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Taurine Ameliorates Toxicity Induced by Acrylamide in Wistar Albino

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Abstract

Background: Acrylamide was well known to induce oxidative stress with an impact on reproductive functions on both male and female. Taurine is a potent antioxidant. This study was conducted as a trail to abrogates acrylamide induced reproductive toxicity in female rats by administration taurine. Animals were divided into 4 groups (N= 10); Control group kept on balanced diet and saline (9%), Acrylamide (AA) group received acrylamide in drinking water (20 mg/kg b.w.) for 21days and acrylamide + taurine (AA+TA) treated with taurine (50 mg/kg b.w.) after acrylamide intoxication for 21 days and taurine (TA) group received taurine (50 mg/kg b.w.). Hormonal, antioxidants and tumor markers (CA125 and CEA) were assayed and correlated with histological changes in ovarian tissue.

Results: Administration of acrylamide produced significant increase in serum levels of estradiol, LH, testosterone and in tumor markers CA125 and CEA. Whereas those of progesterone, FSH and total antioxidant capacity (TAC) were significantly reduced. Histological study showed that AA result in apparent regression of ovarian follicles and corpus luteum degeneration and cyst formation. Treatment with taurine restored altered ovarian histology and serological indices concomitantly towards normal levels.

In conclusion: Results revealed that taurine is able to significantly alleviate the reproductive toxicity induced by AA in female rats via modulating oxidative stress and could be utilized as a potent diatry supplementation.

Keywords: Reproductive female toxicity, Acrylamide, Taurine, Antioxidants. ovarian functions, Histology

1. Introduction

Contaminants are a broad topic in food safety and quality that can be found throughout the food chain, from raw materials to final products. Acrylamide, α, β-unsaturated (conjugated) reactive molecule, has been recognized as a contaminant in a variety of foods [1]. Acrylamide is a molecule that occurs in plant-based foods, such as potatoes and cereal grains, as a result of a natural chemical interaction between sugars and asparagine, an amino acid. It is created when high carbohydrate foods are processed at high temperatures (>120 ^{o}C), such as cooking, frying, toasting, roasting, or baking [2,3]. High doses of acrylamide were found to cause cancer in laboratory animals in investigations. Because of its potential to harm human health, the FDA monitors levels of this contaminant in certain foods. AA derived from food processing has been shown to have neurotoxic [4,5], genotoxic, carcinogenic developmental,[6] and reproductive toxic effects in vivo and in vitro [7,8]. As a result, the dangers of AA to human health mustn't be overlooked. Increasing evidence suggested that AA exposure caused oxidative stress in cells and tissues where the cellular toxin was found. Furthermore, the most important pathogenic mechanism is the oxidative biotransformation of AA by cytochrome P450 2E1 (CYP2E1), which produces the glycidamide metabolite, which is more reactive toward proteins, including hemoglobin and DNA, than AA itself [9]. Naturally occurring antioxidants, such as taurine, have

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recently received increased attention for protection against AA-induced toxicity [10], **such as taurine.**

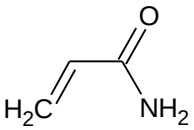

Figure 1: Chemical structure of acrylamide

Taurine (TA) is a sulfur-containing amino acid that performs a variety of important biological roles, including neuromodulation, cell membrane stabiliz-ation, and antioxidant and scavenging [11-16]. It's found in a lot of tissues and cells. Taurine is found in larger amounts in secretory organs such as the hypo-thalamus, adenohypophysis, and neurohypo-physis [17] ; taurine is also one of the main amino acid secreted by the female reproductive tract (female reproductive tract includes uterus and tubal). The ovaries contain taurine transporter RNA [18]. The CSAD route allows ovarian epithelial cells to synthesize taurine, which they then release into the infusion tube's contents [19]. After in vitro fertilization, taurine has been suggested to improve embryonic growth [20].

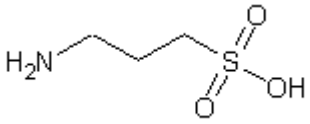

Figure 2: Chemical structure of taurine

The female reproductive system is primarily regulated by five hormones which include estrogen, progesterone, follicle-stimulating hormone and luteinizing hormone. These hormones play a role in one or more stages of development and function of the female reproductive system. Environmental xenobiotics and chemical substances have been demonstrated to impact the concentrations and functions of female reproductive hormones in several investigations [21,22].

The present work was designed to assess the protective effect of taurine as antioxidant against acrylamide induced hormonal disorders in adult female albino rats and the possibility of carcinogenic effect of acrylamide on ovary.

2.Material and Methods

2.1.*Chemicals*

Acrylamide, ≥ 98.0 % (GC), CAS: 79-06-1, MW: 71.08 g / mol, mp: 81-87 ºC and P Code: 101601204 were obtained from SIGMA-ALDRICH Chemical Co. Taurine, ≥ 99.0 %, CAS: 107-35-7, MW: 125.15 g / mol, mp: 300 ºC and P Code: 101601204 were obtained from SIGMA-ALDRICH chemical Co.

2.2. Animals

The experiment was upon forty healthy female albinos rats, (120-150 gm). Animals were provided by animal house in Sohag University, faculty of Science. Rats were kept in the experimental room two weeks before starting the experiment for acclimateization. They were kept in metal cages under hygienic conditions, Animals were fed on a commercial pellet diet and kept under normal light/dark cycle. This study was carried out in accordance with guidelines of Sohag University for animal use and approved by Ethics and Animal Care Committee.

2.3. Experimental design

The animals were sorted to 4 groups, The control group (N = 10) received 1 mL of saline through oral administration for 21 days. Taurine-treated control group received taurine **(TA)** at a dose of 50 mg/kg body weight (bw) through oral administration for 21 days [23]. Acrylamide intoxication induced in rats using twenty rats using freshly prepared Acrylamide (AA**)** in a single dose (20 mg/kg bw) through oral administration for 21days which is less than lethal dose. The LD_{50} of acrylamide in rats (150 mg /kg/ BW) [24].Acrylamide intoxication rats were divided into 2 groups (N=10 each): untreated rats (AA) and taurine-treated after acrylamide intoxication. Taurine (AA+TA) was used for pharmacological validation of taurine (50 mg/kg/day for 21 days) through oral administration [23]. Figure 3 showed a graphic scheme of the study design.

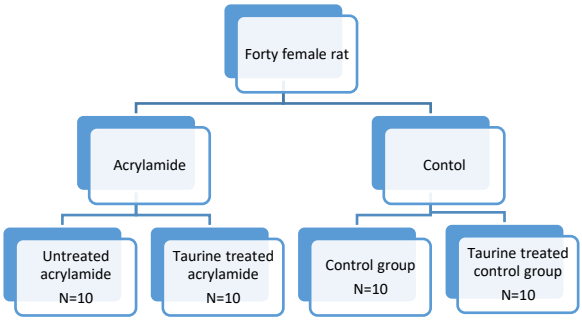

Figure 3: Graphic Scheme of the study design

2.4. Sample collection

Animals were first deeply ether anesthetized and blood samples were taken from the heart. Subsequently, serum was separated from the blood samples in plain tubes and centrifuged at 5000 *rpm* for 10 min, and the samples were stored at -20˚C till further analysis. After blood collection, rats were euthanized, abdomen was opened, and the whole ovaries were dissected. The ovaries were then washed with isotonic saline, fixed in 10% neutral formalin for further histopathological investigations.

2.5. Biochemical assay

2.5.1. Hormonal assay

ELISA procedure was used for the quantitative determination of serum female reproductive hormones (Progesterone (P4) [25] (PG362S), Estradiol (E2) [26] (ES150S-100), follicle-stimulating hormone (FSH) [27] (FS232F), luteinizing hormone (LH) [28] (LH231F), Testosterone [29] (TE187S) Kits were purchased from CALBIOTECH, an Egyptian company.

2.5.2. Ovarian tumor markers assay

Enzyme-linked immunosorbent assay (ELISA) was used for the quantitative determination of ovarian tumor markers (CA125) [30] (CA239T), and carci-noembryonic antigen (CEA) [31] (CE236T) using specialized CALBIOTECH kits obtained from Calbiotch, an Egyptian company.

2.5.3. Assay of total antioxidant capacity TAC

To measure total antioxidant capacity, the sample was mixed with a predetermined amount of exoge-nously delivered hydrogen peroxide to determine the total antioxidant in serum quantitatively using a colorimetric approach utilizing a kit obtained from Biodiagnostic, an Egyptian firm (H_2O_2). The antioxidants in the sample help to remove some of the H_2O_2 that is present. An enzymatic reaction involving the conversion of 3,5, dichloro-2-hydroxy-benzen-sulphonate into a colored product was used to quantify the remaining H_2O_2 using calorimetry**:** TAC (TA 2513) kit obtained from Biodiagnostic Company, Egypt [32].

2.6.Molecular docking

Molecular docking was performed by using Autodock vina 1.5.6..[33] The complex crystal structure of Protein Kinase B/Akt bound to its inhibitor (Ins(1,3,4,5)-Tetrakisphophate) was retrieved from protein data bank with PDB ID: 1UNQ. [34] The water molecules and ligand were removed and PDBQT file was prepared accordingly. Chimera 1.12 software was used to visualize the binding of taurine with the binding pocket of Akt1 and LigPlot$^+$ version v.2.1 was used to analyse the formed hydrogen bonds between taurine and active residues in Akt1.

2.7. Histopathological assay

Ovarian Section Preparation and Histopathological Examination:

The ovaries were collected, fixed in 10% formalin, processed, and sectioned at a thickness of 4-5 mm. Following the normal procedure, the tissue sections were mounted on glass slides, deparaffinized, and stained with Hematoxylin and Eosin stain (Thermo Fisher Scientific, USA). After that, the sections were examined and studied under a light microscope at magnifications of 100X and 400X. (Leica, Germany).

2.8. Statistical Analyses

GraphPad Prism software (San Diego, CA. USA) was used to perform statistical analyses. One way analysis of variables (ANOVA) was used in the analyses as posted by Newman-keuls test. The results are presented as mean ± SE and the level of significance between groups is denoted as *p < 0.05, **p < 0.01, ***p < 0.001.

3. Results

3.1. Biochemical results

3.1.1. Ovarian hormones

3.1.1.1 Progesterone (P4) (ng/mL) level.

There was a highly significant decrease (P < 0.001) in the level of progesterone in response to acrylamide given for 21 days (AA) group compared to the control group; **Table 1, Figure 4a.** The level of P4 in (AA + TA) group was significantly decreased compared to non-treated (AA) group. Treatment of taurine (AA+TA) group effectively attenuated the change in P4 level induced by acrylamide comparable to control values. But, treatment rats with taurine only (TA) group result in high significant increase of progesterone (P<0.001) compared to control group.

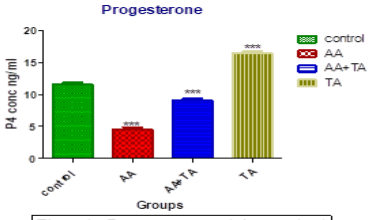

Figure 4a: Progesterone records in control and all expeimenral groups

3.1.1.2. Estradiol (E2) (ng/mL) level.

After acrylamide treatment, the levels of estradiol were found to be highly increased (P<0.001) compared to the control group, on the other hand, there is non significant change (P > 0.05) in the mean values of E2 in (TA) group as compared with control. However significant decrease in E2 level was observed in (AA+TA) group compared to (AA) group. While nonsignificant difference (P > 0.05)was found compared with control group as shown in **Table 1, Figure 4b.**

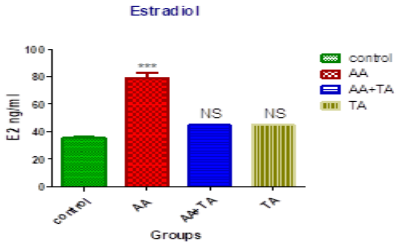

Figure 4b: Estradiol records in control and all expeimenral groups

3.1.1.3. Testosterone (T) (ng/mL) level.

The mean values of serum Testosterone (T) (ng/mL) showed highly significant increase (P<0.001) in (AA) group group as compared with G1 control group. The level of T in (AA+TA) group was significantly decreased compared to non-treated (AA) group. And there is high significant increase (P<0.001) in the mean values of serum T in (AA+TA) group compared to control group. There is nonsignificant change (P > 0.05) in the mean values of T in (TA) group , The data in **Table 1, Figure 4C**

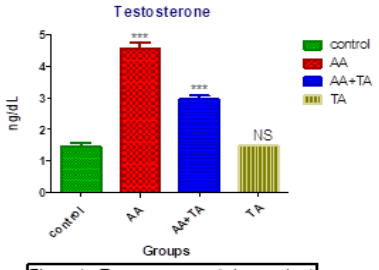

Figure 4c: Testosterone records in control and all experimental groups

3.1.2. Pituitary hormones

3.1.2.1. FSH (mIU/mL) level.

The data in **Table 1**, **Figure 4d** showed that the mean values of serum FSH (mIU/mL) was significantly decreased (P<0.05) in (AA) group as compared with control. The FSH level is non-significant change (P > 0.05) compared to (AA) group and significant decrease (P<0.05) in (AA+TA) group compared to control group. However, there is non-significant change (P > 0.05) in the mean values of FSH in (TA) group compared to control.

3.1.2.2. LH (mIU/mL) level.

The data in **Table1, Figure 4e** showed that the mean values of serum LH (mIU/mL) has highly significant increase (P<0.001) in (AA) group as compared with control. The LH level is significantly decreased (P<0.001) in G3 compared to (AA) group. Also, there is significant increase (P<0.001) in the mean values of serum LH in (AA + TA) group was observed as compared to control group. The LH level is significant increase (P<0.05) in (TA) group as compared to control group.

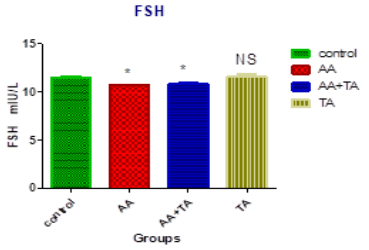

Figure 4d: FSH records in control and all experimental groups

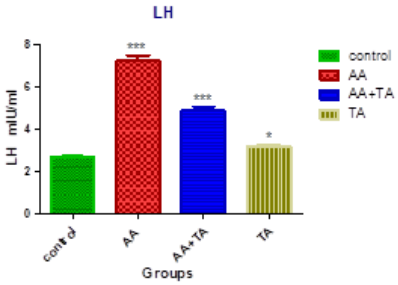

Figure 4e: LH records in control and all experimental groups

3.1.3. Total antioxidant Capacity TAC level.

TAC concentration (mmol/L) on serum of both treated and control group were shown in **Table 2, Figure 5** which revealed that the concentration showed highly significant decrease (P<0.001) in (AA) group. TAC level in (AA+TA) group showed non-significant compared to the control and high significant increase (P<0.001) compared to (AA) group, but on the other hand in (TA) group there was highly significantly increase compared to the control group.

Table 1: Effect of acrylamide (20 mg/kg b.w.) and taurine (50 mg/kg b.w.) on female reproductive hormones.

Parameter	Control	AA	AA+TA	TA
P4 (ng/mL)	11.59±0.28	4.79± 0.38 [a***]	9.05±0.30 [a***, b***]	16 ±0.27 [a***]
E2 (ng/mL)	13.61± 0.07	128±0.88 [a***]	14.78 ±0.18 [a NS, b***]	13.73± 0.15 [a NS]
T (ng/mL)	1.46±0.11	4.57±0.18 [a***]	2.95±0.12 [a ***, b***]	1.49±0.02 [a NS]
FSH (mU/mL)	11.48± 0.47	10.37±0.03 [a*]	10.86±0.096 [a *,b NS]	11.55±0.30 [a NS]
LH (mU/mL)	2.6±0.07	7.25±0.24 [a***]	4.88±0.19 [a***, b ***]	3.19±0.08 [a*]

P4: Progesterone, E2: Estradiol, T: Testosterone, LH: Luteinizing hormone, FSH: Follicle stimulating hormone. Data are expressed as mean ± SE, Significant change in comparison between groups: *p<0.05;**p<0.01; ***p<0.001, N.S Non significant (P > 0.05)

[a] Significant difference between Control & AA ; Control & AA+TA; Control & TA

[b] Significant difference between AA & AA+TA

Where rats received orally GI: control kept on balanced diet and 1 mL of saline; AA:: Acrylamide group received acrylamide in drinking water (20 mg/kg b.w.) for 21 days. AA+TA::Treated with taurine (50 mg/kg b.w.) after acrylamide intoxication for 21 days; TA; Taurine only as control.

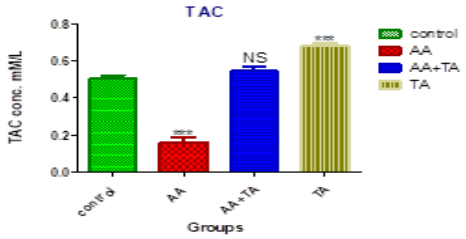

Figure 5: TAC records in control and all expeimenral groups

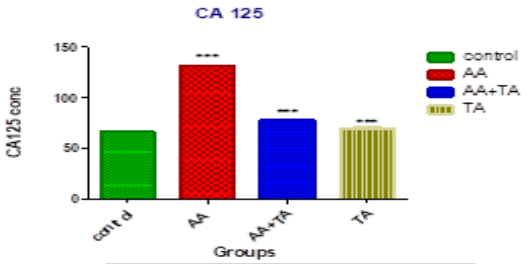

Figure 6a: CA125 records in control and all expeimenral groups

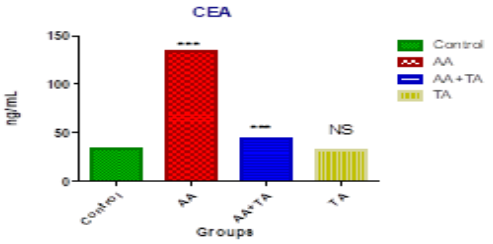

Figure 6b: CEA records in control and all expeimenral groups

3.1.3. Ovarian tumor markers

3.1.3.1. CA125 (U/L) level

The data in **Table 2, Figure 6a** showed that the mean values of serum CA125 (U/L) has highly significant increase ($P<0.001$) in AA group as compared with control. The level of CA125 in (AA+TA) group was significantly decreased compared to non-treated (AA) group. The level of CA125 in (AA+TA) group was still high comparing with control group. On the other hand, there no significant increase ($p<0.01$) in the mean values of CA125 in (TA) group as compared with control.

3.1.3.2. CEA (ng/mL) level

The data in **Table 2, Figure 6b** showed highly significant increase in CEA (ng/mL) ($P<0.001$) in the mean values following acrylamide administration (AA) group. The level of CEA in (AA+TA) group was significantly decreased compared to non-treated (AA) group. The level of CEA in (AA+TA) group still high comparing with control group. On the other hand, there was non-significant differences ($P<0.01$) in the mean values of CEA in (TA) group was observed as compared with control group.

3.4.Molecular docking

Molecular docking analysis was used to evaluate the potential inhibition effect of taurine on AKT1 protein that is responsible for cell proliferation in ovarian cancer [35]. Taurine shows a hydrophobic interaction with the side chain of the amino acids in the active site of AKT1 like G16 and Q17 (Figure 7a). It exhibited a well-fitted structure in the active site of AKT1 protein (Figure 7b). Also, 2d plot was used to analysis the hydrogen bonds pattern of taurine interaction with AKT1 and showed that taurine forms five hydrogen bonds with the side chain of the following amino acids R15, G16, Q17, Q85 and T87 (Figure 7c) and the calculated energy of docking was -3.59±0.19 (kcal/mol). These findings highlight the potential inhibitory role of taurine on the activation of the AKT1siganlling pathway in ovarian cancer progression

Table 2: Effect of acrylamide (20 mg/kg b.w) and taurine (50 mg/kg b.w.) on total antioxidant capacity.

Parameter	control	AA	AA+TA	TA
TAC mM/L	0.55±0.01	0.16±0.038^{a***}	0.59± 0.038$^{a\ NS,\ b***}$	0.88±0.02^{a***}

TAC: Total antioxidant capacity. Significant differences in comparison between groups are represented as mean ± SE. *p<0.05;**p<0.01; ***p<0.001, N.S Non significant (P> 0.05). [a] Significant difference between Control & AA ; Control & AA+TA; Control & TA. [b] Significant difference between AA & AA+TA

Table 3: Effect of acrylamide (20 mg/kg b.w) and taurine (50 mg/kg b.w.) on tumor markers.

Parameter	control	AA	AA+TA	TA
CA125 U/mL	66.10± 0.74	130.90±0.78^{a***}	80.02±0.59$^{a***,\ b***}$	66.45± 0.68$^{a\ NS}$
CEA ng/mL	33.38±0.57	133.60± 0.77^{a***}	42.49±0.13$^{a***,\ b***}$	33.09±0.05$^{a\ NS}$

CA 125: Cancer antigen 125, CEA: Carcinoembryonic antigen. Significant differences in comparison between groups are represented as mean± SE. *p<0.05;**p<0.01; ***p<0.001, N.S Non significant (P > 0.05). [a] Significant difference between Control & AA ; Control & AA+TA; Control & TA. [b] Significant difference between AA & AA+TA

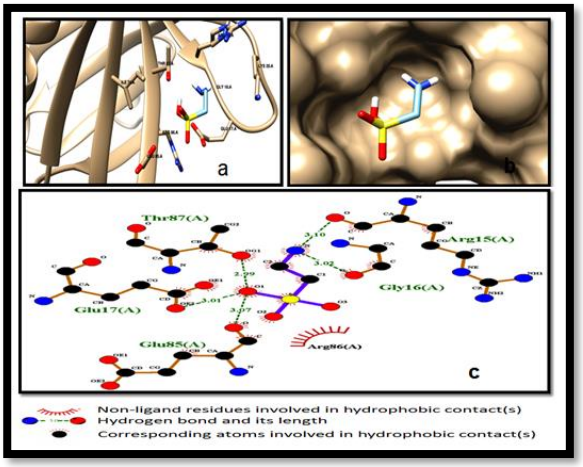

Figure 7: Molecular docking analysis of taurine with AKT1 protein PDB ID (1UNQ). a) Interaction of taurine with the active site of AKT1. b) Surface map of AKT1 that show taurine well fitted in the binding pocket. c) 2D plot shows the hydrogen bonds interaction pattern of taurine with the active site of AKT.1

3.5.Histology result

The purpose of the current histological investigation was to provide proof for the biochemical results. ovaries in control. Control ovary The purpose of the current investigation was to provide proof for the biochemical results. ovaries in control group (**Figure 8 - A**) showed normal texture of ovarian follicles with their intact ova, normal corpus lutum and normal interstitial cells; No alterations in normal ovarian histological features were observed in the group receiving Taurine (TA) alone (**Figure 8-B**).on the other hand , administration of acrylamide (AA) (**Figure 8-C**) for 21days result in formation of atretic follicle, cyst transformation with attenuated layer of granulosa cells. Marked degeneration of corpus lutum cells (shrinked cytoplasm and dark nuclei) was also observed in (AA) group. In (AA+TA) group, ovarian tissue showed potential protection with preservation of some growing follicles Residual cysts are still present with prominence of interstitial cells (**Figure 7-D**) .

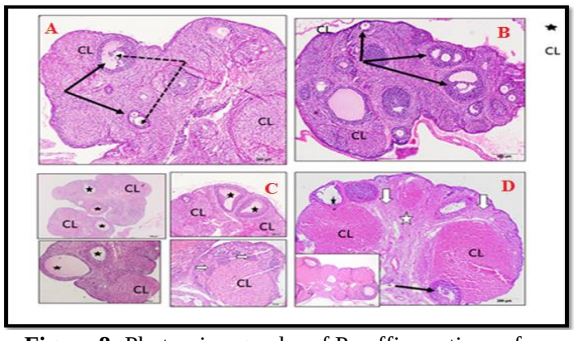

Figure 8: Photomicrography of Paraffin sections of female rat ovary stained by H&E to show: A:Controlgroup; Normal follicles(black arrows) with intact ova (dotted arrows). Normal corpus lutum (CL). B: (TA) group; Taurine: Normal Follicles with intact ova (arrows) and corpus lutum (CL) showed normal more healthy features than control. C:(AA) group; ovaries from different animals showed cystic changes in developing follicle (black stars) corpus lutum showed degenerated cells with dark nuclei (CL). Some ovaries showed massive degeneration of follicles (white arrows). D:(AA+TA); showing potential protection with preservation of some growing follicles (black arrows). Residual cysts are still present (black star), with appearance of interstitial cells (white arrow).

4.Discussion

The data indicated that progesterone level was highly significantly lower in (AA) group compared to control group and this is in agreement with Wei,et al. (2014) [24] who found that in female mice; AA reduced progesterone in a dose dependent manner. The authors attributed this decrease to reduction of the number of corpora lutea by AA. Similar explanation could be given to the present results based on histological finding of degenerated corpora lutea in (AA) group. Another study done by Aldawood et al, (2020) [36] who reported that in female rat, steroid hormone release was affected by AA administration and they linked this disfunction to the apoptotic changes on granulosa cells and lack of corporal lutea formation, Regarding estradiol E2 (ng/ml), there was highly significant increase ($P<0.001$) in the mean value following (AA) group administration compared with control group. This result was disagree with what was reported by Wei, et al, (2014) [24] who found a decrease in E2 in contrast with the increase in progesterone level and explained this decrease by degeneration of follicular granulosa cells which was similar finding to what was found in ovarian histological examination in the present study. Cystic changes observed in in the present study pointed to a status similar to polycystic ovarian syndrome (PCOS) changes. Janssen et al., (2004) [37] reported that hormonally, Low progesterone, normal to high estradiol, and high testosterone are all symptoms of PCOS. The latter hormone was found to be significantly high in the present study. Also, these results are partially matched that of Mannaa et al. found that acrylamide caused considerable reductions in oestrogen and progesterone levels in rats [38]. The lower levels of progesterone and higher levels of estradiol in the AA-treated group could imply that acrylamide directly or indirectly affects ovarian follicles by reducing pituitary gland release of FSH, which increases follicle growth and regulates androstenedione to estradiol conversion [39].The significant decrease in Follicle-Stimulating Hormone (FSH) (mIU/L) levels reported in the current study after exposure to acrylamide is consistent with the fact that observing the FSH secretion peak is difficult due to its short discharge period and the fact that FSH levels are extremely low during the proestrus phase [40,41]. We observed that luteinizing hormone (LH)

level was increased significantly in comparison to the control group (G1) The increase of LH (mIU/L) level over the physiological limits could be explained by the low level of progesterone observed in the present study. The inhibitory activity of acrylamide on aromatase cytochrome P-450, an enzyme required for the bioconversion of androgens into estradiol, could explain the highly significant rise in testosterone T level (ng/ml) in the AA group compared to the control group. The ovarian follicles secrete estradiol.[42] Taurine is a well-known antioxidant with a variety of clinical uses. It is a scavenger that helps the body maintain its delicate oxidant/antioxidant balance by detoxifying excess ROS. Non-enzymatic antioxidants are available in the form of dietary supplements or synthetic formulations. Taurine's antioxidant properties have also been well documented in the field of reproductive health, therefore it could be a useful supplement for lowering female reproductive toxicity [43]. The According to the findings of Ghosh et al., taurine administration improved all sex hormones (P4, E2, FSH, LH, and testosterone) changes [44]. and Mu, T. *et al*., [45]. Taurine has been reported to act directly on the ovaries, promoting ovarian protection against AA intoxication. Taurine has been shown to stimulate the pituitary gland's secretion of LH and FSH [46].

its conversion to E2 under the action of aromatase, whereas LH enhances the synthesis and secretion of follicular theca progesterone [46]. The levels of serum P4 (ng/ml), E2 (ng/ml), LH (mIU/L), FSH (mIU/L), and testosterone (ng/ml) in the taurine alone group were normal or showed no significant increase when compared to the control group, which explained its safety use, which was also confirmed by the lack of any change in ovarian histology observed in this study. Taurine therapy, on the other hand, prevented decreased ovarian steroidogenesis and maintained normality in the hypothalamo-hypophysial-ovarian axis in AA-treated rats, as well as the maintenance of ovarian normal histological characteristics. Taurine's potential usefulness in decreasing AA-induced female reproductive system impairment was highlighted by these findings.

TAC concentration analysis of both treated and control group were shown in Table (2) which revealed that the concentration was highly significant decrease after administration of AA but in (AA+TA) group it showed non-significant changes compared to non-treated (AA) group. On the other hand in (TA) group there was highly significant increase compared to (AA) group. Low level of total antioxidants in serum in (AA) group might be attributed to the AA-induced oxidative damage [47].This finding was supported by Mannaa et al.[38] and Lebda et al. [47], who found that acrylamide reduced total antioxidant levels significantly. According to these findings, overall antioxidant activity in the rat following taurine administration decreases the formation of oxygen free radicals.

On the other hand, the analysis of ovarian tumor markers as CA125 and CEA in Table 2 revealed that the mean value of the two parameters in (AA) group were highly significantly increased than control group, but in (AA+TA) group it was highly significantly decreased than (AA) group, Also in (TA) group there was non-significant changes compared to control group. These findings demonstrated that acrylamide induces oxidative DNA damage, which could contribute to its carcinogenic potential [48]. and these results were consistent with that acrylamide AA being a gene mutagen in rats *via* metabolism of glycidamide. The current study deals with the carcinogenicity of acrylamide and interaction between acrylamide and hormonal disorders in female rats. CA125 and CEA [49].

In this study, histological evaluation of ovarian tissue confirmed the protective effect of taurine against AA-induced ovarian damage. Similar results have been recorded by Wei Q., et al., [24] Amin, K., et al. [50], Duan X., et al., [51] who reported that rats exposure to oral acrylamide showed an obvious reduction in the number of ovarian follicles, together with the atrophy of the ovary and presence of many atretic follicles. But these results are not in agreement with Rawi et al., [52] who reported that AA is not affecting the ovary significantly with presence of mature follicles and corpus luteum in ovarian sections after 28-day treatment with AA. Histological findings are also observed to be corroborated with the present hormonal results and confirmed that the low plasma FSH and increased estradiol levels in the group treated with AA alone corresponded with the prominence and increase of ovarian interstitial cells [53].

As AA may cause disorders of follicular maturation and ovarian structural degeneration. The decreased number of healthy follicles after AA treatment in AA-treated rats has been attributed to low FSH levels [54]. Treatment with taurine reduced ovarian structural deterioration and follicular maturation alterations. The increased folliculogenesis in the taurine-treated group also prevented decreased ovarian steroidogenesis and exerted an impact on the hypothalamo-hypophysial-ovarian axis, presumably by reducing oxidative stress and increasing antioxidant levels [55]. The current work clearly revealed that taurine's antioxidant activities protect against the development of acrylamide-induced ovarian oxidative stress, and this finding is consistent with Ghosh et. Al. [44].

5.Conclusion

Acrylamide exposure disrupted the steroidogenic pathway, altering the female hypothalamic-pituitary-gonadal axis and could increasing the risk of ovarian cancer based on increased tumor markers as early sign of cellular transformation. Histological investigation

also demonstrated that AA exposure caused follicular maturation problems and ovarian structural deterioration. By preventing the changes in female sex hormones and regulating oxidant-antioxidant status, taurine treatment improved ovarian steroidogenesis and maintained normality in the hypothalamo-hypophysial-ovarian axis and these results were proven with taurine molecular docking. The present findings suggested that taurine may be effective in reducing acrylamide-induced female reproductive system toxicity, and that taurine supplementation may be beneficial in people who are at risk of acrylamide toxicity.

5.Conclusion

Acrylamide exposure disrupted the steroidogenic pathway, altering the female hypothalamic-pituitary-gonadal axis and could increasing the risk of ovarian cancer based on increased tumor markers as early sign of cellular transformation. Histological investigation also demonstrated that AA exposure caused follicular maturation problems and ovarian structural deterioration. By preventing the changes in female sex hormones and regulating oxidant-antioxidant status, taurine treatment improved ovarian steroidogenesis and maintained normality in the hypothalamo-hypophysial-ovarian axis and these results were proven with taurine molecular docking. The present findings suggested that taurine may be effective in reducing acrylamide-induced female reproductive system toxicity, and that taurine supplementation may be beneficial in people who are at risk of acrylamide toxicity.

Abbreviations

AA: acrylamide; TA: taurine; AA+TA: acrylamide+taurine ; P4: Progesterone, E2: Estradiol, T: Testosterone, LH: luteinizing hormone, FSH: follicle-stimulating hormone;TAC: total anti-oxidant capacity; CA125: carcinoma antigen 125; CEA: Carcino-embryonic antigen; CL: corpus lutum; CYP2E1:cytochrome P450 2E1 (CYP2E1); CSAD:ɣ-cystathionase and cysteine sulfinic acid; PCOS: polycystic ovarian syndrome

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Conflict of interest

The authors declare that they have no competing interest.

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