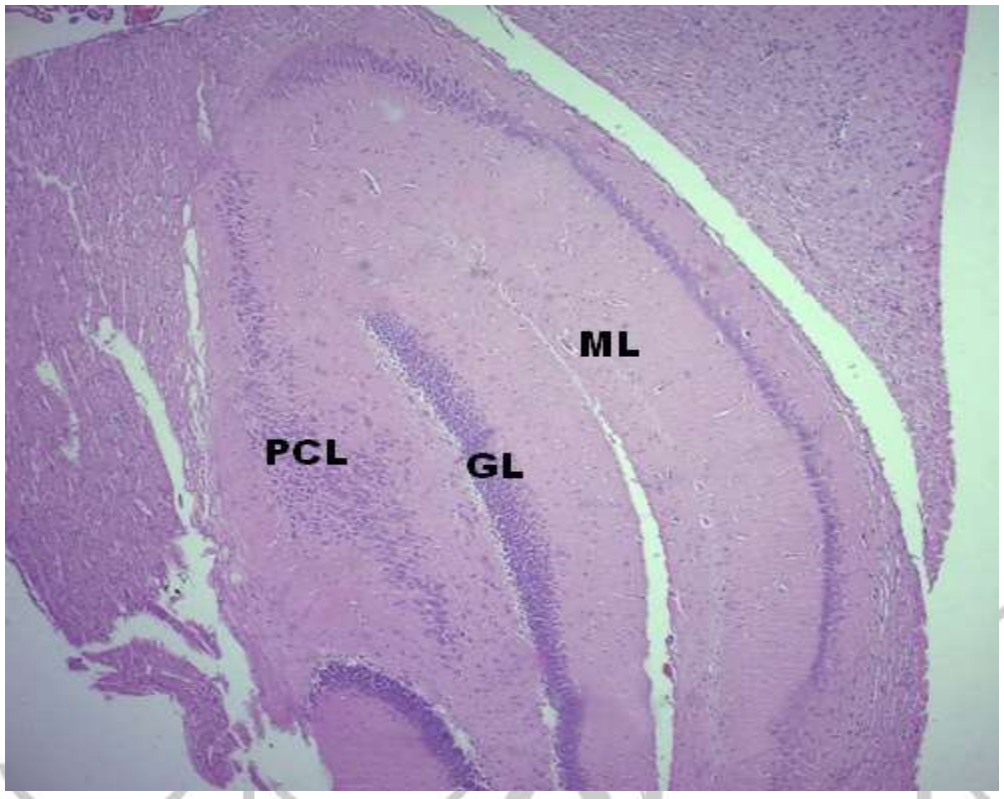


PLATE IB: Photomicrograph of the hippocampus administered with normal saline only showing the normal cyto-architecture of the hippocampal neurons. The CA1, CA2 and CA3 regions revealed compact granular cells of the granular layer (GL) and the dentate gyrus, large pyramidal cells of the pyramidal cell layer (PCL) and normal glial cells and neurons observed on the molecular layer (ML). H&E.x100

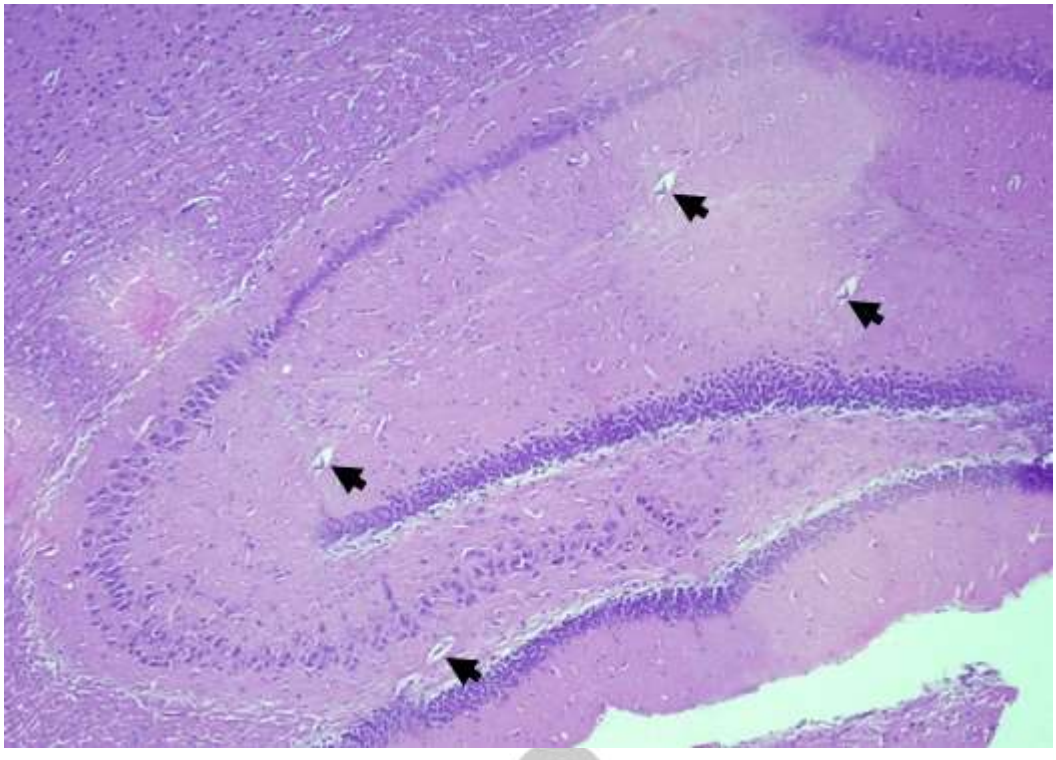


PLATE IIA: Photomicrograph of the hippocampus of a laboratory rodent administered Nicotine (1.5mg/kg) only showing a hippocampal formation with marked decrease in cellularity of the pyramidal cell layer (PCL). Mild cytoplasmic vacuolations and dilated perivascular spaces (Arrows) were also observed. H&E. X100

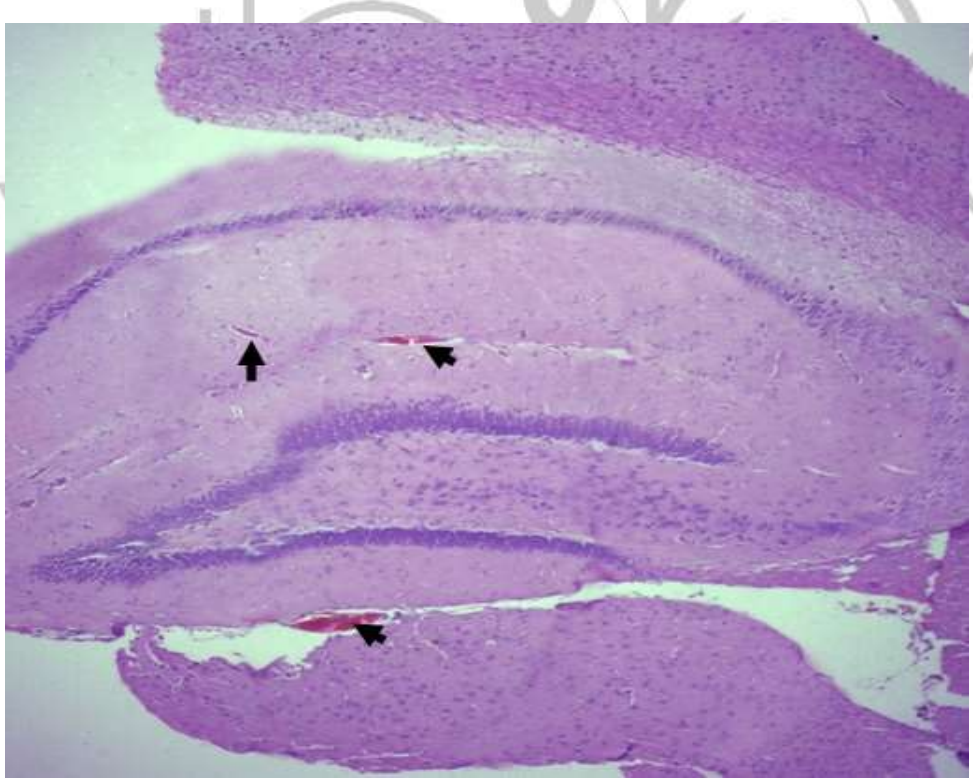


PLATE IIB: Photomicrograph of the hippocampus of a laboratory rodent administered with Nicotine (1.5mg/kg) only showing a hippocampal formation with marked decrease in cellularity of the pyramidal cell layer (PCL). Blood vessels (Arrow). H&E. X100

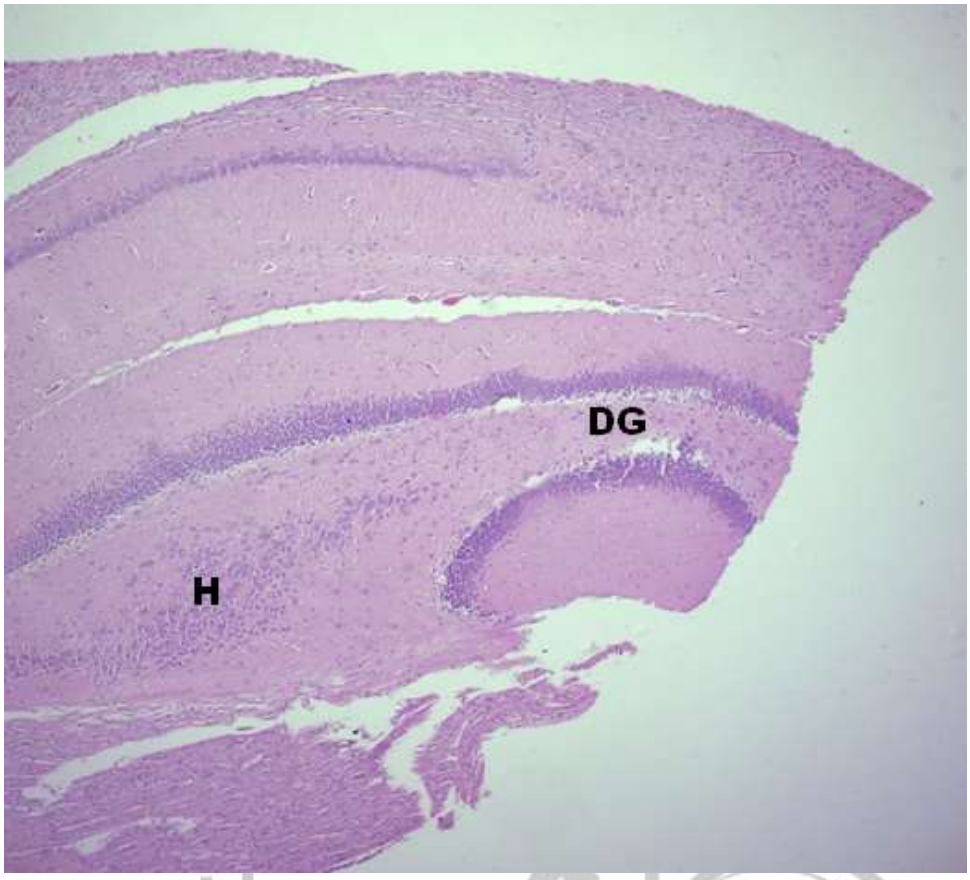


PLATE IIIA: Photomicrograph of the hippocampus of a laboratory rodent administered with Aloe Vera (120mg/kg) only showing a hippocampal formation (H) with normal cyto-architecture of the hippocampal neurons and a compact granular cells of the dentate gyrus (DG). H&E. X100

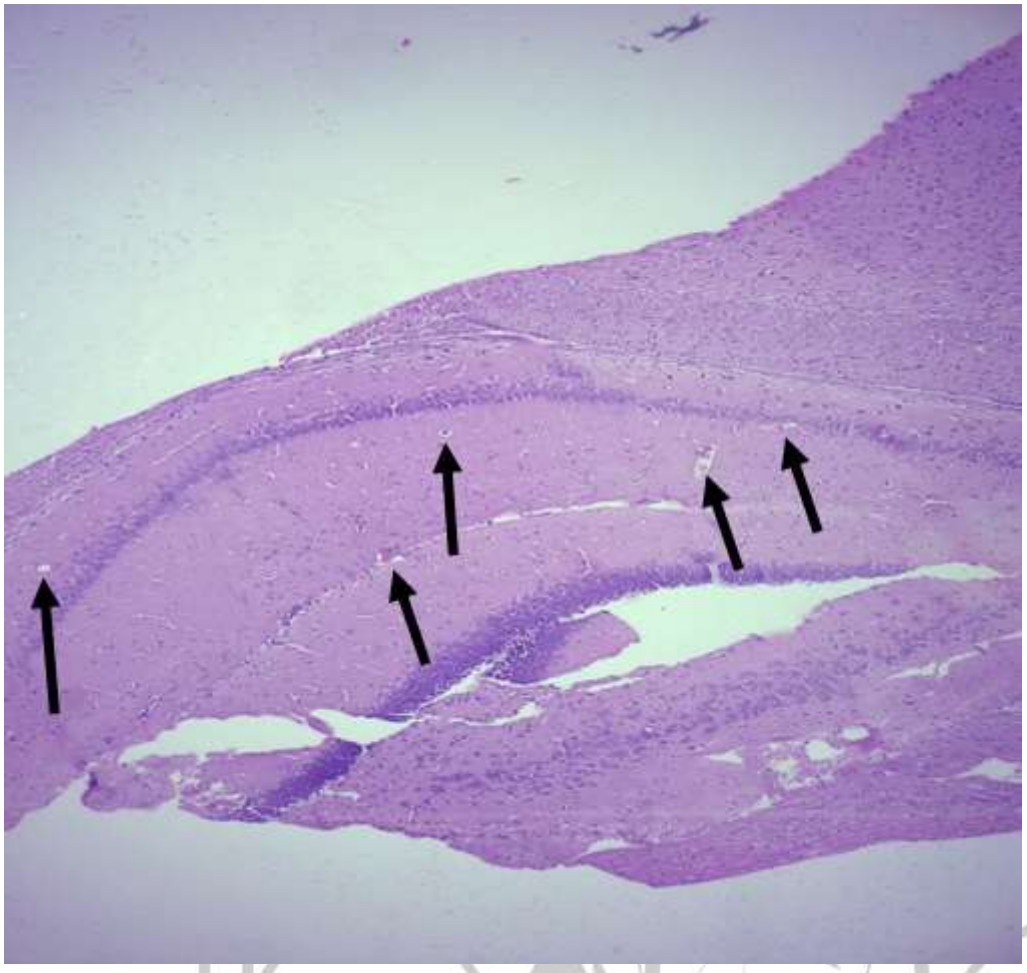


PLATE IIIB: Photomicrograph of the hippocampus of a laboratory rodent administered with Aloe Vera (120mg/kg) only showing a hippocampal formation with mild cytoplasmic vacuolations (Arrow head) and dilated perivascular spaces (Arrows). Hippocampus (H). H&E. X100

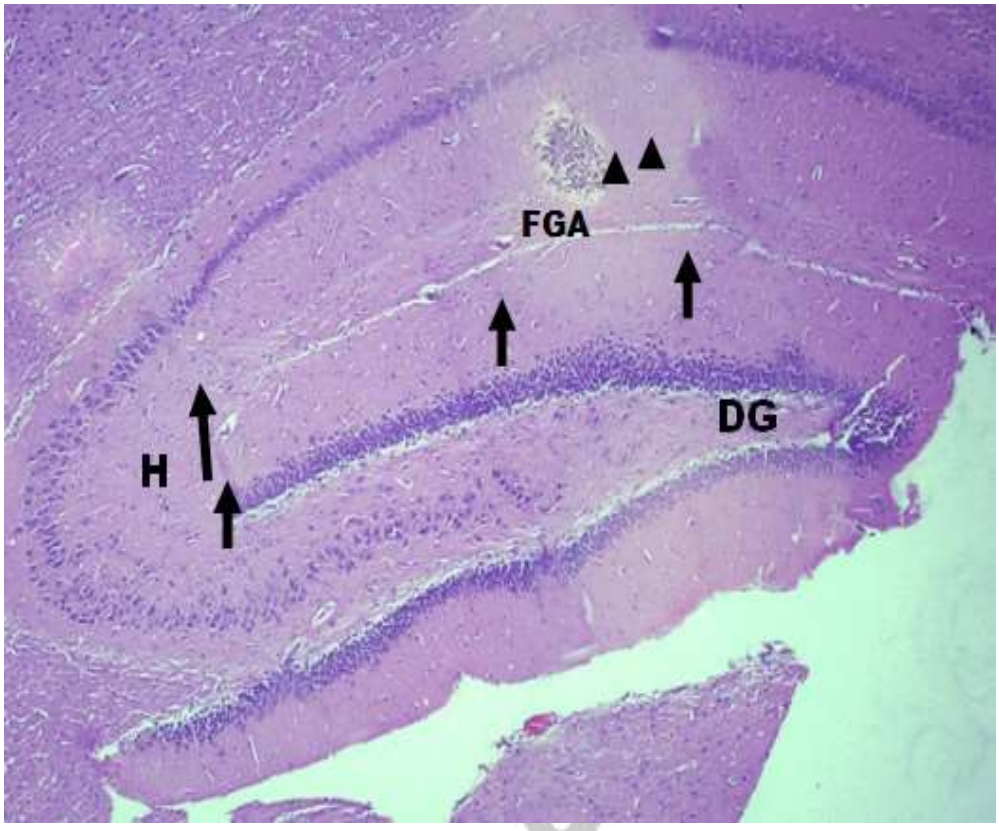


PLATE IVA: Photomicrograph of the hippocampus of a laboratory rodent administered with low dose of Aloe vera (60mg/kg) and Nicotine (1.5mg/kg) showing a hippocampal formation with mild cytoplasmic vacuolations (Arrow head) and dilated perivascular spaces (Arrows). Focal Gliotic Aggregation (FGA) surrounded by a region of degenerating neurofibrillary network was also observed. Dentate Gyrus (DG), Hippocampus (H). H&E. X100

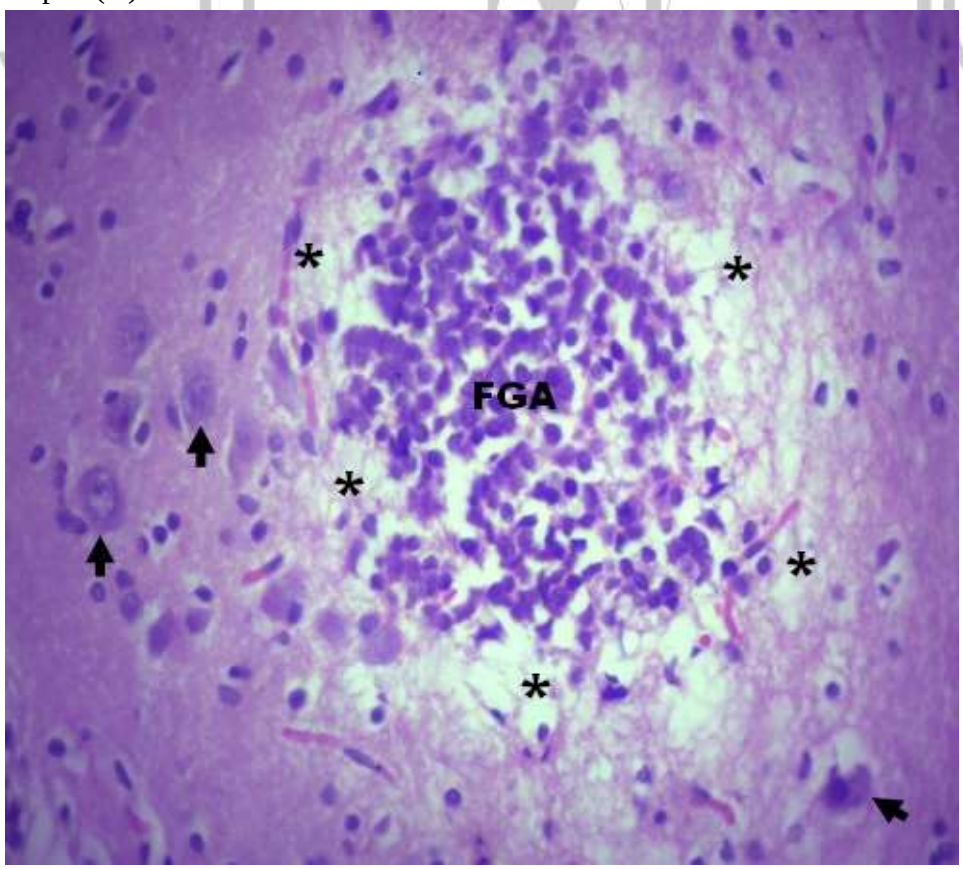


PLATE IVB: Photomicrograph of a hippocampal region of a laboratory rodent administered with low dose of Aloe vera (60mg/kg) and Nicotine (1.5mg/kg) showing a Focal Gliotic Aggregation (FGA) surrounded by a region of degenerating neurofibrillary network (*). Neurons (Arrow). H&E. X100

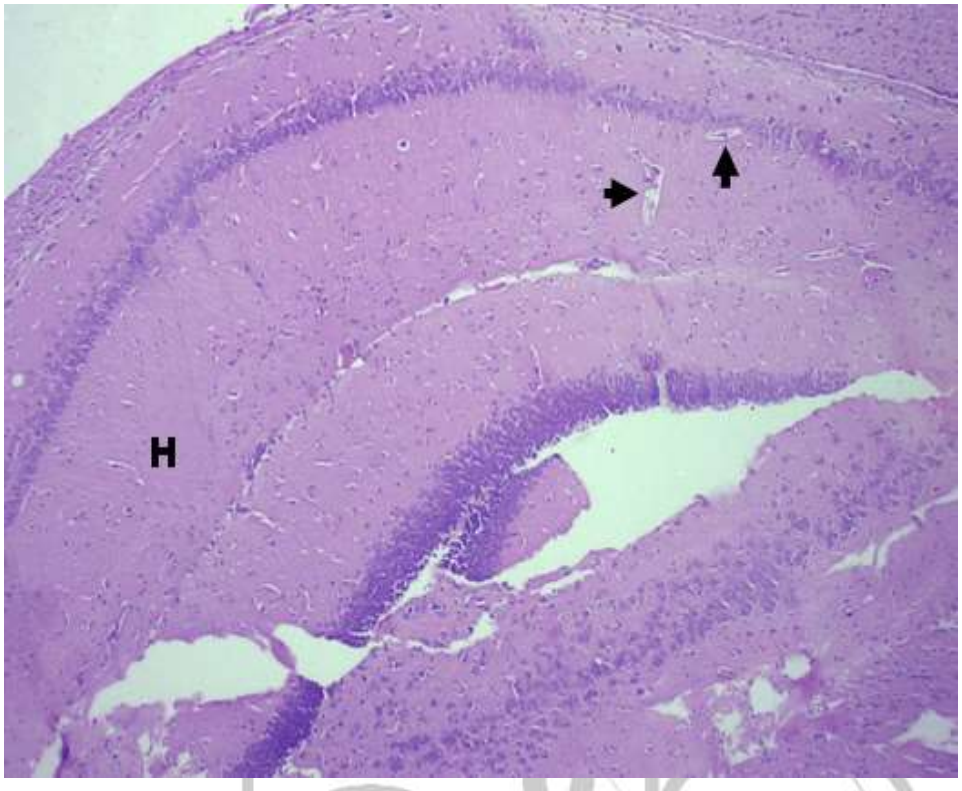


PLATE VA: Photomicrograph of the hippocampus of a laboratory rodent administered with high dose of Aloe vera (120mg/kg) and Nicotine (1.5mg/kg) showing a hippocampal formation with mild cytoplasmic vacuolations and dilated perivascular spaces (Arrows). Hippocampus (H). H&E. X100

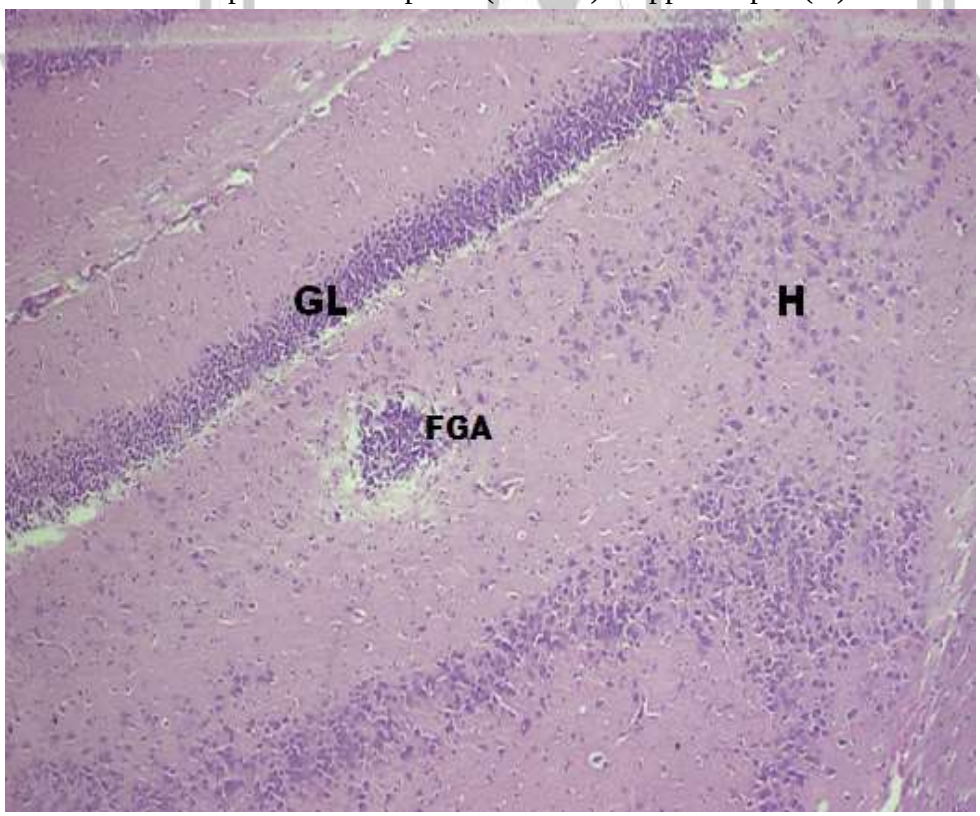


PLATE VB: Photomicrograph of the hippocampus of a laboratory rodent administered with high dose of Aloe Vera (120mg/kg) and Nicotine (1.5mg/kg) showing a hippocampal formation with mild cytoplasmic vacuolations and a Focal Gliotic Aggregation (FGA) . Granular Layer (GL), Hippocampus (H). H&E. X100

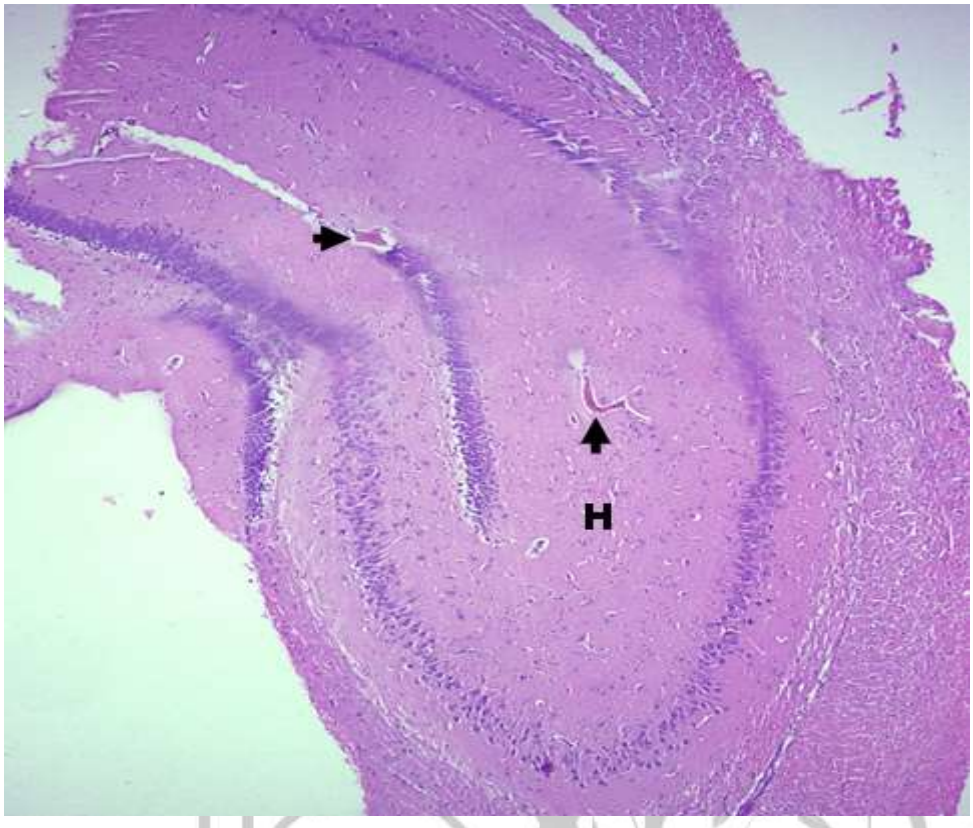


PLATE VIA: Photomicrograph of the hippocampus of a laboratory rodent administered with Imipramine (25mg/kg) and Nicotine (1.5mg/kg) showing a hippocampal formation with mild cytoplasmic vacuolations. Hippocampus (H) Blood vessel (Arrows). H&E. X100

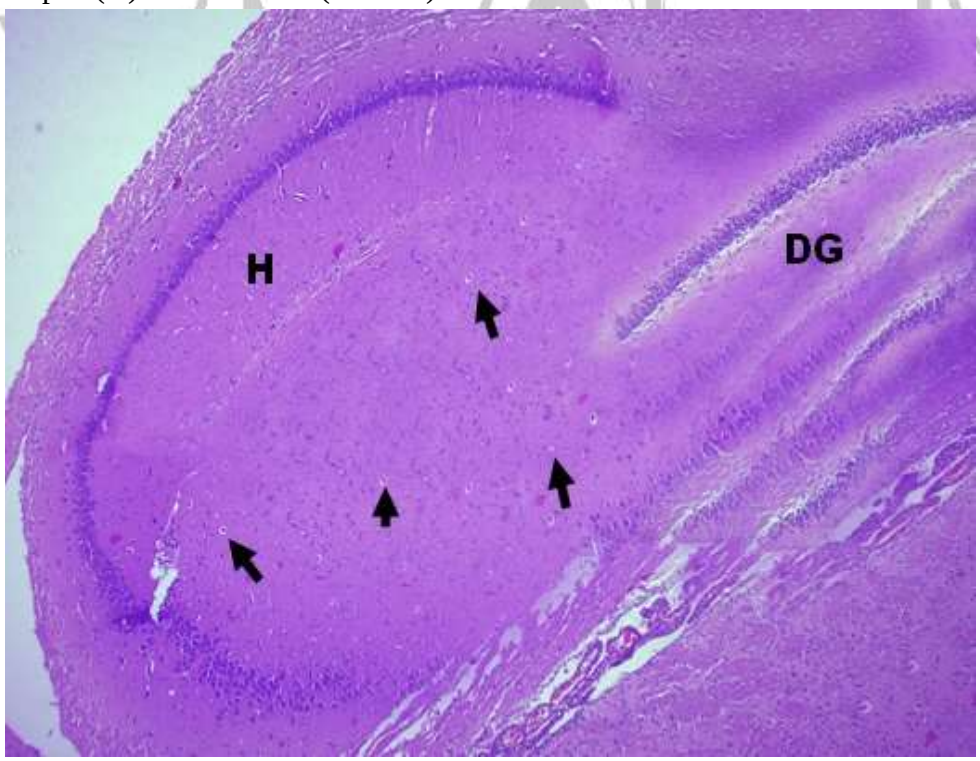


PLATE VIB: Photomicrograph of the hippocampus of a laboratory rodent administered with Imipramine (25mg/kg) and 1.5mg/kg Nicotine showing a hippocampal formation with mild cytoplasmic vacuolations (Arrows head). Hippocampus (H). Dentate gyrus (DG). H&E. X100

3.0 DISCUSSION AND CONCLUSSION

3.1 Discussion

Generally, neuronal oxidative stress involves generation of hydrogen peroxide and hydroxyl radicals, reduction in catalase and SOD activity, and increase in MDA level (Sinha, 1972). Malondialdehyde (MDA) is one of the most used biomarkers of lipid peroxidation, indicating tissue damage caused by free radicals in biological fluids (Fridovich, 1989). The results obtained from this study indicates that nicotine exposed rats have significant ($P<0.05$) increased level of MDA and reduced SOD activity which is in accordance with previous reports by (Jana et al., 2010; Ezugwu et al., 2022) which reported the same variations of oxidative stress activities due to toxicity. This biochemical evidence suggested that exposure to 1.5mg/kg nicotine caused oxidative stress in aloe vera untreated rats. Meanwhile, group treated with only aloe vera showed no significant difference ($p>0.05$) when compared to normal control (group I), which was given food and water only. In group V which received high dose of extract, there was significant difference ($P<0.05$) in level of SOD. In group IV, there was a significant ($P<0.05$) increase in the level of MDA. This finding shows that at high dose, the extract showed more protective effect in a dose-dependent manner. In group V, and VI which were treated with high dose aloe vera and imipramine respectively show slight significant ($P<0.05$) decrase in the level of malondialdehyde (MDA) when compared with group IV, low dose group. This supports the earlier report of Wu et al., 2006 concerning the antioxidant property of aloe vera, and it indicates that aloe vera may have protected the effect of nicotine neurotoxicity. Chattopadhyay, 2008 and Atik et al., 2020 reported that nicotine affects lipid profile, peroxidation and antioxidant enzymes in female rats with restricted dietary protine. These overall results prove that aloe vera has anti-oxidant potentials that might have protected the hippocampus from oxidative stress. The findings of (Manvitha and Bidya, 2014; Shelton,1991) are compatible with the results of this study, they reported the medicinal potentials of aloe vera against oxidative stress.

From the photomicrographs, rats in group V showed no cytoplasmic vacuolations and dilated perivascular spaces, when compared to group II induced with nicotine without treatment with aloe vera. Nicotine induced without treatment which shows severe cytoplasmic vacuolations. This means that the aloe vera extract may have protective effect on the hippocampus. This is also in accordance with Sampath et al., 2010 report while reviewing aloe vera as potential herbs for medicinal purposes. There is no region of degenerating neurofibrillary network in the group treated with high dose of aloe vera (group V) when compared with group II, which was treated with nicotine only.

Oxidative stress related neurodegeneration is associated with structural disruption of the neuronal mitochondria, however Aloe vera have been reported to have a protective effect on the mitochondria of neurons, further enhancing its ability to prevent neurodegeneration following nicotine induced oxidative stress. Aloe vera has flavonoid in abundance which will also enhance its ability to maintain neuronal health (Minjares-Fuentes, 2016). The photomicrographs of the group treated with low dose of Aloe vera showed mild region of degenerating neurofibrillary network, this means that the protective effect of aloe vera might be dose dependent.

3.2 Conclusion

Histology of the tissue samples suggest that oral administration of 1.5mg/kg nicotine daily for 7 days resulted in degeneration of the hippocampal neurons and, caused oxidative stress. Protective test result indicates that aloe vera may have capability of protecting the hippocampal neurons, and preventing oxidative stress in nicotine induced neurotoxicity in wistar rats. Hence, a potential anti-oxidant for treatment and prevention of oxidative stress caused diseases, especially one that resulted from nicotine abuse.

3.3 Recommendation

The ability of aloe vera to protect the hippocampus against nicotine induced neurotoxicity is multifaceted, making it a candidate for intense research in the prevention of hippocampal neuronal degeneration and oxidative stress from different disease conditions. Therefore, we recommend that more studies that involves different design and animal should be carried out on the protective and curative effect of aloe vera.

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