

## Antioxidant activity of celery *in vitro* and *vivo*

Amnah, M. A .Alsuhaibani

Nutrition and Food Sciences Dept, Home Economic Collage, Princess Nora Bint Abdul Rahman -University,  
Riyadh, Saudi Arabia  
[amalsuhaibani@pnu.edu.sa](mailto:amalsuhaibani@pnu.edu.sa)

**Abstract:** The objective of this work was to investigate the main antioxidant components of celery and study the antioxidant effect of celery extract *in vitro* and *in vivo* in rats. Oxidative stability of celery extract was determined by estimation of peroxide value. Celery extract and BHT at level 400 ppm effectively inhibited the increase in peroxide value especially for a period of 32 hrs of heating. Forty Sprague Dawley adult male rats classified into control (-ve) and four groups which received 200 mg/kg body weight of potassium bromate in drinking water for 30 days to induce renal injury and reclassified into positive control (untreated) and treated rat groups that were celery powder, 2.5celery extract and 5 celery extract groups. Results clearly revealed that 2.5 celery extract and 5 celery extract groups showed normal body weight gain, food intake, protein intake and protein efficiency ratio but showed lower food efficiency ratio compared to control (-ve) rat group. Celery powder rat group showed highly significant increase in serum creatinine, urea, ALT and nitric oxide (NO) but showed significant lower in serum antioxidant enzymes and also kidney superoxide dismutase (SOD), compared to control (-ve) rat group. 2.5celery extract group showed significant lower in SOD and GPX while 2.5 celery extract and 5 celery extract groups showed normal in renal function parameters and the values of kidney antioxidant enzymes compared to control (-ve) rat group. [Amnah, M. A .Alsuhaibani. **Antioxidant activity of celery *in vitro* and *vivo***. *J Am Sci* 2013;9(6):459-465]. (ISSN: 1545-1003). <http://www.americanscience.org>.

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### 1.Introduction

Oxidative deterioration of food products during processing and storage produces off-flavor which affect their marketability. Butylated hydroxytoluene (BHT) is synthetic antioxidants have been used extensively to inhibit oxidation in foods. Now epidemiological studies have pointed to the possible health risks associated with consumption of synthetic antioxidants and strict regulations now govern their use in foods. Natural antioxidants help extend the shelf-life of foods. Moreover, Vegetables are abundant sources of polyphenolic compounds which have strong antioxidant capacities and could potentially replace the synthetic antioxidants in food systems (Barlow, 1990 and Hossain *et al.*, 2008). Natural antioxidants have the ability to reduce cancer, heart disease, and other degenerative problems associated with aging. Cell damage is caused by free radicals, which are atoms or molecules with one or more unpaired electrons. Oxygen radicals and lipid peroxidation are involved in several pathogenic conditions (Offord *et al.*, 2000).

Celery (*Apium graveolens dulce*) is an edible vegetable, was firstly described by the Greeks and was popular in the Middle Ages for curing ailments. Celery boasts of a very pleasant and distinctive odor, the reason why it is used as an ingredient in stews, in salads, in soups, as mix in cocktail drinks, etc. Celery has been used in traditional medicine and aromatherapy due to its many health benefits (Jung *et*

*al.*, 2011). Celery is used as an effective remedy for various ailments such as lower blood pressure, bronchitis, liver and spleen disease, arthritic pain and this natural holistic approach to health is becoming more and more popular now a days. Celery stimulates healthy and normal functioning of kidney by helping in the elimination of the body toxins. It also prevents kidney stones (Kolarovic *et al.*, 2010).

The objective of this work was to investigate the main antioxidant components of celery as polyphenols, total chlorophyll, caratenoides, total flavenoides, vitamins (E&C) and minerals (Zn, Cu& Se). Also, study the antioxidant effect of celery extract *in vitro* and treatment effect of the addition of celery powder or extract on potassium bromate induced renal disease in rats.

### 2.Materials and Methods

#### I- Materials:

The plant material used in this investigation was celery plants (*Apium graveolens*) leaves and stalk which purchased from the local market in Riyadh. Cotton seed oil was purchased from Oil and Soap CO, Egypt and was free from any additional antioxidant. Butylated hydroxytoluene (BHT) was obtained from Noarden International Company (Holland). BioMerieux Kits were purchased from Alkan Co. for Chemicals and Biodiagnostics. Potassium bromate (KBrO<sub>3</sub>) is a white crystalline powder purchased from El-Gomhoria Company. Forty Sprague Dawley

strain rats provided from experimental animals center in Medicine collage of King Saudi University in Riyadh. The average weight was  $155 \pm 5$  g. The standard diet was prepared according to **NRC (1995)**.

## B- Methods:

### 1-Chemical investigation of celery:

Approximate chemical composition of celery moisture, ash, crude protein, and fat, were determined according to the methods of the **(A.O.A.C. 1995)**. While total carbohydrates were estimated by subtracting the difference from initial weight of the samples as follows: - Carbohydrates% = 100 - (% moisture + % protein + % fat +% ash).

Phenols, chlorophyll, caratenoides and flavonoid were determined according to **Singleton and Rossi (1965)**, **Wettstian (1995)** and **Geissman (1962)**. Some vitamins (E&C) and minerals (zinc, copper & selenium) in ash were determined according to **Augustin et al. (1985)**, **Diaz-Alarcon et al. (1994)** and **A.O.A.C. (1995)**.

### 2- Preparation of celery powder and ethanolic extract:

Fresh celery leaves was washed three times with tap water, dried in dry freezer and crushed into powder. Celery ethanolic extract was prepared from celery powdered which was refluxed eight times with an 80% ethanol solution for two times, 1 hr each time. The solvent was removed by evaporation under reduced pressure using Rotary Evaporator and stored at 4 ° C until further analysis **(WHO 1983)**.

### 3- The oxidative stability of cotton seed oil after heating period:

Cotton seed oil was used as a substrate for oxidation studies. Celery extract and synthetic antioxidant BHT were added individually to oil at level 100, 200, 400 ppm to test their antioxidant effectiveness. Cotton seed oil with celery extract and BHT was heated in glass beaker at  $180 \text{ }^{\circ}\text{C} \pm 6$  for 32 hrs with intermittent heating period was 4 hrs /day. The oil samples after heating were stored at  $-10 \text{ }^{\circ}\text{C}$  till analysis **(Mona 2007)**. The oxidative stability of celery extract was determined by estimation of peroxide value compared to cotton seed oil and BHT after heating period according to the method of **(AOCS, 1998)**.

### 4-Biological design:

After adaptation period (one week), the rats were randomly classified into five groups of eight rats each. The first group served as a normal control group, fed on standard diet only. The other four groups were fed on standard diet and received 200 mg/kg body weight of potassium bromate in drinking water for 30 days according to previous studies **(Rehab et al.,**

**2008)**. Then, Rats reclassified into four groups which were positive control (untreated) and treated rat groups that were celery powder (10% in diet in substitution of fiber), 2.5 celery extract (2.5mg/kg body weight by stomach tube and 5 celery extract (5mg/kg body weight by stomach tube) groups.

The food intake was calculated daily and the body weight gain was recorded weekly. Food efficiency ratio (FER) and protein efficiency ratio (PER) was determined by **Chapman et al.(1950)**. At the end of experiment (30 days), the rats were anesthetized, blood sample were collected in clean centrifuge tubes and left for coagulation then centrifuged at 3000 rpm for 15 minutes to obtain serum. Kidneys for every rat were immediately removed and rinsed with saline and stored at  $-70^{\circ}\text{C}$  for biochemical analyses.

### 5- Laboratory analysis:

Serum alanine and aspartate aminotransferase (ALT&AST), and alkaline phosphatase (ALP) enzymes activity were performed according to the method of **Bergmeyer and Horder (1980)**, **Kind and King (1954)**, respectively .Serum creatinine, urea, uric acid, total protein and albumin were determined according to **Bonsens and Taussky (1984)**, **Kanter (1975)**, **Fossati et al. (1980)**, **Henry (2001)** and **Bartholomev and Delany (1966)**, respectively. Serum superoxide dismutase (SOD), glutathione peroxidase (GPX), catalase and nitric oxide (NO) were determined by enzymatic colorimetric procedures according to **Dechatelet et al. (1974)**, **Habig et al. (1974)** and **Sinha (1972)** and **Kirima et al.(2003)**, respectively .Kidney superoxide dismutase (SOD), glutathione-peroxidase (GPX) and catalase enzymes activity and malondialdehyde were determined by enzymatic colorimetric procedures according to **Misra and Fridovich (1972)**, **Rotruck et al. (1973)**, **Cohen et al. (1970)** and **Uchiyama and Mihara (1978)** , respectively.

### 6- Statistical Analysis: -

All obtained data was statistically analyzed by SPSS computer soft ware. The calculated occur by analysis of variance ANOVA and follow up test LSD by SPSS ver. 11 according to **Abo-Allam (2003)**.

## 3. Results and Discussion

Protein, fat, carbohydrates, ash and moisture of celery were determined and tabulated in table (1). It was clear that protein, fat, carbohydrates and ash contents were 0.81, 0.31, 11.37 and 1.40 %, respectively in wet weight. It can be noticed that moisture content was 86.11%. These results were in disagreement with results of **Leung et al., 1968** who recorded that the nutritional composition of leaf

celery (leaf blades and small stalks) per 100 g edible portion is: water 92.7 g, protein 1.1 g, fat 0.1 g, carbohydrate 4.5 g, fiber 1.0 g. The raw leaf stalk of celery contains per 100 g edible portion: water 95.1 g, protein 0.5 g, fat 0.2 g, carbohydrate 0.9 g, dietary fiber 1.6 g. The difference may be due to difference in variety and species of celery. **Souci et al., 2000** recorded that celeriac also contains 1.55% of proteins, 0.33% fat, 2.25% of total sugars and 4.23% total dietary fiber.

Table 2 illustrated some antioxidant in celery. Total phenols, chlorophyll, carotenoids and flavonoids were 55.17, 13.11, 5.59 & 8.62 mg/100 g on dry weight basis while vitamin E and C values were 1.2 µg/g and 60.14 mg/100 g, respectively. The obtained mineral results showed that celery contain zinc, copper and selenium in levels 5.66, 1.88 (mg/100 g) and 10.14 µg/g, respectively. These results agreed with **Jung et al., 2011** who recorded that methanol extract had the highest (51.09 mg/g) amount of phenolic compounds. Therefore, the content of total phenolic compounds in the extracts might explain their high antioxidant activities (**Yao et al., 2010**). Recent studies have shown that vitamins and phytochemicals, such as ascorbic acid, carotenoids, polyphenols, and fiber have been regarded as the bioactive substances responsible for these effects the importance of vegetables in a healthy diet and to prevent degenerative diseases caused by oxidative stress. Phenolic compounds are responsible for the antioxidant activity of vegetables (**Zhou and Yu 2006 and Halliwell et al., 2010**). Celery is an excellent source of vitamin C. It is a very good source of dietary fiber, potassium, folate, manganese and vitamin B6 (**Mitra et al., 2001**).

From table (3), it can be observed that increasing heating time from 8 till 32 hr showed increase in peroxide values in both celery extract and also in BHT. The increasing celery extract levels 100, 200 & 400 showed lowering in peroxide values and the same results appeared in addition of BHT. Celery extract and BHT at level 400 ppm effectively inhibited the increase in peroxide value especially for a period of 32 hr of heating which were 12.31 & 11.10, respectively compared with corn oil (98.66). These results indicated that celery extract had antioxidants which retard lipid peroxidation during continuous heating for period reach to 32hrs. These results agreed with **Yao et al., 2010 and Jung et al., 2011** who recorded that celery had the highest antioxidant activity. There was an extremely significant positive correlation between the antioxidant activity of celery and the contents of total flavonoids, total phenolic acids, or total phenolics. The extent of antioxidant activity of the extract is in accordance with the amount of phenolics present in that extract and the

celery leaf vegetable being rich in phenolics may provide a good source of antioxidants.

The obtained results in table (4) showed that control (+ve) and celery powder groups showed highly significant lower of body weight, PER and FER at  $p < 0.05$ ,  $0.01$  &  $0.001$  while 2.5 celery extract and 5 celery extract groups showed only significant lower of FER at  $p < 0.05$  compared to control (-ve). The obtained results were discussed by **Chipman et al., 1998** and **Adeleke and Asani 2009** who recorded that potassium bromate ( $KBrO_3$ ) is a white crystal, granules or powder, which is colourless, odourless, and tasteless. It has no medicinal value but is added to flour as a maturing agent, to dough, to fish paste as a conditioner, and also to beer or cheese.  $KBrO_3$  has been shown to be nephrotoxic in both man and experimental animals. **Ang and Miller (1991) and Thebaudin et al. (1997)** reported that some dietary fiber ingredients could be desirable for their nutritional properties but also for their functional and technological properties. The fiber in celery is the insoluble type, which means it does not dissolve in water and passes through intestines undigested. Insoluble dietary fiber helps keep bowels moving regularly and has been used as fat replacer, fat reducing agent during frying, volume enhancer, binder, bulking agent and stabilizer. Celery provides an excellent source of vitamin B1, B2, B6 & C and fiber. It's a very good source of folic acid, potassium, and calcium.

Data in table (5) indicated that control (+ve) rat group showed a significant higher in ALT, AST and ALP at  $p < 0.001$  &  $0.01$  while celery powder, 2.5 celery extract and 5 celery extract rat groups showed a significant higher in ALT only at  $p < 0.05$  compared to control (-ve) rat group. These results agreed with **Rehab et al., 2008** who found that the activity of alanine transaminase (ALT) was significantly increased in rats received 200 mg  $kg^{-1}$  b.wt of potassium bromate from the first week. **Tsi and Tan, 2000** recorded that in a rat study assessing the effect of celery extract on liver, rats drinking aqueous celery extract for eight weeks showed no undesirable side effects in liver functions. **Abd El-Ghany et al. (2012)** reported that celery contains a large amount of vitamin C which is antioxidant to prevent the free radical damage that triggers the inflammatory cascade. Thus, it helps reduce the severity of inflammatory conditions.

Data in table (6) represented the effect of celery powder and extract on some renal function parameters in serum. The results indicated that control (+ve) showed highly significant increase in creatinine, urea and uric acid at  $p < 0.001$  while celery powder rat group showed highly significant increase in creatinine and urea at  $p < 0.001$  &  $0.05$ , respectively

but 2.5 and 5 celery extract groups showed non significant difference in creatinine, urea and uric acid compared to control (-ve) rat group. All experimental rat groups showed non significant difference in total protein and albumin compared to control (-ve) rat group. The results were agreed with results of **Watanabe et al., 2004** who recorded elevating in relative kidney weight, serum creatinine levels and renal oxidative stress. The reduction of catalase activity by the elevation of blood uric acid levels is a major cause of KBrO<sub>3</sub>-induced acute kidney damage. **Duke (1997) and Balch et al. (1997)** recorded that the seeds and stalks of celery are known to reduce uric acid levels, relieving symptoms of joint pain and immobility. Celery is rich in B-Complex vitamins, adding to its stress reducing and sedative qualities. It is rich in vitamins A and C, and is indicated in arthritis and kidney problems. **Abdou et al., 2009** found that the treatment of celery stimulated the protein biosynthesis to produce antioxidative enzymes which treat the oxidative stress of CCl<sub>4</sub>

Data in table (7) indicated that control (+ve) and celery powder rat groups showed significant lower in SOD, GPX and catalase and significant higher in NO at  $p < 0.001$ , 0.01 & 0.05 while 2.5 celery extract group showed significant lower in SOD and GPX at  $p < 0.05$  compared to control (-ve) rat group. The results indicated that 5 celery extract group showed that the values of SOD, GPX, catalase and NO were within the values of control (-ve) rat group. The results were agreed with **Watanabe et al., 2004** who recorded that KBrO<sub>3</sub> seems to cause hyperuricemic status which in turn brings about acute kidney damage and oxidative stress with reducing catalase activity. **Duthie et al., 1996, Salah et al., 2010 and Yao et al., 2010** reported that Celery is an excellent source of Vitamin C, A, B1 and B2. It has been reported that supplementation of the diet with vitamin C results in

a highly significant decrease in endogenous oxidative base damage in the DNA by reducing the free radical in the body and also increase resistance to oxidative damage *in vitro*. The active effect of celery extract could be possibly due to the presence of sugar or amino acid side chains compounds. Also, Celery extracts containing phytonutrients that have been shown to decrease risk of oxidative damage to body fats and risk of oxidative damage to blood vessel walls. In addition, these celery extracts have been shown to prevent inflammatory reactions in the digestive tract and blood vessels.

Data given in table (8) indicated that control (+ve) rat group showed significant lower in kidney SOD, GPX and catalase and significant higher in MDA at  $p < 0.001$  while celery powder rat group showed significant lower in kidney SOD at  $p < 0.05$  compared to control (-ve) rat group. 2.5 and 5 celery extract rat groups showed the values of kidney SOD, GPX, catalase and MDA within the values of control (-ve) rat group.

These results agreed with **Achukwu et al., 2009** who confirmed that the potassium bromate induces renal oxidative stress which is known to cause renal failure, methaemoglobinaemia and kidney cancer. **Cao et al., 2012** recorded that the activities of superoxide dismutase, glutathione peroxidase, catalase in the dichlorvos induced oxidative stress were declined significantly and MDA was significantly increase when compared with the flavonoid extracts group and flavonoid extracts from celery. The observations showed the protective role of flavonoids of celery in minimizing the oxidative stress induced by dichlorvos in rats.

It may be concluded that celery has antioxidant effects which can be used as natural antioxidant in food industries and also in nutritional planning for patients suffering from renal disease.

**Table (1): Gross Chemical composition of celery**

Variables	Protein %	Fat %	Carbohydrate%	Ash %	Moisture %
Celery	0.81	0.31	11.37	1.40	86.11

**Table (2): Some antioxidants in celery (mg/100 g on dry weight basis)**

constituents	Total phenols	Total chlorophell	Caratenoids	Total flavenoids	Vitamin E	Vitamin C	Zinc	Cu	Se
Values	55.17	13.11	5.59	8.62	1.2*	60.14	5.66	1.88	10.14*

\*µg/g

**Table (3): Effect of celery extract or BHT at 180°C on peroxide value of cotton seed oil**

Heating time (hr)	Corn Oil	Celery extract			BHT		
		100 ppm	200 ppm	400 ppm	100 ppm	200 ppm	400 ppm
0	0.35	-	-	-	-	-	-
8	11.20	10.11	8.41	5.31	8.51	7.01	4.21
16	45.20	39.18	20.14	10.45	22.31	17.21	9.11
24	59.88	36.40	18	11.32	29.51	15.14	9.21
32	98.66	50.41	25.11	12.31	37.11	20.41	11.10

**Table (4): Mean values ± SD of body weight gain, food intake, PER and FER of the experimental rat groups**

Groups Variables	Control (-ve)	Control (+ve)	Celery powder	2.5Celery extract	5Celery extract
Body weight gain(g)	52.71±4.21 <sup>a</sup>	31.14±3.73 <sup>c***</sup>	44.30±3.19 <sup>b*</sup>	49.37±4.11 <sup>ab</sup>	51.20±3.77 <sup>a</sup>
Food intake(g/w)	15.77±1.11 <sup>a</sup>	14.31±1.14 <sup>a</sup>	14.80±1.21 <sup>a</sup>	15.41±1.36 <sup>a</sup>	16.11±1.16 <sup>a</sup>
Protein intake(g)	3.11±0.24 <sup>a</sup>	2.86±0.17 <sup>a</sup>	2.96±0.19 <sup>a</sup>	3.08±0.22 <sup>a</sup>	3.22±0.33 <sup>a</sup>
PER	0.583±0.013 <sup>a</sup>	0.362±0.014 <sup>c***</sup>	0.498±0.010 <sup>b**</sup>	0.534±0.020 <sup>ab</sup>	0.530±0.011 <sup>ab</sup>
FER	0.112±0.011 <sup>a</sup>	0.072±0.001 <sup>d***</sup>	0.099±0.002 <sup>c***</sup>	0.106±0.003 <sup>b*</sup>	0.105±0.001 <sup>b*</sup>

Significant with control (-ve) group \*  $P < 0.05$  \*\*  $P < 0.01$  \*\*\*  $P < 0.001$

Mean values in each raw having different superscript (a, b, c, d) are significant

**Table (5) The Mean values ± SD of serum ALT, AST, and ALP of the experimental rat groups**

Groups Variables	Control (-ve)	Control (+ve)	Celery powder	2.5Celery extract	5Celery extract
ALT(μ/ml)	15.31±4.37 <sup>c</sup>	32.21±7.14 <sup>a***</sup>	24.14±5.11 <sup>b*</sup>	21.61±4.21 <sup>b*</sup>	22.11±3.61 <sup>b*</sup>
AST(μ/ml)	30.21±4.11 <sup>b</sup>	51.21±6.08 <sup>a***</sup>	37.14±5.11 <sup>b</sup>	35.27±4.44 <sup>b</sup>	34.21±5.30 <sup>b</sup>
ALP(μ/ml)	71.71±8.22 <sup>b</sup>	98.71±11.22 <sup>a**</sup>	79.41±9.61 <sup>b</sup>	73.33±8.14 <sup>b</sup>	70.14±8.10 <sup>b</sup>

Significant with control (-ve) group \*  $P < 0.05$  \*\*  $P < 0.01$  \*\*\*  $P < 0.001$

Mean values in each raw having different superscript (a, b, c, d) are significant

**Table (6): Mean values ± SD of creatinine, urea, uric acid, total protein and albumin of the experimental rat groups**

Groups Variables	Control (-ve)	Control (+ve)	Celery powder	2.5Celery extract	5Celery extract
Creatinine(mg/dl)	0.55±0.10 <sup>c</sup>	2.11±0.35 <sup>a***</sup>	1.12±0.24 <sup>b**</sup>	0.65±0.20 <sup>c</sup>	0.58±0.11 <sup>c</sup>
Urea (μ/mg)	34.21±5.54 <sup>c</sup>	90.41±10.22 <sup>a***</sup>	49.61±6.17 <sup>b*</sup>	39.66±5.99 <sup>bc</sup>	33.41±4.22 <sup>c</sup>
Uric acid (mg/dl)	3.11±0.53 <sup>b</sup>	6.31±1.11 <sup>a***</sup>	3.99±0.44 <sup>b</sup>	3.64±0.57 <sup>b</sup>	3.77±0.66 <sup>b</sup>
Total protein(g/dl)	7.81±1.11 <sup>a</sup>	6.14±1.14 <sup>a</sup>	7.11±1.03 <sup>a</sup>	7.84±1.22 <sup>a</sup>	7.91±1.30 <sup>a</sup>
Albumin(g/dl)	3.11±0.66 <sup>a</sup>	3.55±0.88 <sup>a</sup>	3.42±0.47 <sup>a</sup>	3.61±0.53 <sup>a</sup>	3.71±0.65 <sup>a</sup>

Significant with control (-ve) group \*  $P < 0.05$  \*\*  $P < 0.01$  \*\*\*  $P < 0.001$

Mean values in each raw having different superscript (a, b, c, d) are significant

**Table (7): Mean values ± SD of serum SOD, GPX, catalase, and NO of the experimental rat groups.**

Groups Variables	Control (-ve)	Control (+ve)	Celery powder	2.5Celery extract	5Celery extract
SOD(μ/mg)	0.58±0.03 <sup>a</sup>	0.23±0.01 <sup>d***</sup>	0.34±0.01 <sup>c**</sup>	0.45±0.02 <sup>b*</sup>	0.51±0.01 <sup>ab</sup>
GPX(μ/mg)	0.93±0.11 <sup>a</sup>	0.28±0.05 <sup>d***</sup>	0.45±0.01 <sup>c**</sup>	0.69±0.04 <sup>b*</sup>	0.86±0.10 <sup>ab</sup>
Catalase (μ/l)	1.74±0.66 <sup>a</sup>	0.60±0.05 <sup>c***</sup>	0.92±0.02 <sup>b*</sup>	1.08±0.18 <sup>ab</sup>	1.31±0.15 <sup>a</sup>
NO(μmol/l)	4.36±0.54 <sup>c</sup>	8.21±1.30 <sup>a***</sup>	6.30±1.21 <sup>b**</sup>	5.11±0.88 <sup>bc</sup>	4.11±0.55 <sup>c</sup>

Significant with control (-ve) group \*  $P < 0.05$  \*\*  $P < 0.01$  \*\*\*  $P < 0.001$

Mean values in each raw having different superscript (a, b, c, d) are significant

**Table (8): Mean values ± SD of kidney SOD, GPX, catalase, and MDA of the experimental rat groups.**

Groups Variables	Control (-ve)	Control (+ve)	Celery powder	2.5Celery extract	5Celery extract
SOD(μ/mg)	2.39±0.31 <sup>a</sup>	0.44±0.02 <sup>c***</sup>	1.84±0.11 <sup>b*</sup>	2.20±0.32 <sup>a</sup>	2.40±0.40 <sup>a</sup>
GPX (μ/mg)	1.62±0.27 <sup>a</sup>	0.42±0.04 <sup>c***</sup>	0.94±0.11 <sup>ab</sup>	1.22±0.18 <sup>a</sup>	1.21±0.16 <sup>a</sup>
Catalase(μ/l)	4.03±0.63 <sup>a</sup>	1.66±0.21 <sup>b***</sup>	3.02±0.44 <sup>a</sup>	3.54±0.56 <sup>a</sup>	3.81±0.78 <sup>a</sup>
MDA(nmol/g)	6.21±1.87 <sup>bc</sup>	11.41±2.11 <sup>a***</sup>	8.20±1.57 <sup>b</sup>	7.51±1.11 <sup>b</sup>	6.33±1.18 <sup>bc</sup>

Significant with control (-ve) group \*  $P < 0.05$  \*\*  $P < 0.01$  \*\*\*  $P < 0.001$

Mean values in each raw having different superscript (a, b, c, d) are significant

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