



Research Journal of
Botany

ISSN 1816-4919



Academic
Journals Inc.

www.academicjournals.com

Antioxidant Activity and Biological Evaluation of Hot-water Extract of *Artemisia monosperma* and *Capparis spinosa* Against Lead Contamination

A. Al-Soqeer

Department of Plant Production and Protection, Faculty of Agriculture and Veterinary Medicine, Qassim University, P.O. Box 6622, Buraidah, 51452, Qassim, Saudi Arabia

ABSTRACT

Hot-water extracts of *Capparis spinosa* and *Artemisia monosperma* were studied against lipid peroxidation induced by lead acetate in rats. Ten rats were assigned to each of four groups. Group 1 was negative control, group 2 received only lead acetate (0.6%) in drinking water (positive control), group 3 received hot-water extract from *Artemisia* (5%) with lead acetate in drinking water (0.6%) and group 4 received hot-water extract from *Capparis* (5%) with lead acetate in drinking water (0.6%) experiment continued for 6 weeks before scarifying the animals and blood samples were collected. Chemical composition and antioxidant activities of hot-water extract from *Artemisia* and *Capparis* sp. were estimated using chemical methods. Total Antioxidants in *Artemisia* and *Capparis* extracts were 675.33, 115.66 μmol Trolox per 100 mL, respectively. Activity of the antioxidant enzyme glutathione-S-transferase activity decreased after lead administration but extracts from *Artemisia* and *Capparis* maintained the level to normal. Lead administration resulted in significant increases in the concentration of serum triglycerides, urea and aspartate transaminase, alanine transaminase (AST and ALT). Extracts from *Artemisia* and *Capparis* reduced the elevated concentrations to normal values. The obtained results showed that the biochemical alterations produced by lipid peroxidation after lead administration returned to normal values or even improved due to high levels of total antioxidants in extracts of *Artemisia* and *Capparis* sp. Data concluded that the protective effects of hot-water extracts from *Artemisia* and *Capparis* sp. may play a role in protection against lead acetate in rats. This protective effect may be due to high level of total antioxidant contents in these plants.

Key words: Medicinal plants, lead contamination, rats, lipid peroxidation, antioxidants

INTRODUCTION

In recent years the therapeutic importance of herbal drugs has gained considerable attention. It has been found that utilization of cheap plant sources that are without side effects is a trend in all countries.

In Saudi Arabia herbal medicine is widely spread and many local plants are used for treatment of various ailments. One of these plants is *Capparis spinosa* (CS) (Capparidaceae), locally known as Shafalah. Scientific classification and uses of *Capparis spinosa* are shown in Fig. 1. They are native shrubs widely distributed in Al-Qassim region. This plant was found to be common to the Mediterranean basin and has been used by the traditional medicine for its diuretic and antihypertensive effects and also in certain pathological conditions related to uncontrolled lipid peroxidation. The extract contains many constituents, in particular some flavonoids (kaempferol


Species	<i>C. spinosa</i>
Genus	<i>Capparis</i>
Family	Capparaceae
Order	Brassicales
Kindom	Plantae
	Description: Scrabbling, branched shrub, 20-28 cm high leaves alternate or rarely opposite, short petioled, orbicular or broadly ovate. Spines in pairs, short curved at end. Flowers showy, about 8 cm across, white to pale pink colored. Fruits obovate-ellipsoid, 3 cm long green with light longitudinal stripes, and pulp is red. Seeds small, smooth, numerous and 1-3 broad
Habitat	Silty ground over limestone sometimes forming pure stand
Grazing importance	Well browsed by camels
Other uses	Fruits are edible

Fig. 1: Scientific classification and uses of *Capparis spinosa*

and quercetin derivatives) and hydrocinammic acids with several known biological effects such as the anti-inflammatory and the antioxidant ones (Panico *et al.*, 2005). The phytotherapy knowledge of this plant has been of interest to many investigators. The main constituents of CS have been demonstrated by other workers to be flavonoids, alkaloids, lipids and glucosinolates and these constituents may vary from one locality to another (Calis *et al.*, 2002; Sharaf *et al.*, 2000; Brevard *et al.*, 1992).

Shafalah has been used since ancient times in Morocco in the treatment of digestive disorders and was commonly used in phytomedicine as an antibacterial (Singh *et al.*, 2002), antiulcerogenic (Khayyal *et al.*, 2001) antiproliferative (Nakano *et al.*, 1998).

Recently, Yang *et al.* (2010) found that fruits of *Capparis spinosa* contain a significant amount of compounds with many health benefits. Three new alkaloids, (1) Capparisine A, (2) Capparisine B, (3) Capparisine C and (4) two known alkaloids, (4) 2-(5-hydroxymethyl-2-formylpyrrol-1-yl) propionic acid lactone and (5) N-(3'-maleimidyl)-5-hydroxymethyl-2-pyrrole formaldehyde were isolated from the fruits of *C. spinosa*.

Another important plant is *Artemisia* species. Scientific classification and uses of *Artemisia monosperma* (Athir) are presented in Fig. 2.

The herb, *Artemisia monosperma*, is a perennial fragrant plant which grows widely and wildly in the Arabian deserts. The leaves of the plant are taken in folk medicine by certain women of Jordan for abortion induction (Hijazi and Salhab, 2010). In a phytochemical study of *Artemisia monosperma* three compounds were characterised by spectroscopic means. Compounds were evaluated for their ability to inhibit 12-lipoxygenase, as antibacterials and in a cytotoxicity assay (Stavri *et al.*, 2005).

The antioxidant activities of various fractions of *Artemisia* species were investigated, especially, the n-butanol extract that was found to causes significant increase in the rat liver cytosolic superoxide dismutase (SOD) and catalase activities (Juteau *et al.*, 2002; Kim *et al.*, 2003). The *Artemisia* oil has a characteristic flavor, due to the presence of many components with strong


Species	<i>Artemisia monosperma</i>
Family	Asteraceae
Vernacular name	Athir
Life form	Perennial herbaceous shrublet
	Description:
	Ascending perennial shrublet, 50-100 cm high. Leaves linear oblanceolate, solitary or clustered entire or with linear lobes 3-7 cm long, sessile tapering to base. Heads very short peduncled to sub sessile in somewhat 1 sided numerous recemes emerging laterally from the stem apices, together forming an elongated compound inflorescence up to 40 cm long. Heads ovoid, 3-4 cm long
Habitat	Deep sand especially unsettled dunes
Grazing importance	Not grazed
Other uses	None

Fig. 2: Scientific classification and uses of *Artemisia monosperma* (Athir)

sensory properties at a low threshold, such as trans-ethyl cinnamate (20.8%) and thus could be suitable for using as antioxidant and flavoring agent in the food industry (El-Massry *et al.*, 2002).

It was claimed by many researchers that the risk from contamination by heavy metals is mainly due to the oxidative stress produced by these metals and consequently depletion of body antioxidants (Ercal *et al.*, 2001).

Because many synthetic antioxidants (butylated hydroxyanisole and butylated hydroxytoluene) have been proved to have undesirable side effects (Jayaprakasha *et al.*, 2007). There has been an increasing interest in the use of medicinal plants rich in antioxidants to reduce free radicals-induced tissue injury (Zhishen *et al.*, 1999). Oxidative stress is the excess formation of and/or incomplete removal of highly reactive molecules such as Reactive Oxygen Species (ROS). *In vivo* some of ROS play positive role such as energy production, phagocytosis and regulation of cell growth (Halliwell and Gutteridge, 1999). On the other hand, ROS are capable of damaging a wide range of essential biomolecules such as proteins, DNA and lipids (Farber, 1994). Cells have several antioxidant defense mechanisms that help to prevent the destructive effects of ROS. These defense mechanisms include anti oxidative enzymes, such as superoxide dismutase, catalase and glutathione peroxidase and of small molecules such as glutathione and vitamin C and E (Maser *et al.*, 2002). The efficiency of the antioxidant defense system is altered under pathological conditions and therefore the ineffective scavenging and/or over production of free radicals may play a crucial role in determining tissue damage (Aruoma, 1994; Halliwell, 1994).

From the foregoing considerations, it can be concluded that Phyto chemicals content in plants are promising alternatives to synthetic drugs provided that certain precautions were taken in consideration. The present investigation aims at analyzing the chemical composition and nutritive value of *Capparis spinosa* and *Artemisia monosperma* and test their efficacy against lead contamination in rats.

MATERIALS AND METHODS

The study to be described was carried out at the College of Agriculture and Veterinary Medicine, Qassim university, Saudi Arabia during the period 2009/2010.

Plants

***Capparis spinosa* (CS):** Scientific classification and uses of *Capparis spinosa* is shown in Fig. 1. Scientific classification and uses of *Artemisia monosperma* (Athir) is shown in Fig. 2.

Preparation of pressurized hot water extraction: Hot water extraction of *Artemisia* and *Capparis* were prepared according the methods described by Abdel-Salam *et al.* (2009): Approximately 50 g of each of *Artemisia* and *Capparis* materials were cut into small pieces, milled and placed in a flask (2 L) with 1000 mL of distilled water and boiled for 15 min, then the mixture was filtered twice, first through cheese-cloth (50% cotton/50% polyester) and then through filter paper (Whatman No. 2). The final concentrations of the prepared of *Artemisia* or *Capparis* were 5% as a total solids. The amounts of obtained *Artemisia* and *Capparis* extracts were preserved in sterile dark bottles (500 mL) in a cool environment (4°C) until further use.

Antioxidant activity determination in *Artemisia monosperma* and *Capparis spinosa*: Antioxidant activity was determined according to the method of Sanchez-Moreno *et al.* (1998). Antioxidant capacity was quantified as µg Trolox equivalents using a standard curve.

Proximate analysis and nutritive value: The vitamin C content was determined by the titrimetric method according to the method of AOAC (1990). Lipid content of these plants was determined by the direct extraction method. Three grams of dried sample was extracted by 50 mL of petroleum ether at 60°C for 60 min in a Soxhlet system HT (series 1043 Extractor unit, Tecator). The lipid value was obtained by mean of weighing. Protein content was determined by the Kjeldahl method. Other determinations were carried out according to Benjapak *et al.* (2008).

Animals: Forty male Swiss albino rats weighting about 120-150 g were randomly divided into four-test groups (each containing 10 rats). Animals were placed in cages and were assigned to specific diets.

Diets: The composition of the basal diet used in this study is as follows: milk protein (12%), sucrose (5%), fat (10%), vitamin mixtures (1%), salt mixtures (4%), fiber (4%) and starch (64%). Rats were divided into the following groups.

- The first group (G_1) was fed on the basal diet. without lead acetate (control negative)
- The second group (G_2) was fed on the basal diet with lead acetate in drinking water (0.6%) (control positive)
- The third group (G_3) was fed on basal diet + hot-water extract from *Artemisia* (5%) with lead acetate in drinking water (0.6%)
- The fourth fed (G_4) on basal diet + hot-water extract from *Capparis* (5%) with lead acetate in drinking water (0.6%)

The feeding experiment continued for 6 weeks and at the end of this period, rats were anesthetized by diethyl ether, bled and sacrificed. Blood samples were collected and frozen at (4-6°C) for 2 h before centrifugation at 3000X g for 30 min. Sera were harvested, labeled and stored deep frozen (-20°C) until used for assays.

Biochemical analysis: Urea was determined in serum according to the methods of Tietz (1970) and Bonsnes. Triglyceride were determined according to the methods of Stein and Myers (1995).

Alanine aminotransaminase (ALT) and Aspartate aminotransaminase (AST) activities were determined according to the method of Reitman and Frankel (1957). Glutathione-S-Transferase (GST) activity was determined according to Habig *et al.* (1974). GST activity was defined as the amount of enzyme catalyzing the formation of 1 mol of products per min under condition of assay.

$$\text{Activity} = \frac{\text{Å } 340 \text{ nm}}{(9.6) \times 1000} = \text{M/min}$$

Statistical analysis: Mean and standard deviation of the obtained data from each different experimental group were calculated and conducted according the method described by Miller and Miller (1992).

RESULTS

Total antioxidant activity in *Artemisia* and *Capparis* extracts: Total antioxidants in *Artemisia*, *Capparis*, are shown in Table 1. The mean values were 675.33, 115.66 µmol Trolox per 100 mL for *Artemisia*, *Capparis*, respectively.

When total antioxidants are expressed as micromole Trolox per gram D.M, it was found that *Artemisia* contained higher antioxidants (135.66) when compared with *Capparis* (27.10) micromole Trolox per gram D.M.

Nutritional value of *Capparis* are presented in Table 2. As can be noticed from the Table 2 *Capparis* is a rich source of vitamin C. Each 100 g contained 4 mg of Ascorbic acid. It is also a rich source of iron and sodium.

Table 1: Total antioxidants in *Artemisia* and *Capparis* extracts

Total antioxidants (micromole Trolox per 100 mL)	Mean	SD	CV
<i>Artemisia</i> 5% (per 100 mL)	675.33	5.50	0.815
<i>Capparis</i> 5% (per 100 mL)	115.66	5.03	4.350
<i>Artemisia</i> (per g D. M)	135.00	5.50	0.815
<i>Capparis</i> (per g DM)	27.10	5.03	4.350

Table 2: Nutritional value per 100 g of *Capparis spinosa*

Parameter	Unit	Values
Energy	kcal	20
Carbohydrates	g	5
Sugars	g	0.4
Dietary fibers	g	3
Fat	g	0.9
Protein	g	2
Vitamin C	mg	4 mg
Iron	mg	1.7
Sodium	mg	2960

Table 3: Serum urea concentrations in control and in rats treated with *Artemisia monosperma* and *Capparis spinosa* water extracts

Groups	Min.	Max.	Mean (mg dL ⁻¹)	SD	CV (%)
G1	40.3	57.1	49.80 ^a	8.613362	17.29591
G2	52.0	104	73.10 ^b	27.404380	37.54025
G3	25.5	36.2	30.63 ^c	5.363146	17.50755
G4	21.0	27.1	24.93 ^c	3.412233	13.68543

Means in the same column with different superscript are significantly different (p<0.05)

Table 4: Serum triglyceride concentrations in control rats and in rats treated with *Artemisia monosperma* and *Capparis spinosa* water extracts

Groups	Min.	Max.	Mean (mg dL ⁻¹)	SD	CV
G1	70.8	81.8	74.63 ^a	6.21	8.32
G2	154.0	195.0	178.66 ^b	21.73	12.16
G3	70.0	149.0	106.33 ^c	39.87	37.50
G4	77.4	100.0	87.20 ^a	11.59	13.29

Means in the same column with different superscript are significantly different (p<0.05)

Table 5: Activities of AST and ALT in serum of control rats and in rats treated *Artemisia monosperma* and *Capparis spinosa* water extracts

Groups	AST	ALT
	----- (U L ⁻¹) -----	
G1	191.86 ^a	141.71 ^a
G2	219.80 ^b	317.57 ^b
G3	187.59 ^a	169.75 ^a
G4	169.94 ^a	132.89 ^a

Means in the same column with different superscript are significantly different (p<0.05)

Serum urea: As shown in Table 3 there was a significant (p<0.05) increase in the concentration of urea in the positive control group. Administration of water extracts of *Artemisia monosperma* and *Capparis spinosa* resulted in a significant (p<0.05) decrease in levels of urea indicating usefulness of these medicinal plant extracts. Concentration of serum urea was 49.8 mg dL⁻¹ in the control group (negative control) that increased to 73.10 dL in the positive control that received no plant extracts. Concentrations of serum urea decreased significantly (p<0.05) to 30.63 and 24.93 mg dL⁻¹ after administration of *Artemisia monosperma* and *Capparis spinosa*, respectively.

Serum triglycerides: Serum triglycerides concentration increased significantly following lead acetate administration (Table 4). Triglycerides concentration in the negative control group was 74.63 mg dL⁻¹ that increased to 178.66 mg dL⁻¹ in the positive control. Treatment with water extracts from *Artemisia monosperma* and *Capparis spinosa* decreased the concentration of serum triglycerides to 106.33 and 87.20 mg dL⁻¹, respectively.

As presented in Table 5. Lead acetate administration increased significantly (p<0.05) the activity of AST. The activity of this enzyme in the control group was 191.86 U L⁻¹ that increased after lead administration to 219.80 U L⁻¹ in the positive control group. This activity was significantly reduced to 187.59 and 169.94 U L⁻¹ following administration of *Artemisia monosperma* and *Capparis spinosa* water extracts.

Activity of Glutathione-S-transferase in serum is shown in Table 6, the activity in serum of control rats, when expressed as Activity = A/9.6*1000 M min⁻¹, was found to be 16.94 that decreased significantly (p<0.05) to 11.25 in the positive control. When water extract of *Artemisia*

Table 6: Glutathione-S-transferase activity in serum of control rats and in rats treated with *Artemisia monosperma* and *Capparis spinosa* water extracts

Groups	Min.	Max.	Mean	SD	CV	Activity = A/9.6*1000 M min ⁻¹
G1	0.124	0.189	0.162	0.03421	21.03082	16.94 ^a
G2	0.071	0.133	0.108	0.032696	30.27367	11.25 ^b
G3	0.154	0.192	0.178	0.021385	11.96941	18.61 ^a
G4	0.198	0.217	0.205	0.01044	5.092832	21.35 ^a

Means in the same column with different superscript are significantly different (p<0.05)

monosperma and *Capparis spinosa* was administered the activity of this enzyme increased significantly (p<0.05) to 18.61 and 21.35 A/9.6 1000 M min⁻¹, respectively.

DISCUSSION

In various cultures especially in the developing world, people are dependant on plants as medicine against various ailments. In Greek popular medicine a herbal tea made of caper root and young shoots is considered to be beneficial against rheumatism.

In the present study, it was found that lead ingestion disturbs many biological functions in rats mostly through free radicals generation, The antioxidant capacity in the body of rats as in other animals-is limited and usually exhausted by free radicals generated.

Lead administration increased the level of triglycerides and urea in blood. Ingestion in drinking water of *Artemisia monosperma* and *Capparis spinosa* water extracts lowered the concentrations of these metabolites. This may be due to the presence of high levels of antioxidants in *Artemisia monosperma* and *Capparis spinosa* (Table 1) and also due to high level of vitamin C. Nutrient antioxidants may act together to reduce reactive oxygen species levels more effectively than single dietary antioxidants, because they can function as synergists (Eberhardt *et al.*, 2000; Rossetto *et al.*, 2002; Podsedek, 2007).

The antioxidant activities of *Artemisia* species were investigated by Juteau *et al.* (2002) and Kim *et al.* (2003) and they found that extracts from *Artemisia* caused significant increases in the rat liver cytosolic superoxide dismutase (SOD) and catalase (CAT) that are highly involved in the antioxidant system of the body. The increase in the activities of these enzymes will explain the improvement in the pathological changes achieved in kidneys of lead intoxicated rats. It was found that *Artemisia* extract significantly increased gastrointestinal transit time and the reaction time to thermal stimuli, but had no effect on the activity of alkaline phosphatase or concentrations of creatinine and urea in plasma (Marrif *et al.*, 1995). The plant extract showed weak antimicrobial activity. On the other hand, Qureshi *et al.* (1990) reported that ethanolic extracts of the aerial parts of *Artemisia abyssinica* and *A. inculta* when subjected to acute toxicity observations in mice for 24 h and chronic toxicity evaluation for 3 months. It was found that external morphological changes, visceral toxicity, haematological changes, spermatogenic dysfunction and effect on body weight and vital organ weight were recorded. damage was observed in *A. abyssinica* treated mice while *A. inculta* failed to produce any significant spermatotoxic effects.

Administration of lead acetate resulted in elevated activities of AST and ALT enzymes that may be due to liver damage caused by the free radicals, however, ingestion of *Artemisia monosperma* and *Capparis spinosa* water extracts in drinking water decreased the activities of these enzymes indicating a protective effect against liver damage. This is in agreement with the finding of Gadgoli and Mishra (1999). They reported that p-Methoxy benzoic acid isolated from the methanolic soluble fraction of the aqueous extract of *Capparis spinosa* L. (Capparidaceae) was found to possess

significant antihepatotoxic activity against carbon tetrachloride and paracetamol induced hepatotoxicity *in vivo* and thioacetamide and galactosamine induced hepatotoxicity in isolated rat hepatocytes, using *in vitro* technique. through physicochemical and spectral studies. Isolation, identification and antihepatotoxic activity of the compound is reported for the first time in the plant.

On the other hand lead acetate intoxication reduced the activity of the enzyme glutathione-S-transferase. Glutathione-S-transferase (GST) provides glutathione (GSH) and helps to neutralize the toxic neutrophiles (Halliwell, 1994). Treatment with hot water extract of either *Artemisia monosperma* and *Capparis spinosa* improved the activity of this enzyme leading to improved formation of the very potent antioxidant, glutathione.

Previous phytochemical studies on *Artemisia* have yielded polyynes, sesquiterpene (Stavri *et al.*, 2005) and acetophenone natural products (Bohlmann and Ehlers, 1977). Bohlmann and Ehlers (1977) and known metabolites including the sesquiterpene spathulenol, an hydroxylated polyynone and the flavonoid eriodictiol-7-methyl ether. These compounds were evaluated by those authors for their activity in 12-lipoxygenase, antibacterial and found to protect against cytotoxicity. The mechanism(s) of protection offered by *Artemisia monosperma* and *Capparis spinosa* water extract are not clear at present and further work is needed.

It can be concluded that *Artemisia* and *Capparis* extracts contain high antioxidant compounds that protected rats against lipid peroxidation generated by lead. Isolation of individual compounds in these two plants is necessary for further studies.

ACKNOWLEDGMENTS

This study was supported by a research grant from the Deanship of Scientific Research, Qassim University, Saudi Arabia. The author would like to thank Dr. Hassan M. Mousa and Dr. Ahmed Abdel-Salam from the Food Science and Human Nutrition Department, College of Agriculture and Veterinary Medicine for their valuable help with the Proximate and biochemical analysis and nutritive value.

REFERENCES

- Abdel-Salam, A.M., A.S. Ammar and W.K. Galal, 2009. Evaluation and properties of formulated low calories functional yoghurt cake. *J. Food Agric. Environ.*, 7: 218-221.
- Aruoma, O.I., 1994. Deoxyribose Assay for Detecting Hydroxyl Radicals. In: *Oxygen Radicals in Biological Systems*, Sies, H., J. Abelson and S. Melvin (Eds.). Academic Press, San Diego, pp: 57-66.
- AOAC, 1990. Official Methods of Analysis. In: *Food Composition, Additives, Natural Contaminants*, Helrich, K. (Ed.). 15th Edn., The AOAC Inc., Virginia, pp: 993-994.
- Benjapak, N., P. Swatsitang and S. Tanpanich, 2008. Determination of antioxidant capacity and nutritive values of pak-wanban (*Sauropus androgynus* L. Merr.) *Sauropus androgynus*. *KKU Sci. J.*, 36: 279-289.
- Bohlmann, F. and D. Ehlers, 1977. Ein neues p-hydroxyacetophenon-derivat aus *Artemisia monosperma*. *Phytochemistry*, 16: 1450-1451.
- Brevard, H., M. Brambilla, A. Chaintreau and J.P. Marison, 1992. Occurrence of elemental sulphur in capers (*Capparis spinosa* L.) and first investigation of the flavour profile. *Flavour Fragrance J.*, 7: 313-321.
- Calis, I., A. Kuruuzum-Uz, P.A. Lorenzetto and P. Ruedi, 2002. (6S)- Hydroxy-3-oxo-alpha-ionol glucosides from *Capparis spinosa* fruits. *Phytochemistry*, 59: 451-457.

- Eberhardt, M.V., C.Y. Lee and R.H. Liu, 2000. Nutrition-antioxidant activity of fresh apples. *Nature*, 405: 903-904.
- El-Massry, K.F., A.H. El-Ghorab and A. Farouk, 2002. Antioxidant activity and volatile components of Egyptian *Artemisia judaica* L. *Food Chem.*, 79: 331-336.
- Ercal, N., H. Gurer-Orhan and N. Aykin-Burns, 2001. Toxic metals and oxidative stress. Part 1. Mechanisms involved in metal-induced oxidative damage. *Curr. Top. Med. Chem.*, 1: 529-539.
- Farber, J.L., 1994. Mechanisms of cell injury by activated oxygen species. *Environ. Health Perspect.*, 102: 17-24.
- Gadgoli, C. and S.H. Mishra, 1999. Antihepatotoxic activity of p-methoxy benzoic acid from *Capparis spinosa*. *J. Ethnopharmacol.*, 66: 187-192.
- Habig, W.H., M.J. Pabst and W.B. Jakoby, 1974. Glutathione-S-transferases, the first enzymatic step in mercapturic acid formation. *J. Biol. Chem.*, 249: 7130-7139.
- Halliwell, B., 1994. Free radicals and antioxidants: A personal view. *Nutr. Res.*, 52: 253-265.
- Halliwell, B. and J.M.C. Gutteridge, 1999. *Free Radicals in Biology and Medicine*. 1st Edn. Oxford University Press, New York.
- Hijazi, A.M. and A.S. Salhab, 2010. Effects of *Artemisia monosperma* ethanolic leaves extract on implantation, mid-term abortion and parturition of pregnant rats. *J. Ethnopharmacol.*, 128: 446-451.
- Jayaprakasha, G.K., K.K. Mandadi, S.M. Poulouse, Y. Jadegoud, G.A. Nagana-Gowda and B.S. Patil, 2007. Inhibition of colon cancer cell growth and antioxidant activity of bioactive compounds from *Poncirus trifoliata* (L.) Raf. *Bioorg. Med. Chem.* 15: 4923-4932.
- Juteau, F., V. Masotti, J.M. Bessiere, M. Dherbomez and J. Viano, 2002. Antibacterial and antioxidant activities of *Artemisia annua* essential oil. *Fitoterapia*, 73: 532-535.
- Khayyal, M.T., M.A. El-Ghazaly, S.A. Kenawy, M. Seif-el-Nasr, L.G. Mahran, Y.A. Kafafi and S.N. Okpanyi, 2001. Antiulcerogenic effect of some gastrointestinally acting plant extracts and their combination. *Arzneimittelforschung*, 51: 545-553.
- Kim, K.S., S. Lee, Y.S. Lee, S.H. Yung, Y. Park, K.H. Shin and B.K. Kim, 2003. Anti-oxidant activities of the extracts from the herbs of *Artemisia apiacea*. *J. Ethnopharmacol.*, 85: 69-72.
- Marrif, H.I., B.H. Ali and K.M. Hassan, 1995. Some pharmacological studies on *Artemisia herba-alba* (Asso) in rabbits and mice. *J. Ethnopharmacol.*, 49: 51-55.
- Maser, R.L., D. Vassmer, B.S. Magenheimer and J.P. Calvet, 2002. Oxidant stress and reduced antioxidant enzyme protection in polycystic kidney disease. *J. Am. Soc. Nephrol.*, 13: 991-999.
- Miller, J.C. and J.N. Miller, 1992. *Statistics for Analytical Chemistry*. 2nd Edn., Ellis Horwood, New York, London, Tokyo.
- Nakano, Y., H. Matsunaga, T. Saita, M. Mori, M. Katano and H. Okabe, 1998. Anti-proliferative constituents in Umbelliferae plants II. Screening for polyacetylenes in some Umbelliferae plants and isolation of panaxynol and falcarindiol from the root of *Heracleum moellendorffii*. *Biol. Pharm Bull.*, 21: 257-261.
- Panico, A.M., V. Cardile, F. Garufi, C. Puglia, F. Bonina and G. Ronsisvalle, 2005. Protective effect of *Capparis spinosa* on chondrocytes. *Life Sci.*, 77: 2479-2488.
- Podsdek, A., 2007. Natural antioxidants and antioxidant capacity of brassica vegetables: A review. *LWT: J. Food Compo. Anal.*, 40: 1-11.
- Qureshi, S., A.M. Ageel, M.A. Al-Yahya, M. Tariq, J.S. Mossa and A.H. Shah, 1990. Preliminary toxicity studies on ethanol extracts of the aerial parts of *Artemisia abyssinica* and *A. inculta* in mice. *J. Ethnopharmacol.*, 28: 157-162.

- Reitman, S. and S. Frankel, 1957. A colorimetric method for determination of serum glutamic oxaloacetic transaminase and glutamic pyruvic transaminase. *Am. J. Clin. Path.*, 28: 56-63.
- Rossetto, M., P. Vanzani, F. Mativi, M. Lunelli, M. Scarpa and A. Rigo, 2002. Synergistic antioxidant effect of catechin and malvidin 3-glucoside on free radical-initiated peroxidation of linoleic acid in micelles. *Arch. Biochem. Biophys.*, 408: 239-245.
- Sanchez-Moreno, C., J.A. Larrauri and F. Saura-Calixto, 1998. A procedure to measure the antiradical efficiency of polyphenols. *J. Sci. Food Agric.*, 76: 270-276.
- Sharaf, M., M.A. El-Ansari and N.A.M. Saleh, 2000. Quercetin triglycoside from *Capparis spinosa*. *Fitoterapia*, 71: 46-49.
- Singh, G., I.P. Kapoor, S.K. Pandey, U.K. Singh and R.K. Singh, 2002. Studies on essential oils: Part 10; antibacterial activity of volatile oils of some spices. *Phytother. Res.*, 16: 680-682.
- Stavri, M., C.H. Ford, F. Bucar, B. Streit and M.L. Hall, 2005. Bioactive constituents of *Artemisia monosperma*. *Phytochemistry*, 66: 233-239.
- Stein, E.A. and G.L. Myers, 1995. National cholesterol education program recommendations for triglycerides measurements: Executive summary. *Clin. Chem.*, 41: 1421-1426.
- Tietz, N.W., 1970. *Fundamental of Clinical Chemistry*. Sanders, W.B. and Co., Philadelphia, USA.
- Yang, T., C.H. Wang, G.X. Chou, T. Wu, X.M. Cheng and Z.T. Wang, 2010. New alkaloids from *Capparis spinosa*: Structure and X-ray crystallographic analysis. *Food Chem.*, 123: 705-710.
- Zhishen, J., T. Mengcheng and W. Jianming, 1999. The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chem.*, 64: 555-559.