Protective Effect of Ginger *(Zingiber Officinale)* Consumption Against kidney Damage in Rats

Ali Monahi Nazal Al Shammari

Faculty of Home Economics, the Public Authority for Applied Education and Training, Kuwait
anaba71@hotmail.com

Abstract: The present work was carried out to study the therapeutic effect of dried ginger against (KBrO3) induced kidney damage in rats. This study was conducted on twenty albino male rats (6 weeks) and classified into four groups (n=5). The first group kept as normal group (control -ve), the second group (n=15) received (KBrO3) through intragastric (20mg/kg B.W.) twice a week to the end of experiment. Then it classified into three groups as: untreated group (control positive) and two treated groups (2.5 and 5.0% powder of ginger). The results revealed that rats consumed 2.5 and 5.0% ginger showed significant decreases in serum ALT, AST and significant increases in serum albumin and protein. The haematological parameters of rats (Pcv, Hb, RBC, WBC and Platelets) were determined glutathione, catalase and SOD activities in serum and kidney tissue of rats intragastric with (KBrO3) were measured. The results revealed that rats consumed 2.5 and 5.0% ginger showed significant increases in antioxidant enzymes in serum and kidney tissue compared to control group.
[Ali Monahi Nazal Al Shammari. **Protective Effect of Ginger *(Zingiber Officinale)* Consumption Against kidney Damage in Rats.** *Life Sci J* 2018;15(1):80-85]. ISSN: 1097-8135 (Print) / ISSN: 2372-613X (Online). http://www.lifesciencesite.com. 14. doi:10.7537/marslsj150118.14.

Key words: Ginger – KBrO3- Renal oxidative stress - Phytochemical.

1. Introduction

Ginger rhizome (*Zingiber officinale*) is one of the best known spices and it has also been universally used throughout history for its health benifits. It is used traditionally to promote digestion **(Bone, 1997 and Shanmugam, et al., 2011).** Ginger (*Zingiber officinale* Roscoe, Zingiberaceae) rhizome (ginger root) is widely used as a spice or condiment **(Larsen et al., 1999 and Haniadka, et al., 2013)** and medical treatment for certain diseases **(Mohd-Yusof et al., 2002 and Tapsell et al., 2006)**. Ginger contains several compounds such as gingerol, gingerdiol, and gingerdione that possess strong antioxidant activity **(Akhani *et al*., 2004).** The dried extract of ginger contains monoterpenes and sesquiterpenes. The main antioxidant active ingradients in ginger are the gingerols and shogaols and some related phenolic ketone derivatives. Ginger extract possesses antioxidative characteristics, since it can scavenge superoxide anion and hydroxyl radicals **(Cao *et al.,* 1993 and Khaki, et al., 2009).**

Gingerol from ginger inhibited, at high concentrations, ascorbate/ ferrous complex induced lipid peroxidation in rat liver microsomes **(Reddy and Lokesh, 1992)**. Furthermore, ginger acts as a hypolipidemic agent in cholesterol fed rabbits **(Sharma *et al.,* 1996 and Bhandari *et al.*, 2005)**. Feeding rats ginger significantly elevated the activity of hepatic cholesterol-7-hydroxylase, the rate limiting enzyme in bile acids biosynthesis, thereby stimulating cholesterol conversion to bile acids, resulting in elimination of cholesterol from the body **(Srinivasan and Sambaiah 1991).** In addition, a pure constituent from ginger [E-8beta, 17 epoxylabd-12-ene-15, 16-dial (ZT)], was shown to inhibit cholesterol biosynthesis in homogenated rat liver **(Tanabe *et al*., 1993).** Consumption of ginger extract may decrease atherosclerosis development, since it is associated with reduced macrophage-mediated oxidation of LDL, reduced uptake of oxidized LDL by macrophages, reduced oxidative state of LDL and reduced LDL aggregation. All these effects lead to a reduced cellular cholesterol accumulation and foam cell formation, the hallmark of early atherosclerosis. **(Fuhrman *et al*. 2000).** Pretreatment of ginger inhibited the induced hyperglycemia and hypoinsulinaemia, and it has hypolipidemic effect **(Sharma *et al*., 1996).**

Potassium bromate (KBrO3) is widely used as a food additive in food products, fish paste, fermented beverages, bread-making and as a neutralizer in cold-wave hair lotions. It is also found in drinking-water samples as a by-product of ozone disinfection **(Kurokawa et al., 1990)**. Potassium bromate (KBrO3) has been used widely for water disinfection. KBrO3 has been reported to be a potent nephrotoxic agent which can mediate kidney damage, toxicity and tumor response in rats, it also increase kidney lipid peroxidation and hydrogen peroxide formation with reduction in kidney antioxidant enzymes **(Aruoma, I., 2003).**

2. Materials and Methods

Materials:

Ginger:

The fresh ginger was obtained from the local market, washed and cut into bits. The bits was sun

dried for three (3) days, after which a mechanical grinder was used to grind the dried bits into powdered form and stored at room temperature (25OC).

Rats:

Twenty male rats weighing (150-180g) were used in this study purchased from Agricultural Research Center, Giza, Egypt. All animals were housed in plastic cages and kept under the same laboratory conditions of temperature (25±2°C) and lighting (12:12hr light: dark cycle), for one week prior to starting the experiments. The rats were provided *ad libitum* with tap water and fed with standard diet.

Potassium Bromate (KBrO3):

Potassium bromate is a white powder, purchased from El-Gomhoria Co Cairo, Egypt. (KBrO3) used through intragastric (20mg/kg B.W.)

Methods:

Proximate Composition:

Ginger powder was analyzed for moisture, fat, protein, ash, and crude fiber contents according to **AOAC. (2002).** While total carbohydrates were calculated by difference as following:

Carbohydrates % = 100 - (moisture % + fat % +protein % + ash) according to the methods of the **(AOAC, 1995).**

Preliminary phytochemical screening of ginger.

Detection of tannins:

Tannins was detected in the plant sample according to the method of El-**Badrawy (1996).**

Detection of saponins: Saponins substances were detected in different crude extracts under investigation according to the method of **Trease (1961)**.

Detection of flavonoids:

Flavonoids substances were detected in extracts of different samples using the method of **Geissman (1962).**

Detection of carbohydrates and glycosides: Carbohydrates and glycosides were treated by Molish test according to the method of **Blabaa *et al.*, (1976).**

Experimental biological evaluation:

All rats fed with standard diet for one week before starting the experiment, then rats were divided into four groups for five rats each. (KBrO3) used through intragastric (20mg/kg B.W.) **(Thirunavukkarasu, et al. 2004)**. Ginger at concentrations (2.5 and 5.0%) were administered with the normal feed.

Experimental Design:

Animals were divided into four groups of five rats each as follow:

Group 1: Control group fed on basal diet (-ve).

Group2: Control group. (+ve) intragastric KBrO3 (20 mg/kg B.W.)

Group3: Fed on basal diet with 2.5% ginger for 28 days

Group4: Fed on basal diet with 5.0% ginger for 28 days.

Biochemical Analysis:

At the end of experimental period (6 weeks), the rats were anaesthetized by diethyl ether and sacrificed. Blood samples were collected in clean test tubes and left for coagulation then centrifuged at 3000 rpm for 15 minutes to obtain serum. Serum alanine aminotransferase (ALT) and aspartate aminotransferase enzymes (AST) were determined according to the method described by **Jendrassik (1938)**, **Reitman and Frankel (1957)**. Serum albumin and protein were determined according to the method described by **Doumas and Giggs (1972) and Doumas (1975),** respectively. Haematological parameters namely packed cell volume (PCV), haemoglobin concentration (Hb), white blood cell count (WBC), neutrophil and lymphocyte counts were determined using the method of **(Tietz et al. 1994),** GSH (**Beutler *et al.*, 1963**), SOD **(Beuchamp and Fridovich, (1971))** and CAT **(Aebi, 1984)** analysis**.**

Two kidneys of each rats were rapidly removed and perfuse with 50 to 100 of ice cold 0.9%NaCL solution for estimation of superoxide dismutase (SOD), glutathione peroxidase (GPX) and glutathione S-transferase (GST) according to **Beuchamp and Fridovich, (1971), Weiss et al., (1980) and Ellman (1958)** respectively.

Statistical analysis:

All obtained data were statistically analyzed by SPSS computer software. The calculated accorded by analysis of variance ANOVA and follow up LSD (SPSS) Computer program variation **(Sümbüloglu et al. 1998).**

3. Results and Discussion

Chemical composition of ginger g/100g:

The chemical composition of ginger such as moisture, protein, fat, ash and carbohydrates were determined. Their values were 6.5, 8.6, 6.4, 5.6 and 72.8 respectively.

Proximate analyses showed the moisture contain (on dry weight basis) was 6.67% in ginger; while crude protein contents was 8.56%. **(Nwinuka et al, 2005).**

Preliminary phytochemical screening of ginger:

The phytochemical screening of tannins, saponin, flavonoids, glycoside and carbohydrates of ginger were detected and recorded in Table (2). It was noticed that tannins, saponin, flavonoids, glycoside and carbohydrates were found in ginger. These results are agree with **Nwinuka et al. (2005)** Who showed the phytochemical screening of ginger presence of tannins, saponins, oxalates and cynogenic glycosides. Ginger sample had very low concentrations of tannin (0.01g/100g). The saponin level was 3.99g/100g. The

oxalate concentration was 0.23g/100g, while the cyanogenic glycoside level 30.5mg/100g in ginger.

Biological evaluation:

Table (3) showed that kidney function tests were elevated by KBrO3 positive control group (untreated) administration. The level of serum alanine and aspartate amino transferase (ALT & AST) enzymes, albumin and protein were determined in rats Therefore, it is possible to suggest that ginger is safe and may protect against kidney damage as evidenced by normal control group fed on basal diet in serum levels of ALT and AST in treated groups. The positive control group showed increase in serum alanine and aspartate amino transferase (ALT & AST) enzymes compared to normal control group while rats fed on ginger 2.5 and 5.0% showed significant decrease in ALT & AST enzymes at 23.37, 23.62 and 35.00, 26.93 respectively, compared to control positive group 56.50, 66.25. These results agreed with **(Dugasani, et al., 2010 and Ahmed and Sajida (2017)**.

On the other hand, it was found that significant increase in serum albumin and protein were noticed by treated groups with 2.5 and 5.0% ginger compared to positive control group. These results agreed with **Aniya et al., (2005) and Shrivastava (2015)** who reported that hypoalbuminemia and decline in total protein content can be deemed as a useful index of severity of renal damage. The lowered levels of total albumin and protein recorded in positive group.

Table (4) showed the therapeutic effect of ginger 2.5 and 5.0% on the haematological parameters of rats. Some fluctuations were noted in these parameters (Hb, RBC and Platelets) there were no significant differences between the control and the test groups. But Pcv was significant increased at $p < 0.05$ in treated groups fed on ginger 2.5 and 5.0%. On the other hand WBCs was significant decreased at $p < 0.05$ in treated groups fed on 2.5 and 5.0% ginger as compared to positive control group. Intragastric KBrO3 (20mg/kg B.W.) increased WBCs count this may be attributed to the defensive mechanism of immune system **(Patrick-Iwuanyanw et al., 2007 and Ahmed. and Sajida 2017)**. so the ability of free radicals to increase WBCs count indicates that these radicals to an extent affected the defense mechanism of treated rats **(Oluyemi et al., 2007 and Shrivastava2015).**

The results recorded in Table (5) revealed that the activities of serum GSH, Catalase and SOD were highly decreased in control positive group. The activities of serum GSH was significantly increased at $p < 0.01$ in treated group fed on 5.0% ginger, meanwhile Catalase and SOD were significantly increased at $p < 0.05$ in treated groups fed on 2.5 and 5.0% ginger as compared to control group (untreated). Similar results were obtained by **(Amer 2003, and Jinnah, et al., 2006).**

As shown in table (6), the positive control group showed a significant decrease in kidney superoxid dismutase (SOD), glutathione peroxidase (GPX), and glutathione transferase (GST) at $p< 0.001$ while 2.5 and 5% ginger group showed a significant increase in SOD, GPX and GST as compared to positive control group. These results are in the same line with **Lee and Ahn 1985 and Shidfar, et al., 2015).**

Table 1: Chemical composition of ginger g/100g:

Nutrients	Moisture	Crude Protein	Crude Fat	Ash	Carbohydrates
Ginger	6.5	8.6	6.4	5.6	72.8

Each value represents the average of three determinations.

Table 2: Preliminary phytochemical screening of ginger:

	Tannins	**Saponins**	**Flavonoids**	**glycoside**	**Carbohydrates**
Ginger	+	+	+	+	+

Table 3: therapeutic effect of ginger on serum levels of ALT, AST, albumin and protein in experimental rats

Groups	**ALT (U/ml)**	**AST (U/ml)**	**Albumin (g/dl)**	**Protein (g/dl)**
normal control	15.25 + 2.05	17.00 + 1.92	3.95 + 0.09	9.94 + 1.07
Control +ve	56.50 + 3.07	66.25 + 5.20	2.60 + 0.26	5.91 +0.29
2.5%ginger	23.37 + 2.87**	35.00 + 4.33**	3.77 + 0.86*	6.70 + 0.60
5.0% ginge	23.62 + 2.32**	26.93 + 2.88**	3.70 + 0.29*	8.76 + 0.21**

ALT: serum alanine amino transferase AST: serum aspartate amino transferase
Results are expressed as mean + S.D. * significantly compared with control $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

Table 4: Mean values ± SD of blood picture (PCV% value, Hb content, RBCs, WBCs, platelets,) in experimental rats groups.

Groups	PCV %	Hb Conc. (g/dl)	RBCs (x106/mm3)	WBCs (x103/mm3)	Platelets (x103/mm3)
normal control	41.33 ± 4.06	14.00 ± 1.16	7.38±0.5	7.90 ± 1.08	695 ± 31.62
Control +ve	36.33 ± 3.28	12.00 ± 1.00	4.91 ± 0.62	19.27 ± 4.16	263.50 ±44.47
2.5%ginger	41.67 ±2.19*	13.67 ± 0.67	6.9±0.78	13.57 ± 2.75*	264.12 ±38.86
5.0% ginge	42.35 ±1.86*	13.53 ± 0.77	6.03±0.83	14.85 ±2.64*	341.50 ± 2.64

Results are expressed as mean + S.D.
* significantly compared with control P < 0.05 ** P < 0.01 *** P < 0.001 packed cell volume (PCV) Blood haemoglobin (Hb) Red Blood Cell Count (RBC), White Blood Cell (WBC) counts

Table 5: Therapeutic effect of ginger on glutathione, catalase and SOD activities in serum of rats

Groups	Glutathione (mg/g)	Catalase (u/g)	SOD U/mL
normal control	25.43 ±10.60	1.977 ±0.6	103.0 ± 8.0
Control +ve	19.4±2.22	0.65 ± 0.63	59.50 ±5.3
2.5%ginger	24.0±2.8	0.95 ± 0.15*	88.0± 7.6*
5.0% ginge	26.4±0.59**	0.90 ± 0.17*	90.0 ± 8.5*

Results are expressed as mean + S.D.
* significantly compared with control P < 0.05 ** P < 0.01 *** P < 0.001

Table 6: Therapeutic effect of ginger on superoxid dismutase (SOD), glutathione peroxidase (GPX), and glutathione transferase (GST) activities in kidney tissue of rats

Groups	SOD U/mg	GPX U/mg	GST U/mg
normal control	140.8±. 21.1	121.33±.17	8.43 + 0.52
Control +ve	35.8±.3.8	29.14±.4.1	0.52+0.14
2.5%ginger	110.15±.11.5***	89.59±.7.9***	6.05+ 0.45*
5.0% ginge	131.25±.22.6***	118.4±.11.8***	7.19+ 0.59**

Results are expressed as mean + S.D.
* significantly compared with control P < 0.05 ** P < 0.01 *** P < 0.001

Conclusions

From the present study, it is concluded that ginger in diet have an antioxidant effect on potassium bromate induced renal oxidative stress in experimental rats.

References

1. A.O.A.C. (1995): Official Methods of Analysis of tea polyphenols. Mol. Nutr. and Food Res.
2. A.O.A.C. (2000): International. 17th ed., Gaithersburg, Maryland, USA. Chap. 4. pp: 21-39.
3. Aebi, H., (1984):. Catalase in vitro. Methods Enzymol., 5: 121-126.
4. Ahmed M. A. and Sajida H. I. (2017): Protective effect of ginger extract against cisplatin-induced hepatotoxicity and cardiotoxicity in rats. J. Pharm Sci, 21(1).
5. Akhani, S.P.; Vishwakarma, S.L. and Goyal, R.K. (2004): Anti-diabetic activity of Zingiber officinale in Streptozotocin-induced type I diabetic rats. J. of Pharmacy and Pharmacal, 56: 101-105.
6. Amer, M. A. (2003): The efficacy of Ginkgo Biloba extract in ameliorating carbon tetrachloride-induced acute hepatic toxicity in adult male albino rats. J. Egypt Ger. Soc. Zool. Comparative physiology, 40(A): 185-200.
7. Aniya, Y., Koyama, T., Miyagi, C., Miyahira, M. and Inomata, S. *(*2005)*: Biol. Pharm. Bull.* 28, 19-23.
8. Aruoma, O.I., 2003. Methodological considerations for characterizing potential antioxidant actions of bioactive components in plat foods. Mutat. Res., 523-524: 9-20.
9. Beuchamp, C. and J. Fridovich (1971): Superoxide dismutase. Improved assay an assyapplicable to acryloamide gels. Anal Biochem. 44: 276-287.

10. Bhandari, U.; Kanojia, R. and Pillai, K.K: (2005): Effect of ethanolic extract of Zingiber officinale on dyslipidaemia in diabetic rats. J. Ethnopharmacol, (97):227-230.
11. Blabaa, S., Hilal, S. H. and Zaki, A,Y. (1976): Medicinal plant constituents. 2nd edn. General Organization for University and Schoolbooks, Cairo, p. 147-156.
12. Bone, K. (1997): Ginger. Brit. J. Phytother., 4(3): 110-120.
13. Cao, Z. F.; Chen, Z. G.; Guo, P.; Zhang, S. M.; Lian, L.X.; Luo, L. and Hu, W. M. (1993): Scavenging effects of ginger on superoxide dismutase anion and hydroxyl radical. Chung-Kuo Chung Yao Tsa Chib, 18: 750-764.
14. Doumas, B. T. (1975): Colorimetric determination of total protein based on the Biuret method. Clin. Chem. 21: 1159-1166.
15. Doumas, B. T. and Giggs, H. G. (1972): Standard methods of clinical chemistry, Vol. 7; Academic Press New York.
16. Dugasani, S., Pichika, M.R., Nadarajah, V.D., Balijepalli. M.K., Tandra, S., and Korlakunta, J.N. (2010): Comparative antioxidant and anti-inflammatory effectsof [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. J Ethnopharmacol., 127:515–20.
17. El Badrawy, El S. El B.Y. (1996): Biochemical studies on some natural plant products. Ph.D. Thesis, Fac. of Agric., Mansoura Univ., Egypt.
18. Ellman, G.L. (1958): Liver glutathione. A colorimetric method for determining low concentration of glutathione. Arch Biochem Biophys 78: 443–450.
19. Fuhrman, B., Rosenblat, M., Hayek, T., Coleman, R. and Aviram, M. (2000): Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic apolipoprotein E-deficient mice. J. of Nutr. 130: 1124-1131.
20. Geissman, A. (1962): Chemistry of flavonoid compounds. Macmillan and Co. Nework, 72.
21. Haniadka, R., Saxena, A., Shivashankara, R., Fayad, R.and Palatty, L. (2013). "Ginger Protects the Liver against the Toxic Effects of Xenobiotic Compounds: Preclinical Observations." J Nutr Food Sci 3: 5-9.
22. inhibitory component from Zingiber officinale Roscoe. Chem. Pharm. Bull.
23. Jendrassik, L. (1938): Colorimetric determination of bilirubin. Biochem., 97, 72-81.
24. Jinnah, H.A., T. Ceballos-Picot, Iwitkosarsat, V., Meradboudia, A., Mnguyen, T., Thevenin, M., Jaudon, M. C., Zingraff, J., Verger, C., Jungers, P. and Descampslatscha, B. (2006): Glutathione antioxidant system as a marker of oxidative stress in chronic renal failure. Free Radical Biol. Med., 21: 845-853.
25. Khaki, A., F. Fathiazad, M. Nouri, A. A. Khaki and C. C. Ozanci (2009): The effects of ginger on spermatogenesis and sperm parameters of rat." Iran J Reprod Med 7(1): 7-12.
26. Kurokawa, Y., A., Melawi, M., Takahashi, and Y., Hayashi, (1990): Toxicity and carcinogenicity of potassium bromate a new renal carcinogen. Environ. Health Perspect. 87, 309–335.
27. Larsen, K.; Ibrahim, H.; Khaw, S. H. and Saw, L. G. (1999): Gingers of Peninsular.
28. Lee; I.K. and Ahn, S.Y. (1985): *Korean J. Food Sci. Technol*., 17(2), 55-59.
29. Malaysia and Singapore. Natural History Publications (Borneo), Kota Kinabalu, Malaysia.
30. Mohd-Yusof, Y. A., Sieh, S., Murad, N. A., and Wan-Ngah, W. Z. (2002): Anticancer effect of ginger extract (Zingiber officinale) on liver cancer cell lines. Malays. J. Biochem. Mol. Biol, 7:38–42.
31. Nwinuka, N.; Ibeh, G. O. and Ekeke, G. I. (2005): Proximate composition and levels of some toxicants in four commonly consumed spices. J. of Applied Sciences & Environmental Management, Vol. 9, No. 1, pp. 150-155.
32. Oluyemi, K. A., Omotuyi, I. O., Jimoh, O. A., Saalu, C. L. and Josiah, S.J. (2007): Erythropoetic and antiobesity effects of *Garcinia cambogia* (bitter kola) in Wister rats. Biotechnol. Appl. Biochem., 46: 69-72.
33. Patrick-Iwuanyanwu, K.C.; Wegwu, M.O. and Ayalogu, E.O. (2007): Prevention of CCl4-induced liver damage by ginger, garlic and vitamin E. *Pak* J Biol Sci., 15, 10(4): 617-621.
34. Reddy, A. A. and Lokesh, B. R. (1992): Studies on spice principles as antioxidants in the inhibition of lipid peroxidation of rat liver microsomes. Mol. Cell Biochem., 111: 117-124.
35. Reitman, S. and Frankel, S. (1957): Determination of glutamate pyruvat transaminase and glutamate oxaloacetate transaminase. Amer. J. Clin. Path., 28: 56-63.
36. Shanmugam KR, Ramakrishna CH, Mallikarjuna K, Sathyavelu Reddy K. (2011): Protective effect of ginger against alcohol- induced renal damage and antioxidant enzymes in male albino rats. Indian J Exp Biol., 48:143–9.
37. Sharma, I., Gusain, D. and Dixit, V.P. (1996): Hypolipidemic and antiatherosclerotic effects of Zingiber officinale in cholesterol-fed rabbits. Phto. Res, 10:517-518.
38. Shidfar, F., Rajab, A., Rahideh, T., Khandouzi, N., Hosseini, S., and Shidfar, S. (2105): The

effect of ginger (Zingiber officinale) on glycemic markers in patients with type 2 diabetes. J Complement Integr Med., 12:165–170.
39. Shrivastava, S. (2015): The influence of gingerol treatment on aluminum toxicity in rats. J Environ Pathol Toxicol Oncol., 34:11–21.
40. Srinivasan, K and Sambaiah, K. (1991): The effect of spices on cholesterol 7 alpha-hydroxylase activity and on serum and hepatic cholesterol levels in the rat. Int. J. Vitam. Nutr. Res., 61: 363-369.
41. Sümbüloglu K, Sümbüloglu V: Biyoistatistik, (1998): 8thedition, Hatiboglu Yayinevi, Ankara, p. 76-86.
42. Tanabe, M.; Chen, Y.D.; Saito, K. and Kano, Y. (1993): Cholesterol biosynthesis.
43. Tapsell, L. C., Hemphill, I., Cobiac, L., Patch, C. S. and Inge, K. E. (2006):Health benefits of herbs and spices: The past, the present, the future. Med. J. Aust, 185:4–24.
44. Thirunavukkarasu, V. and C.V. Anuradha, 2004. Influence of alpha-lipoic acid on lipid peroxidation and antioxidant defence system in blood of insulin resistant rats. Diabetes Obes. Metab., 6(3): 200-7.
45. Tietz, N.W., and EL Pruden, O. (1994): Siggaard-Andersen. In: Tietz Textbook of Clinical Chemistry, W.B Saunders Company, London, pp. 1354-1374. Tokyo, 41: 710-713.
46. Trease, G.E. (1961): Textbook of pharmacognosybillier, 8th edn. Tindall and Cox., London, 596.
47. Weiss, C., Marker, H.S. and Lehrer, G.M. (1980): Sensitive fluorometric assays for glutathione peroxidase and reductase. Anal Biochem 106: 512–516.

1/27/2018