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The modulatory role of *Moringa oleifera* seed extract on cadmium chloride-mediated the pituitary-gonadal axis and sex hormones disorder in male rats

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Abstract

The present study seeks to ascertain influence of seed extract from the *Moringa oleifera* plant on some hormonal parameters of the pituitary-testicular axis, such as measuring the level of Follicle-Stimulating Hormone (FSH), Luteinizing Hormone (LH), and Testosterone (T). The study also included measuring some seminal variables, sperm concentration, normal and abnormal sperm, sperm movement and vitality, in addition to examining alterations in body and testicle weight, epididymis seminal and seminal vesicle of male white rats after exposure to cadmium chloride. Giving of 6 mg/kg of cadmium chloride (positive control) produced a statistically significant decline ($p > 0.05$) reduction of T, LH, and FSH in comparison with the negative control. When compared to the group that received a cadmium chloride dose alone, the groups that received dosages of 150, 300, and 450 mg/kg of moringa seed extract with cadmium chloride appear to have a substantial raise ($p < 0.05$) in the previously indicated parameters. The results of the group with a view to being dosed with cadmium chloride at 6 mg/kg also appear to be a significant decline ($p > 0.05$) comparative with the negative control group in sperm variables, sperm concentration, normal sperm, sperm movement and vitality, the rate of change in body weight, testicular weight percentage, and epididymis seminal and seminal vesicle weight percentage, as well as a significant raise ($p < 0.05$) in the rates of these parameters in the groups that were administered 150, 300, and 450 mg/kg moringa seed extract with the cadmium chloride as opposed at the positive control group. the aim a research is consistent with the United Nations Environment Program in achieving the third goal of the sustainable development goals to ensure a healthy future and address environmental issues.

Keywords: *Moringa oleifera* seeds, cadmium chloride, fertility index, reproductive performance, semen, testes

Introduction

Naturalistic medicines extracted from medicinal plants and their ingredients are used to prevent and treat many ailments (Nasim, *et al.*, 2022) ^[23]. Research on classical medicine using medicinal plants is growing these days (Salmerón-Manzano E *et al.*, 2020) ^[32]. Furthermore, this treatment approach is characterized by its lower cost compared to traditional chemical treatments, along with a reduced likelihood of associated side effects and a high degree of compatibility with individual patient needs. Consequently, traditional herbal medicine is enjoying widespread adoption and increasing acceptance in therapeutic practice. (El-Dahiyat F *et al.*, 2020) ^[11]. Because nearly every component of the moringa plant, can be used as a dietary supplement, traditional medicine, or for various industrial uses, it is also known as "kelor," or "the Miracle Tree." (Pareek, A., A *et al.*, 2023) ^[28]. The portion of the leaf that is rich in minerals, vitamins, and potent antioxidants is one of them (Peñalver, R., *et al.*, 2022) ^[29]. Moringa seeds are distinguished by active plant components: glycosides, alkaloids, flavonoids, steroids, reducing sugars, carbohydrates, saponins, eugenols, and tannins (Iliyasu *et al.*, 2020) ^[16], moreover, by their high protein, mineral, and vitamin content (Divya, S., *et al.*, 2024) ^[10]. The existence of pollutants that the general public is exposed to through their food, drink, air, industrial materials, and fuel-consuming items is one of the most significant elements that may have an impact on the reproductive system's health (Mohajer, N., & Culty, M. 2025) ^[21].

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ponderous metal contamination is the oldest environmental issue affecting public health. Cadmium is widely recognized as one of the most undesirable heavy metals for the human body. It is not only highly toxic, but also a significant environmental pollutant due to agricultural and industrial activities (Liu YH *et al.*, 2021; Vijayakumar *et al.*, 2021) ^[18, 36]. Manufacturing human activities have increased the concentration of cadmium in the atmosphere, water, soil, and living organisms by a large percentage, leading to its accumulation in the nutrient chain. (Wang, R., *et al.*, 2023) ^[38]. Cadmium is characterized by its long duration of residence and accumulation in the human and animal bodies and the fact that it is found in the environment in a sustainable manner. and due to its high solubility, it has significant toxicity and absorption effects that hold an effect on both human and animal health (Charkiewicz, *et al.*, 2023) ^[9]. Which makes this metal a source of harm and toxicity to all forms of life (Genchi G, *et al.*, 2020) ^[14]. Cadmium enters the respiratory tract at a average of 10-40% of the consumed quantity and amount and passes through the digestive system at a rate of 5% (Satarug S, 2020) ^[34]. Cadmium accumulates and spreads in certain organs, such as the liver and kidneys. Its long-term metabolic effects extend over many years, increasing the risk of its accumulation in organs and causing various adverse effects (Carmona A *et al.*, 2021) ^[8]. Cadmium greatly affects the body's health; it secretes and regulates sex hormones in the endocrine system and causes a steroid disorder. It directly affects the gonads. It also has an effect on the hypothalamic-pituitary-gonadal axis (Vinanthi Rajalakshmi, K. S., *et al.*, 2023) ^[37], and it harms the average weight of the reproductive organs (testicles) and epididymis (relative to body weight) and causes a noticeable decrease in these rates (Mohammad A. S. and Mahmoud K., 2021) ^[22]. Dosing the experimental subjects in our current study with cadmium chloride (6 mg/kg/day) led to clear damage to the male reproductive system, and this is what many studies have indicated (Iqbal, T., *et al.*, 2021; Vinanthi Rajalakshmi, K. S., *et al.*, 2023) ^[17, 37].

Research objectives and importance

The return to using medicinal plants to avoid the harmful effects caused by extraneous substances in the human body has been a remarkable matter in recent decades because of their proven effectiveness compared to chemical preparations that are not devoid of harmful impacts. Hence the importance of this research in testing the efficiency of *Moringa oleifera* seed extract at concentrations of 150, 300, and 450 mg/kg (in the treatment of the effect of cadmium at a concentration (6 mg/kg/day) on several reproductive parameters in male albino rats).

Materials and Methods

Animals and experimental design

The research performed at the College of Biotechnology animal house at Al-Qadisiyah University involved 64 male albino rats, all adults, weighing between 200 and 250 grams and aged between 11 and 14 weeks. The rats were randomly assigned to 8 groups, each containing eight males, as follows:

- 1) **G1:** Oral dosage of a physiological saline (NaCl 0.09%) solution was administered to the negative control group.
- 2) **G2:** For 45 days, the toxic material cadmium chloride was given orally to the positive control group at a dose of 6 mg/kg body weight.
- 3) **G3:** For 45 days, the group received an oral dose of 150 mg/kg of an aqueous plant extract.
- 4) **G4:** For 45 days, the group was giving oral doses of the

Moringa oleifera seed extract at 150 mg/kg and cadmium chloride at 6 mg/kg.

- 5) **G5:** The group received an oral dose of the plant extract for 45 days at a rate of 300 mg/kg body weight.
- 6) **G6:** For 45 days, the group received doses of 300 mg/kg of the *Moringa oleifera* seed extract and 6 mg/kg of cadmium chloride.
- 7) **G7:** For 45 days, the group received a dose of the plant extract at 450 mg/kg.
- 8) **G8:** For 45 days, the group was dosed of the plant extract at 450 mg/kg and then 6 mg/kg of cadmium chloride orally.

Preparing the extract of moringa seeds

The seeds were brought from specialized stores in the city of Diwaniyah that sold therapeutic herbs. The 40 g of powdered dried seeds were measured with a using balance and combined in a 1-liter beaker. Soak the powder in 300 ml of distilled water and leave for 48 hours. After that, spent three hours heating in a water bath at 60 degrees Celsius. The residue was continually mixed with hot water and then filtered. After three repetitions of the process spaced ten to fifteen minutes apart, the filtrate was dried in a water bath at sixty degrees Celsius. Using a rotary evaporator, the liquid extract was subsequently vacuumed at 40 °C. The desiccated extract was then preserved at 4 °C (Iliyasu, D *et al.*, 2020) ^[16].

Animal sacrificing

After administering doses of treatment and control groups, the animals were anesthetized by intra-peritoneal injections of xylazine (0.1 mg/kg body weight) and ketamine (0.3 mg/kg body weight). The animals were dissected, and abdominal vein blood samples were taken. The testis, epididymis and Seminal Vesicle were dissected and weighed (Al-Hichamy, H.H., & Al-Saaidi, J.A. 2024) ^[3].

Blood samples collection

Following anesthesia, blood samples were obtained from the rats' abdominal vein using a disposable 5 ml syringe. There was a collection of blood samples taken in non-heparinized. The samples were allowed to coagulate at room temperature before the serum sample was centrifuged at 5000 rpm for 15 minutes to separate the serum. It was stored sterile, collected in Eppendorf tubes at -20 °C until use for reproductive hormone analysis. (FSH, LH, and testosterone) (Opeyem *et al.*, 2021) ^[26].

Relative organ weight measurement

The male albino rat's body weight and genital organ weights were weighed. In the final of the experiment period. To calculate relative organ weight, the following equation was used (Ikuomola, E., *et al.*, 2022) ^[15]:

$$\text{Relative organ weight (\%)} = \frac{\text{Organ weight (g)}}{\text{Body weight (g)}} \times 100$$

Hormonal analysis

ELISA kits were used to measure the amounts of FSH, LH, and testosterone in accordance with the manufacturer's (Cusabio, China) instructions (Al-Hichamy, H.H., & Al-Saaidi, J.A., 2024) ^[3]. This approach followed the manufacturer's instructions for all reagent preparation and test processes.

Results

The impact of a cadmium chloride at the FSH, LH, and testosterone levels in male albino rats

The results shown in Table 1 indicate a significant decrease

($p < 0.05$) in the levels of reproductive axis hormones, namely testosterone (T), luteinising hormone (LH), and follicle-stimulating hormone (FSH), 45 days after cadmium chloride was administered to male albino rats in the positive control group.

The impact of moringa seed extract at several concentrations on the FSH, LH, and testosterone concentrations in male albino rats treated with cadmium chloride is investigated

Table (1) results indicated that the concentrations of FSH and T hormones were significantly higher ($p < 0.05$) in the two groups of rats given a single dose of moringa seed extract (300

and 450 mg/kg). In contrast, the group that received the extract at a dose of 150 mg/kg for 45 days showed no significant differences in these hormone levels ($p > 0.05$). Additionally, LH hormone levels did not vary statistically ($p > 0.05$) among groups administered 150, 300, and 450 mg/kg of the moringa seed extract and the negative control. While the testosterone hormone (T), LH, and FSH concentrations in groups of rats dosed with extract of moringa seeds at levels (150, 300, and 450 mg/kg) with cadmium chloride over 45 days appeared to have a significant rise ($p > 0.05$) in comparison with the group that was dosed with cadmium chloride alone, the positive control group.

Table 1: The mean concentration of LH, FSH, and testosterone (T) in blood serum to the rats treated with cadmium and *Moringa oleifera* seed extract

Groups	Control group		Moringa group			Moringa + Cadmium chloride group		
Studied standards S.E. ± Mean	Negative control Normal saline (0.09)	Positive control Cadmium chloride group (6 mg/kg)	150 mg/kg	300 mg/kg	450 mg/kg	(150 mg/kg) (6 mg/kg)	(300 mg/kg) (6 mg/kg)	(450 mg/kg) (6 mg/kg)
Testosterone mIU / ml	5.23 ± 0.64	0.79 ± 0.23	5.86 ± 0.84	6.92 ± 0.73	9.96 ± 1.46	4.26 ± 0.74	4.10 ± 0.74	3.98 ± 0.57
Luteinizing hormone (LH) mIU/ml	25.12 ± 2.08	12.78 ± 0.43	26.24 ± 2.23	25.73 ± 0.86	27.12 ± 1.36	25.26 ± 0.63	23.48 ± 0.54	27.10 ± 1.46
Follicle stimulating hormone (FSH) mIU/ml	21.24 ± 0.52	10.96 ± 0.52	22.30 ± 1.12	28.62 ± 1.97	31.45 ± 1.61	22.8 ± 0.78	20.24 ± 0.49	25.12 ± 1.98

Average ± standard error, n = 8

The effect of a cadmium chloride on determining Sperm variables in male albino rats

Compared to the male albino rats in the control group (negative control group), the results of Table 2 demonstrated a significant decline ($p > 0.05$) in sperm concentration, normal sperm, sperm motility, and sperm viability while exhibiting a notable rise ($p < 0.05$) in abnormal sperm in the positive control group in male albino rats that were treated with cadmium chloride for 45 days only.

The effect of moringa seed extract at different concentrations on the sperm variables in male albino rats treated with cadmium chloride

The level of sperm concentration shows no significant variation ($p < 0.05$) in Table 2, normal and abnormal sperm, sperm motility, and normal sperm vitality in the group of rats that

were dosed with moringa seed extract (150 mg/kg). A significant rise ($p < 0.05$) in sperm concentration during two groups in which the extract was dosed at 300 and 450 mg/kg for 45 days contrasted to the negative group of controls, where the concentration reached 450 mg/kg. The 450 mg/kg dose was the best concentration and had the greatest effect in increasing the number of sperm. As for the rats that were given doses of 6 mg/kg of cadmium chloride and moringa seed extract at concentrations of 150, 300, and 450 mg/kg for 45 days, there was An important improvement in seminal variables as a contrast with the group under positive control. treated with cadmium chloride, as the moringa seed extract was able to stop the decline caused by cadmium. Sperm concentration, normal sperm, normal sperm motility, and sperm vitality; and a notable reduction in aberrant sperm.

Table 2: Sperm variables of treated rats of cadmium- and aqueous extract- *Moringa oleifera* seeds

Groups	Control group		Moringa group			Moringa + Cadmium chloride group		
Studied standards S.E. ± Mean	Negative control Normal saline (0.09)	Positive control cadmium chloride group (6 mg/kg)	150 mg/kg	300 mg/kg	450 mg/kg	(150 mg/kg) (6 mg/kg)	(300 mg/kg) (6 mg/kg)	(450 mg/kg) (6 mg/kg)
Sperm concentration	115.21 ± 2.93	33.97 ± 2.73	113.7 ± 0.48	161.76 ± 3.89	192.23 ± 5.68	83.32 ± 1.76	99.97 ± 2.12	119.58 ± 1.76
Normal sperm %	88.37 ± 0.82	61.23 ± 0.91	86.52 ± 0.76	92.14 ± 0.62	86.64 ± 0.73	71.29 ± 0.46	80.58 ± 0.16	87.64 ± 0.51
Abnormal sperm %	11.63 ± 0.37	38.77 ± 0.82	13.48 ± 0.70	7.86 ± 0.82	13.36 ± 0.56	28.71 ± 0.18	19.42 ± 0.63	12.36 ± 0.71
Sperm motility %	89.4 ± 1.02	36.64 ± 0.51	86.74 ± 0.92	91.86 ± 0.46	93.32 ± 0.51	53.65 ± 0.75	74.53 ± 0.84	90.45 ± 0.78
Sperm viability (%)	94.55 ± 0.77	41.51 ± 0.74	96.42 ± 0.68	92.23 ± 0.48	89.64 ± 0.72	82.50 ± 0.41	78.26 ± 0.41	71.80 ± 0.29

* Average ± standard error, n = 8

The effect of cadmium chloride on 'the body and weight of the testes, epididymis, and seminal vesicle of male albino rats

The results of Table 3 revealed a significant decline ($p < 0.05$) in body weight as well as the weights of the testes, epididymis, and seminal vesicles in the male albino rats administered cadmium chloride (6 mg / kg) in comparison to the negative control group.

The effect of moringa seed extract at different concentrations on the body weight and weight of the testes, epididymis, and seminal vesicle in male albino rats given cadmium chloride

Groups of male albino rats were dosed with an extract of moringa seeds (150, 300, and 450 mg/kg) for 45 days. Table 3 indicated no significant variations ($p > 0.05$) in body weight alongside an increase in testicular weights, but it did not reach the level of significance and the appearance of a significant rise ($p < 0.05$) within the weights from the epididymis and seminal vesicle comparison with the negative control group. Also, Table 3 indicated that the male albino rats given the plant extract had a significant rise ($p < 0.05$) in the weights of the body, testicles, epididymis, and seminal vesicle. (150, 300, 450) mg/kg with 6 mg/kg cadmium chloride for 45 days compared to the group of male albino rats that were dosed with cadmium chloride 6 mg/kg only, the positive control group.

Table 3: Relative organ weights (% of cadmium- and *Moringa oleifera* seed extract-treated rats

Groups Studied standards S.E. ± Mean	Control group		Moringa group			Moringa + Cadmium chloride group		
	Negative control Normal saline (0.09)	Positive control cadmium chloride group (6 mg/kg)	150 mg/kg	300 mg/kg	450 mg/kg	(150 mg/kg) (6 mg/kg)	(300 mg/kg) (6 mg/kg)	(450 mg/kg) (6 mg/kg)
Rate of weight change (in grams)	87.02 ± 0.38	51.32 ± 0.23	84.62 ± 0.74	85.89 ± 0.66	86.24 ± 0.86	67.56 ± 0.75	76.56 ± 0.81	81.05 ± 0.75
Testis weight / weight ratio body (in grams)	0.55 ± 0.04	0.42 ± 0.46	0.59 ± 0.70	0.60 ± 0.63	0.62 ± 0.63	0.52 ± 0.34	0.52 ± 0.45	0.53 ± 0.36
Epididymis weight / weight ratio body (in grams)	0.32 ± 0.74	0.28 ± 0.42	0.35 ± 0.76	0.36 ± 0.82	0.36 ± 0.96	0.29 ± 0.45	0.31 ± 0.49	0.32 ± 1.98
Seminal vesicle (in grams)	0.38 ± 0.31	0.32 ± 0.76	0.42 ± 0.28	0.42 ± 0.88	0.41 ± 0.68	0.39. ± 0.46	0.38 ± 0.75	0.36 ± 0.84

*Average ± standard error, n = 8

Discussion

One of the most significant non-essential heavy metals for the body is cadmium. it is an posing compound, and it is known to have detrimental effects on various physiological processes in living organisms (Amer AAE *et al*, 2021) ^[5]. In the context of male reproductive health, treatment with cadmium chloride is due to alterations in hormone concentrations of FSH, LH, and testosterone (Arteaga M *et al.*, 2020) ^[6]. The research appeared to show that treatment with cadmium chloride leads to lower concentrations of FSH, LH, and testosterone in male albino rats. This decrease in hormone levels can be give to the toxic impacts of cadmium chloride on hypothalamic-pituitary axis and gonads the current study's findings agreed with (Bhardwaj, J. K., *et al.*, 2024) ^[7].

Moringa oleifera is a significant medicinal food with excellent nutritional, medicinal, agronomic, and social importance (Liu *et al.*, 2022) ^[19]. the chemical components of *Moringa oleifera* seed extract are biologically active factors applied in the manufacture of pharmaceutical compounds useful in enhancing fertility (Ma *et al.*, 2019) ^[20]. The results showed that administering extract from *Moringa oleifera* seeds at different concentrations led to alteration in the concentration of testosterone, FSH, and LH in male albino rats. The effect signal that the extract from *Moringa oleifera* seeds has a significant impact on the endocrine system of male albino mice, which led to improved concentration of LH, FSH, and testosterone Comparison made with negative control group. This finding is consistent with (El-Hak *et al.*, 2018) ^[12].

The results showed valuable information on the potential preventive effects extract *Moringa oleifera* seed against cadmium-prompt changes in the male reproductive hormones

Treatment with extract from *Moringa oleifera* seeds at different concentrations will alleviate the harmful effects of cadmium chloride on concentrations of testosterone, FSH, and LH in male albino rats. A significant rise in hormone concentration has been observed in comparison to control group exposure with cadmium chloride and the positive control group. The protective impact of the extract from *Moringa oleifera* seeds against cadmium-induced changes in male reproductive hormones can be attributed to its antioxidant properties, which cadmium exerts by stimulating oxidative stress and inflammation in the body, leading to hormonal disturbances. This is consistent with what he found (Obembe, O. O., & Raji, Y., 2018) ^[24].

The toxic effect of cadmium chloride on seminal fluid parameters (sperm) in male albino rats is being studied. Several key factors are usually evaluated, including sperm concentration, normal and abnormal sperm, sperm motility, and normal sperm viability. The results of this research indicate a significant decline in all types of sperm, except for abnormal sperm, which indicate a significant rise in them Compared to made with the negative control group. The decrease in sperm parameters in male albino rats has been indicated in previous studies that demonstrated that cadmium impairs testicular function (Al-Sharafi, N. M., & Alobaidy, S. M. R. 2022) ^[4]. The decrease in sperm count, motility, and vitality may be a result of cadmium intake, which leads to poor sperm formation and loss of sperm due to decreased secretion of testosterone (Zečević *et al.*, 2025) ^[39]. Research has indicated Cadmium's toxic impacts on the reproductive system. It may lead to decline of natural sperm vitality and sperm motility in male albino rats, leading to a decrease in their ability to successfully fertilize an

egg by impeding the ability of sperm cells to swim effectively towards the egg for fertilization, which affects fertility in male albino rats, and this is consistent with (Abd Elhafeez, E. 2019) [20].

As for the impact of Extract from *Moringa oleifera* seeds on sperm variables in male albino rats, the results showed treatment with Extract from *Moringa oleifera* seeds leads to a significant rise in sperm concentration Comparison made with the control group (negative group). This aligns with research carried out by (Akinlolu *et al.*, 2024) [2]. The study revealed a decline in the abnormal shape of sperm and a rise in the normal shape of sperm after treatment with moringa seed extract, and this aligns with studies carried out by Ogunlade, B., *et al.* 2022) [25]. Additionally, it was discovered that after treating male albino rats with moringa seed extract, sperm motility and sperm vitality were positively affected. This aligns with research carried out by Ogunlade, B., *et al.*, 2022) [25]. The improved roles of sperm variables in male albino rats can refer to the antioxidant character of Moringa seed extract, based on a study by (Ove, F.O. *et al.*, 2023) [27].

When studying the effect of various concentrations of *Moringa oleifera* seed extract on sperm variables in male albino rats treated with cadmium chloride, the impact of the extract from *Moringa oleifera* seeds is its anti-inflammatory and antioxidant characteristics (Swelum *et al.*, 2021) [35]. The study indicates that there was a significant rise in seminal variables, including sperm concentration, normal sperm motility, and normal sperm viability, and a significant decrease in abnormal sperm. A comparison was made with the group exposure to cadmium chloride (the positive group), which showed that the extract from *Moringa oleifera* seeds may have effects. Protective in contact with the toxic impact of hefty metals such as cadmium, whose bioactive compounds amino acids, polyphenols, isothiocyanates, flavonoids, tannins, carotenoid, alkaloids, glucosinolates, phenolic acid and saponins present in Extract from *Moringa oleifera* seeds help mitigate. The damages resulting from exposure to cadmium chloride (El-Saadony *et al.*, 2022) [13].

Weights of the body and organs are important standards for evaluating the toxicity of an organ. An increase or decrease in body weights throughout treatment with cadmium chloride generally reflects toxicity. Exposure to cadmium chloride led to a decrease in body weights and relative weights of organs in male albino rats. A significant decline in body, testicular weight, and the weight of the epididymis and seminal vesicles was also observed in our research comparisons to the negative control group. it is because of the toxic impact. of cadmium chloride on the physiological processes in the body, which reduces the animals' ability to move and loss of appetite, which results in a significant decrease in food absorption (Poli, V., *et al.*, 2022) [30]. Cadmium chloride-induced toxicity involves oxidative stress induction that leads to changes in antioxidant conditions that cause serious metabolic problems and weight loss (Renuka M *et al.*, 2021) [31].

The results indicated that Extract from *Moringa oleifera* seeds might have a positive effect on body weight regulation proportional to the different concentrations with which it was treated. In obese mice, dietary treatment with Extract from *Moringa oleifera* seeds was linked to weight loss through improvements in metabolic parameters and decreased fat formation. However, the impact of Extract from *Moringa oleifera* seeds on body weight in the context of exposure to cadmium chloride. A significant rise in body weight and other reproductive measures, weight of the testicle, epididymis, and seminal vessels, was seen in Comparison made with the

positive control group treated with cadmium chloride. In contrast to the effect of cadmium chloride, which caused a clear decrease in the weights of the body, testicle, epididymis, and seminal vessels, and this is consistent with what was found (Ovie, F. O *et al.*, 2023) [27].

Conclusions

The study investigated the potential ameliorative effects of extract from moringa seeds on various indices and functions of the pituitary-gonadal axis in male albino rats exposed to cadmium chloride. Cadmium chloride is a dangerous heavy metal that can interfere with endocrine function, including the hypothalamic-pituitary-gonadal axis. *Moringa oleifera*, on the other hand, is a plant with well-documented medicinal characteristics and was hypothesized to mitigate the adverse effects of cadmium chloride on the reproductive system. The findings suggest that *Moringa oleifera* seed extract has ameliorative properties on the pituitary-gonadal axis in male albino rats exposed to cadmium chloride. The extract shows potential as a treated agent for mitigating reproductive toxicity induced by heavy metals like cadmium.

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