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Full Length Research Paper

Effects of ginger (*Zingiber officinale*) on cadmium toxicity

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Thirty six Winstar rats were divided into six equal groups and investigated for induced cadmium toxicity, and the detoxicating action of ginger on liver-accumulated cadmium. Group 1, the control, were fed with normal rat chow and water for six weeks. Group 2 were fed with normal rat chow and cadmium water (200 ppm Cd in water). Group 3 were fed with rat chow-ginger concentrate (95:5, w/w ratio) and water, while Group 4 were fed with rat chow-ginger concentrate and cadmium water, all for six weeks. Group 5 were fed with normal rat chow and cadmium water initially for one week, followed by rat chow-ginger concentrate and water for five weeks; while Group 6 were fed with rat chow-ginger concentrate for one week, followed by normal rat chow and cadmium water for five weeks. Cadmium accumulated highly in rat livers without ginger administration, and raised serum glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase (GPT), while ginger lowered these parameters. Ginger had better therapeutic than prophylactic detoxication effects on liver cadmium accumulation, especially as further cadmium intake was stopped. It was concluded that cadmium detoxication by ginger was more effective therapeutically, than prophylactically, as further cadmium intake was avoided.

Key words: Bioaccumulation, cadmium, detoxication, ginger, GOT, GPT, Winstar rats.

INTRODUCTION

Cadmium (Cd) is a biotoxic environmental pollutant, which accumulates in the body tissues, such as the lungs, liver, kidneys, bones, reproductive organs and the immune system. Animals are generally tolerant to low doses of Cd exposure, but respond considerably to high lethal doses. Mortality in animals due to Cd toxicity does not occur due to cardiotoxicity or nephrotoxicity, but rather by liver injury, because the liver accumulates substantial amounts of Cd after both acute and chronic exposures (Klaassen and Liu, 1998), and Cd pretreatment does not alter its organ distribution.

Cd is released into the environment from both natural and anthropogenic sources, including agricultural activities (Hutton and Symon, 1986; European Union, 2002; USDOL, 2004; Ogwuegbu and Duruibe, 2005; Duruibe et al., 2007). Activities that cause the release of Cd into the soil, causing soil pollution, result in subse-

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quent water pollution (Nriagu and Pacyna, 1988; OECD, 1994; Peplow, 1999). The presence of Cd in agricultural soils from phosphate fertilizers will also result in its increased uptake by plants, accumulating in plant tissues, more especially corns and vegetables (European Union, 2002; André et al., 2005). Human acute and chronic Cd exposures occur through food, air, water, industrial products; and by occupational exposure (Heyer, 1985; Habashi, 1992; Horsfall and Spiff, 1999; Smolters, 2001; USDOL, 2004; Duruibe et al., 2007), and toxicity dysfunctions resulting from Cd ingestion include bone defects, increased blood pressure, myocardic dysfunctions, proteinuria and pulmonary odema. Death of animals may also subsequently occur (Klaassen and Liu, 1998; Telisman et al., 2001; Jarup, 2003; Young, 2005). In an investigation, Cd exposure was shown to be linked to a wide range of mammalian reproductive dysfunctions. Depending on the steroidogenic tissue involved and dosage administered, it enhances or inhibits the synthesis of progesterone; and antenatal exposure results in reduced birth weight and premature birth (Henson and Chedrese, 2004). Another investigation reveals that the bio-effect of Cd on mice depended on dose administered, absorption and distribution in metallothionein-1 transgenic mice (Liu and Klaassen, 1996). Malgorzata (1998) reported that Cd exposure to fishes resulted in 40% mortality 96 h after the end of the exposure due to disturbances in physiological functions in the fishes. Defects due to acute Cd exposure via food are very unusual, while chronic defects are more frequent (Satarug et al., 2004).

Ginger (*Zingiber officinale*) is commonly used as food spice in many Asian and African countries, including Nigeria. It contains a host of compounds, which include acid resins, vitamin C compounds (folic acid, inositol, choline and panthothenic acid), gingerol, sesquiterpene, vitamins B_3 and B_6, volatile oils, and bio-trace elements (Ca, Mg, P and K). The pungency of ginger is due to gingerol, while its aroma is due to volatile oils, which are bisaboline, zingiberene and zingiberol.

The medicinal values of ginger have been intensively reported. Ginger contains Mg, Ca and P, which play important roles in bone formation, and curbing muscle spasm, depression hypertension, convulsion, nausea, gastrointestinal disorders, paralysis, kidney damage, and a host of other biodysfunctions (Lee and Ahn, 1985; Kikuzaki and Nakatani, 1993; Kikuzaki et al., 1994; Meyer et al., 1995). Ginger extracts exhibit anticholigernic and antihystaminic effects (Qian and Liu, 1992), antihypercholesterolemic effect (Janabai et al., 1984; Tanabe et al., 1993), antihyperlipidaemic effect (Bhandari et al., 1998), antiinflammatory effect (Al-Yahya et al., 1989), antiemetic effect (Philips et al., 1993) and lowers the serum glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase (GPT) levels (Bhandari et al., 2003). Ginger is very useful in the treatment of migraine, motion sickness (Mowrey and Clayson, 1982; Holtman et al., 1989), and rheumatic disorders (Srivastava and Mustafa, 1989, 1992). It is also an antitumor, anticarcinogenic and antitoxic agent (Mascolo et al., 1989; Katiyar et al., 1996; Surh, 1999; Vimala et al., 1999).

Our purpose for carrying out this research was to investigate on the effects of ginger on Cd toxicity, using rats as test specimens. This was done by creating an induced Cd toxicity in the rats, by feeding them with Cd water containing 200 ppm Cd concentration, followed by rat chow mixed with 5% (w/w) ginger. After the test period, the extent of accumulation of Cd in the liver and the antidote effects of ginger on Cd poisoning was evaluated. Literature survey shows different treatment methods for Cd toxicity such as increased intake of Zn, Se, Cu and Ge (Pizent et al., 2001; Paolo et al., 2005), which also act as metallic antioxidant (Yinn and Lin, 1998), and the use of dihydroxyethyldithiocarbamate (DHDC), diethyldithiocarbamate (DEDC), and dicarboxymethyldithiocarbamate (DCDC) in mobilizing metallothionein-bound Cd from some organs and tissues of mice, and promoting its excretion (Gale et al., 1983a,b). However, the use of ginger will be a good viable option since it is a natural plant, which serves as spice for food, hence can be used as food additive, while also detoxicating the body tissues of Cd.

EXPERIMENTAL

Ginger was ground and sieved to a particle size of 250 µm. The rat chow – ginger concentrate (5% w/w of ginger in rat chow) was prepared by mixing normal chow and ginger at 95:5 w/w ratio and stored in a dessicator, while Cd – water concentrate (Cd-H_2O) was prepared at 200 ppm Cd concentration in water (1 g $CdCl_2$ in 5 litre of H_2O).

The specimens (thirty six (36) Winstar rats), weighing about 180 g each, were randomly divided into six equal groups and labeled as Groups 1, 2, 3, 4, 5 and 6, and confined in iron cages. They were allowed a 2-week period to acclimatize with their new environment, after which the experiment proceeded for 6 weeks. Group 1 served as the control, which were fed with normal rat chow and water for 6 weeks. Group 2 were fed with normal rat chow and Cd- H_2O; Group 3 were fed with rat chow – ginger concentrate and water; and Group 4 were fed with rat chow-ginger concentrate and Cd–H_2O, all for 6 weeks. Group 5 were fed with normal rat chow and Cd–H_2O for the first week *ab initio*, then with rat chow – ginger concentrate and water from the second week to the sixth week; whereas Group 6 were fed with rat chow – ginger concentrate for one week, then normal rat chow and Cd–H_2O for the remaining 5 weeks. The grouping and feeding patterns are summarized in Table 1. All administrations were through the oral route.

Enzyme and heavy metal analyses were conducted on the specimens at two-week interval, and two specimens were harvested from each group for each set of analyses. Blood samples were collected from the specimens, from which serum was extracted after coagulation for GPT and GOT analyses. Liver was harvested from dissected specimen and homogenized, and the supernatant solution was extracted for Cd analysis (Gale et al., 1983a,b). Cd was analyzed by atomic absorption spectrophotometer (AAS, UNICAM 919), while GPT and GOT analyses were done according to Reitman-Frankel method (Reitman and Frankel, 1957).

Table 1. Summary of specimen grouping and six weeks feeding pattern.

Week	Groups					
	1*	2	3	4	5	6
1	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F + W_{Cd}	F_g + W
2	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F_g + W	F + W_{Cd}
3	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F_g + W	F + W_{Cd}
4	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F_g + W	F + W_{Cd}
5	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F_g + W	F + W_{Cd}
6	F + W	F + W_{Cd}	F_g + W	F_g + W_{Cd}	F_g + W	F + W_{Cd}

* = Control; F = feed (rat chow); W = water; F_g = feed-ginger concentrate; W_{Cd} = Cd-H_2O (200 ppm Cd in water).

Table 2. Effects of Cd and/or ginger on serum GPT.

Week	Serum GPT concentrations (units/l)					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Group 6
2	4.00	2.67	4.67	4.11	2.88	3.92
4	3.96	2.72	3.47	3.55	2.89	2.38
6	3.88	2.88	1.92	2.42	2.88	0.94

* = Control.

Table 3. Effects of Cd and/or ginger on serum GOT.

Week	Serum GOT concentrations (units/l)					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Group 6
2	4.15	3.19	8.56	3.71	2.83	3.77
4	4.02	3.96	6.89	4.00	3.34	3.45
6	3.86	4.91	4.91	4.34	3.91	3.17

* = Control.

Table 4. Results of Cd concentration in the Liver

Week	Liver Cd concentration (ppm or mg/l)					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Group 6
2	ND	8.59	ND	3.24	1.95	3.24
4	ND	8.38	ND	3.24	2.09	3.84
6	ND	12.05	ND	5.41	1.46	7.81

* = Control; ND = not detected.

RESULTS AND DISCUSSION

The results of the various analyses are summarized in Tables 2 - 4, and reported figures are averages of four readings; two readings for each parameter from each of the two rat specimens. While the GPT and GOT values for the control slightly decreased within the period, Group 2 specimens showed increasing GPT and GOT. Groups 3 and 6 showed decreasing GOT and GPT, with a steeper decreasing trend for Group 3 GOT. While GOT values increased for Groups 4 and 5, GPT values decreased for Group 4, but remained relatively constant throughout the test period for Group 5. Serum GPT and GOT levels increased with Cd administration without ginger (Group 2), and decreased with ginger administration without Cd (Group 3). Hence while Cd raises serum GPT and GOT levels, ginger lowers these parameters. Results for the simultaneous administration of Cd

and ginger to Group 4 specimens showed a dominating effect of ginger on GPT and Cd on GOT. The initial administration of Cd to Group 5 specimens, followed by ginger after the first week for toxicity therapeutic effects, showed no response on GPT, but serum GOT levels increased. Whereas the initial administration of ginger for Cd toxicity prophylaxis on Group 6 followed by Cd administration lowered both serum GPT and GOT.

AAS results showed that Cd concentration in the liver increased tremendously for Group 2 specimens, but remained constant for the first 4 weeks for Group 4, with values still relatively very low after 6 weeks compared with those of Group 2. This is attributable to the detoxication effect of ginger. In Group 5, liver Cd concentration had lowest values; also, this is attributable to the therapeutic detoxication effects of Cd on ginger, thereby showing better effects than the prophylactic effects of ginger for Group 6. The prophylactic effect of ginger on Cd toxicity in Group 6 specimens was effective for the first 4 weeks; after which the values of liver Cd concentration soared high. Thus, it is suggestive that the detoxication of Cd by ginger cannot be effectively achieved by the prophylactic administration of ginger, like medical vaccination.

Conclusion

Overall, the results of these investigations showed that both ginger and Cd altered serum GPT and GOT levels. Ginger had both prophylactic and therapeutic Cd detoxication effects on the specimens, but ginger therapy was more effective as more Cd intake was avoided. Further research can be conducted employing longer durations of induced Cd poisoning and ginger administration and alsousing lactating rats. Other body organs, such as kidney, heart, lungs, as well as breast milk can be analyzed for Cd accumulation and the prophylactic and therapeutic effects of ginger or another known viable antidote.

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