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Thymoquinone Attenuates Hematological and Biochemical Alterations Induced by Potassium Bromate Toxicity in Female Albino Mice, *Mus musculus*

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ABSTRACT: It has never been demonstrated that thymoquinone (TQ), the primary active component of the essential oil present in *N. sativa* seed, protects against the deterioration of blood indices brought on by potassium bromate ($KBrO_3$). Consequently, the objective of this work was to examine Potential protective effects of TQ against $KBrO_3$-induced biochemical and haematological changes in female albino mice. TQ's ability to protect female albino mice against $KBrO_3$-induced haematological and biochemical changes was investigated in this work. We employed 24 mature, female albino mice (*Mus musculus*) in this investigation. For 60 days, they were separated six animals each, divided into four groups Control group (20 mg/kg b.w. dissolved in vehicle corn oil), the $KBrO_3$ group (100 mg/kg b.w. dissolved in double distilled water), the $KBrO_3$ + TQ group (100 mg/kg b.w. dissolved in double distilled water along with 20 mg/kg body weight dissolved in vehicle corn oil) and the TQ group (20 mg/kg b.w. dissolved in vehicle corn oil). Throughout this inquiry, blood metabolites were examined to see how $KBrO_3$ affected several haematological, enzymatic, and oxidative stress indicators as well as glucose, cholesterol and lipid metabolism. In addition, we compared TQ's ability to counteract $KBrO_3$ toxicity and lessen the disruption of serum homeostasis. We discovered in the present study that TQ was significantly enhanced the haematological parameters like total RBCs count ($p \leq 0.001$), WBCs total count ($p \leq 0.001$), and haemoglobin level ($p \leq 0.001$) along with SOD ($p \leq 0.001$), CAT ($p \leq 0.01$) and GPx ($p \leq 0.01$) and high density-lipoprotein HDL ($p \leq 0.001$), on the other hand TQ remarkably lowered the serum glucose ($p \leq 0.001$), cholesterol ($p \leq 0.001$), triglycerides ($p \leq 0.001$), and LDL ($p \leq 0.001$) and platelets count ($p \leq 0.001$) along with Aspartate aminotransferase (AST) ($p \leq 0.001$) Alanine aminotransferase (ALT) ($p \leq 0.001$), and Alkaline phosphatase (ALP) ($p \leq 0.001$), as compared to $KBrO_3$ group. The findings show that TQ ca treat hematological, biochemical, and oxidative changes brought on by $KBrO_3$ poisoning.

Keywords: Potassium bromate, Thymoquinone, Hematology, Oxidative stress and Hepatic marker.

INTRODUCTION

$KBrO_3$ is a common flour enhancer and maturation additive. Since 90 years ago, it has been a culinary ingredient (Oloyede *et al.,* 2009; Vadlamani *et al.,* 1999)**.** In bakeries, it is employed as a flour enhancer to help bread rise while also giving dough strength and flexibility during baking. The bread that results is typically sturdy, supple, and having a fine crumb structure. In dough, bromate encourages the growth of gluten as well. Beer, cheese, and fish paste products frequently contain $KBrO_3$ as an additive (Ahmad *et al.,* 2016a). Additionally, it is a component of cold wave hair treatments and is employed in the pharmaceutical and cosmetic professions (International Agency for Research on Cancer, 1999) (Chipman *et al.,* 1998). An ozonization of bromide-containing water may produce $KBrO_3$ as a byproduct. Free radicals generated due to the biotransformation of $KBrO_3$ may harm vital biological macromolecules in an oxidative manner, significantly harming the kidneys and causing cancer in treated mice (Chipman *et al.,* 1998). Since the International Agency for Research on Cancer (IARC) classified $KBrO_3$ as a potential cancer-causing agent, its usage in food processing was prohibited (category 2BMoreover, $KBrO_3$ has been linked to a variety of organ damage in both humans and lab animals, according to a number of past research (Ahmad *et al.,* 2015; Farombi *et al.,* 2002; Kujawska *et al.,* 2013). Additionally, studies on animals have shown that $KBrO_3$ has mutagenic and carcinogenic effects (Kurokawa *et al.,* 1986). In New Zealand, there were several incidences of unintended child poisoning brought on by the intake of bromate solutions and bromate-tainted sugar (Paul, 1966). The primary vitamins present in bread are destroyed by $KBrO_3$, which has been conclusively demonstrated in toxicological investigations to have an impact on the nutritional quality of bread (Sai *et al.,* 1992). According to several reports, $KBrO_3$ causes oxidative stress in tissues (Chipman *et al.,* 1998; Parsons *et al.,* 2000; Sai *et al.,* 1992; Watanabe *et al.,* 1992). $KBrO_3$ treatment has affected blood biochemistry, renal and hepatic histology, and reduced the capacity of Swiss mice's livers to produce antioxidants, among other impacts (Altoom *et*

al., 2018). Many medicinal plants and their components have the ability to treat a variety of illnesses (Lev *et al.,* 2000). The use of medicinal plants to treat a variety of diseases dates back to ancient times. A significant variety of natural compounds and food components have recently been investigated as possible chemopreventive agents. A higher predisposition for conventional therapies was also brought on by low patient satisfaction with the usage of synthetic pharmaceuticals, which was brought on by their high prices and negative side effects (Al-Attar *et al.,* 2015). It is becoming increasingly common to use herbs to treat a wide range of illnesses. Current studies have concentrated in particular on the benefits of antioxidants given by natural compounds in protecting against toxicity produced by chemical agents. Natural antioxidants have received attention recently due to their ability to defend against the toxicity of numerous contaminants and pathogenic elements (Abdulwahab *et al.,* 2021; Danaei *et al.,* 2019). The components of these plants that have been cleaned up are bioactive, readily available, reasonably priced, somewhat harmless, and come in edible form (Khader *et al.,* 2009). Black seed, also known as *N. sativa* Linn, is a plant that is often found in the Middle East. Its active component is TQ. *N. sativa* seeds have a constant oil, alkaloids, protein, and saponin content that varies from 36-38%. Moreover, 0.4-0.45% of *N. sativa* seeds have oils that are essential which are identified by its primary constituent, TQ. TQ, also known by its scientific name 2-methyl-5-isopropyl-1, 4-benzoquinone, is a monoterpene compound. The seeds of *N. sativa* L., sometimes referred to as black seed or black cumin and a member of the Ranunculaceae family, contain a significant amount of it (Ali *et al.,* 2003; Majdalawieh *et al.,* 2017). The physiological and biochemistry processes that come after reactive oxygen species production are controlled by TQ in order to carry out its biological actions (Dergarabetian *et al.,* 2013). It is capable of effectively scavenging free radicals (Mansour *et al.,* 2002). TQ has potent antioxidant activities that successfully prevent the production of superoxide radicals and lipid peroxidation (Cc *et al.,* 2012). It increases the activities of various enzymes, such as superoxide dismutase, glutathione (GSH) catalase, and glutathione transferase. Two powerful antioxidants are produced by TQ following a reaction with antioxidant enzymes (GSH, NADH, and NADPH): glutathionyl-dihydrothymoquinone and dihydrothymoquinone (Khalife *et al.,* 2007). TQ has significant impacts on a number of pro-inflammatory transcription factors, such as NF-κB/STAT3, which may be activated by a variety of variables, such as stress, bacteria, viruses, free radicals, and cytokines (Ahn *et al.,* 2005). TQ has exceptional anticancer properties. TQ administration has no effect on the heart, liver, or kidneys (Banerjee *et al.,* 2010). TQ fights cancer by a variety of mechanisms, including angiogenesis, cell cycle arrest, ROS production, antiproliferation, and apoptosis. TQ is also utilised with a variety of chemotherapy drugs as an adjuvant. It reduces the negative effects of chemotherapy medications and targets tumour cells specifically (Ali *et al.,* 2003; Majdalawieh *et al.,* 2017).

MATERIAL AND METHODS

Study Design: In this investigation, 24 adult female albino *Mus musculus* mice weighing 20±5g were used. The mice were housed in the bioscience department's animal house at Barkatullah University in Bhopal. They were allowed a week to get acclimated to the lab's conditions (temperature 22°C ±3°C, humidity 45%, light/dark cycle (14L: 10D h). The procedures were approved by the Institutional Ethics Committee of Barkatullah University Bhopal (Ref. No. 1885/GOI/S/16/CPCSEA/IAEC/BU/23). Mice were acclimated before being divided into four groups of six, each of which received a different treatment for 60 days.
Group -I i.e. Control, was given regular pellet diet
Group -II received $KBrO_3$ (100 mg/kg bw).
Group -III was given $KBrO_3$ (100 mg/kg bw) along with TQ (20 mg/kg bw).
Group-IV was supplied with regular pellet diet along with TQ (20 mg/kg bw). Whole blood was drawn immediately from the inferior vena cava using a 1 ml syringe following the start of 60 days of dosage. The blood was then allowed to coagulate, and the serum was separated. The blood samples were drawn into complete blood count (CBC) bottles containing ethylenediamine tetraacetate for hematological analysis (EDTA). Blood samples were centrifuged at 2500 × g for 10 min. within 1 hour of collection for serum biochemistry examination. Before analysis, the serum were kept in a freezer at -80 °C.

Drug and dose: Effective Enterprises (M.P., India) provided the $KBrO_3$, while Tokyo Chemical Industry Co. Ltd. provided the TQ utilised as an antidote. For 60 days, female mice were given $KBrO_3$ (100 mg/kg bw) dissolved in double distilled water along with TQ (20 mg/kg bw) dissolved in vehicle corn oil orally.

Biochemical analysis: The Erba kit was used to measure the blood's glucose, triglyceride (TG), high density lipoprotein (HDL) cholesterol, LDL cholesterol, and total cholesterol levels according to the manufacturer's instructions (Mannhein, Germany).

Hematological analysis: RBCs, WBCs, platelet, and Hb concentration were calculated using the Wintrobe method (Wintrobe, 1974).

Enzymological analysis: While aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured using the Reitman and Frankel technique, and alkaline phosphatase (ALP) and were assessed using the King and Kings method.

Antioxidant assay: The manufacturer's instructions were followed for calculating the superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) activities using the Fine test Elisa kit (Wuhan fine Biotech Co., Ltd., China).

Statistics: The data of current experimental work was in expressed using the mean ± standard error. analysis of variance (ANOVA) by one way method and multiple comparison tukey's test was carried out to find out the significant differences for the control and different treated groups The $p<0.05$ mean value was considered significant, but the $p<0.001$ value was extremely significant. Software tool sigma stat (version 4) was used in this study.

RESULT

Effects of Exposure to $KBrO_3$ and $KBrO_3$ + TQ on biochemical parameters:

Table 1 illustrates how $KBrO_3$ and $KBrO_3$ +TQ affect glucose levels, cholesterol, triglycerides, HDL, and LDL. When Contrasted with the control group, the $KBrO_3$ -treated group showed a substantial rise in blood glucose ($p \leq 0.001$), cholesterol ($p \leq 0.001$), triglycerides ($p \leq 0.001$), and LDL ($p \leq 0.001$), but the levels of HDL ($p \leq 0.001$) was decreased. When compared to the $KBrO_3$ group, the findings of group $KBrO_3$ + TQ revealed lower levels of blood glucose($p \leq 0.001$), cholesterol($p \leq 0.001$), triglycerides (TG)($p \leq 0.001$), and LDL($p \leq 0.001$), However, higher levels of HDL($p \leq 0.001$), was seen when Contrasted with the control group.

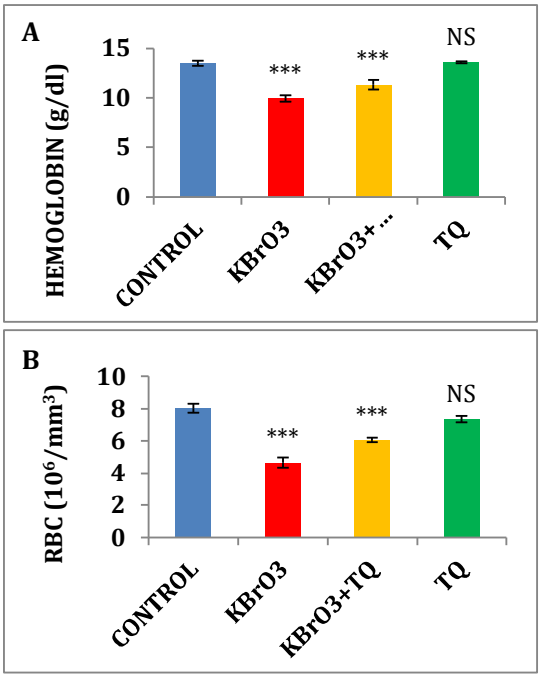
Table1. Effect of $KBrO_3$ & TQ on Glucose, cholesterol, triglyceride, HDL and LDL

Parameters	Control	$KBrO_3$	$KBrO_3$ +TQ	TQ
Glucose	107.83±2.14	153.26±1.98***	133.37±2.22***	100.305±2.32NS
Cholesterol	120.31±2.80	165.42±1.79***	147.48±2.27***	112.28±2.48NS
Triglyceride	131.84±2.39	181.77±2.59***	150.74±2.07***	127.37±2.48NS
HDL	84.81±1.07	44.77±1.42***	67.45±1.98***	88.54±1.11NS
LDL	8.54±0.53	20.36±0.88***	14.40±0.55***	8.90±0.63NS

Depiction of glucose, cholesterol, Triglyceride, HDL and LDL for 60 days control, $KBrO_3$, $KBrO_3$ along with TQ and TQ alone in *Mus musculus* female mice. the data is expressed in mean ± SEM (per experimental group n=6), *p≤0.05, **p≤0.01, ***p≤0.001, and NS= Non significant between control and experimental group by one way ANOVA.

Effects of exposure to $KBrO_3$ and TQ on hematological parameters: Fig.1 (A, B, C & D) shows that the $KBrO_3$-treated group significantly decreased total RBCs count ($p \leq 0.001$), total WBCs count ($p \leq 0.001$), haemoglobin (Hb) level ($p \leq 0.001$) and increased platelet count ($p \leq 0.001$) when compared to the control group, but the $KBrO_3$ +TQ group significantly increased total RBCs count ($p \leq 0.001$), total WBCs count ($p \leq 0.001$), haemoglobin (Hb) level ($p \leq 0.001$) and decreased platelet count ($p \leq 0.001$) when compared to the $KBrO_3$ treated group.

Fig. 1 (A-D). Changes in hematological parameters of female mice *Mus musculus*



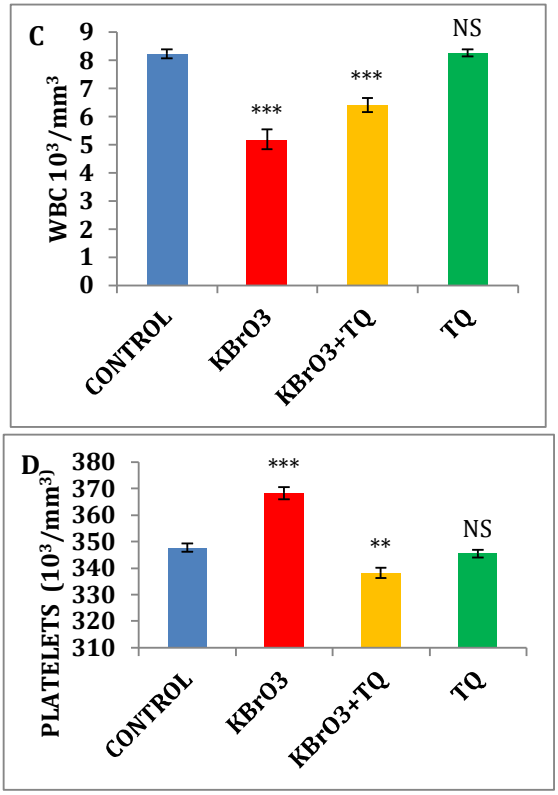


Fig. 1 (A-D). Comparison of haemoglobin (Hb) level, total RBC count, total WBC count and platelets count for 60 days control, $KBrO_3$, $KBrO_3$ along with TQ and TQ alone in *Mus musculus* female mice. The data is expressed in mean ± SEM (per experimental group n=6), *p≤0.05, **p≤0.01, ***p≤0.001, and NS= Non significant between control and experimental group by one way ANOVA.

Effect of exposure to $KBrO_3$ and TQ on enzymological parameters:

Fig. 2 (A, B & C) shows that the $KBrO_3$-treated group had significantly higher levels of the enzymes alkaline phosphatase (ALP), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) compared to the control group ($p \leq 0.001$). Alkaline phosphatase (ALP) ($p \leq 0.001$), alanine aminotransferase (ALT) ($p \leq 0.001$), and aspartate aminotransferase (AST) ($p \leq 0.001$) were all significantly lower in the $KBrO_3$ + TQ group than in the $KBrO_3$ group.

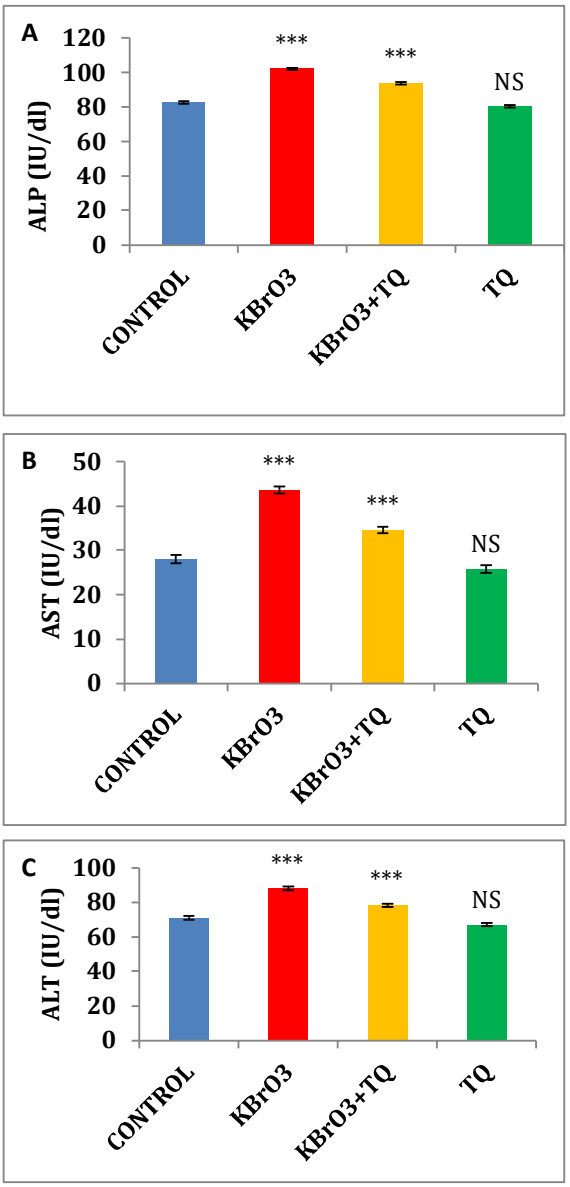


Fig. 2 (A-C). Changes in enzymological parameters of female mice *Mus musculus.* Comparison of enzymes alkaline phosphatase (ALP), aspartate aminotransferase (AST) and alanine aminotransferase (ALT), for 60 days control, $KBrO_3$, $KBrO_3$ along with TQ and TQ alone in *Mus musculus* female mice. The data is expressed in mean ± SEM (per experimental group n=6), *p≤0.05, **p≤0.01, ***p≤0.001, and NS= Non significant between control and experimental group by one way ANOVA.

Effects of exposure to $KBrO_3$ and TQ on antioxidant activity:

Fig. 3 (A, B & C). depicts the role of TQ on serum antioxidant level. In comparison with control, females exposed to $KBrO_3$ has reduced ($p \leq 0.001$) level of GPx, CAT as well as SOD, on the other hand in $KBrO_3$ + TQ, administration of TQ has elevated GPx ($p \leq 0.01$), CAT ($p \leq 0.01$) and SOD ($p \leq 0.001$), compare to $KBrO_3$ alone.

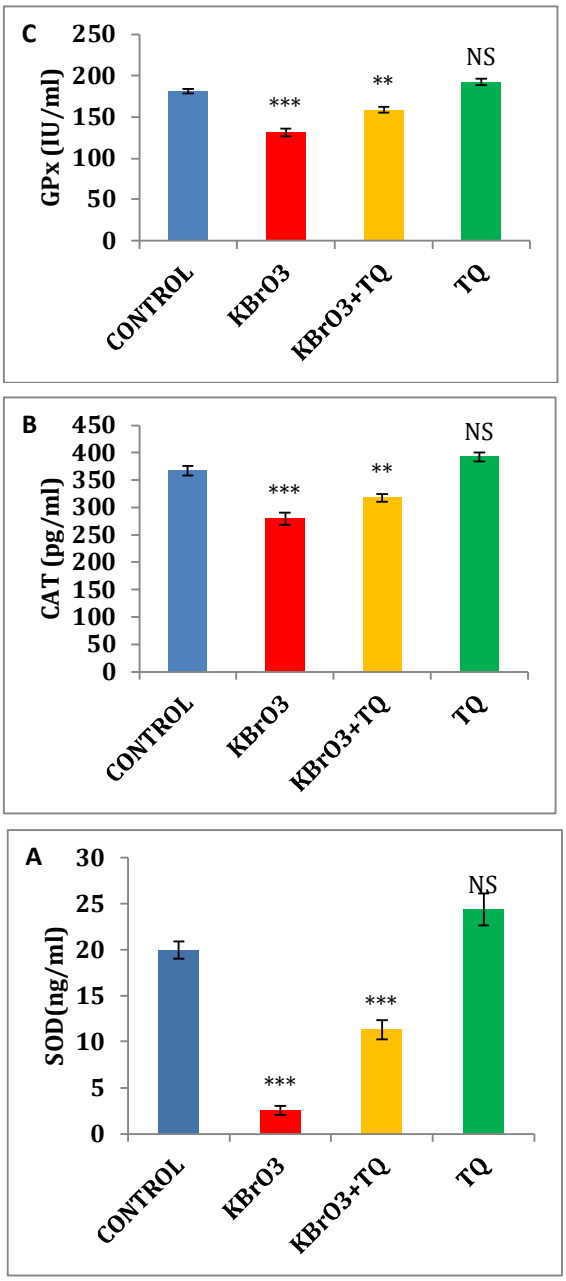


Fig. 3 (A-C). Changes in antioxidant enzyme level in *Mus musculus* female mice. Comparison of GPx(IU/ml), CAT (pg/ml) and SOD (ng/ml), in 60 day Control, $KBrO_3$, $KBrO_3$ along with TQ and TQ alone in *Mus musculus* female mice. the data is expressed in mean ± SEM (per experimental group n=6), *p≤0.05, **p≤0.01, ***p≤0.001, and NS= Non significant between control and experimental group by one way ANOVA.

DISCUSSION

Food additive $KBrO_3$ is commonly used in bakeries to enhance the dough (Ahmad *et al.,* 2015). "Endocrine-disrupting chemicals (EDCs)," also known as "endocrine disruptors," are manmade and natural substances that disturb the endogenous-endocrine functioning (Rosenfeld *et al.,* 2017; Yoon *et al.,* 2014; Zawatski *et al.,* 2013). The key ingredient in *N. sativa* seeds, TQ has numerous and diverse pharmacological actions, including potent antioxidant activity against substances that cause free radicals (Houghton *et al.,* 1995). Our finding revealed that $KBrO_3$ in distilled water decrease the hematological parameters RBC, WBC, Platlates and Hb. Our study supported by Abdulwahab *et al.,* (2021); Altoom *et al.,* (2018). Who stated that $KBrO_3$ decrease blood parameters. Leukocyte and platelet counts may have decreased as a result of DNA strand breaks brought on by the oxidative stress produced by $KBrO_3$ in these cells (Chipman *et al.,* 1998; Thompson *et al.,* 1949; Sai *et al.,* 2000; Parsons *et al.,* 2000). Additionally, selective megakaryocytic depression along with bone marrow suppression may have occurred (Hoffbrand *et al.,* 2011). The majority of metabolic pathways are lacking in erythrocytes, which are terminally differentiated cells. Regardless of how the xenobiotic was consumed, applied to the skin, or inhaled, they are among the first cells to be exposed to it. Erythrocytes constantly face risk from both internal oxygen radicals within the cell and external sources due to their function as oxygen transporters. In addition, they are particularly susceptible to oxidative damage due to the high presence of transition metals and polyunsaturated lipids. Because of this, erythrocytes have a highly developed anti-oxidant system that creates an effective defence against the harmful effects of ROS (Ahmad *et al.,* 2016b). $KBrO_3$ alters the antioxidant defence mechanism and generates oxidative stress in the blood of rats, as we have previously seen (Ahmad *et al.,* 2012). RBC counts rise after TQ pretreatment, and the Hb content also increases until it reaches normal levels (Jrah Harzallah *et al.,* 2012).

Elevated serum AST, ALT, and ALP activities are frequently employed as indicators of liver damage because they show cellular leakage of endogenous enzymes and a lack of stability of the liver cell membrane (Sabiu *et al.,* 2014). The current study's findings showed that TQ therapy of mice successfully defended them against $KBrO_3$-induced hepatotoxicity, as seen by a decline in blood AST, ALT and ALP activity. The study supported by Abdel-Latif *et al.,* (2021). They stated that when $KBrO_3$ was used, blood serum levels of ALT, AST, and ALP significantly increased as compared to the Control group. On the other hand our finding revealed that $KBrO_3$ increase blood glucose level. It has been suggested that *N. sativa's* ability to reduce blood glucose levels is due to the stimulation of insulin production (Fararh *et al.,* 2002). When it comes to Cholesterol, Triglyceride and LDL these all parameters increased in $KBrO_3$ treated group as compare to control group. $KBrO_3$ +TQ treated group significantly normalize those parameters. our finding supported by Kaatabi *et al.,* (2012). HDL significantly increased in $KBrO_3$ + TQ treated group as compare to $KBrO_3$ treated group.

The mechanism of $KBrO_3$-induced toxicity in animal models is supported by a significant several studies that links oxidative stress with ROS (Farombi *et al.,* 2002). The initial line of cellular protection against oxidative damage is thought to be antioxidant enzymes. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) are engaged in the defence against oxidative cell damage and cooperate to minimise the effects of oxidant molecules on tissues because they are free radical scavengers (Nakbi *et al.,* 2010). Based on blood serum data, in present study it was demonstrated that the antioxidant enzymes i.e. CAT, SOD, and GPx level in the $KBrO_3$-treated group was reduced markedly as compare to the animals in control group, which was well supported by previous study (Khan *et al.,* 2012), according to which the mean activity of the antioxidant enzymes CAT, SOD, and GPx was significantly reduced in female treated with $KBrO_3$ (R. A. Khan *et al.,* 2012). In vivo experimental rats showed decreased activity of numerous antioxidant enzymes in the presence of $KBrO_3$ (Khan *et al.,* 2003). The biochemical alterations brought on by $KBrO_3$ in mice were altered by the treatment of TQ with $KBrO_3$, however. The mean antioxidant enzyme activities in the current study were significantly higher than those of the group that received $KBrO_3$ treatment, and they may have had a protective effect.

CONCLUSION AND FUTURE SCOPE

It is clear that TQ ameliorated the toxic effect of Potassium bromate and suppressed the oxidative stress induced in mice through its antioxidant mechanism and overall significantly positive effect on the numerous parameters considered.

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Conflict of interest. Nil.

REFERENCES

Abdel-Latif, A. S., Abu-Risha, S. E., Bakr, S. M., El-Kholy, W. M., & El-Sawi, M. R. (2021). Potassium bromate-induced nephrotoxicity and potential curative role of metformin loaded on gold nanoparticles. *Science Progress*, *104*(3), 368504211033703.

Abdulwahab, Z., Shehab, Rashad, F., & Ghadhban. (2021). Effect of Potassium Bromate on Some Hematological and Biochemical Parameters and Protective Role of Vitamin C on Laboratory Rats (Rattus_Rattus). *Annals of Laboratory Medicine*, *25*, 669–674.

Ahmad, M. K., Khan, A. A., Ali, S. N., & Mahmood, R. (2015). Chemoprotective effect of taurine on potassium bromate-induced DNA damage, DNA-protein cross-linking and oxidative stress in rat intestine. *PloS One*, *10*(3), e0119137.

Ahmad, M. K., & Mahmood, R. (2012). Oral administration of potassium bromate, a major water disinfection by-product, induces oxidative stress and impairs the antioxidant power of rat blood. *Chemosphere*, *87*(7), 750–756.

Ahmad, M. K., & Mahmood, R. (2016a). Protective effect of taurine against potassium bromate-induced hemoglobin oxidation, oxidative stress, and impairment of antioxidant defense system in blood. *Environmental Toxicology*, *31*(3), 304–313. https://doi.org/10.1002/tox.22045

Ahmad, M. K., & Mahmood, R. (2016b). Protective effect of taurine against potassium bromate-induced hemoglobin oxidation, oxidative stress, and impairment of antioxidant defense system in blood. *Environmental Toxicology*, *31*(3), 304–313.

Ahn, K. S., & Aggarwal, B. B. (2005). Transcription Factor NF-κB: A Sensor for Smoke and Stress Signals. *Annals of the New York Academy of Sciences*, *1056*(1), 218–233.

Al-Attar, A. M., & Shawush, N. A. (2015). Influence of olive and rosemary leaves extracts on chemically induced liver cirrhosis in male rats. *Saudi Journal of Biological Sciences*, *22*(2), 157–163.

Ali, B. H., & Blunden, G. (2003). Pharmacological and toxicological properties of Nigella sativa. *Phytotherapy Research: PTR*, *17*(4), 299–305.

Altoom, N. G., Ajarem, J., Allam, A. A., Maodaa, S. N., & Abdel-Maksoud, M. A. (2018). Deleterious effects of potassium bromate administration on renal and hepatic tissues of Swiss mice. *Saudi Journal of Biological Sciences*, *25*(2), 278–284.

Banerjee, S., Padhye, S., Azmi, A., Wang, Z., Philip, P. A., Kucuk, O., Sarkar, F. H., & Mohammad, R. M. (2010). Review on molecular and therapeutic potential of thymoquinone in cancer. *Nutrition and Cancer*, *62*(7), 938–946.

Cc, W., Ap, K., G, S., & Kh, T. (2012). Thymoquinone: Potential cure for inflammatory disorders and cancer. *Biochemical Pharmacology*, *83*(4).

Chipman, J. K., Davies, J. E., Parsons, J. L., Nair, J., O'Neill, G., & Fawell, J. K. (1998). DNA oxidation by potassium bromate; a direct mechanism or linked to lipid peroxidation? *Toxicology*, *126*(2), 93–102.

Danaei, G. H., Memar, B., Ataee, R., & Karami, M. (2019). Protective effect of thymoquinone, the main component of Nigella Sativa, against diazinon cardio-toxicity in rats. *Drug and Chemical Toxicology*, *42*(6), 585–591.

Dergarabetian, E. M., Ghattass, K. I., El-Sitt, S. B., Al-Mismar, R. M., El-Baba, C. O., Itani, W. S., Melhem, N. M., El-Hajj, H. A., Bazarbachi, A. A. H., Schneider-Stock, R., & Gali-Muhtasib, H. U. (2013). Thymoquinone induces apoptosis in malignant T-cells via generation of ROS. *Frontiers in Bioscience (Elite Edition)*, *5*(2), 706–719.

Fararh, K. M., Atoji, Y., Shimizu, Y., & Takewaki, T. (2002). Isulinotropic properties of Nigella sativa oil in Streptozotocin plus Nicotinamide diabetic hamster. *Research in Veterinary Science*, *73*(3), 279–282.

Farombi, E. O., Alabi, M. C., & Akuru, T. O. (2002). Kolaviron modulates cellular redox status and impairment of membrane protein activities induced by potassium bromate (KBrO(3)) in rats. *Pharmacological Research*, *45*(1), 63–68.

Hoffbrand, A. V., & Moss, P. A. (2011). *Essential haematology* (Vol. 28). John Wiley & Sons.

Houghton, P., Zarka, R., de las Heras, B., & Hoult, J. (1995). Fixed Oil of *Nigella sativa* and Derived Thymoquinone Inhibit Eicosanoid Generation in Leukocytes and Membrane Lipid Peroxidation. *Planta Medica*, *61*(01), 33–36.

International Agency for Research on Cancer (Ed.). (1999). *Re-evaluation of some organic chemicals, hydrazine and hydrogen peroxide: This publication represents the views and expert opinions of an IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, which met in Lyon, 17 - 24 February 1998*. IARC.

Jrah Harzallah, H., Grayaa, R., Kharoubi, W., Maaloul, A., Hammami, M., & Mahjoub, T. (2012). Thymoquinone, the *Nigella sativa* Bioactive Compound, Prevents Circulatory Oxidative Stress Caused by 1,2-Dimethylhydrazine in Erythrocyte during Colon Postinitiation Carcinogenesis. *Oxidative Medicine and Cellular Longevity*, *2012*, 854065.

Kaatabi, H., Bamosa, A. O., Lebda, F. M., Al Elq, A. H., & Al-Sultan, A. I. (2012). Favorable impact of Nigella sativa seeds on lipid profile in type 2 diabetic patients. *Journal of Family & Community Medicine*, *19*(3), 155–161.

Khader, M., Bresgen, N., & Eckl, P. M. (2009). In vitro toxicological properties of thymoquinone. *Food and Chemical Toxicology: An International Journal Published for the British Industrial Biological Research Association*, *47*(1), 129–133.

Khalife, K. H., & Lupidi, G. (2007). Nonenzymatic reduction of thymoquinone in physiological conditions. *Free Radical Research*, *41*(2), 153–161.

Khan, N., Sharma, S., & Sultana, S. (2003). Nigella sativa (black cumin) ameliorates potassium bromate-induced early events of carcinogenesis: Diminution of oxidative stress. *Human & Experimental Toxicology*, *22*(4), 193–203.

Khan, R. A., Khan, M. R., & Sahreen, S. (2012). Protective effects of rutin against potassium bromate induced nephrotoxicity in rats. *BMC Complementary and Alternative Medicine*, *12*, 204.

Kujawska, M., Ignatowicz, E., Ewertowska, M., Adamska, T., Markowski, J., & Jodynis-Liebert, J. (2013). Attenuation of $KBrO_3$-Induced Renal and Hepatic Toxicity By Cloudy Apple Juice In Rat. *Phytotherapy Research*, *27*(8), 1214–1219.

Kurokawa, Y., Takayama, S., Konishi, Y., Hiasa, Y., Asahina, S., Takahashi, M., Maekawa, A., & Hayashi, Y. (1986). Long-term in vivo carcinogenicity tests of potassium bromate, sodium hypochlorite, and sodium chlorite conducted in Japan. *Environmental Health Perspectives*, *69*, 221–235.

Lev, E., & Amar, Z. (2000). Ethnopharmacological survey of traditional drugs sold in Israel at the end of the 20th century. *Journal of Ethnopharmacology*, *72*(1), 191–205.

Majdalawieh, A. F., Fayyad, M. W., & Nasrallah, G. K. (2017). Anti-cancer properties and mechanisms of action of thymoquinone, the major active ingredient of Nigella sativa. *Critical Reviews in Food Science and Nutrition*, *57*(18), 3911–3928.

Mansour, M. A., Nagi, M. N., El-Khatib, A. S., & Al-Bekairi, A. M. (2002). Effects of thymoquinone on antioxidant enzyme activities, lipid peroxidation and DT-diaphorase in different tissues of mice: A possible mechanism of action. *Cell Biochemistry and Function*, *20*(2), 143–151.

Nakbi, A., Tayeb, W., Dabbou, S., Issaoui, M., Grissa, A. K., Attia, N., & Hammami, M. (2010). Dietary olive oil effect on antioxidant status and fatty acid profile in the erythrocyte of 2,4-D- exposed rats. *Lipids in Health and Disease*, *9*, 89.

Oloyede, O. B., & Sunmonu, T. O. (2009). Potassium bromate content of selected bread samples in Ilorin, Central Nigeria and its effect on some enzymes of rat liver and kidney. *Food and Chemical Toxicology*, *47*(8), 2067–2070.

Parsons, J. L., & Chipman, J. K. (2000). The role of glutathione in DNA damage by potassium bromate in vitro. *Mutagenesis*, *15*(4), 311–316.

Paul, A. H. (1966). Chemical food poisoning by potassium bromate. Report of an outbreak. *The New Zealand Medical Journal*, *65*(401), 33–36.

Rosenfeld, C. S., Denslow, N. D., Orlando, E. F., Gutierrez-Villagomez, J. M., & Trudeau, V. L. (2017).

Neuroendocrine Disruption of Organizational and Activational Hormone Programming in Poikilothermic Vertebrates. *Journal of Toxicology and Environmental Health. Part B, Critical Reviews*, *20*(5), 276–304.

Sabiu, S., Wudil, A., & Sunmonu, T. (2014). Combined Administration of Telfairia occidentalis and Vernonia amygdalina Leaf Powders Ameliorates Garlic-induced Hepatotoxicity in Wistar Rats. *Pharmacologia*, *5*, 191–198.

Sai, K., Hayashi, M., Takagi, A., Hasegawa, R., Sofuni, T., & Kurokawa, Y. (1992). Effects of antioxidants on induction of micronuclei in rat peripheral blood reticulocytes by potassium bromate. *Mutation Research*, *269*(1), 113–118.

Vadlamani, K. R., & Seib, P. A. (1999). Effect of Zinc and Aluminum Ions in Breadmaking. *Cereal Chemistry*, *76*(3), 355–360.

Watanabe, T., Abe, T., Satoh, M., Oda, Y., Takada, T., & Yanagihara, T. (1992). Two children with bromate intoxication due to ingestion of the second preparation for permanent hair waving. *Acta Paediatrica Japonica: Overseas Edition*, *34*(6), 601–605.

Yoon, K., Kwack, S. J., Kim, H. S., & Lee, B.-M. (2014). Estrogenic endocrine-disrupting chemicals: Molecular mechanisms of actions on putative human diseases. *Journal of Toxicology and Environmental Health. Part B, Critical Reviews*, *17*(3), 127–174.

Zawatski, W., & Lee, M. M. (2013). Male pubertal development: Are endocrine-disrupting compounds shifting the norms? *The Journal of Endocrinology*, *218*(2), R1-12.

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