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AMELIORATIVE POTENTIAL OF *MORINGA OLEIFERA* AQUEOUS LEAF EXTRACT ON PARACETAMOL-INDUCED TESTICULAR TOXICITY IN ADULT MALE SPRAGUE-DAWLEY RATS

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Keywords:

Paracetamol, Testis, *Moringa oleifera*, Histology, Oxidative stress, Hormonal milieu

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ABSTRACT: Testicular toxicity has been associated with long-term paracetamol usage. *Moringa oleifera* is known to eliminate toxins from organs and restore functionality. This study seeks to ascertain the potency of moringa in ameliorating paracetamol-induced testicular toxicity. Forty nine (49) Sprague-Dawley rats were randomly assigned into seven (7) groups composed of 7 rats each treated for 5 weeks. One group served as the control, while 3 other groups were administered graded doses of paracetamol, then the other 3 groups were administered graded doses of paracetamol and 1600mg/kg of moringa extracts simultaneously. The animals were sacrificed 24 hours after the administration of last dose using anaesthesia. The testes and epididymis were harvested, while blood was obtained via ocular puncture. The moringa extract mitigated the paracetamol-induced dose-dependent decrease in sperm count and sperm morphology. Paracetamol toxicity on hormonal milieu was suppressed by the moringa extract treatment, yielding hormonal values closer to those obtained in the control group. The moringa extract treatment controlled the oxidative stress biomarkers as their values were not as variant when compared to the groups treated with paracetamol only. Hypospermatogenesis along with restoration of normal seminiferous tubules and interstitial spaces observed in the paracetamol-induced groups treated with moringa extracts indicates the ameliorative histological effect of moringa on paracetamol-induced testicular toxicity. Therefore, the use of moringa extract therapy reverses the damaging effects of paracetamol on the testis and male fertility.

INTRODUCTION: A common drug used as both an analgesic and an antipyretic is paracetamol [1, 2]. Paracetamol (acetaminophen) is the most popular non-steroidal anti-inflammatory drug (NSAID) available over-the-counter utilized in the treatment of acute and chronic pain associated with numerous clinical conditions [3, 4].

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Though recent extensive researches have indicated that it may not possess as much analgesic efficacy as previously believed [5], it is still the go-to over the counter pain relief medication. This may be primarily because except in cases of serious overdose, paracetamol is thought to have a generally high safety profile with few medication interactions [6, 7].

Although the evident therapeutic efficacy of paracetamol for chronic pain syndromes is minimal, there is mounting evidence of clinically significant adverse effects with long-term usage [8] and overdose [9]. Regular usage of paracetamol may result in toxicity, which might be due to varying

degrees of enzyme activity in one of the drug's metabolic pathways [10]. Early paracetamol exposure has also been known to cause a decrease in testicular testosterone levels with subsequent alterations in its gene expression [11]. High repetitive use of paracetamol has been associated with male reproductive evidenced by distortion of the histological architecture of seminiferous tubules, substantial drop in blood testosterone [12] and seminal quality deterioration [12, 13]. Paracetamol has been linked to the synthesis of reactive oxygen species [14] and elevated oxidative stress [15], which can be harmful to organs including the liver and kidney [16]. Oxidative stress, resulting from unbalanced production of reactive oxygen species [17], impairs both male and female reproductive functions [18]. Oxidative stress is a primary pathogenic process that causes DNA damage in the germ line and male infertility [19], through sperm concentration, motility, and morphology, leading in a decrease in sperm quality with a low conception rate [20].

Moringa oleifera is a tropical food plant with high nutritional, medicinal, industrial, agricultural, and economical importance [21, 22]. *M. oleifera* extracts and leaf powder have exhibited antimicrobial, antioxidant, anticancer [22], immunomodulatory, radioprotective, anti-dyslipidemic, antihypertensive [23, 24, 25] and anti-hyperglycemic properties [22, 24, 26]. *M. oleifera* ameliorates testicular toxicity by restoring its function and structure while normalizing reactive oxygen species synthesis [27]. Paracetamol has been established as a pain relief medication of great efficacy [28], yet it has a number of negative effects on the test is [8]. *M. oleifera* has numerous benefits to the health of humans [29], and has been demonstrated to reduce the impact of some testicular toxins [30]. The focus of this study is to explore the ameliorative potential of aqueous leaf extract of *Moringa oleifera* on paracetamol induced testicular toxicity using Sprague-Dawley rats.

MATERIALS AND METHOD:

Animals Care and Management: Approval for the use of Sprague-Dawley rats for this research was duly obtained from Bowen University's Faculty of Basic Medical Sciences Ethics Committee. Forty nine (49) adult male Sprague-Dawley rats used for this research, weighing 135g±70g were purchased from the College of Medicine, Bowen University, Nigeria. The rats were housed in well ventilated cages in the animal house under controlled room temperature of 26-29 °C with light/dark cycle adequately maintained. All the rats were provided with a commercial pellet chow and fresh tap water *ad libitum*, and the cage was cleaned daily.

Experimental Design: The 49 rats were randomly assigned into seven (7) groups composed of 7 rats each.

Group A served as the control group.

Group B rats were administered with low doses (250 mg/Kg) of paracetamol for 5 weeks.

Group C rats were administered with medium doses (500 mg/Kg) of paracetamol for 5 weeks.

Group D rats were administered with high doses (1000 mg/Kg) of paracetamol for 5 weeks.

Group E rats were administered with low doses (250 mg/Kg) of paracetamol and high dose (1600 mg/kg) of moringa extract simultaneously for 5 weeks.

Group F rats were administered with medium doses (500 mg/Kg) of paracetamol and high dose (1600 mg/kg) of moringa extract simultaneously for 5 weeks.

Group G rats were administered with high doses (1000 mg/Kg) of paracetamol and high dose (1600 mg/kg) of moringa extract simultaneously for 5 weeks.

Drug Preparation: Paracetamol tablets were crushed to powder and dissolved in distilled water. While the moringa powder was mixed with distilled water as well, resulting in a thick mixture. This mixture was filtered and the filtrate collected. The filtrate and the dissolved paracetamol were administered to the rats orally with the aid of an oral cannula.

Animal Sacrifice and Organ Harvest: Five rats from each group were randomly chosen and sacrificed using anaesthetic method (Chloroform) twenty four (24) hours after the last dose administration for each group. The testes were

harvested from each of the sacrificed animals and weighed using a sensitive weighing scale. Each harvested testicular tissue was dissected transversely, with one half immediately stored in an EDTA bottle and put in a freezer for biochemical assay, while the other half was fixed in Bouin's fluid (fixative) for histological assay.

Seminal Analysis: The sperm count was determined using NEUBAUR improved counting chamber (haemocytometer). The morphology of the sperm cells were evaluated with the aid of light microscope at x 400 magnification. Caudal sperm cells were taken from the original dilution for motility and diluted 1:20 with 10% neutral formalin. The progressivity was graded as follows:

A. Excellent forward directional movement (EFDM)

B. Good forward directional movement (GFDM)

C. Fair forward directional movement (FFDM)

D. Poor forward directional movement (PFDM)

Determination of Oxidative Stress: The level of SOD activity was determined by the method of McCord and Fridovich in 1969. The tissues' concentrations of malonaldehyde was determined spectrophotometrically as an index of lipid peroxidation while the catalase activity levels were quantitatively measured using von Euler and Josephson's method.

Hormonal Analysis: Blood was obtained by an ocular puncture from the rats in each study group to determine the follicle stimulating hormone (FSH), luteinizing hormone (LH) and testicular testosterone (TT). Each blood was spun at 2500 rpm for 10 minutes in a desktop centrifuge, to obtain the serum from the whole blood. The serum was then frozen for analysis. The serum were assayed according to the enzyme linked immunoassay (ELISA) techniques instructed by the kit manufacturer (Biotec Laboratory Ltd).

Tissue Processing: The tissues immersed in 10% formal saline for 24 hours to fix. The tissue specimens were dehydrated in ascending grades (70%, 80%, 90%, 95% and absolute) of alcohol. The tissues were cleared using xylene, then infiltrated in 2 changes of paraffin wax at 56-58 ℃ for an hour. After infiltration, the tissues were embedded in a molten paraffin, and allowed to solidify. The tissues were sectioned using a microtome at 4 mm thickness and mounted on microscope slides. The mounted sections were passed through clearene to dissolve the paraffin. Sections were stained using Haematoxylin and Eosin technique.

Statistical Analysis: Numerical data obtained from the quantitative biochemical and hormonal assay, weight measurement, organ weights were analyzed statistically with Graphpad Prism software using analysis of variance (ANOVA) for multiple comparisons between groups. The results were expressed as mean ± standard error of mean (SEM). The significance of the difference between the control and the experimental groups were determined using student's T-test and values of $p<0.05$ which is considered as statistically significant.

RESULTS:

Body and Testicular Weight Analysis: There was a dose dependent decrease in percentage weight difference observed in the groups induced with paracetamol only, compared to the control group. There was significant increase in body weights of the paracetamol-induced rats treated with moringa, when the pre- and post-administration body weights were compared. The increase in body weight was observed to be significantly lower in the paracetamol-induced groups further treated with moringa extracts, as compared to the control group and the groups induced with paracetamol only. Testicular weight was observed to be decrease significantly only in the group induced with high dose of paracetamol, in comparison to the control group. Other treatment groups were shown to have insignificant decrease in the weight of the testes.

Seminal Analysis: There was significant decrease in the sperm count and number of sperm cells with normal morphology in all the treatment groups, compared to control group. This decrease in sperm count and sperm morphology was also observed to be paracetamol-dose dependent. The moringa extract seemed to mitigate the adverse effects of paracetamol on the sperm count and morphology, with better results obtained in the groups treated with medium and low doses of paracetamol.

TABLE 1: BODY AND TESTICULAR WEIGHT OF PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS AND PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS TREATED WITH MORINGA EXTRACTS

Groups	Pre-Administration (g)	Post-Administration (g)	% Weight Difference (%)	Testis Weight (g)
Control	82.20±12.94	197.2±7.14	139.90	1.06±0.07
Low dose paracetamol	119.2±1.32	215.9±5.57	81.12	0.84±0.18
Medium dose paracetamol	144.9±1.33	214.7±7.65	48.17	0.91±0.15
High dose paracetamol	190.6±6.51	227.9±12.06	19.57	0.59±0.11
Low dose paracetamol + Moringa	217.8±6.67	229.8±6.77	5.51	1.18±0.01
Medium dose paracetamol + Moringa	218.4±4.97	232.4±8.42	6.41	1.16±0.03
High dose paracetamol + Moringa	275.4±12.3	303.6±8.93	10.24	0.95±0.02

Values are expressed as Mean ± Standard Error of Mean (SEM).

TABLE 2: THE SPERM COUNT AND SPERM MORPHOLOGY OF PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS AND PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS TREATED WITH MORINGA EXTRACTS

Groups	Sperm Count	Sperm Morphology
Control	98.33±0.78	96.65±1.21
Low dose paracetamol	61.45±0.94	58.13±0.49
Medium dose paracetamol	42.18±0.65	38.47±0.27
High dose paracetamol	31.65±0.70	24.16±0.73
Low dose paracetamol + Moringa	77.12±0.74	68.05±0.70
Medium dose paracetamol + Moringa	58.95±0.16	48.67±0.34
High dose paracetamol + Moringa	38.98±0.34	31.80±0.13

Values are expressed as Mean ± Standard Error of Mean (SEM).

Hormonal Milieu: Paracetamol induced a significant dose dependent decrease in the follicle stimulating hormone (FSH) and testosterone levels when compared to the control group, while inversely, producing an increase in dose dependent manner in lutenizing hormone (LH) levels.

Moringa extract was observed to suppress the paracetamol toxicity on hormonal milieu with the groups treated with moringa extracts yielding hormonal values closer to control group than the counterpart groups induced with paracetamol only.

Oxidative Stress: Oxidative stress biomarkers were observed to elevate with increase paracetamol treatment dosage when compared to the control group. Malondialdehyde (MDA) and superoxide dismutase (SOD) were observed to spike as paracetamol dosage increased, but moringa extract treatment reasonably controlled the spike in these oxidative stress biomarkers as the values were not as elevated as compared to the groups treated with paracetamol only.

The groups treated with high dose of paracetamol yielded significantly increased catalase (CAT) levels, whether moringa extracts were administered or not.

TABLE 3: HORMONAL MILIEU IN PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS AND PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS TREATED WITH MORINGA EXTRACTS

Groups	FSH (mlU m/L)	LH (mlU m/L)	Testosterone (ng m/L)
Control	1.63±0.04	11.27±0.15	5.30±0.07
Low dose paracetamol	1.16±0.01	22.13±0.10	3.80±0.05
Medium dose paracetamol	0.74±0.01	23.35±0.19	3.37±0.02
High dose paracetamol	0.33±0.01	27.59±0.17	3.11±0.04
Low dose paracetamol + Moringa	1.24±0.01	17.91±0.02	4.16±0.02
Medium dose paracetamol + Moringa	0.95±0.01	21.12±0.17	3.93±0.03
High dose paracetamol + Moringa	0.59±0.01	23.83±0.17	3.41±0.12

Values are expressed as Mean ± Standard Error of Mean (SEM).

TABLE 4: OXIDATIVE STRESS BIOMARKERS IN PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS AND PARACETAMOL-INDUCED ADULT MALE SPRAGUE-DAWLEY RATS TREATED WITH MORINGA EXTRACTS

Groups	MDA (Mmol/g)	SOD (Mmol/g)	CAT (Mmol/g)
Control	268.2±1.08	207.7±0.40	562.3±2.44
Low dose paracetamol	360.9±0.29	396.2±0.87	511.1±34.64
Medium dose paracetamol	424.8±1.51	430.1±1.32	527.6±29.40
High dose paracetamol	696.5±1.78	521.2±1.50	673.3±45.89
Low dose paracetamol + Moringa	330.6±5.57	320.1±3.61	530.7±3.92
Medium dose paracetamol + Moringa	381.9±1.12	397.9±0.98	557.2±2.21
High dose paracetamol + Moringa	497.2±4.74	389.3±0.45	670.6±3.30

Values are expressed as Mean ± Standard Error of Mean (SEM).

Histological Sections:

Group A (Control):

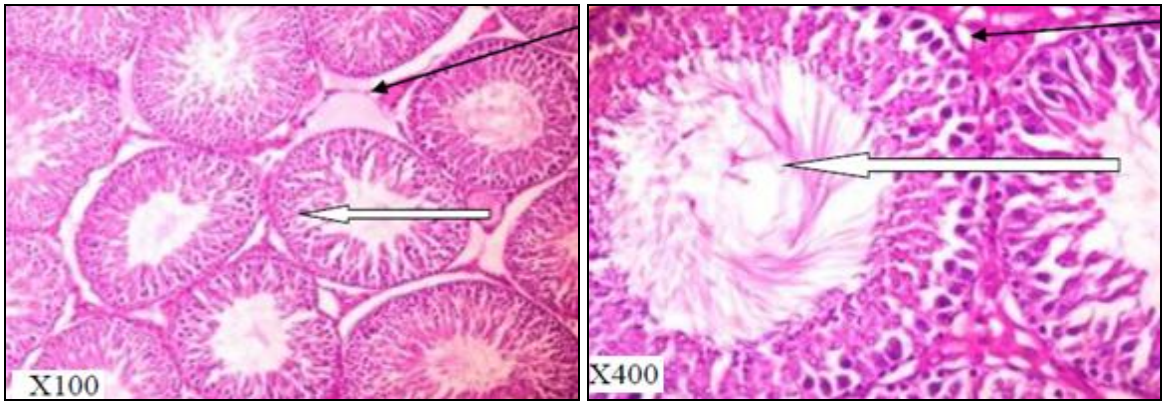

FIG. 1: SECTION OF TESTIS OF RATS IN THE CONTROL GROUP SHOWING NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) AND INTERSTITIAL SPACES (SLENDER ARROW) WITH COMPLETELY DEVELOPED GERMINAL CELLS. SECTIONS SHOWED NORMAL TESTICULAR HISTOLOGY WITH NORMAL SEMINIFEROUS TUBULES CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS, AND INTERSTITIAL SPACES SHOW LEYDIG CELLS. THE NORMAL SPERMATOGENIC CELLS, SPERM, AND SERTOLI CELLS WERE OBSERVED IN THE SEMINIFEROUS TUBULES

Group B (Low Dose Paracetamol):

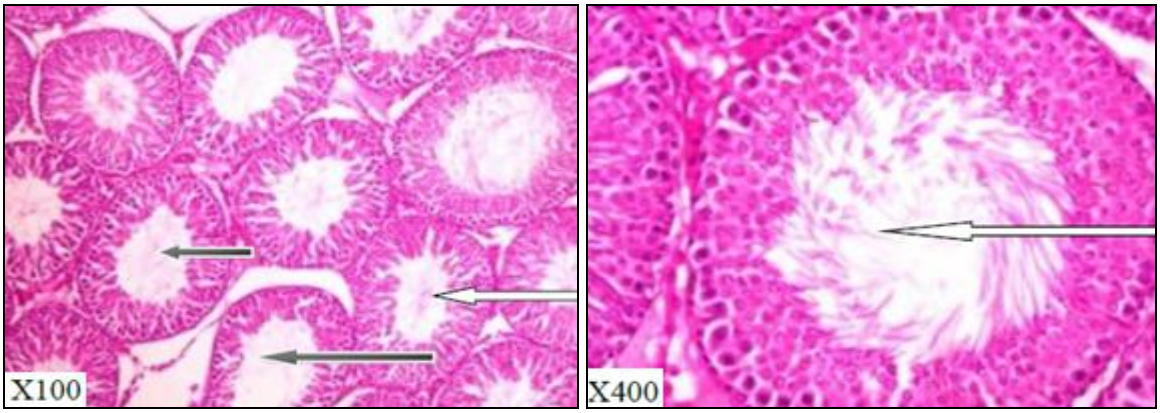

FIG. 2: SECTION OF TESTIS OF RATS TREATED WITH LOW DOSE OF PARACETAMOL FOR 5 WEEKS SHOWING NORMAL SEMINIFEROUS TUBULES WITH MATURATION ARRESTED GERM CELLS. SECTIONS SHOWED NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS. THE LUMEN APPEAR NORMAL CONTAINING SPERMATOZOA (WHITE ARROW). THERE WERE ALSO A FEW SEMINIFEROUS TUBULES WITH GERMINAL CELLS SEEN TO BE UNDERGOING MATURATION ARREST (BLACK ARROW)

Group C (Medium Dose Paracetamol):

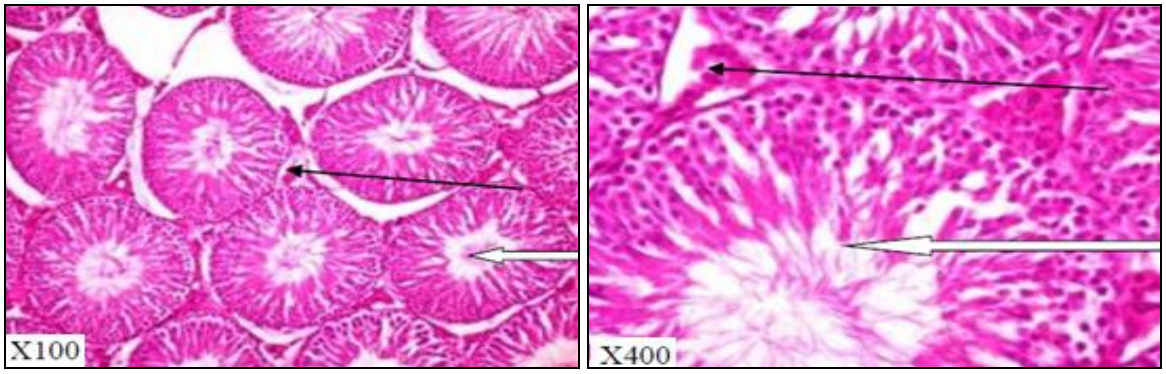

FIG. 3: SECTION OF TESTIS OF RATS TREATED WITH MEDIUM DOSE OF PARACETAMOL FOR 5 WEEKS SHOWING NORMAL SEMINIFEROUS TUBULES AND INTERSTITIAL SPACES WITH LEYDIG CELLS. SECTIONS SHOWED NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS. THE LUMEN APPEARED NORMAL CONTAINING SPERMATOZOA (WHITE ARROW). THE INTERSTITIAL SPACES WERE ALSO OBSERVED TO CONTAIN SOME LEYDIG CELLS (SLENDER ARROW)

Group D (High Dose Paracetamol):

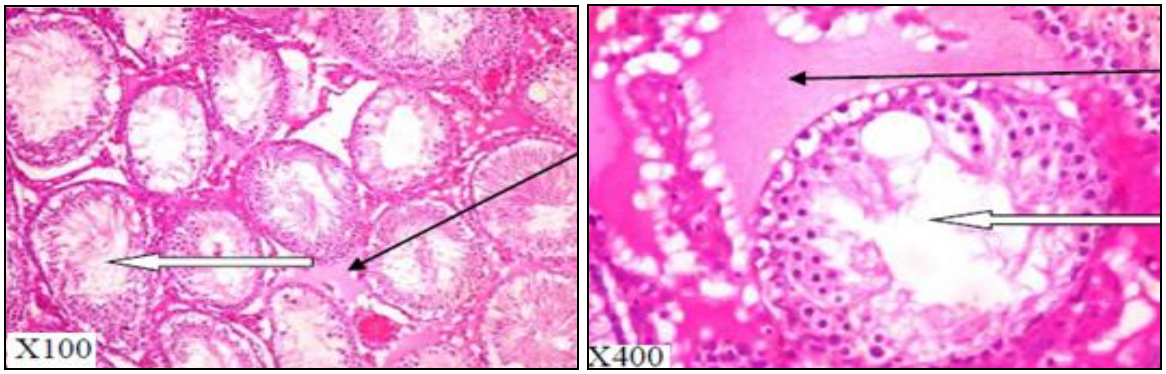

FIG. 4: SECTION OF TESTIS OF RATS TREATED WITH HIGH DOSE OF PARACETAMOL FOR 5 WEEKS SHOWING ABNORMAL SEMINIFEROUS TUBULES AND DEGENERATED GERM CELLS ALONG WITH CONGESTED INTERSTITIAL SPACES WITH LEYDIG CELLS. THE SECTIONS SHOWED DISTORTED SEMINIFEROUS TUBULES, THE SEMINIFEROUS TUBULES ARE ATROPHIC WITH THICKENED PROPRIA AND CONTAINING DEGENERATED GERM CELLS, THEY SHOW CEASATION OF GERM CELLS DEVELOPMENT AS WELL AS VACUOLATIONS (WHITE ARROW), THE INTERSTITIAL SPACES WERE OBSERVED TO BE CONGESTED AND ACCUMULATED WITH FLUID (SLENDER ARROW)

Group E (Low Dose Paracetamol + Moringa Extracts):

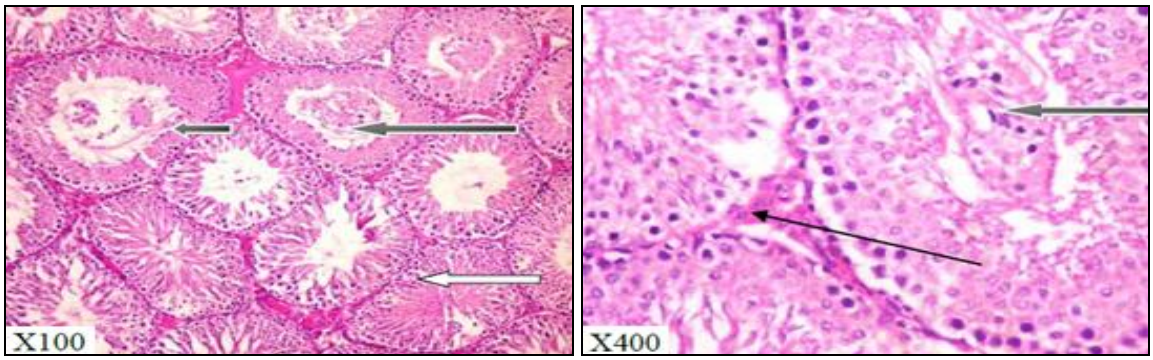

FIG. 5: SECTION OF TESTIS OF RATS TREATED WITH LOW DOSE OF PARACETAMOL AND MORINGA EXTRACTS FOR 5 WEEKS SHOWING NORMAL SEMINIFEROUS TUBULES WITH GERM CELLS AND THE INTERSTITIAL SPACES WITH LEYDIG CELLS. SECTIONS OF THE TEST IS SHOWED SEVERAL NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS. THE LUMEN IN THE HISTOLOGICAL SECTION APPEARED NORMAL, CONTAINING SPERMATOZOA (WHITE ARROW). THERE WERE FEW SEMINIFEROUS TUBULES SHOWING SLOUGHED GERM CELLS WITHIN THE LUMINAR SPACES (BLACK ARROW), AND NORMAL LEYDIG CELLS WERE SEEN IN THE INTERSTITIAL SPACES (SLENDER ARROW)

Group F (Medium Dose of Paracetamol + Moringa Extracts):

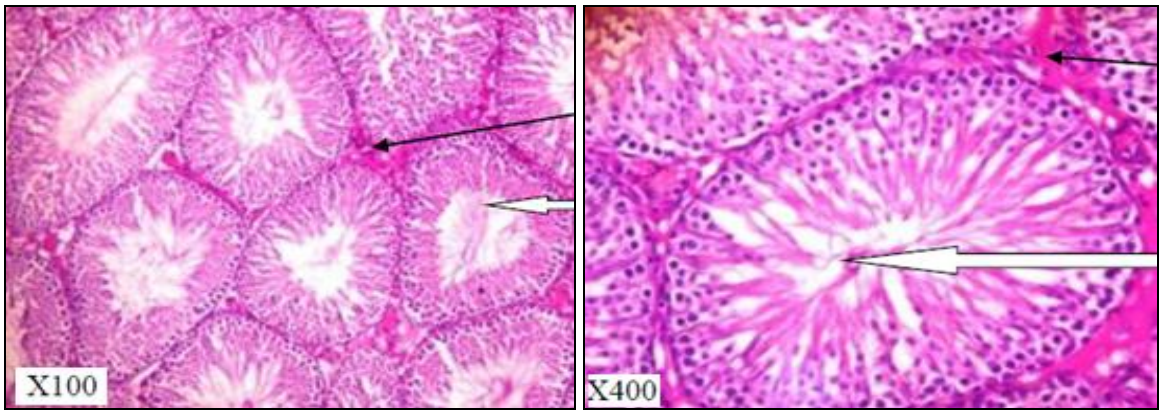

FIG. 6: SECTION OF TESTIS OF RATS TREATED WITH MEDIUM DOSAGE OF PARACETAMOL AND MORINGA EXTRACTS FOR 5 WEEKS SHOWING WELL DEVELOPED GERM CELLS IN SEMINIFEROUS TUBULES AND THE INTERSTITIAL SPACES WITH LEYDIG CELLS. SECTIONS SHOWED NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS. THE LUMEN ALSO APPEARED NORMAL AND CONTAINED SPERMATOZOA, WHILE THE INTERSTITIAL SPACES WERE OBSERVED TO HAVE NORMAL LEYDIG CELLS (SLENDER ARROW)

Group G (High dose of paracetamol + Moringa Extracts):

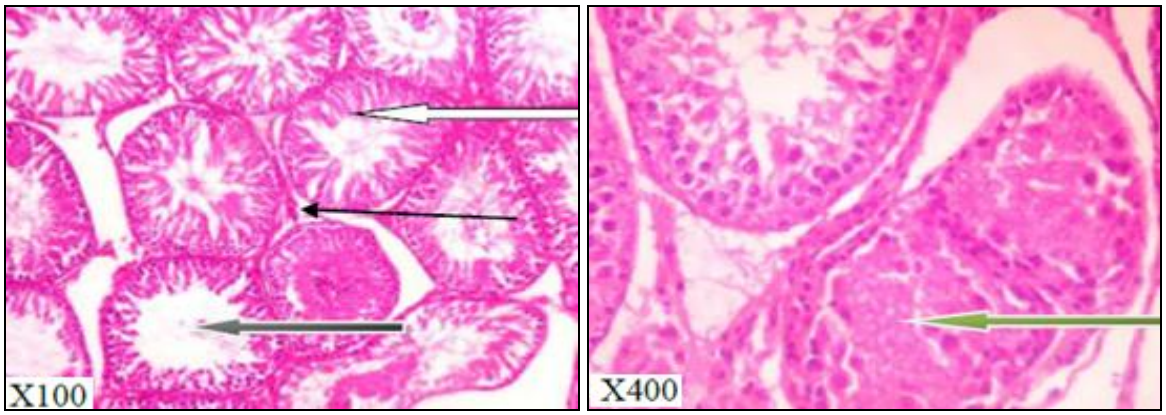

FIG. 7: SECTION OF TESTIS OF RATS TREATED WITH HIGH DOSE OF PARACETAMOL AND MORINGA EXTRACTS FOR 5 WEEKS SHOWING DEGENERATED GERM CELLS IN THE SEMINIFEROUS TUBULES.THE SECTIONS SHOWED HYPOSPERMATOGENESIS WITH SOME NORMAL SEMINIFEROUS TUBULES (WHITE ARROW) CONTAINING NORMAL AND COMPLETELY DEVELOPED GERMINAL CELLS. THE LUMEN APPEARED TO CONTAIN NORMAL CONTAINING SPERMATOZOA (WHITE ARROW). MATURATION ARREST OF SPERMATOGENESIS WAS OBSERVED IN THE SEMINIFEROUS TUBULES EXHIBITING WIDE LUMEN (BLACK ARROW), WHILE LACK OF LUMEN AND DEGENERATED GERMINAL CELLS WERE ALSO SEEN (GREEN ARROW). THE INTERSTITIAL SPACES SHOW NORMAL LEYDIG CELLS (SLENDER ARROW)

DISCUSSION: There is a continuously growing concern in male reproductive science on how effective and healthy reproductive states can be achieved and maintained [31]. Several researches have demonstrated the adverse effects of certain substances on the structure and function of male reproductive system and fertility [32]. Consistent use of high doses of paracetamol has been shown to induce testicular toxicity [33]. In this study, the effects of paracetamol on hormonal milieu, oxidative stress levels, seminal analysis and histology of the testis were observed while assessing the ameliorative effects of moringa on these features. Moringa treatment controlled weight gain, even in paracetamol-induced rats. This is consistent with Redha *et al*., which stated that moringa possesses anti-obesity potency [34], and Metawally *et al*. stated that moringa may be therapeutic for metabolic syndrome while controlling visceral adipose tissue [35]. Moringa treatment was observed to prevent the testicular weight reduction associated with dose dependent

paracetamol usage. As stated by Nayak *et al*., moringa extract administration attenuates cyclophosphamide-induced testicular weight reduction [36]. And testicular weight has been revealed to impact male fertility [37]. Increase in the dosage of paracetamol administered corresponds with the decrease in sperm count and number of sperm cells with normal morphology. Paracetamol produced a dose dependent decrease in sperm count while moringa alleviated the oligospermia, with better improvement observed when induced with low dose of paracetamol. The report by Sulaimon *et al*. is in consonance with our findings stating that paracetamol treatment leads to a dose dependent decrease in sperm count and sperm morphology [38]. And according to Bin-Meferij and El-Kott, moringa extracts significantly improved semen parameters including sperm count and morphology sequel to mobile phone electromagnetic radiation induced-infertility [39]. And moringa has been shown to improve sperm count in hyperinsulinemic male [40].

Reproductive hormones have a significant role in the male reproductive system and determining fertility [41]. The main regulators of male germ cell development are the gonadotropins (FSH, LH), as well as testosterone [42]. The elevated levels of LH and FSH are indicative of primary hypogonadism [43], and as stated by Grinspon *et al*., primary hypogonadism leads to testis dysfunction [44]. Hence implicating abuse of paracetamol in the decrease in male fertility while moringa possesses the propensity to reverse paracetamol's distortion of the reproductive hormonal levels. Our results agree with Greish *et al*. and Abdu *et al*., which stated that moringa could improve reproductive hormonal levels in males [45, 46].

The increase in MDA concentration along with corresponding increases in SOD and CAT activity levels with corresponding increase in the dosage of paracetamol, is indicative of increased oxidative stress and antioxidant activities in the testis associated with consistent paracetamol usage. Elevated MDA is a result of increased lipid peroxidation (LPO) in a variety of disorders [47], while the levels of enzymatic antioxidants (CAT, SOD) may be an indication of how the body defends itself against oxidative stress [48]. And as suggested by Bilgen *et al.*, significantly increased MDA, SOD, and CAT activities also show a balance between oxidant and antioxidant effects [49]. Invariably, moringa regulates the rate of oxidant and antioxidant activities while preserving the homeostasis, hence extra antioxidant supplements may not be required to combat oxidative stress. Several histological alterations in the testis are observed after high dosage of paracetamol treatment [50]. The alterations observed in our study include atrophy of seminiferous tubules, fluid accumulation and congestion of interstitial spaces, vacuolations along with degeneration of germ cells and ceasation of germ cells development. As suggested by Sugita *et al*., this alterations may be due to highly elevated levels of apoptosis in the test is [51]. Our study showed that moringa treatment ameliorates the adverse effects of paracetamol on the testis, as we observed the hypospermatogenesis along with restoration of normal seminiferous tubules and interstitial spaces in the paracetamol-induced groups treated with moringa extracts. This is consistent with Abd *et al*., which suggested that moringa ameliorates the adverse effects of painkillers on the histology of the test is [52].

CONCLUSION: Moringa extract treatment mitigates the effects of paracetamol on the testis and male fertility with better recovery observed in those exposed to reduced or less paracetamol toxicity. Decrease in the usage of paracetamol and consistent use of moringa extract seem to ameliorate the toxic effects of paracetamol on male fertility.

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CONFLICTS OF INTEREST: Nil

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