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Detoxificating effects of *moringa oleifera* leaf and *zingiber officinale* root powder on cadmium toxicity in blood and fur of wistar rats

Abstract

The study was aimed at finding the detoxicating effects of *moringa oleifera* and *zingiber officinale* supplemented feeds in cadmium induced rats. 45 rats were divided into 9 groups of 5 rats and investigated for induced cadmium toxicity and detoxicating action of *moringa–oleifera* (Mo) leaf powder and *zingiber officinale* (Zo) root powder on the fur and blood. Group 1, the normal control was fed with grower mash and water *ad–libitum* for 4 weeks; group 2, the negative control was induced with 0.5mg/bd wt Cadmium nitrate solution and fed with grower mash and water *ad–libitum* for 7 days. Group 3–5 were induced with 0.5mg/bd wt cadmium nitrate solution for 7 days and administered water *ad–libitum* and grower mash feed supplemented with 5%, 10% and 15% *moringa oleifera* leaf powder respectively for 21 days, group 6–8 were induced with 0.5mg/bd wt cadmium nitrate solution for 7 days and was administered grower mash feed supplemented with 5%, 10% and 15% *zingiber officinale* powder respectively and water *ad–libitum* for 21 days. Group 9 was induced with cadmium nitrate solution for 7 days and administered with grower mash feed supplemented with 10% mixture of *moringa* and *zingiber* powder for 21 days. The cadmium concentration in the fur and blood of the rats were analyzed using Atomic Absorption Spectroscopy (AAS). In the fur, the AAS results revealed that the supplemented groups of both biomaterials significantly ($P<0.05$) lowered the concentration of the heavy metal. In the blood, the AAS result showed that the concentration of cadmium was significantly ($P<0.05$) lowered by the supplemented groups in both biomaterials (Mo and Zo). This study reveals that the supplementation of feed with both plants led to a significant detoxification of cadmium and the detoxification ability increased with increased quantity of plant powder.

Keywords: AAS, cadmium, toxicity, ad–libitum, detoxicating

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Abbreviations: PCV, packed cell volume; WBC, white blood cell; AAS, atomic absorption spectroscopy; MO, *moringa–oleifera*; ZO, *zingiber officinale*

Introduction

Heavy metals are hazardous substances that cause serious health risk to ecosystem and organisms due to their high toxicity conferred by nature of their environmental persistence. Heavy metals have been defined based on their specific density (of metals greater than 4 or 5g/liter), having atomic weight between 63.546 and 200.590 (Sagakachi, Makajima & Atoleiye et al). Unlike organic pollutants, heavy metals are non–biodegradable, so they persist for long in their host organism, constituting long term problem (Atolaiye). Cadmium is a soft, malleable, ductile, bluish–white divalent metal. It's average concentration in the earth crust is between 0.1 and 0.5mg/kg.[1,2] It is an environmental toxicant that adversely affect various organs such as liver, lungs, kidney, pancrease, testis, etc.[3–4] Plants are said to contain some phytochemicals which are good potential chelating agents of heavy metals.[5] *Moriga oleifera* is a vegetable belonging to the family Moringaceae which is widespread in both tropical and subtropical regions of sub–Saharan Africa.[6]

It is widely distributed in Asian countries, having a remarkable range of pharmacological properties in addition to significant nutritional values. The extract of *Moriga oleifera* leaves and other parts have been shown to have potent antioxidant actions.[7–10] *Zingiber officinale* (ginger) is commonly used as food spice in many Asian and African countries including Nigeria.[11] *Zingiber officinale* is one of the world's best spices and it has also been universally used throughout history for its health benefits. The main constituents include volatile oil, phenolic derivatives, Zingerone and Oleoresin (gingerols and shogaols are the main antioxidants compounds of the plant).[12] Cadmium is one of most dangerous chemicals in the world's environment and humans are constantly exposed to cadmium through food, water, cigarettes and alcoholic beaverages.[13–16] The aim of the study is to evaluate the effect of *Moriga oleifera* and *Zingiber officinale* Leaf powder in the detoxication of cadmium in Wistar rats.

Materials and methods

Reagents

All chemicals and reagents that were used were of analytical grades and were obtained from Stephmore Chemical Company, Zaria

Collection and identification of plant materials

The leaves of *Moringa oleifera* were obtained from Sabon Gari market, Zaria. The leaves were taken to the Herbarium of the Department of Biological Sciences, Ahmadu Bello University, Zaria, Kaduna State for authentication and voucher number (571) was deposited. The roots of *Zingiber officinale* were obtained from Sabon Gari Market Zaria and were taken to the Herbarium of the Department of Biological Sciences, Ahmadu Bello University, Zaria – Kaduna State for authentification and voucher number (2261) was deposited.

Animal feeds

Grower mash which was used to feed the experimental rats was obtained from Samaru Market, Zaria. This feed was made into balls by addition of water and moulded into balls and dried under the sun. The rats were fed with dried moulded grower mash and water *ad libitum*.

Experimental animals

Sixty adult wistar rats weighing between 150.00 – 300.00g were obtained from the Animal House of the Faculty of Pharmaceutical Sciences, Ahmadu Bello University, Zaria, Kaduna State. These were kept in the Animal House of the Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria. The rats were kept for acclimatization for four weeks. Grower mash and water were administered *ad libitum* to the rats.

The rats were divided into 9 groups of five rats each:

Group 1: Positive Control (PC) – grower mash and water *ad libitum*.

Group 2: Negative Control (NC) – Cadmium nitrate+grower mash and water *ad libitum*.

Group 3: Cadmium Nitrate+5 % *Moringa oleifera* supplemented feed+water *ad libitum*.

Group 4: Cadmium Nitrate+10 % *Moringa oleifera* Supplemented Feed+water *ad libitum*.

Group 5: Cadmium Nitrate+15 % Moringa Supplemnted feed+water *ad libitum*.

Group 6: Cadmium Nitrate+5 % Zingiber supplemented feed+water *ad libitum.*

Group 7: Cadmium Nitrate+10 % Zingiber supplemented feed+water *ad libitum.*

Group 8: Cadmium Nitrate+15 % Zingiber supplemented feed+water *ad libitum*.

Group 9: Cadmium Nitrate+10 % mixture of *Moringa* and *Zingiber* supplemented feed+water *ad libitums*

Preparation of *Moringa oleifera and Zingiber officinale* powder

The *Moringa oleifera* leaves were washed with tap water and rinsed with distilled water. They were air dried at room temperature avoiding direct sunlight. When fully dried, the leaves were pounded using a wooden mortar and pestle and then sieved to fine powder, using 250mm mesh. The powder was kept for use in a polythene bag and labeled.[17] The *Zingiber officinale* roots were washed in tap water and then sliced into pieces and dried under the sun. When fully dried, it was pounded using a wooden mortar and a pestle and then sieved to fine powder using a 250mm mesh. The powder was kept for used in a polythene bag and labeled.[17]

Preparation of cadmium nitrate solution

Stock solution of 250mg/kg body weight was prepared by dissolving 2.50g of cadmium nitrate in distilled water and making it up to the mark in a 250cm^3 standard volumetric flask using distilled water.[18] 0.50mg/kg body weight solution was prepared from the stock solution by serial dilution as in appendix 3.3.[19] The volume to be administered to each rat was calculated using equation– 3.1.[18]

$$Rat\ dose\left(cm^3\right)=\frac{Weight\ of\ rat\times Drug\ dose}{Stock\ solution}$$

This was administered intraperitoneally using syringe and needle.

Preparation of *Moringa oleifera* and *Zingiber officinale* supplemented feeds

Moringa oleifera supplemented feeds (5%, 10% and 15%) was prepared by weighing 5.00g, 10.00 g and 15.00g of *Moringa oleifera* leaf powder and uniformly mixing them with 95.00g, 90.00g and 85.00g of grower mash respectively. These gave 5%, 10%, and 15% *Moringa oleifera* supplemented feeds, respectively.[11] *Zingiber officinale* supplemented feeds was prepared by weighing 5.00g, 10.00g, and 15.00g of *Zingiber officinale* root powder and uniformly mixing them with 95g, 90g, and 85g of grower mash respectively. This gave 5%, 10% and 15% *Zingiber officinale* supplemented feeds respectively.[11]

Preparation of mixture of *Moringa oleifera* and *Zingiber officinale* supplemented feeds

Mixture of *Moringa oleifera* and *Zingiber officinale* supplemented feeds(10%) was prepared by weighing 5g of *Moringa oleifera* leave powder, 5g of *Zingiber officinale* root powder, and 90g of grower mash and mixing them uniformly, this gave 10% mixture of *Moringa oleifera* and *Zingiber officinale* supplemented feeds.

Results

Effect *Moringa oleifera* leaf supplementation in the cadmium concentration of the fur of rats

The effect of *Moringa oleifera* leaf supplementation in the cadmium concentration of the fur of rats is presented in Figure 1. The results shows that the concentration of cadmium in the negative control group was significantly ($p<0.05$) higher than the normal control, and all the treated groups. There was no significant ($p>0.05$) difference in the cadmium concentration of rats treated with 5%, 15% *Moringa oleifera* leaf, and 10% mixture when compared to the control. However, the concentration was significantly ($p<0.05$) higher for rats supplemented with 5% *Moringa oleifera* leaf when compared to the control and other treated groups.

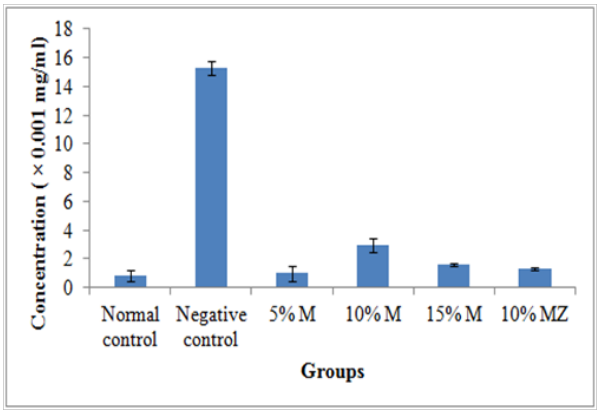

Figure 1 Effect *Moringa oleifera* leaf supplementation in the cadmium concentration of the fur of rats.

N: 5. 5% M: 5% *Moringa oleifera,* 10% M: 10% *Moringa oleifera,* 15% M: 15% *Moringa oleifera,* 10% MZ: 10% *Moringa oleifera* + *Zingiber officinale*

Effect *Zingiber officinale* leaf supplementation in the cadmium concentration of the fur of rats

The effect of *Zingiber officinale* supplementation in the cadmium concentration of the fur of rats is presented in Figure 2. The results shows that the concentration of cadmium in the negative control group was significantly ($p<0.05$) higher than the normal control, and all the treated groups. There was no significant ($p>0.05$) difference in the cadmium concentration of rats treated with 5%, 15% *Zingiber officinale* leaf, and 10% mixture when compared to the control. However, the concentration was significantly ($p<0.05$) higher for rats supplemented with 5% *Zingiber officinale* leaf when compared to the control and groups treated with 10% *Zingiber officinale* leaf and 10% mixture respectively.

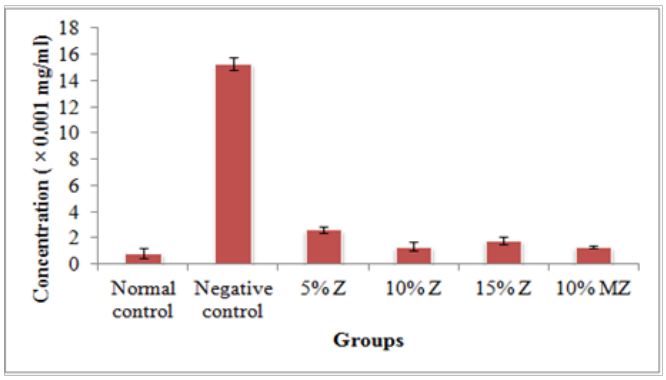

Figure 2 Effect *Zingiber officinale* supplementation in the cadmium concentration of the fur of rats.

N: 5. 5% Z: 5% *Zingiber officinale*, 10% Z: 10% *Zingiber officinale*, 15% Z: 15% *Zingiber officinale*, 10% MZ: 10% *Moringa oleifera* + *Zingiber officinale*

Effects of *Moringa oleifera* supplementation in cadmium concentration in blood of wistar rats

The effect of *Moringa oleifera* leaf supplementation in the cadmium concentration of the blood of Wistar rats is presented in Figure 3. The results shows that the concentration of cadmium in the negative control group was significantly ($p<0.05$) higher than the normal control, and all the treated groups. The concentration of cadmium was significantly ($p<0.05$) higher in the 5% supplemented group than 10% group which in turn was significantly ($p<0.05$) higher than 15% supplemented group. There was no significant difference ($p>0.05$) between 15% supplemented group and 10% mixture of *Moringa oleifera* and *Zingiber officinale*.

Effect *Zingiber officinale* powder supplementation on the cadmium concentration in the blood of wistar rats

The effect of *Zingiber officinale* supplementation in the cadmium concentration in the blood of rats is presented in Figure 4. The results shows that the concentration of cadmium in the negative control group was significantly ($p<0.05$) higher than the normal control, and all the treated groups. There is no significant difference ($p> 0.05$) among the treated groups.

Effect of *Moringa oleifera* leaf supplementation in the haematological parameters of cadmiun intoxicated Rats

The effect of *Moringa oleifera* leaf supplementation on the haematological parameters of cadmium intoxicated rats is summarized in Table 1. The result indicates that there was no significant ($p>0.05$) decrease in the haematological parameters of rats in the negative control group when compared to the normal control. Haematological parameters of rats supplemented with 5%, 10% and 15% of the leaves did not differ significantly ($p>0.05$) from the negative control, except for white blood cell (WBC) count which was significantly ($p<0.05$) lower. Also, the haematological parameters of rats supplemented with 10% mixture did not differ significantly ($p>0.05$) from the positive and negative control groups respectively, except for the WBC count, which was significantly ($p<0.05$) lower than the negative control groups respectively.

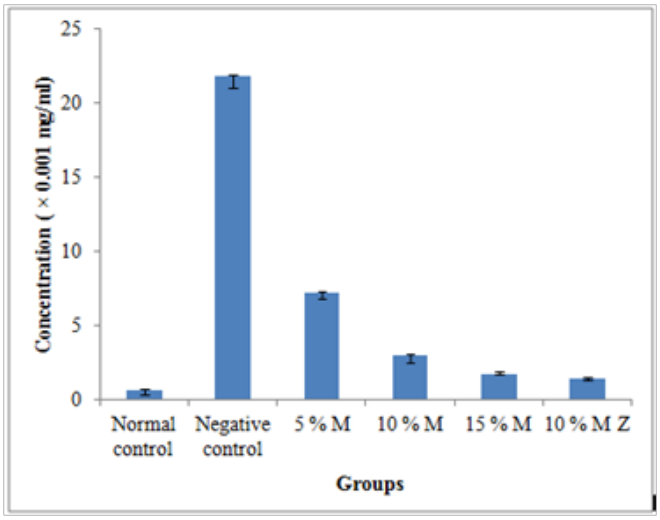

Figure 3 Effects of *Moringa oleifera* supplementation on cadmium concentration in blood of Wistar rats.

N: 5. 5% M: 5% *Moringa oleifera*, 10%M: 10% *Moringa oleifera*, 15%M: 15% *Moringa oleifera*, 10%MZ: 10% *Moringa oleifera* + *Zingiber officinale*

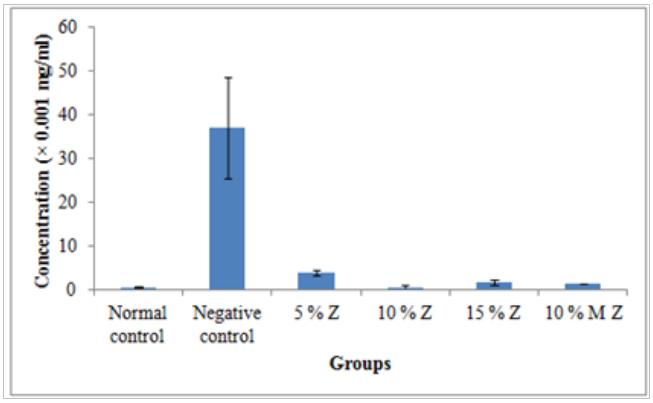

Figure 4 Effects of *Zingiber officinale* supplementation in the cadmium concentration in blood of Wistar rats.

N: 5. 5% Z: 5% *Zingiber officinale*, 10% Z: 10% *Zingiber officinale*, 15% Z: 15% *Zingiber officinale*, 10% MZ: 10% *Moringa oleifera* + *Zingiber officinale*

Effect of *Zingiber officinale* supplementation in the haematological parameters of cadmiun intoxicated rats

The effect of *Zingiber officinale* supplementation on the haematological parameters of cadmium intoxicated rats is shown in

Table 2. The result indicates that there was no significant (p>0.05) decrease in the haematological parameters of rats in the negative control group when compared to the normal control except the packed cell volume (PCV) which was significantly (p<0.05) lower. Haematological parameters of rats supplemented with 5% and 10% did not differ significantly (p>0.05) when compared to each other, and when compared to the positive and negative control, except for PCV WBC count which were significantly (p<0.05) lower. Also, the haematological parameters of rats supplemented with 15%, and 10% mixture did not differ significantly (p>0.05) from the positive control groups, except for the WBC count, which was significantly (p<0.05) lower than the positive and negative control groups respectively.

Table 1 Effect of *Moringa oleifera* leaf supplementation in the haematological parameters of cadmiun intoxicated rats

Groups	PCV (%)	HB (g/dl)	RBC ($\times10^{12}$/l)	WBC ($\times10^{9}$/l)
Normal Control	51.40 ± 1.36^{b}	17.16 ± 0.45^{b}	8.88 ± 0.34^{c}	11.34 ± 0.76^{b}
Negative Control	45.60 ± 2.84^{ab}	15.20 ± 0.93^{ab}	7.60 ± 0.46^{abc}	11.14 ± 1.36^{b}
5% M	35.40 ± 2.36^{a}	11.88 ± 0.76^{a}	5.90 ± 0.41^{a}	8.46 ± 1.69^{ab}
10% M	39.40 ± 1.08^{a}	12.96 ± 0.36^{ab}	6.44 ± 0.16^{ab}	7.52 ± 0.95^{a}
15% M	45.00 ± 7.60^{ab}	13.52 ± 2.91^{ab}	7.74 ± 1.18^{bc}	6.96 ± 0.78^{a}
10% MZ	51.60 ± 1.69^{b}	17.18 ± 0.57^{b}	8.64 ± 0.28^{c}	5.62 ± 0.80^{a}

N: 6. Values are presented as Mean ± SEM. Mean with different superscripts down the column are significantly ($p < 0.05$) different. 5%M: 5% *Moringa oleifera*, 10%M: 10% *Moringa oleifera*, 15%M: 15% *Moringa oleifera*, 10%MZ: 10% *Moringa oleifera* + *Zingiber officinale*

Table 2 Effect of *Zingiber officinale* supplementation in the haematological parameters of cadmiun intoxicated rats

Groups	PCV (%)	HB (g/dl)	RBC ($\times10^{12}$/l)	WBC ($\times10^{9}$/l)
Normal Control	51.40 ± 1.36^{c}	17.16 ± 0.45^{ab}	8.88±0.34c	11.34 ± 0.76^{b}
Negative Control	45.60 ± 2.84^{b}	15.20 ± 0.93^{ab}	7.60 ± 0.46^{b}	11.14 ± 1.36^{b}
5% Z	37.40 ± 1.17^{a}	12.42 ± 0.39^{a}	6.30 ± 0.23^{a}	5.60 ± 0.29^{a}
10% Z	39.00 ± 1.05^{a}	13.00 ± 0.37^{a}	6.64 ± 0.05^{a}	6.58 ± 0.41^{a}
15% Z	47.80 ± 1.50^{bc}	22.08 ± 5.74^{b}	8.14 ± 0.24^{bc}	6.74 ± 0.35^{a}
10% MZ	51.60 ± 1.69^{c}	17.18 ± 0.57^{ab}	8.64 ± 0.28^{c}	5.62 ± 0.80^{a}

N: 5. Values are presented as Mean ± SEM. Mean with different superscripts down the column are significantly ($p < 0.05$) different. 5%Z: 5% *Zingiber officinale*, 10%Z: 10% *Zingiber officinale*, 15%Z: 15% *Zingiber officinale*, 10%MZ: 10% *Moringa oleifera* + *Zingiber officinale*

Discussion

In Figures 1–4, the results of AAS showed that the concentration of cadmium in both the Fur and blood was significantly (P<0.05) higher in the negative control than the normal control and all the supplemented groups in both biomaterials.[11] In the fur, the AAS results revealed that the supplemented groups of both biomaterials significantly (P<0.05) lowered the concentration of the heavy metal. In the blood, the AAS result showed that the concentration of cadmium was significantly (P<0.05) lowered by the supplemented groups in both biomaterials(Mo and Zo) except for 5% *Moringa oleifera* supplemented group that had a significantly (P<0.05) higher concentration of cadmium compared to the rest of the *moringa oleifera* supplemented groups. This suggests that at higher doses of both biomaterials, detoxification of heavy metals is probably more effective in both blood and the fur. The effect of both biomaterials supplementation on the haematological parameters of cadmium induced wistar rats as summarized in Tables 1 and 2 showed that there was no significant (P>0.05) difference in the haematological parameters of rats in the negative control group when compared to the normal control group in both biomaterials, except the packed cell volume (PCV) of the *Zingiber officinale* supplementation which was significantly (P<0.05) lower at 5% and 10% (37.40 ± 1.17, 39.00 ± 1.05) *Zingiber officinale*.

The significant variation in the PCV of 5% and 10% *Zingiber officinale* supplementation may be suggestive of anaemic condition of some sort which may be caused by the biomaterial (*Zingiber officinale*) which seems to be nephrotoxic at higher doses. The insignificant changes (P>0.05) in the haematological parameters may be suggestive of the fact that the biomaterials, especially *Moringa oleifera* has no aneamic effect in the rats.[20]

Conclusion

Supplementation of animal feeds with *Moringa oleifera* leaf and *Zingiber officinale* root powder significantly decreased the concentration of cadmiun, and this was more effective with *Moringa oleifera* leaf at 15% supplementation.

Recommendation

i. *Moringa oleifera* leaf should be incorporated in the diet, especially for people predisposed to heavy metal intoxication

ii. Further studies should be done that would involve other heavy metals such as lead, mercury, and arsenic

Acknowledgements

None.

Conflict of interest

The author declares no conflict of interest.

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