Original Research Article

Costus root extract alleviates blood biochemical derangements of experimentally-induced hypo- and hyperthyroidism in mice

ABSTRACT

Objectives: Thyroid hormones regulate all metabolic activities; therefore, it is not amazing that hepatic; renal dysfunctions and lipid alterations are commonly detected in patients with thyroid disorders. This study estimated some biochemical changes in post pubertal hyperthyroid and hypothyroid mice and their impacts on liver and kidney functions and also on changes in the lipid pattern. In addition, the ameliorating role of Costus root extract supplementation was examined. **Material and methods:** A total of 60 male Swiss albino mice were randomly divided into 5 groups; control, control with costus extract, hypo- and hyper-thyroids post-treated with costus root extract. **Results:** Present results revealed that, a significant increase in serum thyrotropin (TSH), alanine transaminase (ALT) and aspartate transaminase (AST), alkaline phosphatase (ALP), creatinine, urea, potassium, chloride, cholesterol and triglycerides levels in hypothyroid mice compared to control. On the other hand; a significant decrease in serum thyroxine (T_4), tri-iodothyronine (T_3), albumen, total protein and calcium ions levels in hypothyroid mice compared to control. In contrast to hypothyroidism, a significant increase in serum T_3, ALT, AST, ALP, creatinine, urea, sodium, potassium, chloride and total proteins levels in hyperthyroid mice compared to control. On the other hand; a significant decrease in serum TSH, T_4, albumen, calcium ions cholesterol and triglycerides levels in hyperthyroid mice compared to control. Treatments of mice with Costus root extract in both hypo- and hyperthyroidism modulates the measured serum parameters. **Conclusions:** Our results could propose that the extract of Costus roots can be used as an adjuvant co-therapy in hypo- and hyperthyroidism syndromes with propylthiouracil and Eltroxin replacement therapy, respectively.

Keywords: Thyroid dysfunctions, Costus, hepatic and renal dysfunction, blood, mice.

1. INTRODUCTION

Thyroxine and tri-iodothyronine (T_4& T_3) are thyroid hormones that essential for normal organ development and metabolic functions [1-4]. They regulate all metabolic activities such as growth rate, sodium/potassium pump, cholesterol secretion in the bile, heart rate, blood pressure, respiration, oxygen consumption, digestion strength, lipid, carbohydrate and protein metabolism, central nervous system function, and the actions of other endocrine glands and metabolic functions.

Hypothyroidism occurs when the thyroid gland does not produce enough thyroid hormones to meet the body's needs. Hypothyroidism is a progressive disorder presenting with different degrees of thyroid failure and metabolic consequences [5]. Low Levels of thyroid hormones can impose effects on behavior, growth, cardiac output, tissue

oxygen consumption, muscle strength, and immune function [6].

On the other hand, Hyperthyroidism is characterized by increased secretion of thyroid hormones T_3 and/or T_4 [7-9]. Hyperthyroidism is commonly associated with increased food consumption, parallel with a loss of body weight and decreased serum cholesterol level [4,10]. Therefore, it is not amazing that disturbed metabolism in response to thyroid dysfunctions can cause changes in most of biochemical blood parameters.

Many plant extracts and their products have been shown to have significant antioxidant activity which may be an important property of medicinal plants associated with the treatment of several ill-fated diseases including liver toxicity [11-20].

Costus *Saussurealappa*is one plant of Asteraceae family, and it is described as an aromatic seasonal perennial plant. It's essential oil is used as medicinally tonic, stimulant and antiseptic, which differ from *Costus spicatus*, family Costaceae that belong to order Zingiberales. However, costus or*Saussurealappa*is one of these herbal plants that is rich in antioxidant, anti-hepatotoxic, anti-diabetic, antifungal, anthelmentic, anti-ulcer, anti-tumour, anti-inflammatory, antimicrobial effects and immuonostimulant activities.

Fortunately, it is widely utilized in various indigenous system of medicine worldwide for treatment of a variety of disorders for instancediarrhea, tenesmus, dyspepsia, vomiting, and inflammation [21-23]. Therefore; the current study was designed to clarify the possible ameliorating effects of Costus root extracts in improving blood abnormalities against Propylthiouracil induced hypothyroidism and Eltroxin induced hyperthyroidism in male mice.

2. MATERIALS AND METHODS

2.1. Chemicals

Eltroxin (Thyroxin 100 mcg; 100 Tablet) was obtained from Mercury Pharma Group Limited, Capital House, London EC4N 7BL, UK.

Costus: *Saussurealappa* absolute, CAS Number: 8023-88-9, Robertet, Inc., France. Other chemicals, reagents and buffers used in this study were purchased from local distributors and prepared in the research Lab. of Zoology Dept., Faculty of Science, Tanta Univ. Egypt.

2.2. Animals

A total of 60 male Swiss albino mice (*Musmusculus*), 6–8 weeks old, weighing 25 ± 2 g from an inbred colony were used in the present study. Animals were provided with standard mice feed and water *ad libitum***.** The mice were kept in the laboratory for 1 week before the experimental work and maintained on a standard rodent diet (20% casein, 15% corn oil, 55% corn starch, 5% salt mixture and 5% vitaminzed starch; Egyptian Company of Oils and Soap, Kafr-Elzayat, Egypt) and water available ad libitum. The local committee approved the design of the experiments, and the protocol conforms to the guidelines of the Faculty of Science, Tanta University guide for animal, as approved by Institutional Animal Care and Use Committee (IACUC-SCI-TU-0041).

2.3. Experimental design and treatments

The sixty mice were equally divided into 6 groups.

G1: Control group in which mice did not receive any treatment.

G2: Costus group included rats received by oral gavages Costus extract (50 mg/Kg body weight / 2day) for consecutive four weeks [14].

G3:Hypothyroid group; in which, mice received 0.05% 6-n-propyl-2-thiouracil (PTU) daily in drinking water for 4 weeks to induce the hypothyroid status [24].

G4:Hyperthyroid; mice received 100 µg/Kg Eltroxin in drinking water for 4 weeks to induce the hyperthyroid status

[10].

G5:Post treated hypothyroid; in which, mice received 0.05% 6-n-propyl-2-thiouracil (PTU) daily in drinking water for consecutive 4 weeks to induce the hypothyroid status and then mice received, by oral gavage, Costus extract (50 mg/Kg body weight / 2day) for another 4 weeks (from 5th - 8th week).

G6:Post treated hyperthyroid; mice received 100 µg/Kg Eltroxin in drinking water for consecutive 4 weeks to induce the hyperthyroid state and then mice received, by oral gavage, Costus extract (50 mg/Kg body weight / 2day) for another 4 weeks (from 5th - 8th week).

At the end of the experiment, blood samples were collected from each mouse, through orbital veins, in non-heparinized glass tubes to obtain serum. Blood samples were centrifuged to obtain serum used for detection of thyroid hormones, liver and kidney functions and lipid profiles.

2.4. Determination of serum thyroid hormones

Serum was used to determine the triiodothyronin (T_3) according to Thakur et al. [25]; thyroxin (T_4) according to Maes et al. [26] and thyrotropin (TSH) according to Mandel et al. [27]. These hormones were determined by ELIZS method based on labeled antibodies using Horse radish peroxidase with its substrate according to the Manufacturer's instructions.

2.5. Determination of serum liver enzymes

Serum was analyzed to determine alanine transaminase (ALT) and aspartate transaminase (AST) activities using commercial kit (Humann, Germany) according to the method ofSchumann and Klauke [28].Serum alkaline phosphatase (ALP) activity in serum was detected by using commercial kit (Humann, Germany) according to Moss andHenderson [29].

While, serum albumin level was estimated using commercial kit (Diamond, Egypt) according to Doumaset al. [30].Measurement of the serum liver enzymes was performed spectrophotometrically based on the principles and procedures in kit's instructions provided by manufacturer.

2.6. Determination of kidney functions and electrolytes

Photometric analysis of sera was carried out to determine urea and creatinine concentrations according to the method described by Kumar et al. [31]. Also, serum potassium, sodium, calcium and chloride ion levels were determined by using commercial kits (Sensa core electrolyte, India).

2.7. Measurement of lipid profiles

The serum concentration of cholesterol was estimated using a reagent kit (Reactivos Spinreact) according to the method described by Deeg and Ziegenohrm [32]. The serum level of triglycerides was also determined using a reagent kit (ReactivosSpinreact) according to the method described by Fossati and Prencipe [33].

2.8. Statistical Analysis:

Data were expressed as mean values ± SR and statistical analysis was performed using one way ANOVA to assess significant differences among groups of all treatments.

The criterion for statistical significance was set at $p<0.05$, at least, for the biochemical data. All statistical analyses were performed using SPSS statistical program, version 21 software package (SPSS® Inc., USA).

3. RESULTS

3.1. Toxicity

In the present study, there were no deaths in neither hypo- nor hyperthyroid mice after costus treatments indicating no toxicity of costus at its dose regimen used. Mice received 0.05% 6-*n*-propyl-2-thiouracil (PTU) in drinking water (group 3, hypothyroid) had lower activity and loss of appetite as compared to other groups. In contrast, hyperthyroid mice had hyper

activity and excessive appetite as compared to other groups.

On the other hand, hypothyroid mice, which treated with costus (group 2) or after approximate restoration of euthyroidstatus (group 5&6) showed higher activity than other non-treated groups. These results suggest that using of costus at 50 mg / Kg body weight of mice did not show any toxic sign and improved behavioral activities of mice toward euthyroid status.

3.2. Induction of hypothyroid and hyperthyroid mice

Table (1) showed that serum T_3 and thyroitropin (TSH) levels were significantly decreased and increased, respectively in hypothyroid mice (G3) as compared to control and costus groups (G1&G2). Meanwhile, serum T_3 and TSH levels showed significant increase and decrease, respectively in hyperthyroid mice (G4) as compared to control and costus groups (G1&2).

Serum T_4 in hypothyroid mice (G3) and hyperthyroid mice (G4) revealed a significance decrease, but T_4 level was higher in hypothyroid than hyperthyroid mice. On the other hand, treatment of mice with costus extract improved serum T_4 to be around normal levels (Table 1). As shown in Table (1), the co-treatment of both hypo- and hyperthyroid mice with costus extract modulates disturbed thyroid hormones toward normal levels of the control.

3.3. Changes in serum liver functions

As shown in Table (2), measurement of serum revealed significant increase in ALT, AST and ALP activities in both hypo- and hyperthyroid mice, while the serum albumin level was significantly decreased in both thyroid states compared to control and costus groups.

In contrast, estimation of the total protein content showed a significant decrease and increase in hypothyroid and hyperthyroid mice group (G3&G4), respectively compared to control and costus groups (G1&G2). It was shown that treatment of hypothyroid and hyperthyroid mice with costus extract (G5&G6) improved the liver function parameters to normal levels as in the control group (Table 2).

3.4. Changes in serum kidney functions:

In Table (3), serum levels of creatinine and urea in hypothyroid and hyperthyroid mice were significantly increased as compared to control and costus groups. On the other hand, treatment of hypothyroid and hyperthyroid mice with costus extract (group 5&6) decreased the kidney function indices to normal levels as in control group (Table 3).

3.5. Changes in serum electrolytes:

Insignificance decreases in serum sodium (Na^+) and calcium (Ca^{++}) ions were resulted in hypothyroid mice group while serum potassium (K^+) and chloride (Cl^-) ions were significantly increased in hyperthyroid mice group as compared to control and costus groups (Table 4).

The *P*H value showed no changes in different groups under study. On the other hand, treatment of hypothyroid and hyperthyroid mice with costus extract (G5&G6) changed the serum electrolytes to be around normal levels as in control group (Table 4).

3.6. Changes in the lipid profiles

Table (5) shows a significance increase in serum cholesterol and triglyceride of hypothyroid mice and the two indices were significantly decreased in hyperthyroid mice group as compared to control and Costus groups. In contrast; treatment of hypothyroid and hyperthyroid mice with Costus extract (G5&G6) normalized the cholesterol and triglyceride levels as in control group (Table 5).

4. DISCUSSION

Thyroid hormone helps the body to use energy, stay warm and keep the brain, heart, muscles, and other organs working

as they should. Thyroid hormones regulate all metabolic activities such as growth rate, digestion strength, cholesterol secretion in the bile, respiration, oxygen consumption, heart rate, sodium/potassium pump, blood pressure, metabolism of lipid, carbohydrate and protein, regulate body temperature and the actions of other lymphoid organs, and other functions in the body [5-8,34,35]. It is well known that thyroid hormones contribute to the development and maintenance of homeostasis in multicellular organisms to control cell growth and differentiation [36].

Table 1: Assessment of T3 (ng/dl), T4 (ng/dl) and TSH (µIU/ml) levels in different groups.

Groups	T3 (ng/dl)	T4 (ng/dl)	TSH (µIU/ml)
G1	$0.32^{\#} \pm 0.018$	$4.83^{\#} \pm 0.152$	$2.194^{\#} \pm 0.012$
G2	$0.36^{\#} \pm 0.013$	$4.08^{\#} \pm 0.01$	$2.29^{\#} \pm 0.065$
G3	$0.07^{*} \pm 0.010$	$2.95^{*} \pm 0.326$	$3.6^{*} \pm 0.129$
G4	$1.01^{\$} \pm 0.030$	$2.15^{\$} \pm 0.082$	$0.05^{\$} \pm 0.7$
G5	$0.22^{\#*} \pm 0.011$	$4.82^{\#} \pm 0.089$	$2.7^{\#} \pm 0.1$
G6	$0.71^{\#\$} \pm 0.065$	$3.79^{\#} \pm 0.061$	$1.94^{\#} \pm 0.15$

Data are expressed as mean ± SE of 10 observations.G1, Control; G2, Costus; G3, Hypothyroid; G4, Hyperthyroid; G5, Co-treated hypothyroid with costus group; G6, Co-treated hyperthyroid with costus. The symbols (#, * & $) indicate a significant changes in comparison with G1 (negative control), G3 (hypothyroidism group) and G4 (hyperthyroidism group) respectively.

Table 2: Changes in the liver functions [ALT, AST, albumen, ALP and total proteins] levels in different groups under study.

Groups	ALT (U/l)	AST (U/l)	Albumen (g/dl)	ALP (U/l)	T. protein (g/dl)
G1	$38.2^{\#} \pm 1.20$	$149.4^{\#} \pm 3.56$	$4.55^{\#} \pm 0.13$	$160.2^{\#} \pm 4.26$	$5.88^{\#} \pm 0.19$
G2	$28.6^{\#} \pm 0.75$	$137^{\#} \pm 2.83$	$4.81^{\#} \pm 0.06$	$153^{\#} \pm 4.30$	$6.23^{\#} \pm 0.24$
G3	$97.5^{*} \pm 3.91$	$188.3^{*} \pm 9.05$	$3.21^{*} \pm 0.06$	$200.1^{*} \pm 7.32$	$4.96^{*} \pm 0.14$
G4	$55.8^{\$} \pm 2.52$	$168.6^{\$} \pm 3.33$	$2.43^{\$} \pm 0.05$	$173^{\$} \pm 2.17$	$7.25^{\$} \pm 0.28$
G5	$29^{\#} \pm 1.14$	$130.2^{\#} \pm 3.15$	$3.62^{\#*} \pm 0.04$	$161.8^{\#} \pm 2.44$	$6.80^{\#\$} \pm 0.10$
G6	$25^{\#} \pm 1.67$	$128^{\#} \pm 2.43$	$3.43^{\#\$} \pm 0.04$	$122.2^{\#\$} \pm 7.25$	$5.84^{\#} \pm 0.16$

Data are expressed as mean ± SE of 10 observations.G1, Control; G2, Costus; G3, Hypothyroid; G4, Hyperthyroid; G5, Co-treated hypothyroid with costus group; G6, Co-treated hyperthyroid with costus. The symbols (#, * & $) indicate a significant changes in comparison with G1 (negative control), G3 (hypothyroidism group) and G4 (hyperthyroidism group) respectively.

Table 3: Changes in serum kidney functions in both hypo- and hyper-thyroid mice and after oral treatment with costus extract.

	Urea (mg/dl)	**Creatinine** (mg/dl)
G1	$26.2^{\#}$±0.8	$0.46^{\#}$±0.04^{a}
G2	$24.2^{\#}$±1.02	$0.46^{\#}$±0.04
G3	39.2*±0.78	0.96*±0.03
G4	$31.7^{\$}$±2.02	$0.62^{\$}$±0.04
G5	32.6*±1.21	$0.57^{\#}$±0.02
G6	$28.2^{\$}$±2.15	$0.59^{\#\$}$±0.01

Data are expressed as means ± SD; n = 10.G1, Control; G2, Costus; G3, Hypothyroid; G4, Hyperthyroid; G5, Co-treated hypothyroid with costus group; G6, Co-treated hyperthyroid with costus. The symbols (#, * & $) indicate a significant changes in comparison with G_1 (negative control), G_3 (hypothyroidism) and G_4 (hyperthyroidism), respectively

Table 4: Changes in serum electrolyte ions in both hypo- and hyper-thyroid mice and after oral treatment with costus extract.

	Na^+ mEq/L	**K^+** mEq/L	**Ca^{++}** mEq/L	**Cl^-** mEq/L	***P*H**
G1	$136.4^{\#}$±1.20	$5.72^{\#}$±0.12	$0.916^{\#}$±0.02	$107.4^{\#}$±0.80	$7.65^{\#}$±0.05
G2	$137^{\#}$ ±0.74	$5.72^{\#}$±0.06	$0.927^{\#}$±0.01	$104.3^{\#}$±1.18	$7.67^{\#}$±0.03
G3	135.7*±6.15	7.12* ± 0.11	0.789*±0.01	117.3*±2.02	$7.77^{\#}$±0.09
G4	$142.4^{\$}$±3.06	$7.92^{\$}$ ± 0.54	$0.87^{\$}$±0.04	$115.7^{\$}$±2.12	$7.55^{\$}$±0.03
G5	$137.7^{\#}$ ±0.63	$6.51^{\#*}$ ± 0.06	$0.992^{\#}$±0.01	$111^{\#*}$±0.71	$7.70^{\#}$±0.02
G6	$142.2^{\#\$}$±1.12	$7.16^{\#\$}$ ± 0.18	$1.113^{\#}$±0.04	$111.3^{\#\$}$±0.36	$7.44^{\$}$±0.02

Data are expressed as means ± SD; n = 10.G1, Control; G2, Costus; G3, Hypothyroid; G4, Hyperthyroid; G5, Co-treated hypothyroid with costus group; G6, Co-treated hyperthyroid with costus. The symbols (#, * & $) indicate a significant changes in comparison with G_1 (negative control), G_3 (hypothyroidism) and G_4 (hyperthyroidism), respectively.

Table 5: Changes in the lipid profile (cholesterol and triglycerides) levels in both hypo- and hyper-thyroid mice and after oral treatment with costus extract.

Groups	**Cholesterol mg/dl**	**Triglycerides mg/dl**
G1	$147.2^{\#}$ ± 2.653	$178.2^{\#}$ ± 8.345
G2	$145.2^{\#}$ ± 7.235	$153.4^{\#}$ ± 4.864
G3	163.2* ± 21.72	244* ± 13.45
G4	$82^{\$}$ ± 4.827	$153^{\$}$ ± 3.647
G5	$111.2^{\#}$ 5.152	$121.2^{\#}$ ± 6.576
G6	$103.6^{\$}$ ± 2.977	$118^{\$}$ ± 3.209

Data are expressed as means ± SR; n = 10.G1, Control; G2, Costus; G3, Hypothyroid; G4, Hyperthyroid; G5, Co-treated hypothyroid with costus group; G6, Co-treated hyperthyroid with costus. The symbols (#, *& $) indicate a significant changes in comparison with G_1 (negative control), G_3 (hypothyroidism) and G_4 (hyperthyroidism), respectively.

The current study has been represented to examine the effect of a hyperthyroidism and hypothyroidism status on serum biochemical markers. In addition, the protective and ameliorative role of Costus root extract was studied in all treatments. Present results revealed elevation in serum T_3,T_4 and depression of TSH in mice receiving Eltroxin indicating the hyperthyroid state. This finding is compatible with other studies that used L-thyroxin as a thyroid drug agonist for induction of hyperthyroidism [6,10].In the current study, a significant decrease in T_3 and T_4 levels and significant increase in TSH were detected in post treated hyperthyroid mice with costus root extract when compared with hyperthyroid mice. The current results coincide with studies of Shibutani et al. [37] and Beltagy et al. [10]. Also; the current results revealed depletion in serum T_3,T_4 and elevation in serum TSHin mice receiving 0.05% 6-n-propyl-2-thiouracil (PTU) in drinking water for consecutive 4 weeks indicating the hypothyroid state. This finding is compatible with other studies that used PTU as an anti-thyroid drug for induction of hypothyroidism [5,24].

In order to achieve this target we made a hypothyroid status by using a reversible PTU [38,39] and we made a hyperthyroid status by using L-Thyroxin sodium administration [6]. PTU has been used as an anti-thyroid agent, because of its specific and well-characterized mode of action [40,41]. PTU is an anti-thyroid drug which inhibits both the synthesis of thyroid hormones in the thyroid gland, and the conversion of thyroxine (T_4) to its active form, triiodothyronine (T_3), in peripheral tissues.

In order to ensure the hypothyroid status, we regularly determined the serum T_3, T_4 and TSH through the dose period where serum T_3 and T_4 concentrations is depressed and serum TSH concentration is significantly elevated in rats receiving PTU-induced hypothyroidism.

On the other hand; in order to ensure the hyperthyroid status, we regularly determined the serum T_3, T_4 and TSH where serum T_3 and T_4 concentrations are significantly elevatedand serum TSH concentration is depressed in rats receiving L-Thyroxin sodium-induced hyperthyroidism. Hypothyroidism is caused by deficient thyroid hormone secretion. In the present study; TSH was significantly increased in hypothyroid and significantly decreased in hyperthyroid rats; this result coincides with previous studies of Shibutani et al. [37]; Ibrahim et al. [34,42]; Tousson et al. [6,24,35]; Hafez and Tousson [7].

Liver plays an important role in thyroid hormones metabolism, and correspondingly, thyroid hormones regulate hepatic functions and bilirubin metabolism, therefore not surprisingly, syndromes of either organ have the potential to affect functions of the other [43]. Changes in the activities of plasma AST, ALT and ALP are the well-known secretory indicators of liver damage [44]. The current results revealed a significant increase in serum ALT, AST, ALP and significant decrease in the albumen levels in hyperthyroid and hypothyroid mice confirmed that hyperthyroidism and hypothyroidisminduced hepatic dysfunctions in mice.In the same concern, Giannini et al. [45]; Hull et al. [46] found a significant increase in serum direct bilirubin, ALT, AST and ALP in hyperthyroidism. The mechanism of the elevation in serum AST, ALT and ALP activities appears to be relative hypoxia in periventricular regions of the liver [47]. Also,Salama et al. [5] found a significant increase in serum ALT and AST and a decrease in total proteins and albumen in hypothyroidism.

In the current results, the treatment of hyperthyroid or hypothyroid mice with Costus root extract modulates liver function parameters as compared with non-treated hyperthyroidism or hypothyroidism.Eliza et al. [48] reported that Costus speciosus could alter plasma enzyme (AST, ALT, LDH, ALP and AP) levels to be around normal. Also, Nitin and Khosa [49] studied the hepatoprotective effect of the ethanolic extract of the rhizomes of Costus speciosus on carbon tetrachloride poisoned rats.

Current results revealed a significance increase in serum urea and creatinine in hypothyroid and hyperthyroid mice as compared to control and costus groups. The effect on thyroid hormones on electrolytes and minerals has not been well established and the underlying mechanisms are not well understood. The current serum sodium (Na^+) and calcium (Ca^{++}) ions in hypothyroid mice group showed a significance decrease while a significance increase in serum potassium (K^+) and chloride (Cl^-) ions were detected in hyperthyroid mice group as compared to control and costus groups. Also,

serum urea showed a significant increase in hyperthyroid mice groups as compared to control. These results are agreed with Malik and Hodgson [50] who studies the relationship between the thyroid gland and the liver. This finding was consistent with Iglesias et al. [51] who suggested that the increase in creatinine in hyperthyroid status is caused by reduced glomerular function and creatinine generation from possible myopathy and rhabdomyolysis (immediate release of creatinine through muscle break down). Hyperthyroidism enhances serum creatinine levels due to decreased clearance and increased production of creatinine.

Treatment of hyperthyroid mice with costus root extract decreases the elevation in serum creatinine in the hyperthyroid and hypothyroid mice. So the increase in serum creatinine is reversible in hyperthyroid or hypothyroid status after treatment with thyroid hormone supplementation. These results are in disagree with Bharti et al. [52] and Kumara et al. [53] who reported that no significant difference in the levels of the measured electrolytes among the controls and patients in subclinical hyperthyroidism.

So, thyroid patients should be regularly checked for serum electrolytes, where early detection and treatment can prevent further complications and will be helpful during the management of thyroid patients. Results of the current study are in agreement with Basu and Mohapatra [54] who studies the interactions between thyroid disorders and kidney disease.

The current serum levels of cholesterol and triglycerides were significantly increased in hypothyroid mice and significantly decreased in hyperthyroid mice group as compared to control and Costus groups. In contrast, oral treatment of hypothyroid and hyperthyroid mice with Costus extract recovered the cholesterol and triglyceride levels to normal levels as in control group.

Tousson et al. [55,56] and Ali et al. [57] who reported that the decrease of thyroid hormone (hypothyroidism) can cause an increase in levels of total cholesterol and low-density lipoprotein cholesterol and a possible change in high-density lipoprotein cholesterol due to a change in metabolic clearance. Herein, the administration of the aqueous extract of Costus decreased the levels of both total cholesterol and triglycerides. Such decrease in serum cholesterol level after administration of the aqueous extract of Indian Costus may be due to erase of LDL-cholesterol from plasma by increasing LDL-receptor activity.

5. CONCLUSION

The present study confirmed that hypo- or hyper-thyroidism in male mice was associated with biochemical indices alterations, and also the treatment with Costus improved these alterations in blood indicating ameliorative therapeutic effect of costus during thyroid disorders.

So; our results could propose that the extract of Costus roots can be used as an adjuvant co-therapy in hypo- and hyperthyroidism syndromes with propylthiouracil and Eltroxin replacement therapy, respectively

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

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