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Research Article

Therapeutic efficacy of tomato (*Lycopersicum esculentum*) extract against sodium arsenite ($NaAsO_2$) induced oxidative stress and alternations in tissue glycogen content

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Abstract:

Arsenic exposure increases the risk of diabetes and pancreatic cancer because it damages the pancreas by induction of oxidative stress via beta cell dysfunction and triggering cellular death pathway. The present study has been undertaken to evaluate the protective potential of tomato extract against sodium arsenite induced oxidative stress and elevation in glycogen level in albino rats.

In this study rats were divided into four groups and five rats were kept in each. Group I rats were kept as control. Group II rats were administered a single oral dose of sodium arsenite ($NaAsO_2$) only. Group III kept as positive control and given tomato extract (TE) only. Group IV kept as therapeutic group treated with sodium arsenite and tomato extract ($NaAsO_2$ + TE). The results showed that after sodium arsenite exposure tissue content of glycogen was increased due to oxidative stress. After tomato extract (TE) supplementation, oxidative stress was decreased that was estimated by low the level of malondialdehyde (MDA) in thyroid tissue. The tissue content of glycogen was also decreased significantly.

Keywords: Sodium arsenite (NaAsO2), oxidative stress, pancreas, glycogen content and tomato extract

Introduction

Arsenic poisoning is a global health issue affecting millions of people worldwide. Its exposure has been linked with many neurological, cardiovascular and non-communicable diseases such as diabetes mellitus [1,2] Arsenic is emitted into the atmosphere by volcanic eruptions, weathering of the arsenic rich minerals, ores and

from the industrial processes [15]. It has been confirmed that arsenic is a human carcinogen because it can induce multi-organ cancer [3].

Arsenic compounds can be classified into three major forms: Inorganic, organic and arsine gas. In the environment inorganic compounds combined with oxygen, chlorine and sulfur. It usually exits either as trivalent (As^{+3}) or pentavalent (As^{+5} arsenate) forms. Trivalent species are more toxic than pentavalent because it can easily reacts with the sulfhydryl group of proteins, disrupts their function due to its higher chemical reactivity [4]. Organic arsenic compounds are formed when arsenic combines with carbon and hydrogen. Whereas most of the organic arsenic compounds found in the environment get methylated by the process of biomethylation. Arsenic gas is formed by the reaction of hydrogen with arsenic and produce garlic like odor. It is used commercially in the semiconductor industries [5].

Arsenic toxicity produces free radicals in organisms by disturbing many cellular pathways and suppresses the cellular antioxidant defense system. The free radicals have unpaired electron that are highly reactive which further starts the process of lipid peroxidation [9]. Arsenic is a protoplastic toxicant because it primarily affects the sulphydryl group of cells and disrupts the integrity of cellular enzymes and their respiration [6]. Arsenic metabolism follows two major pathways: Classical reduction and oxidative methylation with the help of methytransferase enzyme. The end products of both pathways are same which are: Monomethylated and dimethylated arsinic acid [7].

Type 2 diabetes (T_2D) is recognized as a serious public health concern. Arsenic toxicity results into pancreatic dysfunction by interfering with insulin secretion from the beta cells of pancreas. The oxidative stress caused by arsenic leads to cell damage and results into apoptosis i.e. programmed cell death [14].

Phytotherapy is the science based medical practice of using plant-derived medications, extracts and active chemicals constituents to cure diseases. Tomatoes (*Solanum Lycoperscium*) are an excellent source of phytochemicals because they have abundance of natural ingredients e.g. lycopene, potassium, folate, vitamin C, beta-carotene, flavonoids, phenolic compounds, lutein, kaempferol, minerals, calcium and magnesium. Due to the presence of citric acid and malic acid tomato juice is acidic in nature and have pH is from 3.8 to 4.7 [11].

Lycopene present in tomatoes is a non-provitamin A carotenoid that is responsible for red to pink color seen in them. It is a potent antioxidant molecule because it scavenges the reactive oxygen species (ROS) and lowers the oxidative stress [12]. Lycopene and other antioxidants present in tomatoes reduce oxidative stress and have anti-cancer, anti-inflammatory and anti-diabetic potential.

MATERIALS AND METHODS

Animals: Albino rats weighing 100-150 grams were procured from Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar. They were kept and acclimatized to the laboratory conditions for 15 days under optimal condition of light and temperature. They had ad libitium access to tap water and the standard rat feed in form of pellets purchased from M/S Aashirwad industries, Ltd., Chandigarh. The animals were handled with humane care in accordance to the guidelines given by Institutional Animal Ethical Committee.

Sources of chemicals: Sodium arsenite ($NaAsO_2$) was bought from Himedia laboratories pvt. ltd. Mumbai. It was dissolved in double glass distilled water and administered orally.

Preparation of extracts: Tomato extract (TE) were made by the method of Salawu *et al.* 2009[34].

Experimental Design: Albino rats were divided into four groups and five rats were kept in each group.

Group I (Control): Rats were kept as control.

Group II (As): Rats were administered a single oral dose of 10 mg/kg bw of sodium arsenite and left for 30 days.

Group III (TE): Rats were given an oral dose of 50 mg/kg body weight of tomato extract for 30 days.

Group IV (As+TE): Rats were treated with sodium arsenite (10 mg/kg bw of sodium arsenite) + tomato extract (50 mg/kg bw of tomato).

Autopsies were done on 30 days post treatment.

Biochemical Studies:

Thyroid gland homogenates were prepared with the help of tissue homogenizer in 3 ml of phosphate buffer and used for estimation of lipid peroxidation (MDA) and glycogen concentration by the methods of thiobarbituric acid assay (TBARS) and Montgomery (1957) respectively.

Statistical analysis:

The data was analysed by using student's t-test and one way ANOVA test. The data was statistically analyzed and presented in the figure as mean ± SEM.

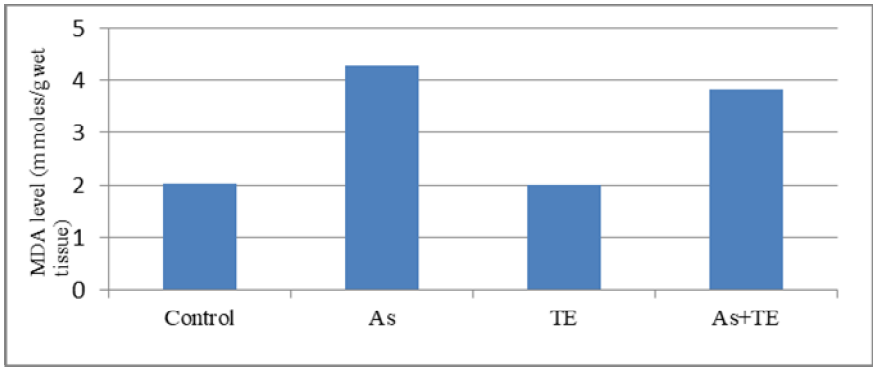

Fig (1.) MDA level of thyroid tissue in control, arsenic, tomato extract and arsenic+tomato extract treated groups.

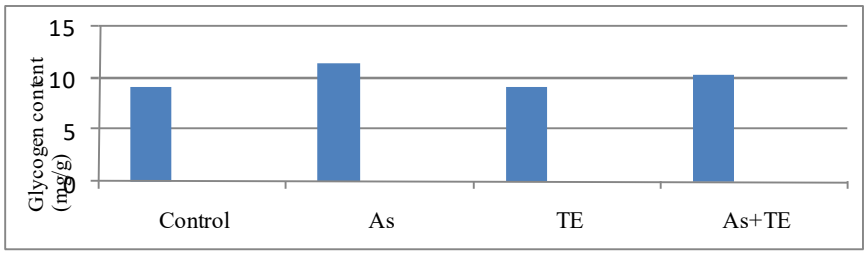

Fig (2.) Total glycogen content of thyroid tissue in control, arsenic, tomato extract and arsenic+tomato extract treated groups.

Results and discussion:

Arsenic in drinking water is serious health concern because regular exposure to high amount of arsenic causes pigmentation, ulceration, hyperkeratosis, skin cancer and damage internal organs i.e. liver, kidney, pancreas, thyroid, lungs, and heart [13]. It is an omnipresent metalloid and enters into environment naturally through

weathering and erosion of rocks as well as by volcanic eruption. Human induced environmental pollution through various activities such as mining, burning of vegetation, smelting and industrial processes as well as through use of pesticides and insecticides [15]. Both acute and chronic exposure of arsenic is highly lethal. Acute arsenic toxicity causes nausea, vomiting and diarrhea whereas its chronic exposure causes 'arsenicosis' which results into skin lesions and multiple organ cancer [16].

Plants are called as 'Phytochemical hub' because they contained powerful antioxidants which can combats with oxidative stress caused by toxic metals [17]. Tomatoes and its products are also called 'functional food' because they are rich in dietary supplements that play role in prevention of cardiovascular diseases, cancer, boost the immune system and also improves health of skin [18].

Bianchi *et al*. [19] reported that processed tomato products are best for consumption than the raw tomatoes. Cooking in the presence of slight oil increases the bioavailability of antioxidants present in it. The active component of tomato i.e. lycopene became more powerful after cooking because heat change its configuration from trans to cis-isomers. The aim of present research work was to find out the curative potential of tomato extract against the oxidative stress and alternation in thyroid tissue glycogen content in albino rats.

Thyroid gland is located at front of neck just below the adam's apple (larynx). The gland is major gland of endocrine system which secretes three hormones: triiodothyronine (T3), thyroxine (T4) and calcitonin [20]. Brown *et al*. [21] expained that thyroid hormones T3 & T4 are essential for the normal functioning of body because they play key role in regulating body temperature, control blood pressure, balance the metabolism, maintains blood sugar level and the reaction of the body to other hormones. Thyroid hormone influences the development of pancreatic cells, functioning of islet cells and also affected the secretion of insulin from beta cells of pancreas [10].

In present study sodium arsenite (NaAsO2) administration caused 'hypothyroidism' in rats that was evidenced biochemically by significant decrease in serum level of T3 and T4 hormones. The tissue level of malondialdehyde (MDA) was significantly increased which indicated that thyroid tissue undergoes oxidative damage due to formation the reactive oxygen species (ROS). Tissue glycogen content was also high in sodium arsenite exposed rats because arsenic exposure caused pancreatic injury. Arsenic toxicity distorted the pancreatic cells hence beta cell of pancreas unable to secrete appropriate amount of insulin.

Navas- Acein *et al*.[8] reported that thyroid gland play essential role in maintenance of the functional integrity of pancreatic cells. Arsenic directly effects on whole-body glucose homeostasis, insulin-stimulation glucose uptake (ISGU), glucose-stimulated insulin secretion (GSIS) and damage pancreatic cells [22,23]. Kirkley *et al*. [24] also noticed that arsenic toxicity impaired glucose tolerance in mice.

The results of present study are in accordance to the study of Paul *et al*. [25] who reported diabetogenic effects of high level of arsenic in the mouse model. They suggested that arsenic toxicity alters the insulin-stimulated glucose uptake (ISGU) by skeleton muscles and adipose tissues that are the key processes which are responsible for the normalization of glucose level. Ahangarpour *et al*. [26] also reported that arsenic creates oxidative stress because it increases mitochondrial level of ROS, MDA, declined the concentration of GSH and insulin secretion from beta – cells of pancreas. Glucose-stimulated insulin secretion pathway (GSIS) is major pathway which controls level of glucose in living system. Reactive oxygen species (ROS) produced due to toxic attacks on pancreatic cells and leads

to pancreatic injury. Thus, arsenic provokes a cellular adaptive oxidative stress and disturbs the function of the beta- cell of pancreas [27].

Lei *et al*. [28] also examined that arsenic contribute to the development of type-2 diabetes mellitus (T_2DM) or insulin resistance by impairing insulin-stimulated glucose uptake in muscle and adipose tissue. High dose of arsenic not only alters the body weight but also caused pancreatic injury in mice, effects insulin secretion, elevates the blood glucose level and hastening the progression of diabetes mellitus.

Diabetes mellitus (DM) is an enormous public health issue worldwide. Acute or chronic exposure to arsenic increases the risk of developing type-2 diabetes [29]. From decades plants based remedies are used to treat and prevent various diseases. Tomatoes and their products are diabetic friendly diet because they have low carbohydrates content and low glycemic index [30]. Banihani, [31] also reported anti-hyperglycemic effects of tomatoes because they prevents oxidative damage and enhance the activities of antioxidant enzymes and decreases the formation of reactive oxygen species (i.e. H_2O_2).

The results of present study are in accordance with the previous study who reported that daily intake of tomato juice reduces the blood glucose level in overweight women. Lycopene present in tomato extract has ability to resist free radicals and reduces oxidative damage in living system [32]. Tarigan *et al*. [33] also examined anti-hyperglycemic effects of tomato juice in humans. They find out that natural antioxidant present in tomato juice, boost up the immune system, reduce the formation of reactive oxygen species and deplete blood glucose levels without consuming any pharmacological therapy.

The results of present study are in agreement with previous study, which reported that tomato extract acts as anti-atherogenic and controls hyperglycemic condition in rats. Khalil *et al*. [34] also reported that after supplementation of tomato extract to diabetic rats it improves their immune system by increment the level of endogenous antioxidants i.e. glutathione (GSH) and superoxide dismutase (SOD) and reduced blood glucose level.

Conclusion

The present study was undertaken to evaluate curative potential of tomato extract (TE) against sodium arsenite induced oxidative stress and alternation in tissue glycogen content in albino rats. Arsenic toxicity depletes crucial internal antioxidants, allows reactive oxygen species (ROS) to run rampant and alters glucose metabolism. The results showed that natural antioxidants present in tomato extract (TE) reduced the oxidative stress and showed therapeutic role against arsenic induced hyperglycemia.

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Conflict of Interest: The authors declare that there are no conflicts of interest

Ethical statement

All experimental procedures were approved by the Institutional Ethics Committee (IEC) of Punjabi University, Patiala. All procedures performed in studies involving animal subjects were in strict accordance with the ethical standards of the institution and the relevant national/international guidelines for the care and use of laboratory animals.

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Declaration of Non-Use of AI: The authors confirm that no artificial intelligence tools were used in this study.

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