



RESEARCH ARTICLE

SOME CARDIOPROTECTIVE EFFECTS OF AQUEOUS EXTRACT OF GINGER AGAINST MONOSODIUM GLUTAMATE INDUCED TOXICITY IN THE HEART OF ADULT WISTAR RATS

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ABSTRACT

Research findings have indicated cardiovascular disease (CVD) to be the major morbidity and mortality in adult man. The protective effect of ginger extract against Monosodium Glutamate-induced cardiotoxicity was evaluated in 48 wistar rats (weighing 150-250 g) classified into 6 groups (8 rats per group). The rats in control group (Group A) received distilled water for 21 successive days. The rats in treated (Group B) were treated with 4g/kg/day of MSG orally for 21 successive days, rats in treated group (Group C) were treated with 1g/kg/day of ginger extract orally for 21 successive days, rats in treated group (Group D) received 2g/kg/day of ginger extract orally for 21 successive days, rats in treated group (Group E) received 4g/kg/day of MSG and 1g/kg/day of ginger extract orally for 21 successive days, rats in treated group (Group F) received 4g/kg/day of MSG and 2g/kg/day of ginger extract orally for 21 successive days. Results show that MSG administration resulted in changes in body weight, significant increase in the levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP) and distortions to cardiac tissue as compared to rats treated with ginger extract. The cardiac tissues of the aqueous Ginger- treated rats showed preserved tissue compared with distorted cardiac in MSG-treated rats. Ginger extract improves the histological changes by induced by MSG in the cardiac muscle cells in comparison with the control. The study concluded that, ginger extract when used concomitantly with MSG protects the heart against the toxicity induced by this flavour enhancer.

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INTRODUCTION

Cardiovascular Disease (CVD) has been shown from various reports to be the major morbidity and mortality in adult human being (John *et al*, 1999). Various drugs, food additives, toxins and plant extracts have been reported to have contributed to the increase of Cardiovascular Diseases. Monosodium Glutamate (MSG) is one of the commonly and widely used food spices in our daily diets (Walker and Lupein, 2000). Its consumption has increased world wide as flavouring and food additive in our daily cooking (Chaudari and Roper, 1998) to improve palatability and food preference in a meal (Bellisle *et al*, 1996). However, consumption of this food additive has been shown to cause metabolic disorders including hyperlipidaemia, hyperglycaemia and oxidative damage of tissues (Dinz *et al*, 2005; Nagata *et al*, 2006) which may possibly be responsible for the pathophysiology of many diseases like cancer, diabetes, endothelial dysfunction (Naderali *et al*, 2004; Dinz *et al*, 2005), brain lesion (Mallick, 2007) and Coronary Heart Disease (CHD) (Dinz *et al*, 2005; Nagata *et al*, 2006; Singh and Pushpa, 2005).

Monosodium Glutamate, an example of food additive and flavour enhancer has been reported to possibly induce oxidative stress in the heart tissue of adult wistar rats when subcutaneously administered by altering the activities of SOD, GSH and CAT, which invariably predisposes to Coronary

Heart Disease/Atherosclerosis (Singh and Pushpa, 2005). Nayira *et al* (2009) reported that administration of MSG to adult albino rats resulted in oxidative stress and cardiac tissue damage with pronounced increase in the activities of diagnostic serum marker enzymes: CPK and AST as compared to that of the control rats. Histopathological examination of the heart tissue also showed that MSG induced myocardial infarction observed as areas of necrotic lesion in the cardiac tissue of the rats treated with MSG.

Chronic administration of chloroquine, widely used anti-malarial and anti-rheumatic drug may result in cardiac tissue damage. Histological results suggested toxicity of myocardial cells of wistar rats upon chronic oral administration of chloroquine and this was shown by the moderate hypertrophy of cardiomyocytes (Izunya *et al*, 2011). Cisplatin, a platinum-based drug is one of the most effective anti-neoplastic agents used for the treatment of testicular, ovarian, bladder, cervical, lung and cancers (Abu-surrah and Kettunen, 2006). Moreover, this substance has been associated with several toxic side effects including cardiotoxicity and hepatotoxicity (Abdulhakeem, 2006). Administration of Cisplatin to albino rats resulted in degeneration and necrosis of the cardiac muscle fibres with fibrous tissue reaction on histological examination and also significant increase in AST and ALT activities (P<0.05) (Ahmed and Sajida, 2012). Histopathological

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changes have been observed in foetal heart of rats that was treated with enalapril maleate, an anti-hypertensive drug that reduces blood pressure (Khaki *et al*, 2005.)

Rodents that were exposed to isoproterenol treatment showed myocardial infarction (Upaganlawar *et al*, 2011). Similarly, aqueous extract of *Ocimum gratissimum* administered to adult wistar rats resulted in degenerative changes of cardiac tissue which might consequently impair some cardiac function (Ajibade *et al*, 2011). Man has evolved a highly sophisticated and complex antioxidant protection system in order to protect the cells and organs of the body against reactive oxygen species, which involves a variety of endogenous and exogenous substances that have interactive and synergistic impact to neutralize free radicals (Jacob, 1995).

Monosodium glutamate also known as sodium glutamate or MSG is the sodium salt of glutamic acid, one of most abundant naturally occurring non-essential amino acids (Ninomiya, 1998). Harmful effects of different environmental chemicals, industrial pollutants and food additives have been reported by previous investigators (Moore, 2003). Much controversy has been associated with safety of MSG consumption locally and globally (Biodun and Biodun, 1993). In Nigeria, most communities and individuals often use MSG as a bleaching agents for the removal of stains from cloth. Though MSG improves taste stimulation and enhances appetite, reports indicate that it is toxic to human and experimental animals (Belluardo *et al*, 1990). It has been reported that MSG has neurotoxic effects resulting in brain cell damage, retinal degeneration, endocrine degeneration and some pathological conditions such as stroke, epilepsy, brain-trauma, neuropathic pain, schizophrenia and many other pathological conditions (Eweka and ,2007). It has also been reported that MSG has toxic effects on the kidney causing disruptions and distortions of the cyto-architecture of the kidneys which resulted in the cellular in the cellular necrosis and sparsely distribution of the Bowman's spaces (Eweka, 2007).

Ginger or ginger root is the rhizome of the plant *Zingiber officinale*, which is consumed as a delicacy, medicine, or spice. Ginger cultivation began in south Asia and has since spread to East Africa and Caribbean (Spices, 2007). Ginger as an herb, spice and preservative have been reported to have many medicinal values. Preliminary researches indicates that nine compounds found in ginger may bind to human serotonin receptors which may influence gastrointestinal functions (Nievergelt *et al*, 2010). Ginger also has effect on the cardiovascular system by lowering blood pressure (Ghayur *et al*, 2005). It has also been reported that ginger had protective effect against liver damage induced by Adriamycin and this is due to its antioxidant activities (Sakr *et al*, 2010). This study assessed the protective effect of ginger on MSG toxicity on the heart of adult Wistar rats.

MATERIALS AND METHODS

Location and duration of study

This study was conducted at the animal house of the Department of Human Anatomy, Ladoké Akintola University of Technology, Ogbomosho, Oyo state, Nigeria. The preliminary studies animal acclimatization, actual animal experiment and evaluation of results, lasted for a period of three months. However, the actual administration of MSG and

ginger extract to the test animals lasted for three weeks. Wistar rats weighing 150-250g were used for the experimental design. A total number of 48 rats (male and female) were involved. The experimental animals were housed in standard plastic cages, fed with rat chow, and water daily. The experimental animals were divided into six groups.

Preparation of Ginger extract and MSG

MSG was purchased in open market in Ogbomosho. Ginger roots were also purchased in open market in Ogbomosho, Nigeria. The plant was authenticated to be ginger root by a seasoned Botanist; Dr Ogunkunle from the Department of Biology, LAUTECH. The ginger roots were washed and cut into pieces and were air-dried for two weeks before grinding with a mechanical blender. The fine powder was taken to the Department of Food Science and Engineering, LAUTECH for further processing into a coarse powdery form. The powder form of the ginger was macerated in distilled water following the methods of Morakinyo *et al*, 2010.

Experimental design and Grouping

After the acclimatization period, rats were weighed and randomly divided into six groups comprising eight animals in each group. Animals were administered with Ginger (1g/kg and 2g/kg for low and high dose respectively) and MSG (4g/kg). The groups are as follows:

Group A: Rats were given stock diet and water, they served as control.

Group B: Experimental animals were given stock diet and 2.5ml of MSG orally for 3 weeks.

Group C: Experimental animals were given stock diet and 2ml of ginger extract (low dose) orally for 3 weeks.

Group D: Experimental animals were given stock diet and 3ml of ginger extract (high dose) orally for 3 weeks.

Group E: Experimental animals were given stock diet, 2ml of ginger extract (low dose) and 1.9ml of MSG orally for 3 weeks.

Group F: Experimental animals were given stock diet, 4ml of high dose of ginger extract and 2.2ml of MSG orally for 3 weeks

Procedure for animal sacrifice and harvesting of tissue

The animals were sacrificed by cervical dislocation on the 22nd day. Blood was collected from the heart for biochemical analysis of enzymes and the tissue (heart) was harvested immediately, weighed and fixed in 10 % formal saline for histological analysis using Hand E

Statistical analysis

Data obtained were analysed using the analysis of variance and tested for significance by the unpaired one-tailed student's t-test

ENZYME ASSAY

The assay for AST, ALP and ALT was done using the colorimetric method described in the RANDOX kits following the methods of Varley *et al* (1980).

RESULTS

Weight of animals in Group A increased from mean value of 184±7 to a mean value of 228±3 denoting a 23.9% weight gain.

Table 1 showing effects of MSG and Ginger on body weights of adult wistar rats

Groups	Period in weeks				%Weight Gain or loss
	Week 0	Week 1	Week 2	Week 3	
A(n=8)(g)	184 ± 7	200 ± 7	209 ± 8	228 ± 3	23.9
B(n=8)(g)	247 ± 15	244 ± 18	256 ± 17	255 ± 24	3.24
C(n=8)(g)	203 ± 6	191 ± 7	207 ± 7	189 ± 7	-6.9
D(n=8)(g)	159 ± 5	171 ± 9	175 ± 5	165 ± 6	3.8
E(n=8)(g)	191 ± 5	186 ± 5	200 ± 6	200 ± 0	4.71
F(n=8)(g)	219 ± 6	207 ± 11	220 ± 12	225 ± 14	2.74

Values are represented as Mean ± SEM.

In Group B, weight of animals increased from mean value of 247±15 to mean value of 255±24 denoting 3.24% weight gain. Animals in group C has an initial weight mean value of 203±6 and a final mean value of 189±7 denoting a decrease in weight thereby representing -6.9% weight loss.

Animals in Group D increased in weight from mean value of 159±5 to a mean value of 165±6 representing a 3.8% weight gain.

Weight of animals in Group E increased from mean value of 191±5 to a mean value of 200±0 representing 4.71% weight gain.

Weight of animals in Group F increased from mean value of 219±6 to a mean value of 225±14 representing a 2.74% weight gain.

Animals in Group B has a weight loss (3.24%) compared with animals in Group A (23.9%) which is the control group.

Animals in Group C experienced a weight loss (-6.9%) as compared to Group A (23.9%).

Animals in Group F experienced a weight loss (2.74%) as compared with Group A (23.9%) and Group E (4.71%).

Group D experienced a weight loss (3.8%) as compared to Group A (23.9%) and a weight gain as compared to Group C (-6.9%)

Table 2 showing effects of MSG and Ginger on heart weights of adult wistar rats

Groups	Mean weight of organ(Heart)	% organ body weight
A(n=8)(g)	0.59 ± 0.05	0.26
B(n=8)(g)	0.70 ± 0.06	0.28
C(n=8)(g)	0.57 ± 0.03	0.30
D(n=8)(g)	0.53 ± 0.01	0.32
E(n=8)(g)	0.59 ± 0.01	0.29
F(n=8)(g)	0.74 ± 0.05	0.33

Values are represented as Mean ± SEM

From the table above the % of organ weight upon MSG administration increased as it can be seen in group B (0.275%) compared to animals in the control group which had 0.261% organ weight.

Table 3 showing effects of MSG and Ginger on Serum marker enzymes activity

Enzymes	Group A n=5	Group B n=5	Group C n=5	Group D n=5	Group E n=5	Group F n=5
ALT(IU/L)	62.20±11.56	87.00±9.24	62.60±7.86	63.60±15.58	48.40±6.91	41.20±4.77
AST(IU/L)	141.40±20.0	149.60±6.3	137.20±6.9	146.40±9.4	144.20±19.9	111.40±8.9
ALP(IU/L)	14.40±2.42	18.80±6.61	16.60±6.30	7.80±0.92	14.40±5.24	13.40±1.12

Values are represented as Mean ± SEM

The heart weight of animals in Group B (0.70±0.06) increased in relation to their body weight compared to heart weight of animals in control group which had a heart weight of 0.59±0.05. Heart weight of animals in Group C (0.57±0.03) and Group D (0.53±0.01) which were Ginger low and high dose respectively, reduced compared to Group B (0.70±0.06). Heart weight of animals in Group E (0.59±0.01) and Group F (0.74±0.05) which was Ginger low and high dose respectively were reduced compared to Group B (0.70±0.06)

HISTOLOGICAL ANALYSIS

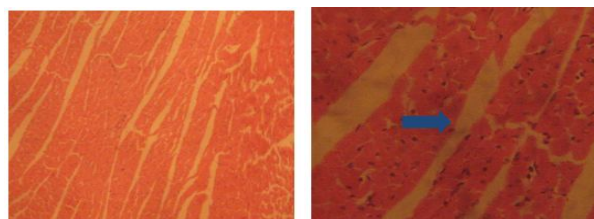


Plate 1 (Group A): A transverse section of the heart showing a normal cardiac muscle cells. Haematoxylin and Eosin (H&E) stain X100 and X 400 respectively. Blue arrow showing the cardiac muscle cell.

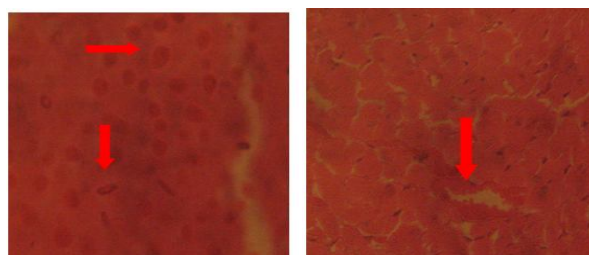


Plate 2 (Group B): A transverse section of the heart showing the eosinophilic nature of the cells of the cardiac muscle and mild enlargement of the cells as well as haemorrhage occurrence. Haematoxylin and Eosin (H&E) stain X100 and X 400 respectively. Red arrow showing haemorrhage and enlargement of the cells.

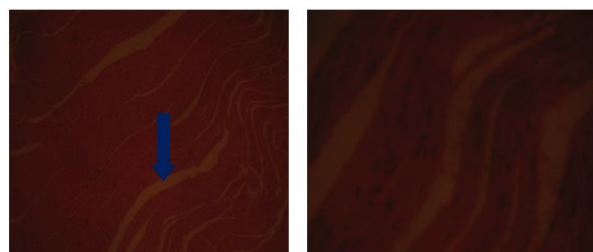


Plate 3 (Group C): A transverse section of the heart showing a normal cardiac muscle cells. Haematoxylin and Eosin (H&E) stain X100 and X 400 respectively. Blue arrow showing the connective tissue.

Biochemical changes

The table above shows the activities of serum enzymes in different experimental groups. It can be noticed from the table that the activity of ALT increased upon MSG administration in Group B (87.00±9.24) as compared to the control group (62.20±11.56). Also, ALT activity reduced in Group C (62.60±7.86) and Group D (63.60±15.58) which are Ginger low and high dose respectively as compared to Group B (MSG- Treated group) (87.00±9.24).

Co-administration of Ginger at low and high dose respectively with MSG reduces the ALT activity level as seen in Group E (48.40±6.91) and Group F (41.20±4.77) respectively. Activities of AST also increased upon MSG administration as seen in Group B (149.60±6.3) compared to the control group (141.40±20.0). Administration of Ginger at low and high dose respectively reduces the activity of AST as seen in Group C (137.20±6.9) and Group D (146.40±9.4) respectively as compared to Group B (149.60±6.3). Co-administration of Ginger at low and high dose respectively with MSG reduces the AST activity as seen in Group E (144.26±19.9) and Group F (111.40±8.9) respectively.

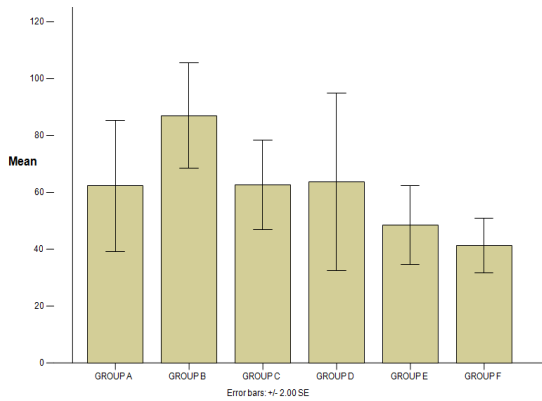


Fig II showing effect of MSG and Ginger on ALT activity level

ALP level activity was reduced in control group (14.40±2.42) as compared to increased seen in Group B (18.80±6.61). Administration of Ginger at low and high dose respectively reduces the activity of ALP as seen in Group C (16.60 ±6.30) and Group D (7.80±0.92) respectively. Co-administration of Ginger at low and high dose respectively with MSG also decreases the activity level of ALP as seen in Group E (14.40±5.24) and Group F (13.40±1.12)

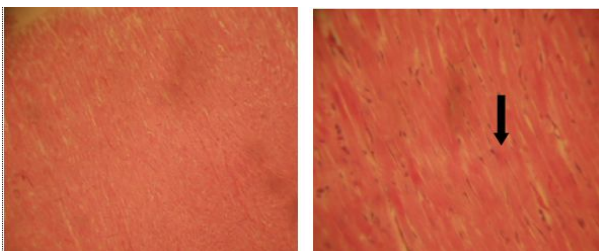


Plate 4 (Group D): A transverse section of the heart showing a normal cardiac muscle cells. Haematoxylin and Eosin (H&E) stain X100 and X 400 respectively. Black arrow showing the cardiac muscle cell.

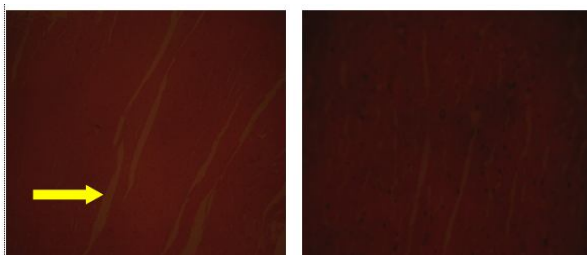


Plate 5 (Group E): A transverse section of the heart showing no damage to the cells but the adipose tissue is highly reduced and increase in eosinophilic nature. Haematoxylin and Eosin (H&E) stain X100 and X 400 respectively. Yellow arrow showing the connective tissue.

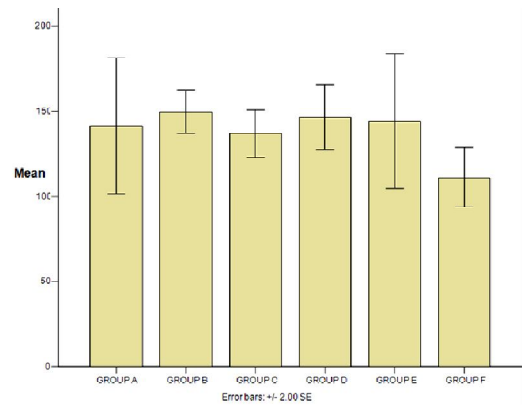


Fig II showing effect of MSG and Ginger on AST activity level

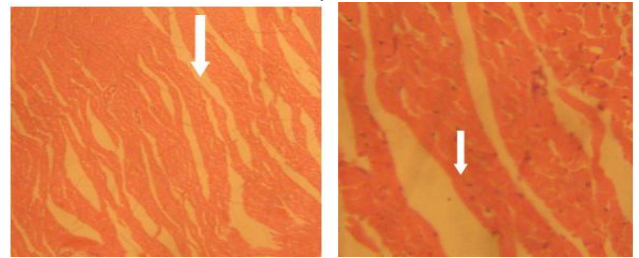


Plate 6 (Group F): A transverse section of the heart showing a normal muscle of the cardiac tissue but with mild enlargement of the connective tissue. Haematoxylin and Eosin (H&E) stain X100 and X400 respectively. White arrow showing the connective tissue.

Histological changes

Histological plates above showed the histology of the heart tissue in different experimental groups.

Plate1 shows the photomicrograph of normal cardiac muscle cells of animals in the control group (Group A) as compared to Plate 2 which shows the photomicrograph of eosinophilic nature of the cardiac muscle cells as well as mild enlargement of the cells and haemorrhage occurrence upon MSG administration at 4g/kg body weight.

Plate 3 (Group C) and 4 (Group D) respectively shows photomicrographs of normal cardiac muscle cells on administration of Ginger at low (1g/kg body weight) and high (2g/kg body weight) doses respectively.

Plate 5 (Group E) photomicrograph shows no damage to the cells but the adipose tissue is highly reduced and increase in eosinophilic nature.

Plate 6 (Group F) respectively also shows photomicrograph of a normal cardiac muscle tissue as compared with Plate 2 (Group B) where the cardiac muscle cells appeared not to be normal.

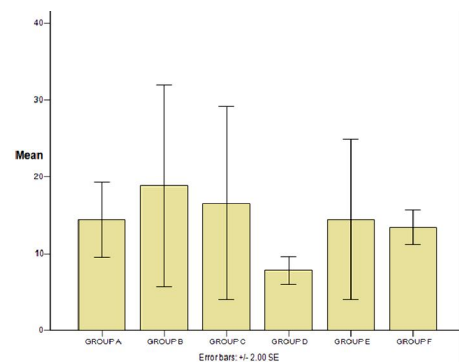


Fig V Showing effect of MSG and Ginger on ALP activity level

DISCUSSION

The oxidative cardiac tissue damage induced by toxic effects of MSG in rats by pronounced increase in the activities of diagnostic serum marker enzymes, CPK and AST as compared to normal rats (Nayira *et al*, 2009). Pre-treatment of rats with antioxidant β -carotene and N-acetylcysteine each alone to MSG-treated rats restore the activity of serum AST to its normal and significantly improved the activities of CPK in relation to MSG-treated rats. Histopathological findings of the used antioxidant (either alone or in combination) pre-treated myocardial infarcted heart showed a near normal morphology of the cardiac muscle with the absence of necrosis as compared to MSG-induced heart. It was concluded that β -carotene and N-acetyl Cysteine(NAC) have important role in preventing the development of cardiopathy induced by MSG and this might be due to their antioxidant properties (Nayira *et al*, 2009). Paul *et al* (2012) reported that chronic oral administration of MSG (4g/kg body weight) to adult wistar rats for a period of 180days caused oxidative stress and histological alteration to the cardiac tissue. The oxidative stress was manifested by significant increase ($P < 0.05$) in malondialdehyde, conjugate dienes and by the decrease in the activities of Superoxide Dismutase, catalase, reduced glutathione, glutathione peroxidase and glutathione S-transferase in cardiac tissue. The significantly increased ($P < 0.05$) activities of Aspartate Transaminase (AST), Creatine Phosphokinase (CPK) and Lactate Dehydrogenase in serum suggested a cardiac functional disorder. Histological examination of the cardiac tissue showed cloudy swelling, fibers separation and vascular congestion.

Oral ingestion of MSG at dose level of 4mg/g body weight and above with or without alcohol has been suggested to have increase the oxidative stress by decreasing ($P < 0.001$) the level of activities of SOD, CAT, and GSH in the cardiac tissue of adult male mice which could act as an additional factor for the initiation of atherosclerosis (Kuldip and Pushpa, 2012). Rodents that were exposed to isoproterenol treatment showed myocardial infarction (Upaganlawar *et al*, 2011).

Aqueous extract of *Ocimum gratissimum* administered to adult wistar rats resulted in degenerative changes of cardiac tissue which may consequently impair some cardiac function (Ajibade *et al*, 2011). Another antioxidant, α -tocopherol has been reported to have ameliorative effect on MSG induced cardiac histological alteration and oxidative stress. Administration of α -tocopherol (200mg/kg) to rats significantly ($P < 0.05$) attenuated the MSG-induced biochemical alteration in serum and cardiac tissue. α -tocopherol also prevented the pathological changes in cardiac tissue when compared with MSG-treated group. It was concluded that α -tocopherol may have a protective effect against MSG-induced cardiotoxicity, possibly through its antioxidant activity (Paul *et al*, 2012). Various antioxidants have been reported to have protective effects on the hearts. Dietary antioxidant like Ginger has been reported to have protective effect on the cardiovascular system by having stimulatory action on the heart muscle which results in the stimulation of blood circulation throughout the body (Shoji *et al*, 1982). Ginger has also been reported to reduce blood pressure and cardiac workload (Tanabe *et al*, 1993).

Monosodium Glutamate (MSG) is a substance widely used as a flavouring agent in the whole world. However, its safety has been questioned (Biodun and Biodun, 1993) and it was discovered to be possibly harmful to the body organs including

the heart after extended consumption (Nayira *et al*, 2009). Ginger extract have been reported to provide antioxidant defense role against isoproterenol induced oxidative myocardial injury in rats (Bhandari *et al*, 2006).

Ginger extract have protective effect against Cisplatin-induced cardiotoxicity in rats by reduction of the serum enzymes levels and reversing the histological changes revealed by low and incidence of degeneration and necrosis in addition to diminishing fibrous tissue reaction (Ahmed and Sajida, 2012). Mansour *et al* (2008) reported that 6-gingerol act as a potentially selective cardio-protective agent against cardiotoxicity induced by doxorubicin by augmentation of endogenous myocardial antioxidant activities.

The extent of cardio protection offered by Ginger is associated with a significant attenuation of serum LDH, CPK, AST, and ALT levels, a possible explanation is that Ginger via its effect against lipid peroxidation causes stabilization of cardiac membranes and prevents the leakage of cardiac enzymes. Also may be due to amelioration of renal functions and inhibition of suppression of carnitine levels and antioxidant enzymes such as catalase and superoxide dismutase (Ansari *et al*, 2006). Administration of monosodium glutamate has been associated with increased body weight (Egbonu *et al*, 2010). In the course of this research work, animals in MSG-treated group increased in body weight (3.24%) initially but reduced in weight as compared to animals in control group which had a 23.9% weight gain. This might be due to reduction in food intake which was noticed after the 2nd week of administration of MSG to the animals.

Rats treated with MSG has been reported to have their kidney, liver, brain and heart weights to be significantly increased (Osfor *et al*, 1997), this was also seen as the heart weights of animals in MSG-treated group (0.7020 ± 0.06) significantly increased compared to the heart weights of animals in the control group (0.5940 ± 0.05). Histological evaluations of rats in MSG-treated group showed the eosinophilic nature of the cells of the cardiac muscle, mild enlargement of the cells as well as haemorrhage occurrence and this is in contrast to animals in the control group where the cardiac muscle cells appeared normal.

Ginger (*Zingiber Officinale*) is one of the most widely used species of ginger family and is common condiment for various foods and beverages. Medical researchers have verified that ginger contain many active substances which actually share in keeping the body healthy (Abeer, 2009). Ginger has been used to treat a wide range of ailments (Grzanna *et al*, 2005). In this research work, the body weight statistics showed a decrease in body weight of rats treated with Ginger at dose level of 1g/kg and 2g/kg respectively as compared to MSG-treated rats which had an increase in body weight initially at dose level of 4g/kg (Abeer, 2009). Organ statistics analysis showed a decrease in heart weight of animals treated with ginger as compared to increase in heart weight of animals treated with MSG. Also, animals in groups where MSG and ginger were co-administered at dose level of 4g/kg b.w & 1g/kg b.w and 4g/kg b.w & 2g/kg b.w respectively had their heart weights to be reduced as compared to MSG-treated group.

Histological evaluations showed that animal in the control group have a normal cardiac muscle cells.

Histological evaluations showed that animals in Ginger-treated groups at a dose of 1g/kg and 2g/kg respectively had a nearly normal cardiac muscle cells with mild enlargement of the connective tissues. Histological evaluations of animals in groups where MSG and Ginger were co-administered at dose level of 4g/kg & 1g/kg respectively showed no damage to the cells but the adipose tissue is highly reduced and also increase in eosinophilic nature. Histological evaluation of animals in groups where MSG and ginger were co-administered at dose level of 4g/kg and 2g/kg respectively showed a normal muscle of the cardiac tissue but with a mild enlargement of the connective tissues.

From the histological evaluations, it can be observed that there are less damage to cardiac muscle cells and connective tissue of animals treated with Ginger as compared to animals in MSG-treated group in which there was a much more damage to the cardiac muscle cells. The less damage to cardiac muscle cells in Ginger treated groups may be due to the active substances present in Ginger (Abeer, 2009) and also it may be due to antioxidant properties that ginger possessed (Kikuzaki and Nakatani, 1993; Jayakumar *et al*, 1999). It has also been shown that Ginger has a stimulatory action on the heart muscle which results in stimulated blood circulation throughout the body (Shoji *et al*, 1982). Ginger has also been said to reduce cardiac work load (Tanabe *et al*, 1993).

The result of the Biochemical parameters showed a significant increase in the activity levels of the enzymes (AST, ALT, and ALP) in the serum of the rats administered with MSG when compared to the control group and Ginger pre-treated groups. In this study, the cardiotoxicity of MSG was clearly observed through a significant elevation of the serum marker AST level in the serum (149.60 ± 6.3 U/L) of MSG-treated rats compared with the control group (141.40 ± 20.0 U/L) and Ginger pre-treated groups. This was also confirmed by Nayira *et al*, 2009 in which there was a significant increase in AST level upon MSG administration. This findings confirm the onset of myocardial lesion and leaking out of the marker enzyme from the heart to the blood (Suchalata and Shyamala, 2004; Ganesan *et al*, 2009) Increased activity of AST has also been reported in CCL₄ induced toxicity in rats (Halim *et al*, 1997; Patrick Iwuanyanwu *et al*, 2007). There was also a significant increase in AST level in Cisplatin-induced hepatotoxicity and cardiotoxicity in rats (Ahmed and Sajida, 2012).

The activity of ALT was also significantly higher in rats ingested with MSG when compared to the control. Such elevation is indicative of liver injury. ALT might have leaked from damaged cells, due to necrosis indicating organ dysfunction (McIntyre and Rosalki, 1992). The result of this study is also in agreement with the findings of Salie *et al*, (1999) who reported that the rise in the enzyme AST is usually accompanied by an elevation in the levels of ALT which plays a vital role in the conversion of amino acids to keto-acids. Alkaline phosphatase activities in rats induced with MSG were also increased when compared to the control and Ginger-treated group. Increased activity of this enzyme in the serum is reported to be increased in liver damage (Halim *et al*, 1997).

The extent of cardio protection offered by Ginger was evident in this study with a significant attenuation of serum AST, a possible explanation is that ginger through its effect against lipid peroxidation causes stabilization of cardiac membranes

and prevents the leakage of cardiac enzymes. This was also confirmed by Ahmed and Sajida (2012) that ginger has cardio protective effect and reduces the serum AST activity. Pre-treatment of Ginger to MSG-treated rats restored the activities of the diagnostic serum markers to their nearly normal levels (Ahmed and Sajida, 2012).

CONCLUSION

In conclusion, the results generated from this study is suggestive of the fact that Monosodium Glutamate (MSG) has adverse effects on the body weights, organ weight and cardiac tissue of rats which could lead to initiation of Cardiovascular Diseases (CVD) and that Ginger (*Zingiber officinale*) has cardio- protective effect on MSG-induced cardiotoxicity and this may due to the antioxidant properties possessed by Ginger.

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