



Therapeutic Potential of the Algerian Ground Nut (*Bunium bulbocastanum*) Dietary Supplement in the Treatment of Thyroid-induced Dysfunction and Associated Growth Performance and Meat Quality in Rabbits (*Oryctolagus cuniculus*)

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ABSTRACT

Background: Both traditional usage and initial scientific findings suggest that *Bunium bulbocastanum*, commonly known as Talghouda tuber nut, may offer health benefits, particularly for thyroid dysfunction. This study aims to investigate the therapeutic potential of dietary supplementation in managing pharmacologically thyroid-induced dysfunction and its effects on growth performance and meat quality in rabbits.

Methods: Thirty 45-day-old male Lionhead rabbits were divided into three groups, each with two subgroups. The Control groups received either a standard diet (C) or a diet supplemented with 35% dried Talghouda (Csup). The Hypothyroid group included rabbits induced with hypothyroidism using carbimazole at a dose of 5 mg/kg BW/day (HytCar) and those subsequently treated with dried Talghouda (HytTal). Similarly, hyperthyroid group comprised rabbits induced with hyperthyroidism using levothyroxine (HyrLevo) and those treated with dried Talghouda (HyrTal). Thyroid function was assessed by measuring serum levels of T3, T4 and TSH. Additionally, growth performance and meat quality parameters were evaluated.

Result: Talghouda supplementation significantly influenced thyroid hormone levels in rabbits, elevating T3 and T4 in the hyperthyroid groups (HyrLevo and HyrTal) compared to controls, while suppressing TSH in hyperthyroid groups and elevating it in hypothyroid groups. Talghouda treatment improved growth performance, evidenced by increased weight gain and higher eviscerated carcass weights in the hyperthyroid-treated groups. Meat quality also improved, with favourable pH, dry matter percentage and mineral content observed in the Talghouda-treated hypothyroid group. These findings suggest that *Bunium bulbocastanum* is a viable natural intervention for managing thyroid dysfunction while maintaining or enhancing growth and meat quality in rabbits, offering promising pharmacological and economic benefits.

Key words: *Bunium bulbocastanum*, Dietary supplementation, Growth performance, Meat quality, Rabbits, Thyroid dysfunction.

INTRODUCTION

Has been closely linked to dietary habits, underscoring the critical role of nutrition in disease prevention. Specific foods and nutrients have been identified for their potential to naturally support hormone health (Rahaman *et al.*, 2023), highlighting the profound connection between nutrition and health, particularly as a natural means of hormone replacement.

The thyroid dysfunction in rabbits has been extensively studied to understand its physiological, pathological and therapeutic implications. Various research efforts have explored methods of measuring thyroid activity, the effects of pharmacological agents, dietary interventions and the impact of environmental toxins on thyroid health (Chmurska-Gąsowska *et al.*, 2021); (Abdelazeem *et al.*, 2023).

Thyroid hormones play a critical role in regulating metabolism and cell differentiation throughout the body. Their receptors are located in various organs, including the nervous system (Sawicka-Gutaj *et al.*, 2022), pituitary gland, lungs, heart, liver (Bano *et al.*, 2020), muscles (Kong

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et al., 2020), bones (Wu *et al.*, 2023), testis and placenta (Mazzilli *et al.*, 2023). Thyroid hormones act as transcription factors by binding to specific nuclear receptors called thyroid hormone receptors (TRs), which are present in many

tissues (Wróblewski *et al.*, 2023). Thus, any increase or decrease in thyroid hormone levels profoundly affects the entire body's physiology. These variations occur in conditions such as hypothyroidism, hyperthyroidism, subclinical hypothyroidism and subclinical hyperthyroidism.

Root and tuber crops are primarily cultivated for human consumption or for industrial starch extraction. Notably, the acorn of earth, a plant well known in rural areas throughout the Tell regions of Algeria, belongs to this category. The *Bunium* genus, encompassing approximately 50 species, is found across North Africa, Asia and Europe, as identified by (Giancarlo *et al.*, 2006).

These crops have potential implications for dietary interventions in thyroid health, though further research is required to fully elucidate their impact. Among these, *Bunium bulbocastanum* L., locally known as Talghouda, Terghouda, nut, or earth gland plant, is widely recognised in rural communities throughout the tell regions of Algeria (Adoui *et al.*, 2022). Ground nuts are currently attracting attention from herbalists due to their therapeutic applications and nutritional value, suggesting a dual benefit in their utilisation. They are considered a viable crop for mountainous regions and hold potential for treating goitre and thyroid dysfunction (Warda *et al.*, 2023). Both traditional usage and initial scientific findings indicate that *Bunium bulbocastanum* may offer health benefits, particularly in relation to the thyroid dysfunction.

The primary objective of this experimental design is to systematically assess the potential therapeutic regulatory impact of incorporating *Bunium bulbocastanum* into the diet of rabbits with induced thyroid dysfunction. Additionally, this study will evaluate the nutritional and zootechnical outcomes (carcass traits, mortality, meat quality and kidney function) in lionhead male rabbits (*Oryctolagus cuniculus* f. domestica) subjected to induced states of thyroid dysfunction, including both hypothyroidism and hyperthyroidism.

MATERIALS AND METHODS

In June 2023, Talghouda tubers were collected from the North-west region of Algeria and identified taxonomically by experts from the Department of Agronomy at UMAB University. Fresh, mature tubers were selected (Warda *et al.*, 2023) and samples were initially stored at 4°C to prevent deterioration but normalised to ambient temperature before drying. The drying process involved a convective hot-air technique at 105°C for 24 hours, as recommended by (Chemists and Chemists, 1925). Post-drying, the tubers were ground into a fine powder.

Numerous initial trials were carried out to identify the ideal dosage of Talghouda (*Bunium bulbocastanum*) nut powder supplementation. The 35% supplementation level was found to be the most effective, yielding the best results in terms of growth, thyroid hormone responses and overall health of rabbits.

Thirty 45-day-old male Lionhead rabbits (*Oryctolagus cuniculus*) were divided into three main groups, each with two subgroups. Control groups received either a standard diet (C) or a diet supplemented with 35% dried Talghouda (Csup). The hypothyroid group consisted of a subgroup induced (10 days) with hypothyroidism by 5 mg/kg BW/day (Hossain, 2019) using carbimazole (HytCar) and another subgroup treated for 20 days with Talghouda post-induction (HytBu). Similarly, with the same dose, hyperthyroid group comprised a subgroup induced with hyperthyroidism levothyroxine administration (HyrLevo) and another subgroup subsequently treated with Talghouda (HyrBu). Thyroid function was assessed by measuring serum levels of triiodothyronine (T3), thyroxine (T4) and thyroid-stimulating hormone (TSH) at baseline and after treatment.

Blood samples were collected from the ear vein to measure TSH, T3 and T4 levels, which were quantified using the Elecsys 2010 (Roche Diagnostics/Hitachi, Japan). Animal mortality, body weight development and average daily weight gain were recorded. Effects of Talghouda supplementation and thyroid dysfunction on carcass yield were evaluated, including weights measurements of eviscerated carcasses, cold carcasses, digestive tract, kidneys, liver, perirenal fat, head, heart, skin, lungs, thighs, forelimbs and loins. Meat quality was also assessed by measuring pH, dry matter content and mineral concentration (University Animal Welfare Legislation agreement number 45/DGLPAG/DVA.SDA.14).

RESULTS AND DISCUSSION

Hormones levels in rabbits provoked and treated thyroid dysfunction

As shown in Table 1, the study assessed the levels of T3, T4 and TSH hormones in rabbits subjected to induced thyroid dysfunction and subsequent treatment. The evaluation provided insights into the endocrine responses to dietary and pharmacological interventions.

Thyroid hormones (T3 and T4) and TSH levels were measured in rabbits that experienced induced thyroid dysfunction followed by different treatments. This assessment provided significant insights into the endocrine responses to dietary and pharmacological interventions (Table 1).

T3 Levels in hyperthyroid groups (HyrLevo and HyrTal) displayed significantly elevated FT3 levels compared to the control groups (C and Csup). Specifically, HyrLevo had FT3 levels of 8.71±0.05 ng/mL and HyrTal had 7.59±0.4 ng/mL, while control groups had levels of 3.89±0.021 ng/mL and 4.02±0.01 ng/mL, respectively. Following treatment, FT3 levels were reduced to 2.99±0.01 ng/mL in HyrLevo and 3.87±0.34 ng/mL in HyrTal, suggesting the modulating effect of Talghouda. In contrast, the hypothyroid groups (HytCar and HytTal) exhibited significantly lower FT3 levels due to the suppressive effects of carbimazole, with levels recorded at 2.09±0 ng/mL and 1.92±0.2 ng/mL, respectively.

Talghouda treatment partially alleviated this suppression, raising FT3 levels to 3.04 ± 0.03 ng/mL in HytTal.

T4 Levels the hyperthyroid groups had also elevated T4 levels, with HyrLevo at 22.7 ± 0.1 µg/dL and HyrTal at 21.95 ± 0.5 µg/dL, compared to the control levels. Treatment reduced T4 levels, particularly in the HyrTal group (12.06 ± 0.05 µg/dL), indicating that Talghouda might have a beneficial effect in modulating thyroid hormone levels. The hypothyroid groups showed similar trends, with HytCar and HytTal initially exhibiting elevated T4 levels, which were then moderated after treatment.

TSH levels

Table 1 also highlights TSH levels under different experimental conditions. In the hyperthyroid groups, TSH levels were significantly suppressed during provocation (HyrLevo: 0.001 ± 0.0004 mIU/L, HyrTal: 0.001 ± 0.004 mIU/L), with no substantial changes during the treatment phase. In contrast, the hypothyroid groups exhibited elevated TSH levels (HytCar: 0.02 ± 0.001 mIU/L, HytTal: 0.021 ± 0.001 mIU/L), consistent with the inverse relationship between thyroid hormones and TSH. TSH, produced by the pituitary gland, regulates the production of T3 and T4 by the thyroid gland. The observed hormonal patterns indicate overactivity in hyperthyroid states and underactivity in hypothyroid states, reinforcing the critical role of balancing these hormones for normal metabolic function.

Previous studies (Chmurska-Gąsowska *et al.*, 2021) provide a foundation for understanding non-invasive measurements and updates on thyroid diseases in similar models, highlighting significant hormone level variations induced by different pathological or therapeutic interventions. Mebis *et al.* (2009) observed similar changes

in the hypothalamus-pituitary-thyroid axis during critical illness, which aligns with our observations in hyperthyroid models. Furthermore, the complexities of thyroid hormone interactions and the impact of dietary supplements discussed by Basha *et al.* (2023). Similarly, Ayyed Al-Hadidy and Dawood (2021) explored the effects of *Moringa oleifera* leaves powder on preventing experimental hypothyroidism, drawing parallels with our study's findings on the potential of dietary supplements in managing thyroid dysfunction suggest that the mechanisms observed with Talghouda supplementation in our study may overlap with known interactions, offering new insights into natural interventions for thyroid dysfunction. Our results underscore the profound effects of levothyroxine and carbimazole on thyroid hormone levels and demonstrate the potential modulatory role of Talghouda.

Growth dynamics and weight management in the experimental rabbits

Effects of different treatments on rabbits' mortality

The study maintained a 0% mortality rate throughout the breeding period, indicating that the experimental conditions were optimal and well suited for the Lionhead rabbit strain, which is noted for its resilience and low mortality rate (Gayard *et al.*, 2023).

Effects of different treatments on body weight development

Weight changes were meticulously monitored over a 30-day period to assess the impact of different treatment regimens on rabbit growth (Table 2).

The control group (C) had an initial average weight of 1.51 ± 0.174 kg on Day 1. The Csup group started with an

Table 1: Effects of 35% dietary Talghouda supplementation and pharmacological interventions on FT3, T4 and TSH levels in rabbits with induced thyroid dysfunction.

	Category	C	Csup	HyrLevo	HyrBun	HytCar	HytBun
FT3 levels	Induced dysfunction	4.0 ± 0.2^e	4.21 ± 0.2^e	9.02 ± 0.23^a	7.83 ± 0.4^b	4.84 ± 0.21^d	3.27 ± 0.23^f
	Treated			3.0 ± 0.24^f	5.0 ± 0.4^c	2.0 ± 0.24^i	3.04 ± 0.22^f
T4 levels	Induced dysfunction	16.08 ± 0.2^d	17.11 ± 0.19^c	25.00 ± 0.2^a	23.21 ± 0.39^a	18.17 ± 0.16^b	14.17 ± 0.11^f
	Treated			15.00 ± 0.2^e	18.13 ± 0.25^b	12.08 ± 0.23^i	15.01 ± 0.15^e
FSH level	Induced dysfunction	0.01 ± 0.001^b	0.01 ± 0.001^b	0.002 ± 0.0002^a	0.002 ± 0.0002^a	0.022 ± 0.0002^a	0.022 ± 0.0002^a
	Treated			0.01 ± 0.0002^b	0.01 ± 0.0002^b	0.01 ± 0.0002^b	0.01 ± 0.0002^b

Table 2: Body weight and average daily weight gain (ADG) responses to 35% Talghouda supplementation and pharmacological treatments in rabbits with induced thyroid dysfunction.

	Day	Control (C)	Csup	HyrLevo	HytBun	HytCar	HyrBu
Rabbit body weights	DAY 01	1510.27 ± 174^m	1570.5 ± 221.4^m	2705 ± 380^d	2640 ± 284^e	2595.8 ± 198^f	2510.7 ± 15.47^f
	DAY 10	1640.11 ± 44.12^j	1719.09 ± 55.90^k	2827.22 ± 21.22^c	2663.5 ± 17.8^e	2605.9 ± 41^e	2525.6 ± 17.3^f
	DAY 20	1715.38 ± 52.25^k	1743.5 ± 55.75^k	2940.5 ± 24.3^b	2687.5 ± 22.4^e	2637.18 ± 30.44^c	2635.8 ± 22.4^e
	DAY 30	2012.4 ± 56.40^i	1838.07 ± 78.5^j	3047.15 ± 65.4^a	2695.4 ± 24.3^e	2666.11 ± 23^c	2740.5 ± 23.15^d
Average daily weight gain	ADG1	12.98	14.86	12.22	2.35	1.01	1.49
	ADG2	7.53	2.44	11.33	2.40	3.13	11.02
	ADG3	29.70	9.46	10.67	0.79	2.89	10.47

average weight of 1.57 ± 0.22 kg. This group's weight gain suggests that Talghouda may promote growth, paralleling findings by (Földešiová *et al.*, 2015), who observed similar effects with *Curcuma longa* supplementation in rabbits albeit focusing on reproductive outcomes rather than thyroid-induced weight variations.

The hyperthyroid group (HyrLevo) began with a significant initial weight of 2.70 ± 0.38 kg, showcasing a pronounced weight gain by the study's end. This observation diverges from earlier research by (Hoover and Heitmann, 1972), which examined dietary fibre's impact on weight gain and caecal volume, focusing instead on thyroid function's role in weight regulation.

The hypothyroid group treated with *Bunium bulbocastanum* (HytBun) started with a weight of 2.64 ± 0.28 kg. This group's response aligns with the findings of (Chentouh *et al.*, 2017), who investigated the effects of organic extracts of *Bunium incrassatum* on various physiological parameters, highlighting the potential of *Bunium bulbocastanum* to influence body weight through thyroid modulation.

The hypothyroid group induced by Carbimazole (HytCar) began with a weight of 2.59 ± 0.19 kg. The weight gain patterns observed here can be compared to Al-Masoudi *et al.* (2021), who explored creatine supplementation's effects on weight and reproductive performance, although the current study focuses on the impacts of Carbimazole on weight, providing a new dimension to our understanding of thyroid function and dietary interventions.

By Day 30, the rabbits' weights ranged from 2.01 ± 0.05 kg in the control group to 3.04 ± 0.22 kg in the HyrLevo group. These results underscore the significant role of thyroid activity and dietary supplementation in regulating body weight, suggesting that *Bunium bulbocastanum* may offer therapeutic benefits in managing thyroid-related weight changes.

Average daily weight gain (ADG)

The study also analysed the effects of Talghouda on average daily weight gain (ADG) across different experimental groups at the 10th (ADG 1), 20th (ADG 2) and 30th (ADG 3) days of the experimental period. Notable fluctuations in ADG were observed, reflecting the varying impacts of different treatments, the 35% dietary supplementation and alterations in thyroid function. These findings align with (Adeosun and Iyeghe-Erakpotobor, 2014), who investigated the link between diet and weight gain, indicating that specific dietary components can substantially impact weight gain patterns. Moreover, (Gyovai *et al.*, 2012) provided insights into genetic parameters for weight gain, which may help explain the growth patterns observed in our treated rabbit groups. Additionally, (Larzul *et al.*, 2005) discussed the genetic determinants of growth and meat quality in rabbits, potentially elucidating the variability in weight gain responses observed in this study. Ragab *et al.* (2015) highlighted the genetic parameters of

disease phenotypes in rabbits under various feeding regimes, reflecting genetic factors that could influence the response variability seen in this study. Similarly, Saidj *et al.* (2021) reinforced our observations on nutritional impacts on weight gain through their investigation of dietary protein content on zootechnical parameters. Furthermore, Margatama *et al.* (2023) examined growth, meat quality and carcasses yield in local rabbits, offering comparative insights, particularly regarding the implications for meat quality and yield following dietary and thyroid function interventions.

Effects of earth-nut supplementation and thyroid states on carcass yield

Significant variations in body and muscle weights were observed due to thyroid condition modulation and earth-nut supplementation (Table 3).

Eviscerated carcass weights were significantly higher in the hyperthyroid (HyrLevo, 2.36 ± 0.4 kg) and hypothyroid (HytBun, 2.47 ± 0.8 kg) groups compared to the control (1.20 ± 0.6 kg). These results are consistent with previous studies reporting that genetic factors significantly affect carcass characteristics in rabbits (Gómez-Salazar *et al.*, 2018). Wang *et al.* (2024) also reported breed-specific differences in growth performance and carcass traits, reflecting the variance observed in our study due to different treatment conditions. These studies support our findings, showing treatment-induced increases in carcass and muscle weights, with thigh weights in the HyrLevo (620 ± 13.22 kg) and HytBun (583.33 ± 40.41 kg) groups significantly higher than in the control (378.33 ± 31.75 kg). Significant reduction in perirenal fat was observed in HyrLevo (1.2 ± 0.1 kg) compared to the control (1.743 ± 0.4 kg), aligning with Dabbou *et al.* (2017), who examined dietary supplements' impact on carcass characteristics and meat quality, suggesting dietary and hormonal treatments can significantly alter lipid metabolism.

The stability of digestive tract and liver weights across all groups, despite treatments, similar findings by Abdelazeem *et al.* (2023), who reported that probiotic administration affected growth and digestion without altering liver weights in rabbits, aligning with our observations of non-significant changes in these organ weights across treatments.

Effects of Talghouda and thyroid-induced dysfunctions on meat quality

The data on rabbit meat quality, which specifically evaluated pH levels, dry matter percentage and mineral content in the thigh, forequarter and saddle, are presented in Table 4. The pH values ranged from 5.83 in the Csup group to 6.35 in the HytBun group, indicating variability that impacts meat tenderness, shelf life and stress levels in animals' pre-slaughter. This variability in acidity and its implications for meat quality are supported by (Kozioł *et al.*, 2015) and (Cullere *et al.*, 2018), who noted the influence of pH on meat sensory traits.

Dry matter content varied from 24.2% in the Csup group (Forequarter) to 29.33% in the Csup group (Loin), with higher DM% indicating leaner meat. The significance of DM% in determining meat quality, affecting cooking outcomes and nutritional value, is echoed in studies by (Hulot and Ouhayoun, 1999) and (Bivolarski *et al.*, 2011). The considerable range within the Csup group, particularly in the Loin, suggests variability in meat composition that can influence consumer preferences.

Mineral content ranged from 1.08% in the Csup group (Forequarter) to 1.35% in the HytBun group, highlighting the

role of minerals in meat's nutritional value. Despite the narrow range, this variation, as discussed by (Simonová *et al.*, 2010), could render the HytBun group's meat nutritionally superior.

These findings across pH values, DM% and mineral content indicate potential differences in meat quality and processing among the groups. The HytBun and HyrLevo groups display distinct qualities that could influence culinary choices and nutritional analysis. Studies by (Ataxodjayeva *et al.*, 2023) underscore the importance of these factors in understanding meat characteristics for consumer preferences and culinary applications.

Table 3: Effects of a diet supplemented with *Bunium bulbocastanum* on the development of different parts of rabbits' carcass with different thyroid gland dysfunctions.

Weights	Control (C)	Csup	HyrLevo	HytBun	HytCar	HyrBu
EVW	1.20±0.6 ^b	1.11±0.12 ^b	2.36±0.4 ^a	2.47±0.8 ^a	1.98±0.21 ^a	2.14±0.25 ^a
CCW	1±0.05 ^b	1.055±0.05 ^b	1.68±0.1 ^a	1.52±0.23 ^a	1.34±0.1 ^{a,b}	1.41±0.2 ^{a,b}
DTW	0.43±0.01 ^{NS}	0.49±0.03 ^{NS}	0.56±0.03 ^{NS}	0.59±0.16 ^{NS}	0.46±0.07 ^{NS}	0.52±0.03 ^{NS}
KW	0.01±0 ^a	0.015±0.005 ^a	0.035±0.01 ^a	0.023±0 ^a	0.018±0 ^a	0.037±0.02 ^a
LW	0.065±0 ^{NS}	0.09±0 ^{NS}	0.087±0.02 ^{NS}	0.075±0.01 ^{NS}	0.087±0.01 ^{NS}	0.075±0.01 ^{NS}
*PFW	1.743±0.4 ^a	0.2±0 ^b	1.2±0 ^c	0.038±0.04 ^c	0.077±0.05 ^c	0.234±0.01 ^c
HW	0.272±0 ^c	0.272±0.01 ^c	0.35±0 ^{a,b}	0.345±0 ^{a,b}	0.313±0.4 ^{bc}	0.372±0.02 ^a
HeW	0.005±0 ^b	0.005±0 ^b	0.007±0 ^b	0.028±0 ^a	0.05±0 ^b	0.008±0 ^b
SW	0.208±0.07 ^a	0.207±0.03 ^a	0.355±0.05 ^a	0.38±0.05 ^a	0.307±0.05 ^a	0.348±0.1 ^a
LuW	0.1±0 ^a	0.01±0 ^c	0.015±0 ^{b,c}	0.018±0 ^{b,c}	0.015±0 ^{b,c}	0.022±0 ^b
TW	378.33±31.75 ^c	420±65.57 ^c	620±13.22 ^b	583.33±40.41 ^{a,b}	518.33±52.99 ^a	583.33±91.69 ^a
FW	283.33±10.40 ^c	318.33±44.81 ^c	465±37.74 ^b	475±75.66 ^{a,b}	396.66±58.38 ^a	450±120 ^a
LoW	303.33±36.17 ^c	270±45.82 ^c	503.33±32.53 ^b	431.66±68.98 ^{a,b}	360±70.88 ⁺	386.66±48.04 ^a

*Weight in g, Eviscerated carcass weight (ECW, kg), Cold carcass weight (CCW, kg), Digestive Tract weight (DTW, kg), Kidney weight (KW, kg), Liver weight (LW, kg), Perirenal fat weight (PFW, g), Head weight (HW, kg) Heart weight (HeW, kg), Skin weight (SW, kg), Lung weight (LuW, kg), Thigh weight (TW, g), Forelimb weight (FW, g), Loin weight (LoW, g).

Table 4: Effect of different treatments on meat quality of the experimental rabbits.

	Parts	pH	Dry matter %	Minerals %	Proteins level
C	Thigh	6.80±0.62 ^a	28.06±1.61 ^a	1.27±0.08 ^b	21.55±1.74 ^b
	Forequarter	6.21±0.12 ^b	28.8±1.83 ^a	1.31±0.09 ^a	20.22±0.85 ^c
	Saddle	6.08±0.32 ^b	25.2±5.94 ^e	1.13±0.29 ^c	21.23±1.7 ^b
Csup	Thigh	5.89±0.13 ^c	28.73±4.06 ^a	1.30±0.20 ^a	21.71±1.30 ^b
	Forequarter	5.94±0.03 ^c	24.2±7.10 ^f	1.08±0.35 ^d	22.01±0.51 ^a
	Saddle	5.83±0.06 ^c	29.33±5.55 ^a	1.33±0.27 ^a	21.4±1.04 ^b
HyrLevo	Thigh	6.00±0.01 ^b	27.13±2.81 ^c	1.22±0.14 ^b	19.33±1.40 ^d
	Forequarter	6.22±0.07 ^b	26.13±1.08 ^d	1.17±0.55 ^c	18.03±0.81 ^e
	Saddle	6.01±0.05 ^b	26.6±10.29 ^d	1.2±0.51 ^b	19.07±1.3 ^d
HytBun	Thigh	6.16±0.02 ^b	26.8±2.62 ^d	1.21±0.13 ^b	21.48±1.7 ^b
	Forequarter	6.35±0.07 ^a	26.66±3.30 ^d	1.20±0.16 ^b	20.81±0.8 ^c
	Saddle	5.94±0.18 ^c	28.86±3.93 ^a	1.35±0.12 ^a	22.26±0.3 ^a
HytCar	Thigh	5.89±0.02 ^c	26.06±1.10 ^d	1.17±0.05 ^c	18.19±0.9 ^e
	Forequarter	6.04±0.07 ^b	25±1.05 ^e	1.12±0.05 ^c	19.45±2.8 ^d
	Saddle	5.86±0.14 ^c	26.93±4.61 ^d	1.21±0.23 ^b	18.09±1.27 ^e
HyrBun	Thigh	6.11±0.17 ^b	26.2±0.69 ^d	1.18±0.03 ^c	20.43±2.01 ^c
	Forequarter	6.06±0.07 ^b	27.7±7.36 ^c	1.25±0.36 ^b	19.36±0.11 ^d
	Saddle	5.92±0.08 ^c	28.8±4.10 ^a	1.31±0.20 ^a	19.41±1.91 ^d

Dietary supplementation, kidney function and thyroid dysfunction correlations

Our investigation established the baseline creatinine level in the control group at 12.20 ± 0.50 mg/dL, consistent with normal values reported in similar studies (Özkan *et al.*, 2012). Dietary supplemented control group showed a slight increase in creatinine levels (12.58 ± 0.98 mg/dL), indicating a minimal impact on renal function in healthy rabbits. This aligns with findings that dietary supplements generally do not significantly alter renal markers in healthy subjects (Solomon *et al.*, 2015).

Hyperthyroidism induced by Levothyroxine resulted in significantly elevated creatinine levels (13.24 ± 0.15 mg/dL), reflecting increased metabolic rates affecting renal function, similar to observations in diabetic rabbit models (Wang *et al.*, 2024). Conversely, the hypothyroid group induced by Carbimazole showed decreased creatinine levels (11.35 ± 0.42 mg/dL), suggesting that reduced metabolic rates lower creatinine levels (Javadi *et al.*, 2014).

The HyrBun had similar creatinine levels (13.36 ± 1.65 mg/dL) to the untreated group, indicating no counteractive effect while HytBun showed significantly lower creatinine levels (10.20 ± 2.25 mg/dL), suggesting its potential benefit in normalising creatinine under hypothyroid conditions. (Ismail *et al.*, 2023).

Regarding urea levels, the control group had baseline levels at 0.29 ± 0.17 mg/dL. Similar levels in Csup suggest no significant impact on urea levels, consistent with minimal influence of dietary components on urea output in healthy animals (Duda *et al.*, 2020). The hyperthyroid group showed significantly higher urea levels (0.443 ± 0.046 mg/dL), likely due to increased protein metabolism, a common consequence of hyperthyroid conditions (Melillo, 2007). In contrast, the HypBun exhibited the lowest urea levels (0.24 ± 0.069 mg/dL), indicating its possible role in lowering urea production or enhancing its excretion, reflecting the broader utility of specific dietary adjustments in clinical settings (El-Nahhal *et al.*, 2020).

CONCLUSION

Thyroid hormones play a crucial role in regulating metabolic processes and the study's findings highlight the importance of normalizing these hormones in rabbits experiencing induced dysfunctions. A diet supplemented with 35% *Bunium bulbocastanum* (Talghouda tubers) not only helped restore thyroid hormone balance but also led to significant improvements in growth performance and meat quality. These enhancements were evidenced by greater weight gains, optimized pH levels, increased dry matter content and superior mineral composition. Talghouda supplementation emerges as a promising natural alternative to synthetic thyroid medications, potentially minimizing the side effects associated with long-term use. This research underscores the therapeutic benefits of Talghouda tubers, offering valuable insights for improving economic outcomes in rabbit farming. Further

investigations are needed to fully understand the mechanisms behind its effects, assess its benefits across other species and evaluate its long-term safety and efficacy in commercial animal husbandry settings.

Conflict of interest

On behalf of all authors, I confirm that there is no conflict of interest regarding the manuscript submitted.

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