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Effects of plant-based beverage consumption on serum levels of thyroid hormones

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Consumption of functional beverages has a significant impact on human health. This study aimed to develop a new plant-based beverage that incorporates extracts from cruciferous vegetables and pumpkin, offering a new formulation in the beverage industry with potential health-promoting properties. To achieve this, hydroethanolic (70%) extracts were prepared from selected plants, and their antioxidant capacity was assessed using the DPPH method. In addition, the physicochemical, microbial, and sensory characteristics of the beverage samples were evaluated. To investigate the effects of these beverages on thyroid function in humans, serum levels of thyroid-stimulating hormone (TSH) and thyroxine (T_4) were measured before and after a one-month consumption period. The results demonstrated a high level of free radical scavenging activity by the extracts, particularly at a concentration of 800 µg/mL. In the analysis of the beverages' antioxidant activity, increasing the extract concentration enhanced antioxidant properties. Prolonged storage (up to 90 days) led to a gradual decline in these properties. Assessment of thyroid hormone levels revealed no significant change in serum T_4 after one month of beverage consumption ($P > 0.05$). Although TSH levels decreased during the consumption period, they remained within the normal reference range (0.32–5.2 mU/L) before and after the intervention. Overall, the findings suggest that the developed herbal beverage possesses notable antioxidant activity due to the presence of bioactive compounds and may contribute to human health. Furthermore, it appears to exert no adverse effects on thyroid gland function.

Keywords: Antioxidant activity, Plant extract, Functional foods, Thyroid gland hormones

Thyroid hormones are essential regulators of metabolism, growth, and development in the human body. They play a key role in controlling basal metabolic processes, including oxygen consumption, and are crucial for the development of the nervous system during the embryonic period. These hormones also regulate the function of several vital organs, including the heart, blood vessels, digestive system, and reproductive system. Any imbalance in thyroid hormone levels can lead to a wide range of clinical disorders. Thyroid-stimulating hormone (TSH), produced by the anterior pituitary gland, plays a central role in regulating thyroid function. It is considered the most reliable physiological marker of thyroid hormone activity, as it stimulates thyroid follicular cells to synthesise and secrete thyroid hormones[1,2].

Given the side effects associated with chemical medications used to treat hypothyroidism, and the relatively low side-effect profile of medicinal plants, the exploration of plant-based alternatives appears to be a logical and promising avenue for research[3]. However, concerns have been raised regarding the potential effects of natural products containing glucosinolates and isothiocyanates in cruciferous vegetables on thyroid function. Some animal and human studies, as reviewed by Felker *et al.* and Chang *et al*. suggest that these compounds may interfere with iodide uptake and subsequently reduce thyroid hormone synthesis, potentially leading to hypothyroidism[4,5].

Despite these concerns, a study examining the daily consumption of a broccoli sprout extract beverage over 84 days in healthy human volunteers reported no adverse effects on thyroid function or thyroid autoimmunity markers[6]. Beverages serve as an effective medium for delivering nutrients and bioactive compounds to the body, enhancing their bioavailability. These bioactive compounds, including phytochemicals such as phytoestrogens, phenolic compounds, flavonoids, and carotenoids, can be

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incorporated into functional beverages to contribute to disease prevention strategies particularly during the early stages of disease development[7,8]. Notable compounds in plant-based functional beverages include β-glucan (associated with improved blood glucose control and insulin sensitivity)[9], phytosterols (beneficial for cardiovascular health)[10], and isoflavones (linked to reduced risk of cardiovascular disease, cancer, and osteoporosis)[11].

Pumpkin (*Cucurbita* spp.), a highly nutritious member of the Cucurbitaceae family, which comprises more than 130 genera and 800 species[12], is known for its health benefits. All parts of the plant are valuable, with pumpkin seed oil shown to improve thyroid hormone levels in adult male rats[13]. The Brassicaceae family, belonging to the order Brassicales, includes several nutritionally valuable vegetables. Broccoli (*Brassica oleracea* var. *italica*) exhibits anticancer properties due to its content of ascorbic acid (vitamin C), vitamin E (α-tocopherol), flavonoids (quercetin and kaempferol), carotenoids (β-carotene and lutein), and glucosinolates[14,15]. Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is particularly rich in phytochemicals, including polyphenols, flavonoids, anthocyanins, ascorbic acid, α-tocopherol, β-carotene, and lutein[16]. White cabbage (*Brassica oleracea* var. *capitata* f. *alba*) is another major cruciferous crop, widely recognised as a source of phenolic acids, flavonoids, tannins, terpenoids, dietary fiber, and antioxidant compounds[17,18].

Given this background, the present study aimed to develop a novel functional beverage incorporating plant extracts from pumpkin and various cabbage varieties (red cabbage, white cabbage, broccoli, and cauliflower). The objective was twofold: To explore the potential of such a beverage to support thyroid hormone regulation as an alternative to chemical drugs, and to ensure that the inclusion of cruciferous vegetables does not adversely affect thyroid function.

Materials and Methods

Preparation of extracts of pumpkin and Cruciferae plants family

The selected plant materials, including pumpkin (*Cucurbita moschata*), white cabbage, red cabbage, broccoli, and cauliflower, were initially subjected to detailed identification and confirmation by the Research Institute of Medicinal Plants of Jihad University. Each plant was assigned a unique herbarium code as follows: pumpkin (413Cm*IMPSB), cauliflower (409B0*IMPSB), white cabbage (411B0*IMPSB), and red cabbage (412B0*IMPSB). Extraction was carried out using the maceration method. After purchase, the plant materials were thoroughly washed and dried in the shade at 25–35°C for 20–25 days. Subsequently, 30 grams of the dried plant powders were soaked in 150 mL of 70% hydroethanolic solvent at room temperature for 48 hours. The extracts were then filtered through filter paper, and the solvent was evaporated using a Bain-Marie at 30°C. The concentrated residues were freeze-dried using a freeze dryer (ZIRBUS, D-37539, Germany), resulting in powdered extracts, which were stored at -70°C in the dark until further use[19].

The prepared extracts were analysed for their ascorbic acid content using the titration method[20], total phenolic content (TPC) via the Folin-Ciocalteu method[21], total flavonoid content (TFC) using the aluminum chloride colorimetric method[22], and antioxidant activity using the DPPH assay at a wavelength of 517 nm, with concentrations of 50, 100, 200, 400, and 800 µg/mL[23].

Production of plant-based beverages

A plant-based beverage was formulated using a mixture of hydroethanolic extracts from the five selected plants (red cabbage, white cabbage, broccoli, cauliflower, and pumpkin), with emphasis on those showing the highest antioxidant activity at concentrations of 400 and 800 µg/mL. Five beverage formulations were prepared as follows: (1) control beverage consisting of additives and water (1000 mL) without extract; (2) basic beverage 1 with 400 µg/mL of extract and water (1000 mL); (3) basic beverage 2 with 800 µg/mL of extract and water (1000 mL); (4) apple-kiwi beverage 1 with 400 µg/mL of extract, additives, and water (1000 mL); and (5) apple-kiwi beverage 2 with 800 µg/mL of extract, additives, and water (1000 mL). Additives included 0.5% edible essential oil with apple-kiwi flavour (Argeville, France) per extract, 0.1% natural sweetener derived from Stevia (Steviol Glycosides; Sigma-Aldrich, Germany), 0.5% tragacanth gum (Phaidyme, Iran) to reduce phase separation, and citric acid to stabilise the pH.

All ingredients were mixed in water in a tank equipped with a stirrer at room temperature for 15 min to ensure uniformity. The beverages were then pasteurised in a water bath (Brookfield, Model TC 502, USA) at 85°C for 20 sec. Hot-filled beverages were dispensed into polypropylene (PP) bottles and immediately cooled to room temperature by immersion in cold water. For subsequent analyses, the beverages

were stored in a refrigerator at 1–4°C for a period of three months. During the storage period, antioxidant activity was assessed using the DPPH assay, microbial stability was evaluated using plate count agar (PCA) incubated at 30°C for 48 hours[24], and sensory properties were assessed using a 9-point hedonic scale[25].

Thyroid hormone tests

Participants and inclusion and exclusion criteria

This segment of the study followed a cross-sectional design and included ten participants (both male and female), aged between 20 and 60 years. Before initiating the clinical trial, the study objectives and procedures were thoroughly explained to the participants, and written informed consent was obtained. The clinical assessment was conducted after one month of regular consumption of the apple-kiwi beverage containing 0.8 grams of extract, chosen based on its high antioxidant potential and favourable sensory evaluation outcomes. Participants consumed 1000 mL of the beverage daily, divided into three servings (morning, noon, and night). Exclusion criteria included individuals with a history of addiction to drugs, psychoactive medications, alcohol, or tobacco; those with acute or chronic liver, kidney, or cardiovascular diseases; individuals diagnosed with diabetes, Cushing′s syndrome, or congenital adrenal hyperplasia; and those suffering from metabolic disorders such as bulimia nervosa, polycystic ovary syndrome, liver and kidney failure, or neurological and psychiatric illnesses. Additionally, individuals taking hormonal therapies, anticonvulsants, non-steroidal anti-inflammatory drugs, corticosteroids, cyproheptadine, antipsychotics, sodium valproate, tricyclic antidepressants, or lithium were excluded. Participants who could not maintain regular consumption of the beverage or who used other herbal products during the study were also excluded.

Hormonal assay

A total of 10 mL of venous blood was drawn from each participant while seated. Serum levels of TSH and T_4 hormones were measured both before and after the one-month beverage consumption period. To prepare the serum, blood samples were allowed to stand at room temperature for 10 min, then centrifuged at 1500 rpm for 10 min. The serum samples were either used immediately or stored for no more than seven days at –20°C. Serum T_4 concentrations were measured using the radioimmunoassay (RIA) method, while TSH levels were determined using immunoradiometric assay (IRMA)[26].

Statistical analysis

All experimental procedures were performed in triplicate. Statistical analysis was conducted using SPSS software version 19. The results are presented as mean ± standard deviation. Independent samples t-tests were used to compare mean values between two groups, while one-way analysis of variance (ANOVA) was employed to assess differences across more than two groups. Duncan′s multiple range test was applied at a 95% confidence level to determine significant differences among means. Microsoft excel (2021) was used for graph preparation.

Results

Examining the biochemical characteristics of the extracts

The concentrations of ascorbic acid, total phenolic content (TPC), and total flavonoid content (TFC) in the prepared plant extracts are presented in Table 1, while DPPH radical scavenging activity is illustrated in Fig. 1. Among the extracts, pumpkin exhibited the

Table 1 — Comparison of ascorbic acid content, TPC and TFC between plant extracts

Extracts	Ascorbic acid (mg/100mL)	TPC (mg GAE/100g)	TFC (mg QU/100g)
Pumpkin	13.29^{a**}± 98.66	0.00^{a}± 1.66	0.01^{b}± 0.38
Red cabbage	9.06^{d}± 15.96	0.00^{e}± 1.06	0.00^{b}± 0.37
White cabbage	11.51^{b}± 74	0.02^{b}± 1.63	0.00^{a}± 0.42
Broccoli	11.11^{c}± 48.75	0.00^{c}± 1.33	0.00^{b}± 0.37
Cauliflower	9.06^{c}± 53.68	0.00^{d}± 1.11	0.00^{b}± 0.38

[*Three replicates report data as (mean ± SD).**Similar lowercase letters (a-d) in each column indicate no significant difference (P< 0.05) between the data according to Duncan's test]

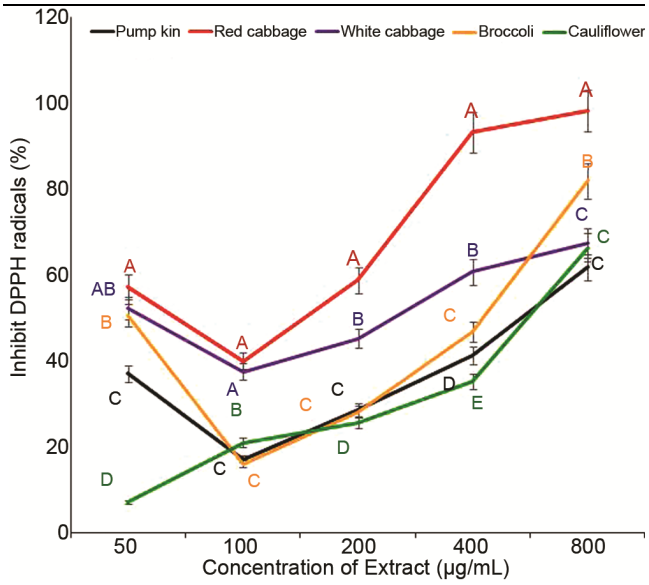

Fig. 1 — Comparison of the ability to inhibit DPPH radicals by hydroethanolic extracts.

highest levels of ascorbic acid and TPC, whereas white cabbage contained the highest TFC. As shown in Fig. 1, DPPH radical inhibition was most pronounced at concentrations of 400 and 800 µg/mL, with red cabbage extract demonstrating the highest antioxidant activity.

Investigating antioxidant, microbial, and sensory properties of beverages

The antioxidant and microbial properties of the formulated beverages are reported in Table 2, and the results of the sensory evaluation are shown in Fig. 2. The data indicate that increasing the concentration of plant extracts enhanced the antioxidant activity of the beverages. However, during the three-month storage period, a significant decrease in the level of active antioxidant compounds was observed ($P < 0.05$), indicating a decline in free radical scavenging potential over time (Table 2).

Table 2 — Examination of the DPPH radical scavenging and total bacterial count of beverages

Beverage	DPPH radical scavenging (%)	
	First time	End of time
Control	ND	ND
Base beverage 1	61.07 ± 0.58 ^{bA**}	50.79 ± 0.96 ^{bB}
Base beverage 2	80.60 ± 0.53 ^{aA}	70.22 ± 1.13 ^{aB}
Apple-Kiwi 1	61.18 ± 0.79 ^{bA}	49.96 ± 1.27 ^{bB}
Apple-Kiwi 2	81.77 ± 0.57 ^{aA}	71.37 ± 1.09 ^{aB}
	Total bacterial count (LogCFU/mL)	
Control	0.67 ± 0.57 ^{aB**}	3.33 ± 0.58 ^{aA}
Base beverage 1	1.00 ± 0.58 ^{aA}	1.67 ± 0.57 ^{bA}
Base beverage 2	1.00 ± 0.00 ^{aA}	1.33 ± 0.57 ^{bA}
Apple-Kiwi 1	0.67 ± 0.57 ^{aA}	1.67 ± 1.15 ^{bA}
Apple-Kiwi 2	1.00 ± 0.00 ^{aA}	1.33 ± 0.57 ^{bA}

[*Three replicates report data as (mean ± std. Dev). **Similar lowercase letters (a-b) in each column and similar capital letters (A-B) in each row indicate no significant difference ($P< 0.05$) between the data according to Duncan's test]

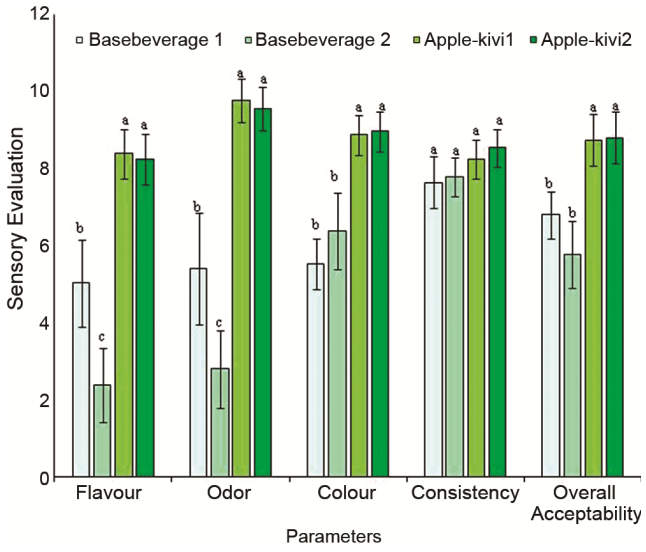

Fig. 2 — Sensory evaluation of beverages during storage.

Microbiological analysis revealed that, after ninety days of storage, the microbial content of the extract-containing samples did not differ significantly from that observed on the first day ($P > 0.05$), suggesting microbial stability. Sensory evaluation showed that both apple-kiwi beverages received the highest scores across all sensory attributes. Notably, significant differences were found between these flavoured beverages and the two basic formulations in all evaluated parameters except for consistency ($P < 0.05$) (Fig. 2).

Biochemical tests to measure serum levels of TSH and T_4 hormones

Individual serum TSH values generally exhibited a slight decreasing trend after 30 days of herbal beverage consumption, although inter-individual variability was observed (Fig. 3A). The mean TSH level decreased modestly from pre- to post-consumption, but this change was not statistically significant ($P > 0.05$) (Fig. 3B). Similarly, individual serum T4 values showed an overall increasing trend following the intervention period (Fig. 3C), with the mean T4 level rising slightly after 30 days, albeit without statistical significance ($P > 0.05$) (Fig. 3D). Importantly, TSH values remained within the normal reference range (0.32–5.2 mIU/mL), and T4 levels stayed within the clinically acceptable range for adults (4.7–5.12 µg/dL), indicating that regular consumption of the herbal beverage did not adversely affect thyroid hormone homeostasis.

Discussion

Thyroid disease refers to a dysfunction of the thyroid gland, which may result in the overproduction or underproduction of thyroid hormones[27]. A decline in thyroid hormone levels triggers increased synthesis of thyrotropin-releasing hormone (TRH) by the hypothalamus, which in turn stimulates the anterior pituitary to secrete thyroid-stimulating hormone (TSH). TSH promotes the production and release of thyroid hormones from thyrocytes. Thyroid hormones, particularly thyroxine (T_4), are secreted following the proteolysis of thyroglobulin (Tg), with T_4 being the predominant form released by the thyroid gland. Given the central role of these hormones in metabolism, it is essential to monitor factors that may

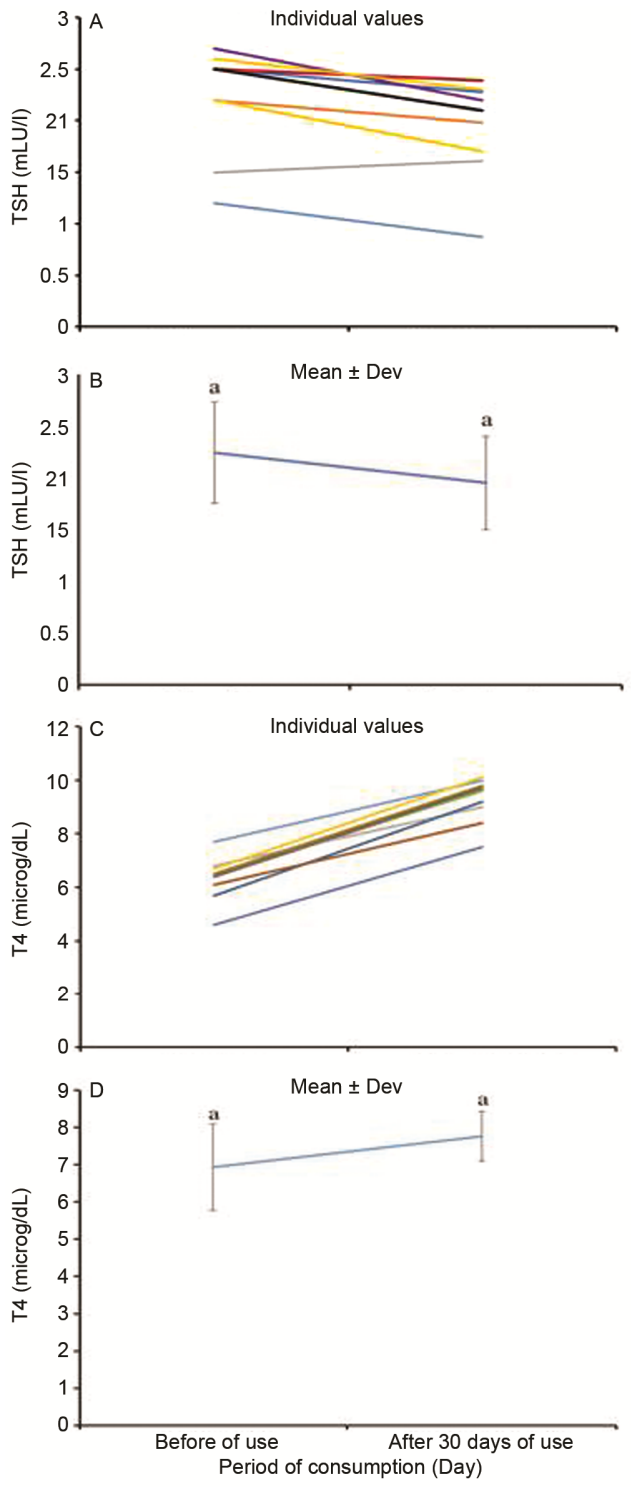

Fig. 3 — Individual and mean (± Dev) values of TSH (A and B) and T_4 (C and D), respectively, before and after 30 days of consumption of an apple-kiwi beverage containing 800 µg/mL extract.

influence TSH and thyroid hormone levels, particularly among vulnerable populations such as individuals with thyroid disorders and pregnant women[28]. T_4 levels are commonly used as a diagnostic indicator for thyroid disorders, reflecting the concentration of circulating thyroxine. In a previous study, it was shown that the consumption of Brassica vegetables, particularly when accompanied by adequate iodine intake, did not negatively affect thyroid function and may have helped regulate TSH levels[29].

In the present study, a non-significant increase in serum T_4 levels was observed following one month of consumption of a herbal beverage composed of red cabbage, white cabbage, broccoli, cauliflower, and pumpkin extracts. Concurrently, TSH levels remained within the normal physiological range (0.32–2.5 mU/L). These findings suggest that the beverage did not disrupt thyroid homeostasis and may support thyroid function without adverse effects. The observed trend toward increased T_4 suggests potential stimulation of thyroid activity, possibly due to the bioactive compounds present in the beverage.

According to Latifi *et al*., hydroethanolic and aqueous extracts of pumpkin are rich in various bioactive components, including phenolic compounds, tocopherols, ascorbic acid, and phthalates. Specifically, 5,2-dichlorophenol and the phthalate compounds diethyl phthalate and dibutyl phthalate were identified as constituents of pumpkin extract, all of which are known for their biological activity[30]. Similarly, phytochemical analyses of Cruciferae family plants have confirmed the presence of terpenoids, alkaloids, tannins, steroids, and saponins. Gas chromatography–mass spectrometry (GC-MS) analyses have revealed a diverse array of antioxidant compounds in these plants, including γ-sitosterol, dimethyl trisulfide, campesterol, hexadecenoic acid, stigmasterol, and vitamin E[31]. The abundance of such bioactive antioxidants may contribute to improved thyroid function by mitigating oxidative stress and enhancing the physiological activity of thyroid hormones. These findings are supported by several studies[32-35].

TSH, secreted by the anterior pituitary, plays a crucial role in regulating thyroid hormone synthesis and secretion. Therefore, maintaining balanced levels of TSH and thyroid hormones is vital, as significant deviations can result in serious health consequences. With the increasing interest in using medicinal plants, fruits, and vegetables for the prevention and treatment of diseases, numerous studies have highlighted the role of plant-derived compounds in modulating thyroid function. Phenolic compounds, for instance,

act as effective antioxidants by neutralising reactive oxygen species, while flavonoids may influence thyroid hormone metabolism by inhibiting deiodinase type I activity and interfering with iodine utilisation in thyroid cells. Moreover, steroidal and coumarin compounds have been reported to modulate the thyroid–pituitary axis[36,37].

Some studies demonstrated the effects of medicinal plants on the hypothalamic–pituitary–thyroid axis. For instance, using leaf extracts of *Costus pictus* (commonly known as the "insulin plant") in an experimental model of hypothyroidism significantly increased serum T_3 and T_4 levels while markedly reducing TSH. The findings suggested that plant-derived compounds with antioxidant and hormone-modulating properties could enhance thyroid gland function, which is consistent with the results of the present study[38].

Results from prior research demonstrated that hydroalcoholic extracts of truffle (*Terfezia boudieri*) increased serum T_4 levels and decreased TSH levels in rats. These effects were attributed to the presence of omega-3 like compounds, antioxidants, and essential minerals in the truffle extract[36]. Also, in another study, mice supplemented with Egyptian red cabbage extract exhibited elevated T_4 and reduced TSH levels compared to control animals. The authors attributed these effects to the high content of glucosinolates, polyphenols, carotenoids, phytosterols, flavonoids and alkaloids in red cabbage. These compounds are known for their anti-inflammatory and antioxidant properties[39]. These findings align with the outcomes of the present study, supporting the potential of the formulated beverage to positively influence thyroid function through its rich composition of plant-based bioactive compounds.

In contrast to the favourable outcomes of the present study and the aforementioned research highlighting the beneficial effects of plant-derived compounds on thyroid function, some studies have reported no significant impact of plant consumption on thyroid gland activity. For example, a long-term administration of peanut seed coat (*Arachis hypogaea*) in rats resulted in significant reductions in T_3 and T_4 levels, thyroid enlargement, and inhibition of key thyroid hormone–synthesising enzymes such as TPO and DIO1[40]. These findings highlighted the importance of careful selection of botanical sources in functional formulations to ensure favourable outcomes for thyroid function.

For instance, in a randomised clinical trial investigating the long-term effects of a broccoli extract beverage rich in sulforaphane, 45 female participants consumed the beverage daily for 84 days. Biochemical assessments of thyroid function, including serum levels of thyroid-stimulating hormone (TSH), free thyroxine (fT_4), and thyroglobulin (Tg), as well as markers of thyroid autoimmunity revealed no significant changes compared to baseline, indicating that daily consumption of broccoli extract did not affect thyroid hormone levels or autoimmune status, nor did it cause any adverse effects on thyroid function[6].

The production and regulation of thyroid hormones are tightly controlled by the hypothalamic pituitary thyroid (HPT) axis. Thyrotropin-releasing hormone (TRH), secreted by the periventricular nucleus of the hypothalamus, stimulates the anterior pituitary to release TSH, which in turn promotes the secretion of thyroxine (T_4) from the thyroid gland. A reduction in TSH levels is often attributed to the negative feedback mechanism within the HPT axis, whereby an increase in circulating thyroid hormones suppresses TSH secretion[41]. Therefore, in the present study, the observed decrease in TSH following an increase in T_4 was an anticipated physiological response.

The results of the current investigation demonstrated that consumption of the formulated plant-based beverage over a one-month period led to an increase in serum T_4 levels and a concurrent decrease in TSH levels among both male and female participants. This effect is likely attributable to the presence of a diverse array of bioactive antioxidant compounds in the beverage, derived from red cabbage, white cabbage, broccoli, cauliflower, and pumpkin extracts. These compounds may stimulate thyroid activity, enhance hormone production, and contribute to the observed hormonal changes, supporting the potential role of such functional beverages in maintaining or modulating thyroid function.

In a study in 2019, the antioxidant effects of broccoli (*Brassica oleracea* var. '*italica*') extracts on thyroid function were investigated. The results demonstrated that the consumption of this plant contributed to the regulation of thyroid hormone levels and protected against oxidative damage[42]. Moreover, another study evaluated the antioxidant and anti-inflammatory effects of compounds present in Chinese cabbage (*Brassica rapa* subsp. *pekinensis*) on thyroid function. The findings revealed that consuming this plant supported

the regulation of thyroid hormone levels and reduced oxidative stress[43]. Overall, the formulated plant-based beverage appears to support thyroid function without adverse effects, likely due to its rich content of bioactive antioxidant compounds.

Conclusion

The results of serum analysis for thyroid hormones TSH and T_4 demonstrated that, over the one-month consumption period of the plant-based beverage, T_4 levels increased while TSH levels decreased. Importantly, the levels of both hormones remained within the clinically acceptable range before and after consumption. Overall, these findings suggest that the formulated plant-based beverage, containing 800 µg/mL of extract, may serve as a potential health-promoting product. Its high antioxidant activity, microbial stability, and lack of adverse effects on thyroid function were likely due to the presence of various bioactive compounds, thereby supporting its efficiency as a functional beverage with beneficial physiological effects.

Conflict of interest

The authors declare no conflict of interest.

References

1 Pang KL, Lumintang JN & Chin KY. Thyroid-modulating activities of olive and its polyphenols: A systematic review. *Nutrients*, 13 (2021) 529.

2 Visser TJ. Regulation of thyroid function, synthesis and function of thyroid hormones. In: Thyroid Diseases. Endocrinology. Springer, Cham (2018) 3.

3 Krysiak R, Gilowska M, Szkróbka W & Okopień B. The effect of metformin on the hypothalamic-pituitary-thyroid axis in patients with type 2 diabetes and amiodarone-induced hypothyroidism. *Pharmacol Rep*, 68 (2016) 490.

4 Felker P, Bunch R & Leung AM. Concentrations of thiocyanate and goitrin in human plasma, their precursor concentrations in brassica vegetables, and associated potential risk for hypothyroidism. *Nutr Rev,* 74 (2016) 248.

5 Chan HHL, Ribeiro RV, Haden S & Hirani V. Plant-based dietary patterns, body composition, muscle strength and function in middle and older age: a systematic review. *J Nutr health Aging,* 25 (2021) 1012.

6 Chartoumpekis DV, Ziros PG, Chen JG, Groopman JD, Kensler TW & Sykiotis GP. Broccoli sprout beverage is safe for thyroid hormonal and autoimmune status: Results of a 12-week randomized trial. *Food chem toxicol*, 126 (2019) 1.

7 Fernandes CG, Sonawaneb SK & SS A. Cereal based functional beverages: a review. *J Microbiol Biotechnol Food Sci*, 8 (2021) 914.

8 Uifălean A, Schneider S, Gierok P, Ionescu C, Iuga CA & Lalk M. The impact of soy isoflavones on MCF-7 and MDA-MB-231 breast cancer cells using a global metabolomic approach. *Int J Mol Scie,* 17 (2016) 1443.

9 Munekata PE, Domínguez R, Budaraju S, Roselló-Soto E, Barba FJ, Mallikarjunan K, Roohinejad S & Lorenzo JM . Effect of innovative food processing technologies on the physicochemical and nutritional properties and quality of non-dairy plant-based beverages. *Foods,* 9 (2020) 288.

10 Pineli LdLdO, Botelho RB, Zandonadi RP, Solorzano JL, de Oliveira GT, Reis CEG & Teixeira DdS. Low glycemic index and increased protein content in a novel quinoa milk. *LWT,* 63 (2015) 1261.

11 Gómez-Zorita S, González-Arceo M, Fernández-Quintela A, Eseberri I, Trepiana J, Portillo & MP. Scientific evidence supporting the beneficial effects of isoflavones on human health. *Nutrients*, 12 (2020) 3853.

12 Perez Gutierrez RM. Review of *Cucurbita pepo* (pumpkin) its phytochemistry and pharmacology. *Med chem,* 6 (2016) 1000316.

13 Abed N & Alkalby J. Ameliorative effect of pumpkin seed oil on alterations in thyroid gland functions induced by chlorpyrifos in adult male rats. *Basrah J Vet Res*, 17 (2018) 307.

14 Deng Z, Rong Y, Teng Y, Mu J, Zhuang X, Tseng M, Samykutty A, Zhang L, Yan J, Miller D, Suttles J & Zhang HG. Broccoli-derived nanoparticle inhibits mouse colitis by activating dendritic cell AMP-activated protein kinase. *Mol Ther,* 25 (2017) 1641.

15 Raza A, Hafeez MB, Zahra N, Shaukat K, Umbreen S, Tabassum J & Hasanuzzaman M. The plant family Brassicaceae: Introduction, biology, and importance. The Plant Family Brassicaceae: *Biol Physiol Responses Environ Stres,* (2020) 1.

16 Vega-Galvez A, Gomez-Perez LS, Zepeda F, Vidal RL, Grunenwald F, Mejías N & Ah-Hen KS. Assessment of Bio-Compounds Content, Antioxidant Activity, and Neuroprotective Effect of Red Cabbage (Brassica oleracea var. Capitata rubra) Processed by Convective Drying at Different Temperatures. *Antioxidants,* 12 (2023) 1789.

17 Aziz M & Karboune S. Natural antimicrobial/antioxidant agents in meat and poultry products as well as fruits and vegetables: A review. *Crit Rev Food sci Nutr*, 58 (2018) 486.

18 Seong G-U, Hwang I-W & Chung SK. Antioxidant capacities and polyphenolics of Chinese cabbage (*Brassica rapa* L. ssp. Pekinensis) leaves. *Food Che,* 199 (2016) 612.

19 Chauhan H & Singh M. Phytochemical characterization and antibacterial potential of Indian and Chinese cabbage genotypes against human pathogens in Uttarakhand, India. *Int J Recent Sci Res*. 10 (2019) 36462.

20 Farah HS, Alhmoud JF, Al-Othman A, Alqaisi KM, Atoom AM, Shadid K & AlQaisi T. Effect of pH, temperature and metal salts in different storage conditions on the stability of vitamin C content of yellow bell pepper extracted in aqueous media. *Syst Rev Pharm*, 11 (2020) 661.

21 Hmamou A, Eloutassi N, Alshawwa SZ, Al Kamaly O, Kara M, Bendaoud A & Lahkimi A. Total phenolic content and antioxidant and antimicrobial activities of Papaver rhoeas L. organ extracts growing in Taounate region, Morocco. *Molecules*, 27 (2022) 854.

22 Yusof N, Munaim MA & Kutty RV. The effects of different ethanol concentration on total phenolic and total flavonoid content in Malaysian propolis. *IOP Conf Ser Mater Sci Eng*, 991 (2020) 012033.

23 Gurning K, Lumbangaol S, Situmorang RF & Silaban S. Determination of phenolic contents and antioxidant activity

test of ethanol extract of Sirih merah (Piper crocatum Ruiz & Pav.) leaves using the DPPH method. *J Pendidik Kim*, 13(2021) 137.

24 Saad AM, Mohamed AS, El-Saadony MT & Sitohy MZ. Palatable functional cucumber juices supplemented with polyphenols-rich herbal extracts. *LWT*, 148 (2021) 111668.

25 Mashau ME, Jideani AIO & Maliwichi LL. Evaluation of the shelf-life extension and sensory properties of mahewu–A non-alcoholic fermented beverage by adding Aloe vera (*Aloe barbadensis*) powder. *Br Food J*, 122(2020) 3419.

26 Ghazal K, Brabant S, Prie D & Piketty ML. Hormone immunoassay interference: a 2021 update. *Ann Lab Med,* 42 (2020) 3.

27 Singh D, Alam T, Singh PP, Bhardwaj A & Masud S. Efficacy of feeding of soy fortified Shrikhand as functional food on thyroid hormone (T_3, T_4) and thyroid stimulating hormone (TSH) of rats. *J Pharmacogn Phytochem*, 7 (2018) 671.

28 Babić Leko M, Gunjača I, Pleić N & Zemunik T. Environmental factors affecting thyroid-stimulating hormone and thyroid hormone levels. *Int J Mol Sci*, 22 (2021) 6521.

29 Galanty A, Okoń K, Prochownik E, *et al*. Do Brassica Vegetables Affect Thyroid Function? *Antioxidants*, 13 (2024) 594.

30 Latifi Z, Abediankenari S & Mashayekh A. Comparison of the effect of hydroethanolic and aqueous solvents on functional potential and evaluation of active compounds in pumpkin extract (*Cucurbita moschata*) by GC/MS method. *Food Hyg*, 11 (2021) 37.

31 Panihar N. Preliminary Study of Antioxidant Potential and Gas Chromatography-mass Spectroscopy (GC-MS) Analysis of *Brassica oleracea* Florets. *Int J Green Pharm*, 12 (2018) 02.

32 El Omari N, *et al*. Unveiling the molecular mechanisms: dietary phytosterols and their role in health and disease. *J Food Biochem,* 48 (2024) e13245.

33 Napolitano G, *et al*. Vitamin E supplementation and mitochondria in hyperthyroidism: A protective role against oxidative damage. *Free Radic Biol Med*, 134(2019) 1.

34 Panda S, *et al*. Thyroid inhibitory, antiperoxidative and hypoglycemic effects of stigmasterol isolated from Butea monosperma. *Phytomedicine*, 16(2009) 218.

35 Reza A, *et al*. Antiproliferative and antioxidant potentials of bioactive compounds from marine algae. *J Appl Phycol*, 33(2021) 2735.

36 Zabihi E, Motavallibashi SE, Panahpour H & Sheikhkanloui Milan H. Effect of hydroalcoholic extract of truffle (*Terfezia Boudieri*) on serum level of thyroid hormones in male rats. *J Arak Uni Med Sci*, 22 (2020) 182.

37 Zarei A, Taheri S & Ramazani M. Effect of alcoholic extract of Portulaca Oleracea on serum level of thyroid hormones in hypercholestrolemic Rats. *J Gorgan Univ Med Sci*, 17 (2015) 52.

38 Arunachalam S, Subramanian S, Effect of Costus pictus D. Don leaves on thyroid hormone levels in experimental hypothyroid rats. *Indian J Exp Biol*, 55 (2017) 239.

39 Helal E, El Sayed RA & Ebrahiem S. Effect of Egyptian Red Cabbage on Some Physiological Parameters in Hyperthyroidimic Rats. *Egypt J Hosp Med,* 69 (2017) 2137.

40 Chandra AK, Mondal C, Sinha S, Chakraborty A & Pearce EN. Synergic actions of polyphenols and cyanogens of peanut seed coat (Arachis hypogaea) on cytological, biochemical and functional changes in thyroid. *Indian J Exp Biol,* 53 (2015) 143.

41 Shekar Forosh S, Changizi-AshtiyaniS APB & Attari M. The effect of Physalis alkekengi alcoholic extract on thyroid hormones concentrations in rats. Zahedan *J Res Med Sci*, 13 (2012) 1.

42 Zhao Z, Wang Y, Zhang L, *et al*. Antioxidant and anti-inflammatory activities of broccoli (Brassica oleracea var. italica) extracts. *Antioxidants*, 8 (2019) 225.

43 Seong G-U, Hwang I-W, Chung S-K. Antioxidant capacities and polyphenolics of Chinese cabbage (Brassica rapa L. ssp. Pekinensis) leaves. *Food Chem,* 199 (2016) 612–618.