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Coconut (*Cocos nucifera*) and Moringa (*Moringa oleifera*) Oils Protect Against Cadmium-induced Toxicity in Albino Rats

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ABSTRACT

Exposure to heavy metals is currently an increasing source of concern worldwide. The present study evaluated the effect of moringa (*Moringa oleifera*) and coconut (*Cocos nucifera*) oils on endogenous metabolites and enzymes in the plasma of rats exposed to cadmium-induced toxicity. Rats were divided into 5 groups. Group A served as the control, Groups B, C, D and E were exposed to 4 mg Cd/Kg body weight, 4 mg Cd/Kg body weight + 100 mL Moringa oil /Kg body weight, 4 mg Cd/Kg body weight + 100 mL coconut oil/Kg body weight and 4 mg Cd/Kg body weight + 100 mL Moringa oil/Kg body weight + 100 mL coconut oil/Kg body weight, respectively for a period of 21 days. Results obtained show that cadmium-induced negative alterations in the lipid profile of rats, endogenous metabolites and tissue marker enzymes. There were, however, ameliorated with the use of coconut and moringa oils, separately and in combination. Conclusively, though these oils have been shown to possess protective effect against cadmium toxicity in the plasma of rats, moringa oil showed greater antioxidant potential than coconut oil on the various biochemical parameters analyzed.

***Keywords*:** Cadmium, coconut oil, moringa oil, lipid profile, endogenous metabolites, marker enzymes.

Introduction

Heavy metals are usually present in trace concentrations in different environmental matrices and exposure to these metals has become an increasing source of concern globally.[1-2] Cadmium (Cd) is one of the most toxic heavy metals present in the environment due to its wide range of organ toxicity. It could be present in food, air and water where it could be ingested, inhaled or even absorbed through the skin.[3-5] It has a long elimination half-life that ranges between 10–30 years.[5] Cadmium even at low concentrations, has been shown to be highly toxic to living cells and tissues.[5,6] Cadmium has no essential biological function but has been shown to negatively affect various enzymatic systems,[4-7] thus has become a serious threat to living organisms.[8]

Medicinal plants are the bases of traditional medicine.[9] The coconut (*Cocos nucifera*) tree is often called the "tree of life"[10] due to its various therapeutic uses. It belongs to the *Cocoideae* subfamily and *Arecaceae* family. The oil is obtained from the kernel of *Cocos nucifera* and is rich in medium-chain triglycerides (MCTs).[11,12] Coconut oil contains approximately, 50% of lauric acid[13] which has potential bactericidal and viricidal actions.[14] Coconut oil is well known for various therapeutic properties such as antioxidant, anti-microbial, antiviral and antifungal properties.[15,16]

Moringa oleifera is referred to as "Miracle tree".[17] It is native to South Asia (particularly India) but grown currently in the entire West African sub-region, Nigeria inclusive. Every part of the tree possesses some nutritional and medicinal properties.[18] The seed and its oil, roots, flowers, leaves, fruit, bark, and gum are being used medically in the treatment of different ailments.[19-21] Nutritionally, the dried leaves are good source of protein, calcium, vitamin A, C and E, *β*-carotene, amino acids, various polyphenolics and some natural anti-oxidizing agents.[22] *M. oleifera* is also a good source of naturally occurring phytochemicals.[23]

Considering the vast therapeutic properties of moringa and coconut oils, the present study aims to investigate and compare the protective effect of coconut and moringa oils (singly and in combination) on some endogenous metabolites and hepatic marker enzymes in the plasma of rats exposed to cadmium-induced toxicity.

Materials and Methods

Supplements and chemicals

Cadmium chloride salt (Sigma Aldrich Co) was used as source of cadmium. All other chemicals and biochemicals used (supplied by Sigma Aldrich Co, May & Baker, Dagenham, England, and British Drug House Chemicals, Poole, England) were of analytical grade. Moringa oil was gotten from moringa seeds using the cold press method as described by Janaki and Yamuna.[24] Coconut oil was obtained from coconut meat using the Natural fermented virgin coconut oil (NF VCO) method as described by Oseni *et al*.[25]

Experimental design

Forty (40) male Sprague Dawley rats weighing between 150-200 g were obtained from the Animal House of the Faculty of Basic Medical Sciences, Delta State University, Abraka, allowed to acclimatize for 1 week and used for the study. The rats were divided into 5 groups of 8 rats each. Group A served as the control. Rats in Groups B, C, D, and E were exposed to 4 mg Cd/Kg body weight, 4 mg Cd/Kg body weight + 100 mL Moringa oil/Kg body weight, 4 mg Cd/Kg body weight + 100 mL Coconut oil/Kg body weight and 4 mg Cd/Kg body weight + 100 mL Moringa oil/Kg body weight + 100 mL Coconut oil/Kg body weight, respectively. These were administered orally to the experimental rats. The experimental treatment was carried out for

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a period of 21 days. During this period, rats were allowed free access to water and commercial feed. Animal treatments were carried out in accordance with the principles of laboratory animal care.[26]
At the end of the specified periods of exposure, the rats were weighed and sacrificed under chloroform anaesthesia. While under anaesthesia, blood samples were collected from each rat by heart puncture, using a hypodermic syringe and needle. Plasma was obtained from the blood by centrifugation at 3000 x g for 10 mins and stored using lithium heparin containers.

Lipid profile analysis
Plasma total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-Chol) fraction was determined according to the methods of Allain *et al*.[27] and Assmann,[28] respectively, as outlined in the Randox diagnostic kit. Plasma triglycerides (TG) were determined spectrophotometrically by the method of Buccolo and David,[29] as outlined in the Cromatest diagnostic kit. Low-density lipoprotein cholesterol (LDL-Chol) and very low-density lipoprotein cholesterol (VLDL-Chol) values were calculated using the Friedewald[30] equation which calculates these values using analysed values of TC, TG, and HDL-Chol.

Analysis of liver marker enzymes
The L-alanine aminotransferase (L-ALT) and L-aspartate aminotransferase (L-AST) activities in the plasma were estimated by the method of Reitman and Frankel[31] using the Randox Kit. Plasma alkaline phosphatase (ALP) activity was measured with Randox Enzyme Kit based on the optimized standard method according to the recommendation of the German Society of Clinical Chemistry.[32] The lactate dehydrogenase (LDH) (EC 1.1.1.2) activity in plasma was estimated using LDH assay kit from N.S. BIO-TEC according to the procedure suggested by the manufacturer in accordance with the method of Moss *et al*.[33]

Analysis of renal metabolites
The assay for creatinine and urea were carried out using the colorimetric method as outlined in Randox laboratories Kit based on the methods of Bartels *et al*.[34] and Fawcett and Scott,[35] respectively.

Statistical Analysis
Data obtained were expressed as mean ± standard deviation (SD) and statistical analysis was performed using ANOVA followed by Fisher's least significant difference (LSD). A p-value less than 0.05 was considered as statistically significant. The data analysis was done with SPSS version 20.

Results and Discussion

The toxicity induced by cadmium is directly linked to its absorption and bioaccumulation in tissues.[5,36] Due to the various toxicity symptoms associated with cadmium, the present study was carried out to ascertain the possible use of moringa and coconut plant oils (singly and in combination) in treating cadmium-induced toxicity. Results obtained in the present study show that the body weight of the test groups (Groups B, C, D and E) were significantly ($p < 0.05$) reduce as compared to the control (Group A) (Table 1). The effect has also been recorded by another study.[5,37-41]

It has been reported that the ability of cadmium to inhibit digestive and absorption enzymes could account for the reduction in weight of the experimental rats.[38,40] A reduction in body weight of rats has been used as indicator of the deterioration of rat general health status.[42,43]
Evidence abound that cadmium exposure alters the lipid profile[7,44] in rats. The present study showed that plasma total cholesterol levels were significantly elevated along with triglyceride, low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) cholesterol fractions with a significant reduction in the HDL cholesterol level, in the group administered cadmium only (Group B) (Table 2). This is in consonance with the study of Skoczyńska.[45] Alterations in lipid profiles have been shown to be significantly linked to cardiovascular diseases, diabetes, and liver dysfunction.[46] The administration of coconut and moringa oils (singly and in combination) after induction with Cd however showed a significant reversal therapeutic potential on cadmium-induced lipid toxicity. Moringa and coconut oils are examples of the world's most versatile natural products that have multifarious utility. Reduction in the levels of TC, TG, LDL, and VLDL by moringa and coconut oil (singly and in combination) provides evidence that these oils exerts protective effect against cadmium-induced toxicity. The study also recorded a significant increase in HDL level in groups (Groups C, D, and E) where coconut and moringa oil were given after cadmium induction when compared to Group B. This could be considered as being protective against chronic heart diseases associated with alterations in lipid profiles.
Results presented in Table 3 show significant increases in the activities of AST, ALT, LDH and ALP in Group B when compared with the control and the other test Groups. This has been attributed in previous studies to the loss of the histo-structural integrity of the liver hepatocytes.[47] However, administration of coconut and moringa oils led to significant reduction in the levels of these enzymes when compared to Group B. Thus, the results of the present study have shown that treatment with moringa and coconut oils (singly and in combination) could possess some therapeutic effect against increased serum level of AST, ALT, LDH and ALP, thus offering protection to hepatic cells against cadmium-induced toxicity and maintaining the functional integrity of the cells.

Table 1: Effect of cadmium, moringa and coconut oils on body weight gain of rats.

Group	Body weight gain (g)
A	18.25 ± 1.48^{a}
B	-23.43 ± 1.1^{7b}
C	-6.32 ± 0.23^{c}
D	-7.52 ± 0.55^{c}
E	-1.47 ± 0.12^{d}

A, Control; B, 4 mg Cd/Kg Cadmium only; C, 4mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg; D, 4 mg Cd/Kg Cadmium + 100 mL Coconut oil/Kg; E, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg + 100 mL Coconut oil/Kg. Results are expressed as Mean ± SD. n = 8. Values not sharing same superscript in same column differs at ($P < 0.05$).

Table 2: Effect of cadmium, moringa oil and coconut oil on lipid profile of rats.

Group	Lipid profile (mmol/L)				
	TC	TG	HDL-Chol	LDL-Chol	VLDL-Chol
A	161.79 ± 10.45^{a}	144.62 ± 9.39^{a}	51.71 ± 3.94^{a}	44.35 ± 8.49^{a}	65.73 ± 2.12^{a}
B	171.10 ± 10.36^{b}	151.81 ± 5.82^{b}	37.32 ± 5.42^{b}	64.78 ± 9.28^{b}	69.00 ± 3.01^{b}
C	142.83 ± 6.54^{c}	137.69 ± 8.82^{a}	40.87 ± 4.68^{c}	39.37 ± 11.17^{c}	62.59 ± 1.23^{c}
D	149.72 ± 6.63^{a}	140.29 ± 9.20^{a}	52.95 ± 8.83^{a}	33.00 ± 6.11^{b}	63.77 ± 2.45^{a}
E	126.71 ± 16.79^{c}	128.54 ± 5.48^{a}	44.05 ± 3.19^{c}	24.23 ± 17.77^{c}	58.43 ± 2.64^{d}

A, Control; B, 4 mg Cd/Kg Cadmium only; C, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg; D, 4 mg Cd/Kg Cadmium + 100 mL Coconut oil/Kg; E, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg + 100 mL Coconut oil/Kg. TC, Total cholesterol; TG, triglycerides, HDL-Chol, high density lipoprotein-cholesterol; LDL-Chol, low-density lipoprotein-cholesterol; VLDL-Chol, very low-density lipoprotein-cholesterol. Results are expressed as Mean ± SD. n = 8. Values not sharing same superscript in same column differs at ($P < 0.05$).

Table 3: Effect of cadmium, moringa oil and coconut oil on the activities of liver enzymes in the plasma of rats.

Groups	AST (U/mL)	ALT (U/mL)	ALP (U/mL)	LDH (U/mL)
A	11.72 ± 1.06^{a}	19.47 ± 3.95^{a}	25.19 ± 2.22^{a}	151.78 ± 5.36^{a}
B	17.78 ± 2.56^{b}	36.50 ± 0.97^{b}	31.13 ± 2.40^{b}	183.90 ± 15.12^{b}
C	12.66 ± 3.00^{c}	23.21 ± 2.43^{c}	20.53 ± 3.71^{c}	166.49 ± 4.76^{c}
D	11.97 ± 1.13^{c}	24.31 ± 9.77^{c}	25.53 ± 2.07^{c}	155.10 ± 16.14^{a}
E	16.30 ± 3.12^{b}	25.30 ± 4.55^{c}	24.39 ± 3.12^{a}	164.15 ± 0.97^{c}

A, Control; B, 4 mg Cd/Kg Cadmium only; C, 4mg Cd/Kg Cadmium + 100 mL Moringa oil / Kg; D, 4 mg Cd/Kg Cadmium + 100 mL Coconut oil/Kg; E, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil /Kg + 100 mL Coconut oil/Kg. AST, Aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; LDH, lactate dehydrogenase. Results are expressed as Mean ± SD. n = 8. Values not sharing same superscript in same column differs at ($P < 0.05$).

Table 4: Effect of cadmium, moringa and coconut oils on the level renal metabolites in the plasma of rats.

Groups	Creatinine (mmol/L)	Urea (µmol/L)
A	1.46 ± 0.16^{a}	16.91 ± 3.64^{a}
B	2.45 ± 0.41^{b}	41.12 ± 12.93^{b}
C	1.67 ± 0.28^{c}	23.06 ± 2.17^{c}
D	1.31 ± 0.15^{d}	26.62 ± 6.10^{d}
E	1.30 ± 0.25^{d}	27.87 ± 0.74^{d}

A, Control; B, 4 mg Cd/Kg Cadmium only; C, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg; D, 4 mg Cd/Kg Cadmium + 100 mL Coconut oil/Kg; E, 4 mg Cd/Kg Cadmium + 100 mL Moringa oil/Kg + 100 mL Coconut oil/Kg. Results are expressed as Mean ± SD. n = 8. Values not sharing same superscript in same column differs at ($P < 0.05$).

Plasma creatinine and urea are used to assess renal glomerular function.[48] The present results show a significant increase in plasma creatinine and urea in Group B treated with cadmium only. However, significant reductions were observed upon administration of moringa and coconut oils, singly and in combination (Table 4). Significant increase in the level of plasma creatinine and urea is an indication of compromised renal glomerular function which was combated by moringa and coconut oil administration, singly and in combination.
Generally, results presented in Tables 1-4 show that on a comparable basis, moringa oil was able to reduce the cadmium-induced toxicity in rats better than coconut oil. The lower potential of coconut oil in combating cadmium toxicity when compared to moringa oil could be attributed to the absence of flavonoids and acidic compounds in coconut oil as reported by Obidoa *et al*.[49] and Odenigbo and Otisi.[50] These could account for the lower antioxidant potential when compared to moringa oil.

Conclusion

The present study has provided evidence that moringa and coconut oils could be useful in preventing the deleterious consequences of oxidative stress induced by cadmium. Also, moringa oil was shown to possess greater antioxidant potential than coconut oil in combatting the cadmium-induced toxicity.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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