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Research Article

Launaea taraxacifolia leaf extract protected against gamma radiation–induced haematological, behavioural and histological alterations in the hippocampus and cerebellum of rats

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Abstract

Radiotherapy is used as treatment for brain tumours but the side effects of radiotherapy are associated with oxidative damage which antioxidants are expected to minimize. *Launaea taraxacifolia* leaf extract has been reported to possess antioxidant activity. The present study was carried out to investigate the possible protective role of the *Launaea taraxacifolia* ethanolic extract (EELT) against radiation-induced injury of rat brain. Thirty rats were divided into five groups of 6 each: control, propylene glycol, EELT 400 mg/kg, gamma radiation (5 Gy) and EELT 400 mg/kg plus gamma radiation (5 Gy). Radiation was administered as a single dose on 15th day, while all other administrations were given orally for 14 days. Behavioural tests were conducted on the 16th day after which rats were euthanized same day. Blood parameters and brain tissue were examined with regard to micro-anatomical parameters. Gamma radiation induced a 67% reduction of the WBC, 67% of lymphocytes, 81% of neutrophils and 95% of monocytes which were significant ($p<0.05$). Behavioural results showed that radiation caused a reduction in line crossing, rearing, forelimb grip and latency of geotaxis. Microscopically, radiation induced histological alterations in the cerebellum, dentate gyrus and cornu ammonis3. Pre-treatment with EELT 400 mg/kg significantly reduced the effect of radiation on the histological, haematological and, behavioural alterations. In conclusion, EELT demonstrated protective effects against radiation-induced haematological, behavioural and alteration of microanatomy of rat cerebellum and hippocampus.

*Keywords: Launaea taraxacifolia***,** Gamma radiation, neuroprotection, cerebellum, hippocampus

INTRODUCTION

Despite efforts by medical researchers, the incidence, morbidity and mortality associated with cancer presents it as a killer disease thereby making it a major public health problem in many parts of the world. Siegel *et al*. (2014) reported a projected 1,665,540 new cancer cases and 585,720 cancer related deaths in United States of America for the year 2014.

Radiotherapy as one of the main treatment modality is effective and beneficial. Although radiotherapy regimes are designed to maximize tumoricidal effects while causing minimal damage to normal organs, it may still cause damage to adjacent non-cancerous tissue (Belka *et al*., 2001; Malomo *et al*., 2005). For example, irradiation of neck and head structures may affect important adjacent neural structures, but despite this hazard, radiotherapy is used extensively to treat primary brain tumors and metastases and to prevent intracranial relapse in many malignancies (Wu *et al*., 2012). Radiation side effects have been attributed to ionization which leads to generation of reactive oxygen species (ROS) which may be free radicals or non-radicals (Lee *et al*., 2006). When ROS are in excess, they overwhelm the body's natural defence causing oxidative damage by interacting with biological systems and may attack various biomolecules including DNA, proteins, and membrane lipids, eventually leading to significant cellular damage (Adaramoye, 2010). Antioxidants have been reported to mitigate the effects of free radical damage by mopping them up (Owoeye *et al*., 2014). In the continuing search for potent plant-based antioxidants that may neutralize the released ROS associated with irradiation, and thus offer protection for normal tissue adjacent to the target cancer cells during radiotherapy, there is need to investigate other plants. Plants reported to possess active antioxidant properties include: *Cassia alata (*Sarkar *et al*., 2014), *Vernonia amygdalina (*Farombi and Owoeye, 2011); *Garcinia kola* (Adaramoye, 2010). *Launaea taraxacifolia* Wild, of the Asteraceae family (Bitter lettuce, Wild lettuce) is known as *Yanrin* in the south-west Nigeria where it is a common vegetable. Gbadamosi *et al*. (2012) and Oduse *et al*. (2012) have reported the antioxidant activity of *L. taraxacifolia* leaves due to its flavonoids, while phenol and ascorbic acid have been reported in the water and methanol extracts of its leaves (Arawande *et al*., 2013). *L. taraxacifolia* as a known source of antioxidant will be expected to reduce the toxicity

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associated with radiation by mopping up the excess free radicals generated during radiotherapy.

The cerebral cortex is involved in various functions: decision making, cognition, learning, vision, auditory, visual etc.; the cerebellum is involved in co-ordination of willed muscular movements, balance, and posture maintenance (Affi and Bergman, 2005); whereas the hippocampus is involved in memory storage as well as some limbic functions (Snell, 2006). Any of the components of the central nervous system may be affected by radiation toxicity administered to nearby diseased organs.

Literature is scanty concerning the effect of *L. taraxacifolia* leaf extract on radiation-induced alteration of the microanatomy of rat brain. This study aimed to answer the question: 'What effect would the ethanolic extract of *L. taraxacifolia* have on radiation-induced neuropathy in rats?'

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MATERIALS AND METHODS

Experimental Animals: Thirty male Wistar rats were acquired from the Central Animal House of College of Medicine, University of Ibadan, Nigeria. They were housed in transparent plastic cages with wood shavings at a freely ventilated and naturally illuminated house of Department of Veterinary Physiology, Biochemistry and Pharmacology, University of Ibadan. The rats were fed with standard rat diet produced by Vital Feeds, Jos, Nigeria, and water provided *ad libitum.* The experimental protocols were carried out according to the approval and guidelines given by the University of Ibadan Ethical Committee which also conformed to the acceptable guidelines on the ethical use of animals in research (Public Health Service, 1996).

Plant preparation and extraction procedures: The leaves of *Launaea taraxacifolia* were collected in May, 2014 from a farm at Olomi area of Oluyole Local Government Ibadan, Oyo State. The leaves were identified and authenticated at the Department of Botany, University of Ibadan, Nigeria where a voucher specimen with Herbarium Identification Number UIH: 22400 was deposited. The leaves were air-dried and 193.58 g of it was extracted with 2 litres of 99.1% ethyl alcohol at room temperature and the filtrate was evaporated with a rotary vacuum evaporator in the University of Ibadan Central Laboratory. The extract termed ethanolic extract of *Launaea taraxacifolia* (EELT) weighed 5.83 g, a yield of 3.3%. The administered dose was then calculated per kilogram body weight of the rats.

Preparation and administration EELT: 1g of EELT was dissolved in 10 mL of propylene glycol to form the stock solution. A dose of 400 mg/kg of EELT was orally administered daily using gavage.

Preparation and administration of PG: Propylene glycol (PG) was administered to rats orally at a dose of 0.2 mL/rat/daily using gavage.

Chemicals: Ketamine was manufactured by Rotex Medica, Trittau, Germany. Propylene glycol was manufactured by Guangdong Guanghua Science Tech. Co Ltd. (China). All other reagents were of analytical grade and were obtained from the British Drug Houses (Poole, Dorset, UK).

Experimental Design: The animals whose weights at the time of randomization was 86-110 g were assigned into five treatment groups of six rats per group and then allowed one week to acclimatize to animal room conditions before treatment commenced. Animal grouping was as follows:

Group I: C, control rats given water *ad libitum.*

Group II: PG, received daily dose of 0.2 mL/rat of propylene glycol for 14 days.

Group III: EELT, received once daily dose of 400 mg/kg of EELT in 10ml of propylene glycol for 14 days.

Group VI: RAD, received single dose of 5 Gy gamma radiation on day 15 of experiment.

Group V: EELT+RAD, received once daily dose of 400 mg/kg of EELT in 10ml of propylene glycol for 14 days + single dose of 5 Gy gamma radiation on day 15 of the experiment.

All the treatments were carried out using gavage with the exception of irradiation. The dose of EELT was based on the method of Adejuwon *et al*. (2014) while that of gamma radiation using cobalt-60 was based on the method of Adaramoye (2010), the duration of treatment for 15 days was premised on our previous reports (Owoeye *et al*., 2011) .

Irradiation procedures: Dosimetry and irradiation procedures were carried out at the Radiotherapy Department of the University of Ibadan and University College Hospital, Ibadan, Nigeria. Irradiation procedure was done as described by Owoeye, *et al*. (2010). Briefly, on experimental day 15, rats in groups IV and V were weighed and administered with 10 mg/kg body weight Ketamine hydrochloride injection i.p. and Diazepam injection at 3 mg/kg body weight i.p for muscle relaxation. Rats were restrained by strapping in a prone position within well-ventilated cardboard boxes using cotton strapping. A batch of five animals was whole body irradiated at a time with a single fraction of 5 Gy of gamma rays obtained from a Bhabhatron II Telecobalt Unit with energy of 1.25 MeV, delivered at a dose rate of 212.561 cGy/min for 2.35 minutes. With a field size of 18 cm by 18 cm, the percentage depth dose was 100%. Rats were thereafter placed in their cages and transferred to the animal house for recovery from anaesthesia, and after recovery were given feeds and water ad libitum.

Behavioural tests: The neurological tests done were: (1) negative geotaxis (2) forelimb grip test and (3) open field test. The rats were weighed and then subjected to the tests on the 16^{th} day of the experiment so as to investigate the effects of radiation on behaviour of the rats.

Negative geotaxis: Negative geotaxis was tested by placing rats head-down on an inclined plane and then watched the rat orient in a head-up direction (Kreider and Blumberg, 1999). The time it took for each rat to orient in a head-up direction was recorded with a stopwatch. The average of two trials was obtained.

Forelimb grip test: This test was performed according to a modification of the method of VanWijk *et al*. (2008). Each rat was suspended with both forepaws on a horizontal steel wire

(1 meter long, diameter 7 mm). The animal was held in a vertical position when its front paws were placed in contact with the wire. When the rat grasped the wire, it was released, and the latency to fall was recorded with a stopwatch. Rats were randomly tested and each animal was given two trials with a 30 min inter trial rest interval. This test assessed muscle strength and balance.

Open field test : The apparatus used was a slight modification of the method of Mohammad *et al*. (2010). It consisted of a square arena (56×56×20 cm) made of white wood and its floor divided by lines into 16 squares that allowed the definition of central and peripheral parts. At the beginning of the session, each rat was individually placed in the centre of the arena and its activity was recorded for 5 min. The number of squares crossed with all paws (crossing) and standing on legs (rearing) were evaluated during 5 minute sessions. The crossing numbers were indicators of locomotor while the rearing numbers indicated vertical and exploratory activities. At the end of each session, rats were removed from the open field and the experimental chamber was thoroughly cleaned with a damp cloth and dried.

Sample collection and histological preparation : After the completion of the behavioural tests on day 16 of the experiment, all animals in all groups were weighed, euthanized by ketamine (100 mg/kg) i.p. followed by cervical dislocation. Blood was collected via the retro-orbital venous sinus into heparinized bottles for haematological parameters. Each rat was decapitated at the cervico-medullary junction for uniformity and the skulls opened after which the brains were quickly extracted. The cerebellum and brain of each rat were dissected and then preserved in 10% formalin and later processed for histology by paraffin embedment technique.

Histology: The cerebellum from each group was obtained and homologous sampling was assured by obtaining transverse sections of the right cerebellum from each specimen from the lateral zone portions of the cerebella hemisphere (vermal, paravermal and flocullus portions were not utilized) for uniformity. Coronal sections of the right half of each brain were made to obtain samples of the cerebral cortex and hippocampal tissue. The tissues were sectioned at 5-6 µm thickness and then stained with Haematoxylin and Eosin according to the method of Bancroft and Gamble (2008). After staining, the slides were viewed with an Olympus CH (Japan) light microscope with 16x objective. The image capturing was performed with a Sony DSC-W 3 digital camera (Japan).

Determination of haematological parameters: K2 EDTA-added whole blood samples were used for hematological analyses immediately after collection with the aid of Sysmex Automated Hematology (KX-21, Kobe, Japan) Analyzer. The haematocrit or packed cell volume (PCV), haemoglobin (Hb), red blood cell count (RBC), mean cell volume (MCV), mean cell haemoglobin (MCH), and mean cell haemoglobin concentration (MCHC) and white blood cell count (WBC), were obtained.

Statistical analysis: All data were expressed as the Means ± Standard Deviation. Data were analyzed using one-way analysis of variance (ANOVA) using GraphPad Prism TM 4.0 version software, San Diego, CA, USA. Post-hoc comparisons were performed after ANOVA using Dunnett's test. Statistical significance was set at $p<0.05$.

RESULTS

The changes in the body weight and brain weight of the rats were not significantly affected by either EELT or radiation treatment during the 14 days exposure as presented in Table 1.

Haematological parameters

Table 2 presents a summary of the effect of EELT and radiation on erythrocyte indices of the rats. Gamma radiation caused a significant 17% reduction of the packed cell volume (PCV) and 16% of the haemoglobin level (HgB) of the rats. Other indices like red blood cell count (RBC), mean corpuscular volume (MCV), and mean corpuscular haemoglobin concentration (MCHC) were not significantly altered.

Table 1:
Weight changes in radiation and EELT treated male Wistar rats

Groups	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Brain Weight (g)	Relative brain Weight
Control	88.5±4.2	134.00±11.51	45.5±8.509	1.55±0.05	1.16±0.05
PG	104.17±13.57	143.83±18.00	39.76±8.17	1.59±0.07	1.11±0.11
EELT	110.00±12.05	151.00±35.69	41±10.24	1.61±0.13	1.07±0.19
RAD	91.66±8.8	128.75±11.09	47.09±2.50	1.56±0.25	1.21±0.17
EELT+RAD	86.67±11.69	130±13.22	43.33±7.64	1.57±0.0	1.21±0.14

Values are expressed as mean ± SD of six animals. * P< 0.05 versus Control group; ** P< 0.05 versus radiation group. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation.

Table 2:
Effect of radiation and EELT on Erythrocyte indices of male Wistar rats.

Groups	PCV (%)	HB (g/dL)	RBC ($x10^6/\mu L$)	MCV (fL)	MCHC (g/dL)
Control	46.00±1.41	15.10±0.42	7.48±0.07	61.00±1.41	33.33±0.58
PG	45.00±3.0	15.53±0.85	7.44±0.51	60±2.08	34.00±0.58
EELT	42±2.00	14.40±0.28	7.25±0.19	59.00±0.0	34±0.00
RAD	38.00±6.08*	12.63±1.85*	6.52±0.80	60.00±1.73	31.67±0.58
EELT+RAD	44.67±5.77	14.73±2.02	7.45±0.97	59.67±1.7	33.27±0.52

Values are expressed as mean ± SD of six animals. * P< 0.05 versus Control group; ** P< 0.05 versus radiation group. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation.

Table 3:
Effect of radiation and EELT on the Leukocyte indices of male Wistar rats.

Groups	WBC ($x10^3$/µL)	Lymphocytes ($x10^3$/µL)	Neutrophils ($x10^3$/µL)	Monocytes ($x10^3$/µL)	Eosinophils ($x10^3$/µL)
Control	5.57±1.46	2.25±0.41	3.99±1.22	1.28±0.31	0.00±0.00
PG	6.11±1.71	4.84±1.20	2.25±0.81	1.52±0.20	1.0±0.01
EELT	4.70±1.11	2.23±0.40	2.367±0.80	1.1±0.11	1.0±0.01
RAD	1.83±0.5*	0.75±0.11*	0.75±0.10*	0.6±0.10*	0.4±0.01
EELT +RAD	2.92±1.4	2.25±0.21**	0.88±0.11	0.79±0.10	1.0±0.02

Values are expressed as mean ± SD of six animals. * P< 0.05 versus Control group; ** P< 0.05 versus radiation group. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation.

Table 4:
Effect of radiation and EELT on behavioural and locomotor activities of male Wistar rats.

Groups	Centre square	Line Crossing	Rearing	Forelimb grip (s)	Geotaxis (s)
Control	3.40±1.2	46.20±5.8	17.00±4.5	5.67±1.8	2.60±0.5
PG	3.0±1.2	23.67±4.1*	11.25±2.8	4.80±1.7	2.50±1.0
EELT	3.2±1.0	44±5.6	16.25±4.9	4.00±1.6	2.00±1.2
RAD	4.00±1.5	23.50±3.9*	14.50±4.7	3.75±1.5	1.0±0.3*
EELT+RAD	3.00±1.2	30±4.0**	15.5±3.5	4.00±1.4	2.27±0.6**

Values are expressed as mean ± SD of six animals. * P< 0.05 versus Control group; ** P< 0.05 versus radiation group. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation.

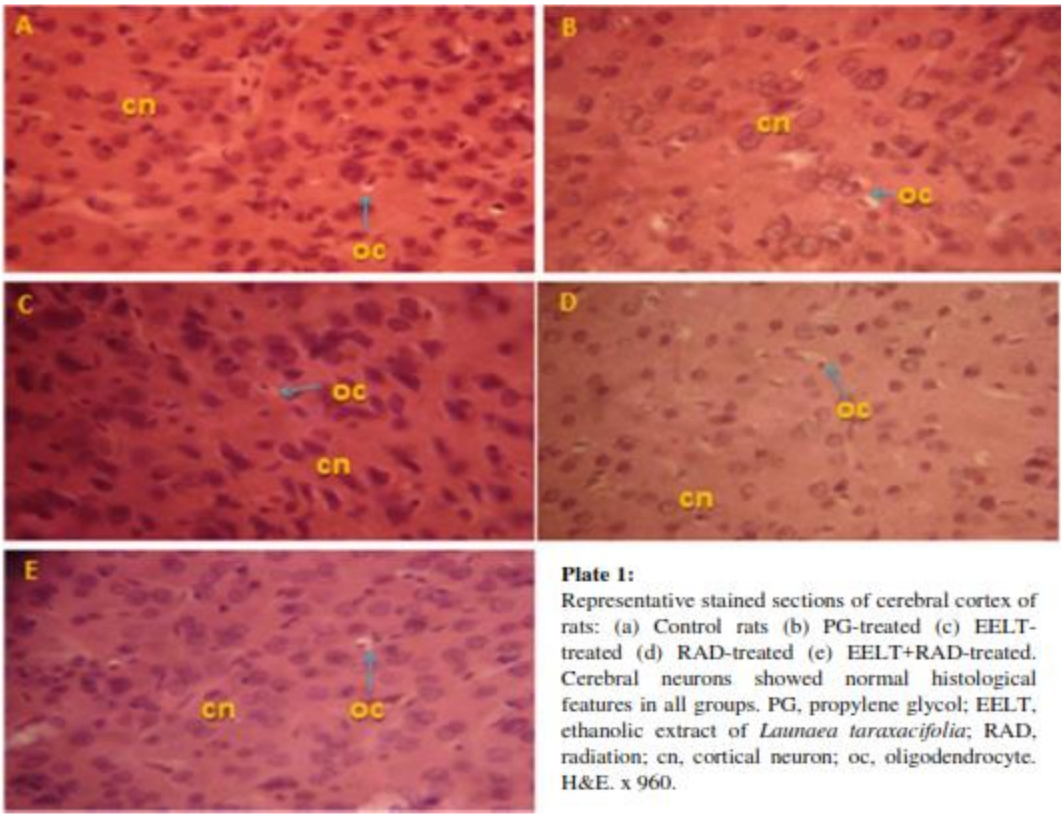

Plate 1:
Representative stained sections of cerebral cortex of rats: (a) Control rats (b) PG-treated (c) EELT-treated (d) RAD-treated (e) EELT+RAD-treated. Cerebral neurons showed normal histological features in all groups. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation; cn, cortical neuron; oc, oligodendrocyte. H&E. x 960.

Table 3 shows that gamma radiation induced a 67% reduction of the total white blood cell (WBC), 67% of lymphocytes, 81% of neutrophils and 95% of monocytes which were significant (p<0.05) when compared with control. However, pre-treatment of radiation with EELT ameliorated these parameters: WBC (60%), lymphocytes (67%), neutrophils (17%) and monocytes (24%) when compared with the irradiated group.

Behavioural parameters
The behavioural tests results are shown in Table 4. The number of lines crossed and geotaxis were significantly reduced (p<0.05) by radiation. There was however, significant increases in the EELT+RAD group compared with the radiation only group for these two parameters (p<0.05).

Histological parameters
Cerebral cortex: There was no observable effect of radiation on the cerebral cortex of the rats as shown by the histological features in the radiation group (Plate 1D) when compared with other treatment groups as in Plates 1A, 1B, 1C, and 1E. The cortical neurons showed the normal round or ovoid nuclei exhibiting dispersed chromatin as shown in all the groups.

Dentate gyrus: The histological features of dentate gyrus showing molecular layer, granule cell layer and the polymorphic layer are shown in Plates 2A, 2B, and 2C. The effect of radiation is shown in Plate 2D with some of the granule cell neurons undergoing pyknotic changes (arrow-heads). **Plate 2E** shows some ameliorative effect of pre-treatment with EELT when compared with Plate 2D.

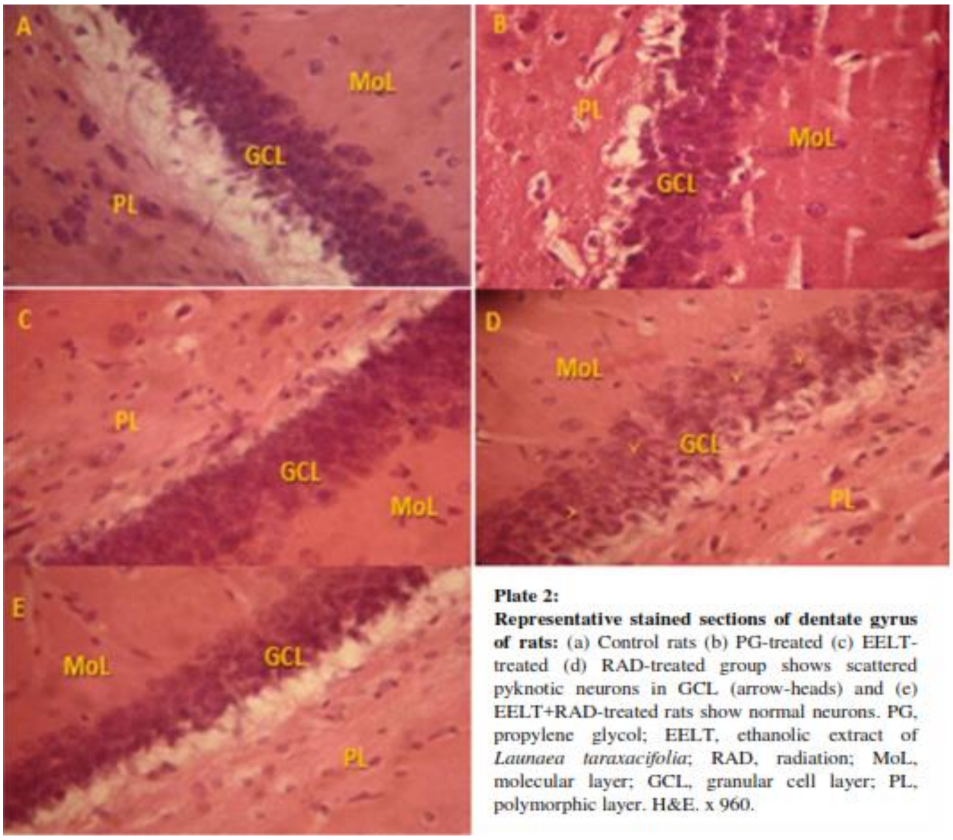

Plate 2:
Representative stained sections of dentate gyrus of rats: (a) Control rats (b) PG-treated (c) EELT-treated (d) RAD-treated group shows scattered pyknotic neurons in GCL (arrow-heads) and (e) EELT+RAD-treated rats show normal neurons. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation; MoL, molecular layer; GCL, granular cell layer; PL, polymorphic layer. H&E. x 960.

Ammonis 3 (CA3): The CA3 subfield of the hippocampal formation of the control rats showed portions of the normal histological features of the stratum oriens, pyramidal cell layer, stratum radiatum, all of which show normal cytoarchitecture as shown in Plate 3A, 3B, and 3C. In Plate 3D, radiation toxicity on the pyramidal neurons was exhibited by neuronal degeneration (arrow and arrows-heads). Plate 3E shows the effect of pre-treatment with EELT before irradiation, the pyramidal neurons are noted to be similar to the control when compared with the irradiated group of Plate 3D.

Cerebellum: The normal histological layers of an adult rat cerebellum namely: granular, molecular, and Purkinje are observed in Plates 4A, 4B, and 4C. While some of the Purkinje cells of the irradiated rats are noted to be eosinophilic (Plate 4D)**,** some retained little basophilic staining when compared with the control and the other groups. In Plate 4E, the basophilic staining of the Purkinje cells are noted compared with the irradiated group of Plate 4D

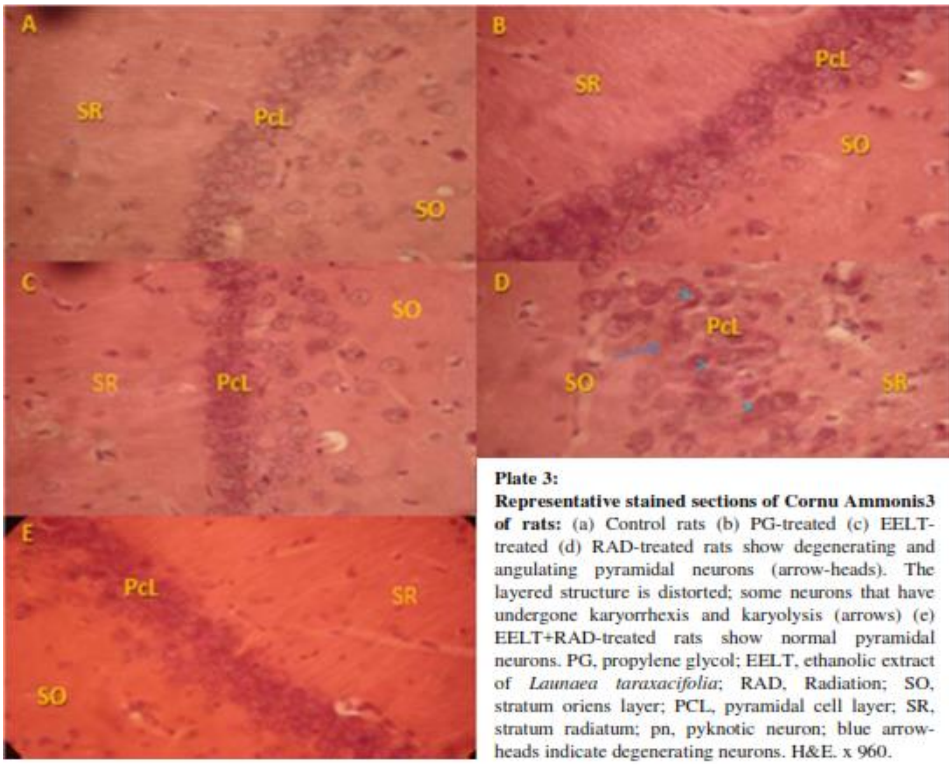

Plate 3:
Representative stained sections of Cornu Ammonis3 of rats: (a) Control rats (b) PG-treated (c) EELT-treated (d) RAD-treated rats show degenerating and angulating pyramidal neurons (arrow-heads). The layered structure is distorted; some neurons that have undergone karyorrhexis and karyolysis (arrows) (e) EELT+RAD-treated rats show normal pyramidal neurons. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, Radiation; SO, stratum oriens layer; PCL, pyramidal cell layer; SR, stratum radiatum; pn, pyknotic neuron; blue arrow-heads indicate degenerating neurons. H&E. x 960.

DISCUSSION

In the present study, our findings showed that gamma radiation treatment caused alterations in the some of the parameters studied. However, pre-treatment with ethanolic extract of *Launaea taraxacifolia* leaves (EELT) ameliorated these alterations.

The dentate gyrus (DG) subfield of the hippocampus plays an important role in the formation of memory traces in mammals (Wu *et al*., 2012). Its alteration by radiation as shown by pyknosis of granule neurons agrees with the findings of Nakaya *et al*. (2005) who reported that radiation may lead to apoptotic death of neurons. According to Fike *et al*. (2007), the precursor cells of the DG are extremely sensitive to radiation which partly may account for our observation. Pyknosis is an indicator of cessation of DNA transcription which is an early sign of cell death (Stevens and Lowe, 2000). The effect of granule cell death is the possible interruption of the neural pathway transmitting fibres from the entorhinal cortex to the molecular layer of the DG. The information to be passed on from the granule cell to CA3 subfield via the Mossy fibres will also be distorted. Of special interest is adult neurogenesis for which the subgranular zone of the DG is noted for, as this may be affected if the granule cell neurons die in large numbers since it plays a key role in memory formation and storage (Viva and Praag, 2013).

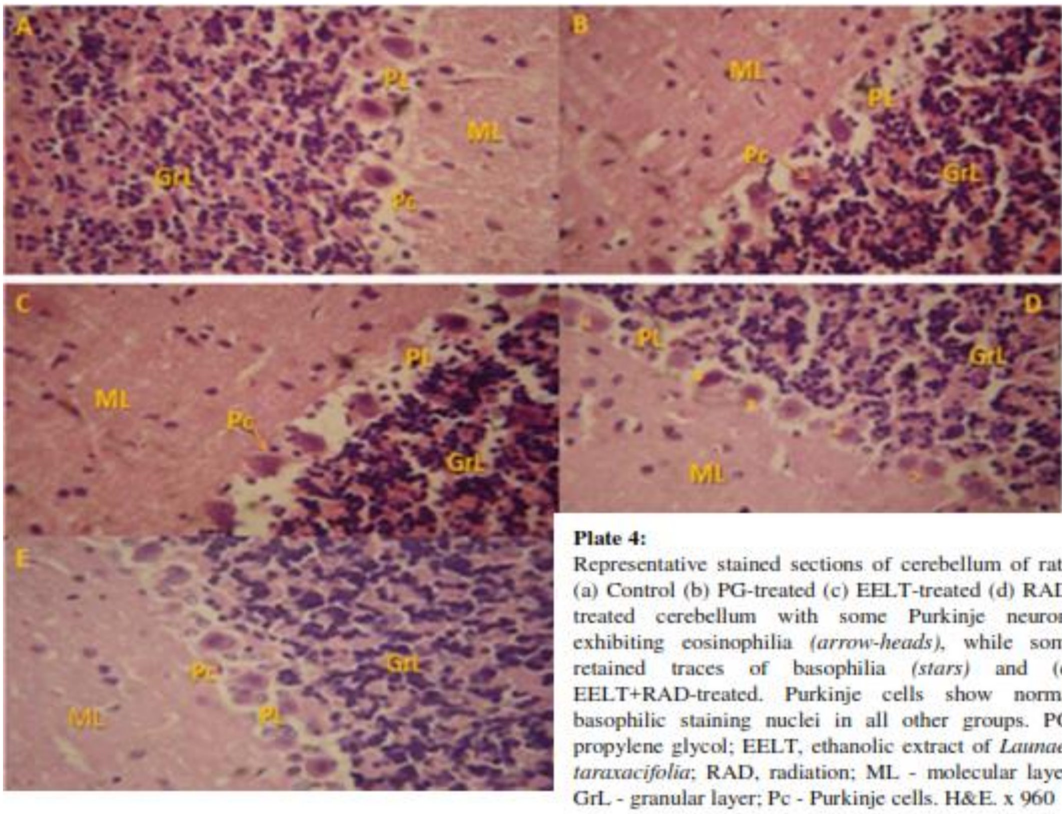

Plate 4:
Representative stained sections of cerebellum of rats: (a) Control (b) PG-treated (c) EELT-treated (d) RAD-treated cerebellum with some Purkinje neurons exhibiting eosinophilia *(arrow-heads)*, while some retained traces of basophilia *(stars)* and (e) EELT+RAD-treated. Purkinje cells show normal basophilic staining nuclei in all other groups. PG, propylene glycol; EELT, ethanolic extract of *Launaea taraxacifolia*; RAD, radiation; ML - molecular layer; GrL - granular layer; Pc - Purkinje cells. H&E. x 960

Gamma radiation caused a distortion of the layered structure of CA3 with pyramidal neurons exhibiting degeneration showing features of pyknosis, karyorrhexis and karyolysis (Steven and Lowe, 2000), thus altering microanatomy of the CA3 subfield of the hippocampus of rats. This is in agreement with the report of Li *et al*. (2014) who reported widespread damage of rats' pyramidal neurons of the CA3, twenty four hours after exposure to 4-Gy dose of radiation in the hippocampi. Our findings may not be unusual since we administered 5 Gy dose of radiation on our rats and this observation is likely due to the toxicity of the gamma rays. The death of these pyramidal neurons might interrupt the flow of information received from the DG for onward transmission via the Schaffer's fibres to the cornu ammonis1 before terminating in the subiculum and other areas (Viva and Praag, 2013). This suggests that memory and other hippocampal functions might potentially be affected in such rats. A possible effect of this might be the observed reduction of the number of lines crossed, rearing and latency of the geotaxis in the irradiated rats when compared with those that were concomitantly treated with EELT.

The main function of the cerebellum is the coordination of voluntary muscular movements, balance and posture in mammals. Histological alteration of the cerebellum of rats by radiation shown by the partial loss of the basophilic staining of the Purkinje cell nuclei in the irradiated rats is in keeping with radiation damage. The eosinophilia implies a loss of nuclei DNA and cytoplasmic RNA material termed 'karyolysis' (Stevens and Lowe, 2000). This might lead to poor control and processing of new neuronal protein synthesis, necessary for axonal flow and the maintenance of the integrity of the neuron itself. This might affect the function of the Purkinje neurons which are responsible for final projection of the deep cerebellar nuclei to cerebellar target (Afifi and Bergman, 2005). This might ultimately affect the main function of the cerebellum leading to poor coordination of voluntary muscular movements, balance and posture in the affected rats. Note is however, taken of the reduction of muscle strength reflected by diminution of latency of the forelimb grip, observed smaller number of crossing movement, and reduced latency in geotaxis which are related to the integrity of locomotor activity (Reckziegela *et al*., 2011), in the irradiated rats. The absence of alteration to the cerebral cortex histology by the gamma radiation was observed. It could be that the cortical neurons of these rats possess some unexplainable tolerance to or resistance against radiation insult that we cannot explain.

The reduction of erythrocytes parameters by irradiation is in agreement with Hla *et al*. (2003) who ranked erythrocytes as relatively radio-resistant compared with other blood cellular components. Gamma radiation reduced the total white cell, neutrophils, lymphocytes and monocytes in agreement with Shaheen and Hassan (1991). Jagetia *et al*. (2002) had observed that lymphocytes were very radiosensitive. In general, the haematological alterations is in agreement with Rana *et al*. (1992) who reported that as low as 2.25 Gy of gamma radiation induced haematological changes in peripheral blood, in this study, we applied 5 Gy of gamma radiation.

Oxidative damage has been implicated as the basis of radiation injury in the brain (Lee *et al*., 2006) with the brain particularly vulnerable to oxidative stress due to the high rate of ROS generation without commensurate levels of antioxidant defenses (Villeda-Hernandez *et al*., 2001). Some plants that have been reported to exhibit radioprotection by virtue of their antioxidant activity against oxidative damage, namely: *Hibiscus sabdariffa*, *Vernonia amygdalina*, and *Garcinia kola (*Adaramoye *et al*., 2008; Owoeye *et al*., 2010; Adaramoye, 2010), respectively. *Launaea taraxacifolia leaf was* reported to possess antioxidant activity due to presence of flavonoids, phenol and ascorbic acid (Gbadamosi *et al*., 2012; Oduse *et al*., 2012; Arawande *et al*., 2013). Thus, we hypothesized that the antioxidant activity of this extract to be involved in mopping up of the excess free radicals generated during radiotherapy in the present study. EELT demonstrated significant protective effect against the radiation-induced alterations in the parameters studied.

Taken together, the results from this study showed that 5 Gy of gamma radiation elicited some haematological, neurobehavioural and histological alterations in male rats whereas pre-treatment with 400 mg/kg of EELT for 14 days ameliorated these effects.

In conclusion, ethanolic extract of *Launaea taraxacifolia* pre-treatment mitigated the effect of radiation on the haematological, neurobehavioural and histological alterations in male rats. This suggests that *Launaea taraxacifolia, a* readily available vegetable, could be further investigated as a potential radio-protector during radio-therapeutic procedures.

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