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Research Article

Protective Effect of Taurine and Curcumin on Lung Toxicity of Bisphenol A in Rats

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Abstract

Bisphenol A (BPA) is an endocrine disruptor chemical that is frequently used in industry. Taurine is a low molecular weight organic compound in living organisms. Curcumin is a yellow colored bioactive compound of turmeric with antioxidant properties. In this study, the protective effects of taurine and curcumin on the histopathological changes, antioxidant enzyme activities [superoxide dismutase (SOD), catalase (CAT), glutathione-S-transferase (GST), glutathione peroxidase (GPx)] and malondialdehyde (MDA) levels that BPA may cause in the lung tissue of rats were investigated. Rats were divided into 7 groups. 1st group: control group, 2nd group: oil group, 3rd group: taurine (100 mg/kg day) treated group, 4th group: curcumin (100 mg/kg day) treated group, 5th group: BPA (130 mg/kg day) treated group group, 6th group: BPA plus taurine treated group, 7th group: BPA plus curcumin treated group. After the application by gavage for 4 weeks, a statistically significant increase was observed in the MDA levels in the lung tissues of the rats when the BPA treated group was compared with the control group, while a statistically significant decrease was observed in the antioxidant enzyme activities (SOD, CAT, GST, GPx). When the groups treated with BPA plus taurine, BPA plus curcumin were compared with the group treated with BPA, a decrease was observed in the MDA levels in the lung tissues of the rats, while a statistically significant increase was observed in SOD, CAT, GST and GPx enzyme activities. In histopathological examinations, it was determined that while BPA caused cell infiltration, hemorrhage, atrophy and emphysema in the lung tissue of rats, taurine and curcumin reduced these pathological changes.

Keywords: Lung, Antioxidants, Bisphenol A, Histopathology, Oxidative stress

1. INTRODUCTION

Some substances that threaten public and environmental health are known as endocrine disruptors. These substances act on the endocrine system, control the release of hormones and cause negative effects on living things [1].

Many chemicals are classified as endocrine disruptors by acting on the endocrine system. Among these, plastics and plasticizers are the endocrine disruptors that living things are most exposed to. The very long half-life of these substances in nature causes accumulations and environmental pollution, and accordingly, they negatively affect the ecosystem and threaten the life of living things [2].

Bisphenol A (4,4'-dihydroxy-2,2-diphenylpropane, BPA) is a crystalline and white colored substance [3]. BPA is an endocrine disruptor and is frequently used in industry. It is found in various daily use products such as water pipes, electronic equipment, paper and toys [4,5]. BPA causes leaching of polycarbonate plastics, especially after exposure to heat. It has been stated that BPA leaking from plastics binds to the estrogen receptor [6]. However, there are studies that show that BPA may have negative effects on the central nervous system and immune system [7,8]. It is stated that BPA, an endocrine disruptor, disrupts the function of sex hormones, hormones secreted from the pancreas and thyroid gland, and has hepatotoxic and negative effects on the immune system [9–11].

Since BPA is also used in food contact materials such as packaging, bottle and can coatings, it may cause consumers to be exposed to BPA from their food and beverage [12–14].

Taurine is an amino acid that contains thiol and is found in many tissues such as brain, lung, liver, kidney and spleen [15]. Meat and seafood are rich in taurine [16]. Taurine is a protective and supportive antioxidant that protects cell integrity and increases body resistance [15]. Taurine has an important property that suppresses cell proliferation and directs tumor cells to apoptosis [17].

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Curcumin (diferuloylmethane) is a phenolic compound derived from turmeric (*Curcuma longa*). It is widely used as a dyestuff, spice and herbal medicine in foods [18]. Curcumin has many pharmacological properties besides its anti-inflammatory and antioxidant effects [19–21].

The aim of this study is to investigate the protective effect of taurine and curcumin, which have antioxidant properties, on the effect of BPA, which is widely used, on the lung tissue of rats. For this purpose, the histopathological effect of BPA in the lung tissue of rats, antioxidant enzyme activities [superoxide dismutase (SOD), catalase (CAT), glutathione-s-transferase (GST) and glutathione peroxidase (GPx)] and malondialdehyde levels possible changes and the protective effects of taurine and curcumin on these changes were investigated.

2. MATERIAL AND METHODS

2.1 Animals and Treatment

The animal experiments in this study were approved by Gazi University Animal Experiments Local Ethics Committee (G.U.ET-14.075). 42 male Wistar rats (250-300 g) were used in the experiments. Rats were fed standard laboratory diet and water.

In this study, 7 groups were formed, with 6 rats in each group.

1. Control group: Rats were given 1 ml/kg of distilled water.
2. Oil group: Rats were given 1 ml/kg of olive oil.
3. Curcumin treated group: 100 mg/kg curcumin was given to rats.
4. Taurine treated group: Rats were given 100 mg/kg taurine.
5. BPA treated group: 130 mg/kg BPA was given to rats.
6. BPA plus curcumin treated group: 100 mg/kg of curcumin and 1 hour later 130 mg/kg of BPA was given rats.
7. BPA plus taurine treated group: 100 mg/kg of taurine and 1 hour later 130 mg/kg of BPA was given rats.

Curcumin and BPA were dissolved in olive oil. Taurine was dissolved in distilled water. The substances given to the rats were given daily by gavage and after 4 weeks of treated, the rats were dissected and their lung tissues were taken.

2.2 Preparation of Tissues for Biochemical Studies

Lung tissues were prepared by centrifugation after homogenization for the determination of SOD, CAT, GPx and GST enzyme activities and the MDA levels. MDA levels and antioxidant enzyme activities were determined by measuring in spectrophotometer. Protein concentration Lowry et al. [22] was determined according to the method described.

For the measurement of MDA, Ohkawa et al. [23] was measured in a spectrophotometer at 532 nm, and the results were calculated as nmol/mg protein.

For the determination of SOD enzyme activity in lung tissues, the method of Marklund and Marklund [24] was used and the results are given as U/mg protein. For the determination of CAT enzyme activity, the method determined by Aebi [25] was used and the results are given as mmol/mg protein. The method of Paglia and Valentine [26] was used for GPx activity and was given as nmol/mg protein. For the determination of GST enzyme activity, measurement was made at 340 nm and given as nmol/mg protein.

2.3 Preparation of Tissues for Light Microscopy

Tissues for light microscopy studies were fixed in Bouin's fixative. Sections of 5-7 µ thickness were taken from the lung tissues, stained with hematoxylin-eosin and examined under a microscope and photographed.

2.4 Statistical Analysis

One-way analysis of variance and Tukey test were used in Windows SPSS 23 computer program. $P<0.05$ was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Evaluation of Malondialdehyde Levels

While no statistically significant difference was observed between the control, oil, taurine and curcumin groups in terms of MDA levels, a statistically significant increase was observed in the BPA-treated group compared to the control group. While a significant increase was observed in the BPA plus taurine and BPA plus curcumin treated groups compared to the control group, a statistically significant decrease was observed in the MDA level when compared to the BPA-treated rats (Figure 1).

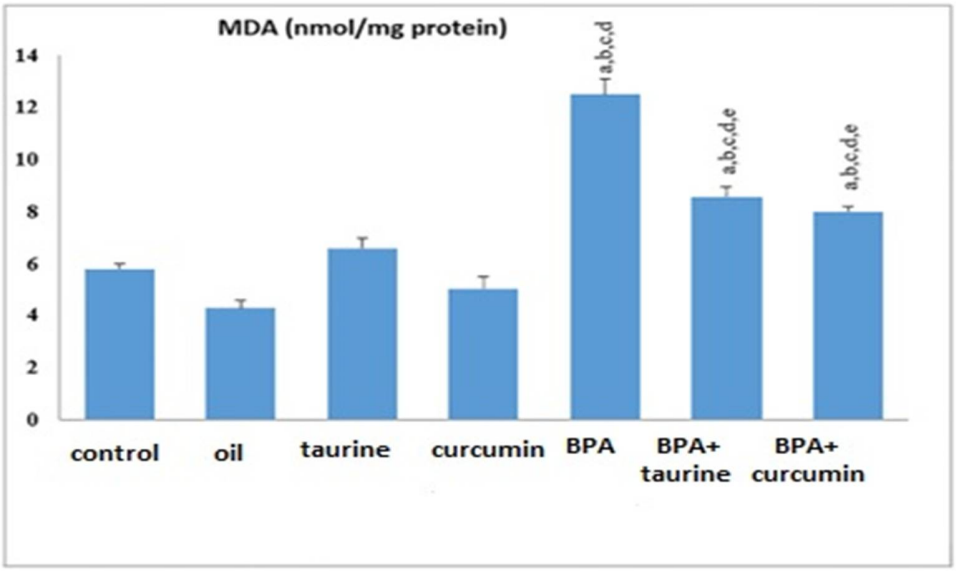

Figure 1. Comparison of [a]control group, [b]Oil treated group, [c]Taurine treated group, [d]Curcumin treated group, [e]BPA treated group and other treated groups. Mean±Standard Deviation ($P<0.05$)

3.2 Evaluation of Antioxidant Enzyme Activities

No statistically significant difference was observed between control, fat, taurine and curcumin groups in terms of SOD, CAT, GPx and GST enzyme activities in lung tissues. A statistically significant decrease was observed in the BPA treated groups compared to the control group. A statistically significant decrease was observed when the control group and BPA plus taurine and BPA plus curcumin groups were compared, while a statistically significant increase was detected when the BPA plus taurine and BPA plus curcumin groups were compared with the BPA-treated group (Table 1).

Table 1. Antioxidant enzyme activities in lung tissues of rats after BPA, taurine and curcumin administration

Groups	SOD	CAT	GPx	GST
Control	128±18	75,1±6,7	45,8±3,5	43,7±3,8
Oil	138±15	69,7±6,3	42,8±2,8	42,5±2,8
Taurine	141±22	74,1±5,8	50,8±3,5	45,7±3,3

Curcumin	131±14	70,8±6,4	49,8±4,1	44,5±4,6
BPA	74±12 [a,b,c,d]	50,5±6,6 [a,b,c,d]	36,7±3,8 [a,b,c,d]	32,0±4,8 [a,b,c,d]
BPA+Taurine	105±15 [a,b,c,d,e]	55,5±7,8 [a,b,c,d,e]	44,5±3,2 [a,b,c,d,e]	38,9±3,5 [a,b,c,d,e]
BPA+Curcumin	109±16 [a,b,c,d,e]	60,2±7,2 [a,b,c,d,e]	42,5±3,7 [a,b,c,d,e]	40,4±2,9 [a,b,c,d,e]

Comparison of [a]control group, [b]Oil treated group, [c]Taurine treated group, [d]Curcumin treated group, [e]BPA treated group and other treated groups. Mean±Standard Deviation (p<0.05)

3.3 Histopathological Evaluation

When the histological preparations of the lungs taken from the control group, fat group, taurine and curcumin-treated rats are examined under the light microscope, it is seen that the alveoli and bronchioles are in normal structure (Figure 2a). No pathological findings were found in the histological examinations of these groups. Mononuclear cell infiltration, reduction in alveolar sacs and consequent emphysema and thickening of the interalveolar septum were observed in the lungs of rats treated with BPA for 4 weeks (Figure 2b). Pathological changes were also observed in the lung tissues of the groups treated with BPA plus taurine and BPA plus curcumin. However, these changes were observed to be less in BPA-treated group compared to lung tissue.

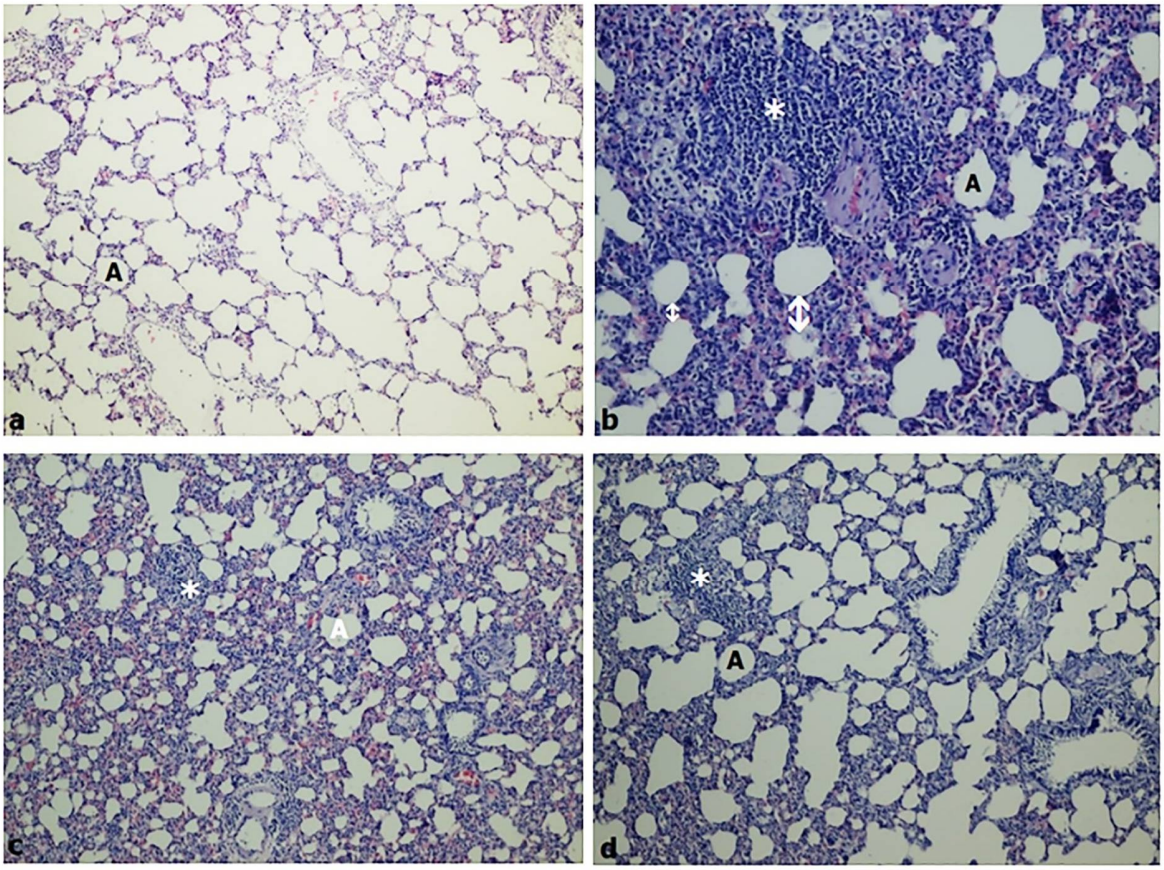

Figure 2. Histology of lung tissues of a. Control group, b. BPA group, c. BPA+Taurine group, d. BPA+Curcumin group rats, A: Alveolar sac, ∗; Cell infiltration, ↕: Interalveolar septum H&E, X100

Endocrine disruptors affect health negatively because they cause hormonal changes in humans and animals. BPA is a compound that disrupts the function and structure of the hormonal system [4]. BPA is used as a monomer in the production of plastics. When BPA is used in packaging such as tin cans, plastic water bottles, they leak into the environment they are in depending on time and temperature [27].

It has been stated that BPA increases the risk of developing cancer [28]. BPA affects heart [29], liver [30], kidney [31] tissues, male and female reproductive systems [32] and pancreatic functions [33] is stated to cause damage. It has been observed that BPA inhibits spermatogenic cell proliferation and increases the number of apoptotic cells in experimental animals [34]. When BPA was administered subacutely to rats, it was observed that it caused pathology in the sarcoplasmic reticulum and mitochondria of myocardial cells of the rats in the study with electron microscopy. In this study, BPA caused pathological changes in the lung tissue of rats. BPA caused cell infiltration in the lungs in light microscopy examinations. This result can be accepted as an indication that BPA causes inflammation in the lungs. In addition, shrinkage and reduction in alveolar sacs were observed in this study.

Many chemical substances cause the formation of free radicals in cells. The system that renders free radicals harmless or eliminates them in the cell is called the antioxidant enzyme system [35]. Reactive oxygen species formed in cells as a result of toxic substances act on fatty acids in membrane structures, causing a hydrogen atom to be detached from the methylene group and initiation of lipid peroxidation. One of the indicators of lipid peroxidation is the change in MDA level. Because MDA is the end product of lipid peroxidation [36]. In this study, BPA caused an increase in the amount of MDA by causing lipid peroxidation in the lung tissue. Taurine and curcumin caused a decrease in the increase in the amount of MDA caused by BPA in the lung tissue.

Enzymes such as SOD, CAT, GPx and GST, which are in charge of the antioxidant enzyme system in the cell, operate to render the reactive oxygen species/free radicals formed in the cell harmless [37]. Substances with cytotoxic properties, especially chemical substances, can suppress the antioxidant enzyme system and cause oxidative stress [15]. As a result, reactive oxygen species, which are formed as a result of various activities in the cell, bind to various molecules in the cell, causing disruption of their functions and ultimately deterioration of cell hemostasis [38]. When BPA was administered orally to rats subacutely, it was observed that it suppressed antioxidant enzyme activities in liver, kidney, heart and testis tissues. Taurine and curcumin reduced the effect of BPA [30–33]. In this study, BPA suppressed the antioxidant enzyme system in the lung tissue, and taurine and curcumin partially prevented this negative effect caused by BPA [39].

4. CONCLUSION

As a result, subacute oral BPA administration caused histopathological changes, lipid peroxidation and suppression of the antioxidant enzyme system in the lungs of rats, and taurine and curcumin reduced the negative effects of BPA. Therefore, when using plastic material products, consumers should pay attention to the plastic numbers, and they should prefer products with reliable plastic numbers in the use of other materials, especially foodstuffs.

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AUTHOR'S CONTRIBUTIONS

The authors contributed equally.

CONFLICTS OF INTEREST

There is no conflict of interest.

RESEARCH AND PUBLICATION ETHICS

The author declares that this study complies with Research and Publication Ethics.

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