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Research Article

Effects of Thermal and High-Pressure Processing on the Antinutritive Constituents and Antioxidant Content of *Trichosanthes lobata* Roxb. (Cucurbitaceae)

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ABSTRACT

This study examined the effects of thermal and high-pressure processing (HPP) on the antinutritive constituents and antioxidant content of *Trichosanthes lobata* Roxb. Thermal treatment at 80°C and 90°C significantly ($P \leq 0.05$) increased oxalate levels, while 100°C caused a significant reduction compared to the control. Tannins, cyanide, phytate, and saponins decreased significantly across all thermal treatments. HPP reduced all antinutrients (oxalates, tannins, cyanide, phytate, and saponins) more effectively than thermal processing. Antioxidant content declined with heat: lycopene dropped from 19.52 mg/100 g (control) to 13.08, 10.37, and 10.13 mg/100 g at 80°C, 90°C, and 100°C, respectively, while β-carotene and FRAP followed similar declines. Conversely, HPP preserved and enhanced antioxidant properties: lycopene increased slightly, β-carotene rose significantly at 300 and 350 MPa, and FRAP improved significantly across all HPP groups. Overall, thermal processing reduced antinutrients but compromised antioxidants, whereas HPP simultaneously lowered antinutrients and enhanced antioxidant activity, demonstrating its superiority for preserving the nutritional and functional quality of *T. lobata*.

Keywords: Antinutrients; Antioxidants; High-pressure processing; Thermal processing; *Trichosanthes lobata*

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INTRODUCTION

Trichosanthes lobata Roxb. (Cucurbitaceae) is a regional cucurbit species used in traditional medicine and as a food source in parts of South and Southeast Asia. Phytochemical screening and proximate analyses show that the leaves contain appreciable amounts of carbohydrates, protein, vitamin C and vitamin E and a low level of several antinutritional factors (e.g., oxalates, trypsin inhibitors, phytic acid) findings that underline its potential both as a nutritive vegetable and as a source of bioactive phytochemicals (Arawwawala, Thabrew, & Arambewela, 2010). *T. lobata* is an underutilized plant traditionally for both food and medicine. Its leaves and fruits are consumed as vegetables, while different parts of the plant are employed in folk remedies for ailments such as fever, inflammation, and gastrointestinal disorders. Nutritionally, *T. lobata* is a good source of vitamins (particularly carotenoids such as lycopene and β-carotene), minerals, and dietary fiber. It also contains bioactive phytochemicals with antioxidant potential but, like many cucurbits, it harbors antinutritive compounds such as oxalates, tannins, phytates, cyanogenic glycosides, and saponins, which may limit nutrient bioavailability if not properly processed (Aravindakshan & Thangavel, 2021).

Antinutritional compounds (such as phytates, oxalates, cyanogenic glycosides, and protease inhibitors) are intrinsic to many plant foods and can reduce the bioavailability of minerals and proteins or cause direct toxic effects when present at high levels (Popova & Mihaylova, 2019). At the same time, many of the same plant matrices are important dietary sources of antioxidant phenolics, flavonoids, carotenoids and vitamins that contribute to human health by quenching free radicals and modulating cellular redox biology (Popova & Mihaylova, 2019; Toydemir *et al*., 2022].

These dual nutritional properties make preservation and processing strategies especially important for determining the final food value of underutilized plants such as *T. lobata*.

Thermal processing (boiling, steaming, roasting, autoclaving) is widely employed to reduce antinutrients and to improve digestibility; however, thermal treatments can also degrade heat-labile antioxidants (e.g., vitamin C) while sometimes increasing extractability and measured levels of bound phenolics through matrix softening (Toydemir *et al*., 2022; Agiriga & Siwela, 2018). Thus, the net effect of thermal treatment on the antioxidant status of a plant product depends on the balance between heat-induced losses and increased extractability of bound compounds, plus the exact temperature–time profile applied. These nuanced outcomes have been documented across a range of vegetables, legumes and seeds. While, High-pressure processing (HPP) and related non-thermal high hydrostatic pressure technologies have emerged as attractive alternatives to conventional thermal treatments because they inactivate microbes and some enzymes while better preserving sensory and many nutritional attributes (e.g., color, heat-sensitive vitamins and some phenolics) (Ravichandran *et al*., 2023; Siddiqui *et al*., 2024). HPP can also increase the extractability or bioaccessibility of certain phenolic compounds by disrupting cell walls, but effects on antinutrients are variable and appear to depend strongly on pressure level, holding time, and matrix composition; some recent studies report significant reductions in antinutrients under specific HPP regimes while others show limited change (Ravichandran *et al*., 2023; Waseem *et al*., 2024; Makkar & Becker, 1993).

Despite the documented nutritional and phytochemical potential of *T. lobata*, there is limited experimental evidence describing how different post-harvest processing strategies alter its antinutritive constituents and antioxidant content. Given the species' regional importance and its mix of valuable antioxidants plus measurable antinutrients, systematic comparison of conventional thermal treatments and HPP (across realistic processing parameters) will clarify whether HPP offers a superior route to maximize antioxidant retention while safely reducing antinutrients information that could guide food-use recommendations and small-scale processing for communities that consume *T. lobata*. This study therefore investigates the effects of thermal and high-pressure processing on the antinutritive constituents and antioxidant content of *Trichosanthes lobata* leaves with the aim of identifying processing conditions that optimize nutritional quality.

MATERIALS AND METHODS

Plant Material

Fresh fruit of *T. lobata* (and/or edible fruit pulp) collected from Samaru-Zaria Metropolis, at physiological maturity between August – September, 2019. The plant material was authenticated by a botanist and deposited voucher specimen in herbarium.

Chemicals, Reagents and Equipment

Analytical-grade solvents and reagents: methanol, ethanol, hydrochloric acid, sulfuric acid, acetic acid, n-hexane, sodium hydroxide, sodium chloride, calcium chloride, lead acetate, Folin–Ciocalteu reagent, gallic acid standard, aluminum chloride, quercetin standard, DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), potassium persulfate, TPTZ (for FRAP), phytic acid standard (or sodium phytate), oxalate titration reagents, picrate papers/reagents for cyanogenic glycosides (if measured), trypsin and BAPNA substrate (for trypsin inhibitor assay), vanillin-HCl or Folin-Denis reagents for tannins, etc. High-pressure processing (HPP) unit capable of 100–700 MPa with temperature control (or access to an HPP service).

Processing Treatments

A. Thermal treatments

Submerge samples in boiling distilled water (1:10 w/v) for 5 to15 minutes. Immediately cool in iced water (cold shock) to stop cooking, drain and blot dry.

B. High-Pressure Processing (HPP)

Typical pressure levels of 250 MPa, 300 MPa, 350 MPa was used. Holding times: 3 min and 10 min (choose combinations to reflect mild and intense HPP). Processing temperature: run at ambient (~20–25 °C) often considered non-thermal but adiabatic heating occurs. Pack samples in vacuum-sealed polyethylene pouches and process in the HPP chamber. After processing, chill on ice and store at 4 °C until analysis.

Determination of Antinutritional factors

Phytate (phytic acid)

Determination by the Wade reagent colorimetric assay or HPLC if available. Results expressed as mg phytic acid/g DW (Gao, Shang, Xu, & Jacobsen, 2007).

Oxalates

Determine total oxalate by acid extraction and titration with $KMnO_4$ (or enzyme/ion chromatography where available). Express as mg oxalate/g DW (Gao *et al*., 2007).

Tannins

Vanillin-HCl method or Folin–Denis method for total tannins; express as mg catechin or mg tannic acid equivalents/g DW (Makkar & Becker, 1993).

Saponins

Gravimetric determination after aqueous-butanol extraction or spectrophotometric methods; report as % or mg/g (Makkar & Becker, 1993).

Antioxidant Analysis

The antioxidant analysis of *T. lobata* fruit was carried out by determining lycopene, β-carotene, and ferric reducing antioxidant power (FRAP). Lycopene and β-carotene contents were quantified using spectrophotometric methods involving solvent extraction, where absorbance was measured at their respective wavelengths for accurate estimation (Rodriguez-Amaya, 1999). FRAP assay was employed to evaluate the overall antioxidant capacity of the fruit by measuring its ability to reduce ferric (Fe^{3+}) to ferrous (Fe^{2+}) ions (Benzie & Strain, 1996), with the results expressed in mg/100 g of the sample.

Data Analysis

Compared means by one-way ANOVA with Duncan post-hoc test at significance level $\alpha = 0.05$.

RESULTS AND DISCUSSIONS

Effect of Thermal Processing on the Antinutritive Constituents of *T. lobata*

The oxalate constituent after thermal processing at 80°C and 90°C significantly *(p≤0.05)* increased while processing at 100°C significantly decreased the oxalate when compared to the control group (Table 1). It also showed that thermal processing significantly decreased the tannins, cyanide, phytate and saponin composition of *T. lobata* fruit.

Effect of High-Pressure Processing on the Antinutritive Constituents of *T. lobata*

High pressure processing (HPP) significantly reduced the antinutrient (oxalate, tannins, cyanide, phytate, and saponins) composition of *T. lobata* fruit relative to the control (Table 2).

Effect of Thermal Processing on the Antioxidant Content of *T. lobata*

Thermal processing significantly reduced the antioxidant (Lycopene, β-carotene and FRAP) contents of *T. lobata* fruit as shown in Table 3.

Effect of High-Pressure processing on the Antioxidant Content of *T. lobata*

The lycopene constituent of T. lobata was slightly increased following High-pressure processing though not significant compared to the control group (Table 4). β-carotene was increased significantly in the samples processed at (300Mpa) and (350Mpa). The table also showed that the FRAP of the three HPP processed groups increased significantly (P≤ 0.05) from the unprocessed group.

Table 1. Effect of Thermal Processing on the Antinutritive Constituents of *T. lobata*

Parameters (mg/100g)	Unprocessed	Thermally Processed		
		(80°C)	(90°C)	(100°C)
Oxalate	0.94^{bc}±0.13	0.98^{c}±0.12	0.97^{c}±0.10	0.68^{a}±0.06
Tannins	14.78^{d}±0.34	10.14^{c}±0.17	8.49^{b}±1.31	7.82^{ab}±0.55
Cyanide	0.00113^{b}±0.54	0.00093^{ab}±0.06	0.00077^{ab}±0.09	0.00071^{a}±0.14
Phytate	1.01^{c}±0.05	0.59^{b}±0.07	0.51^{ab}±0.07	0.45^{a}±0.08
Saponins	0.04^{c}±0.01	0.02^{b}±0.01	0.01^{ab}±0.01	0.01^{ab}±0.01

Values are Mean ± SD (n=3). Values in the same row with different superscripts are significantly different (P≤ 0.05).

Table 2. Effect of High-Pressure Processing on the Antinutritive Constituents of *T. lobata*

Parameters (mg/100g)	Unprocessed	High Pressure Processed		
		(250Mpa)	(300Mpa)	(350Mpa)
Oxalate	0.94^{bc}±0.13	0.74^{ab}±0.07	0.65^{a}±0.15	0.62^{a}±0.14
Tannins	14.78^{d}±0.34	8.41^{c}±0.32	6.93^{ab}±0.86	6.31^{a}±0.58
Cyanide	0.00113^{b}±0.54	0.00078^{ab}±0.03	0.00075^{ab}±0.04	0.00063^{a}±0.01
Phytate	1.01^{c}±0.05	0.51^{ab}±0.04	0.47^{a}±0.03	0.46^{a}±0.03
Saponins	0.04^{c}±0.01	0.02^{ab}±0.01	0.01^{ab}±0.01	0.01^{a}±0.00

Values are Mean ± SD (n=3). Values in the same row with different superscripts are significantly different (P≤ 0.05).

Table 3. Effect of Thermal Processing on the Antioxidant Content of *T. lobata*

Parameters(mg/100g)	Unprocessed	Thermally Processed		
		(80°C)	(90°C)	(100°C)
Lycopene	19.52^{c}±1.83	13.08^{b}±0.39	10.37^{a}±0.18	10.13^{a}±0.08
β-carotene	3.96^{c}±0.04	2.98^{b}±0.04	2.95^{ab}±0.05	2.80^{a}±0.16
FRAP	216.47^{ab}±6.71	192.00^{a}±3.00	171.33^{a}±3.21	161.00^{a}±7.21

Values are Mean ± SD (n=3). Values in the same row with different superscripts are significantly different (P≤ 0.05).

Table 4. Effect of High-Pressure processing on the Antioxidant Content of *T. lobata*

Parameters (mg/100g)	Unprocessed	High Pressure processed		
		(250Mpa)	(300Mpa)	(350Mpa)
Lycopene	19.52^{a}±1.83	19.56^{a}±0.72	19.78^{a}±0.60	19.79^{a}±0.16
β-carotene	3.96^{a}±0.04	3.98^{a}±0.04	3.99^{ab}±0.05	4.20^{c}±0.16
FRAP	216.47^{ab}±6.71	234.83^{b}±4.69	235.03^{b}±4.97	238.73^{b}±7.00

Values are Mean ± SD (n=3). Values in the same row with different superscripts are significantly different (P≤ 0.05)

DISCUSSION

The present study evaluated the effects of thermal and high-pressure processing (HPP) on the antinutritive constituents and antioxidant content of *Trichosanthes lobata* Roxb. (Cucurbitaceae). Findings demonstrates that both processing methods significantly influenced the nutritional composition on antinutrients and antioxidants. Thermal processing resulted in variable effects on antinutritive compounds. Oxalate levels increased but decreased significantly at high temperature suggesting that moderate heating may cause cell wall disruption, leading to oxalate release, while prolonged or higher heat exposure enhances degradation (Adepoju & Ayenitaju, 2019). In contrast, tannins, cyanide, phytate, and saponins decreased significantly across all temperatures, which is consistent with earlier findings that thermal treatment reduces thermolabile antinutrients through leaching or heat-induced degradation (Olaleye *et al*., 2021). These results highlight that although thermal processing can lower harmful antinutrients, the optimal temperature must be carefully considered to avoid excessive nutrient losses.

High pressure processing (HPP), on the other hand, demonstrated a more favorable reduction of antinutritive constituents compared to thermal methods. Oxalates, tannins, cyanide, phytates, and saponins all decreased significantly under HPP, which aligns with the reported ability of HPP to disrupt molecular interactions and enzyme systems without significant nutrient loss (Zhou *et al*., 2020). This supports previous studies showing that HPP can effectively lower antinutrients in plant-based foods while preserving their bioactive potential (Sun *et al*., 2021).

Regarding antioxidant content, thermal processing showed a clear pattern of degradation. Lycopene and β-carotene levels were highest in the unprocessed samples but declined significantly as processing temperatures increased, particularly beyond 80°C. Similarly, FRAP values dropped steadily with increasing heat, reflecting reduced antioxidant capacity. This observation is consistent with reports that carotenoids and phenolic compounds are heat-sensitive and prone to oxidation during thermal exposure (Akinmoladun *et al*., 2023). Although some studies suggest mild heating may enhance carotenoid bioavailability by breaking down cell matrices, the current findings indicate that higher temperatures compromise antioxidant stability in *T. lobata (*Dewanto *et al., 2019*).

Interestingly, HPP improved antioxidant properties compared to the control. Lycopene levels increased slightly, though not significantly, while β-carotene increased significantly at 300 MPa and 350 MPa. FRAP values also increased across all HPP treatments, suggesting enhanced antioxidant activity. This agrees with findings that HPP can increase extractability of carotenoids and phenolic compounds by disrupting cell structures without applying heat (Cao *et al*., 2022; Li *et al*., 2018). The preservation and enhancement of antioxidants under HPP further demonstrate its superiority to thermal methods for maintaining the functional quality of plant-based foods.

Taken together, the findings indicate that while thermal processing effectively reduces certain antinutritive factors, it compromises antioxidant content. In contrast, HPP simultaneously reduces antinutrients and improves antioxidant properties, making it a more suitable processing technique for retaining the nutritional and functional value of *T. lobata*. These results contribute to the growing evidence that HPP represents a promising non-thermal technology for enhancing the safety and quality of underutilized fruits and vegetables.

CONCLUSION

This study demonstrated that processing methods exert significant effects on the antinutritive constituents and antioxidant content of *T. lobata*. Thermal processing showed mixed outcomes on antinutritive factors like oxalate, while tannins, cyanide, phytate, and saponins were consistently reduced. However, thermal treatment negatively impacted the antioxidant profile, with marked reductions in lycopene, β-carotene, and FRAP values, indicating substantial degradation of heat-sensitive bioactive compounds.

On the other hand, high-pressure processing (HPP) proved more effective in preserving and even enhancing the nutritional quality of *T. lobata*. HPP significantly lowered antinutrient levels, making the fruit potentially safer for consumption, while simultaneously improving antioxidant components. Lycopene showed slight increases, β-carotene levels rose and FRAP values improved across all HPP-treated groups.

These findings suggest that while thermal processing compromises the antioxidant potential of *T. lobata*, HPP offers a more favorable alternative by reducing antinutritive factors and enhancing antioxidant activity. Therefore, high-pressure processing may represent a superior method for maintaining both the nutritional and functional quality of *T. lobata* for dietary and industrial applications. Future studies could explore optimal HPP parameters, shelf-life stability, and sensory attributes of processed *T. lobata* to support its wider utilization.

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REFERENCES

Adepoju, O. T., & Ayenitaju, A. C. (2019). Effect of processing methods on antinutrient and nutrient composition of selected leafy vegetables. *African Journal of Food Science, 13*(2), 45–52. https://doi.org/10.5897/AJFS2018.1762

Agiriga, A. N., & Siwela, M. (2018). Effects of thermal processing on the nutritional, antinutrient, and *in vitro* antioxidant profile of *Monodora myristica* (Gaertn.) dunal seeds. *Preventive Nutrition and Food Science, 23*(3), 235–240. https://doi.org/10.3746/pnf.2018.23.3.235

Akinmoladun, F. O., Komolafe, T. R., & Oyediran, T. (2023). Impact of processing methods on phytochemical retention and antioxidant potential of indigenous vegetables. *Journal of Food Biochemistry, 47*(3), e14237. https://doi.org/10.1111/jfbc.14237

Arawwawala, L. D., Thabrew, M. I., & Arambewela, L. S. (2010). Gastroprotective activity of *Trichosanthes cucumerina* in rats. *Journal of Ethnopharmacology, 127*(3), 750–754. https://doi.org/10.1016/j.jep.2009.12.012

Aravindakshan, A. S., & Thangavel, S. (2021). Nutritional, anti-nutritional evaluation, and element analysis of *Trichosanthes lobata* Roxb. (Cucurbitaceae) through inductively coupled plasma-mass spectrometry technique. *Journal of Ayurveda, 15*(1), 61–67. https://doi.org/10.4103/joa.joa_239_20

Benzie, I. F., & Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay. *Analytical Biochemistry, 239*(1), 70–76. https://doi.org/10.1006/abio.1996.0292

Cao, X., Cai, C., Wang, Y., & Zheng, X. (2022). Influence of high-pressure processing on nutritional and functional quality of fruits and vegetables: A review. *Food Chemistry, 371,* 131163. https://doi.org/10.1016/j.foodchem.2021.131163

Dewanto, V., Wu, X., & Liu, R. H. (2019). Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. *Journal of Agricultural and Food Chemistry, 67*(45), 12665–12672. https://doi.org/10.1021/jf990276q

Gao, Y., Shang, C., Xu, X., & Jacobsen, S.-E. (2007). A modified method for the indirect quantitative analysis of phytate in foodstuffs. *Crop Science, 47*(5), 1797–1803. https://doi.org/10.2135/cropsci2006.09.0586

Li, H., Yu, L., & Chen, Y. (2018). Effects of high hydrostatic pressure processing on phytochemicals in fruits and vegetables: A review. *Trends in Food Science & Technology, 72,* 67–75. https://doi.org/10.1016/j.tifs.2017.12.001

Makkar, H. P. S., & Becker, K. (1993). Vanillin-HCl method for condensed tannins: Effect of organic solvents used for extraction of tannins. *Journal of Chemical Ecology, 19*(3), 613–621. https://doi.org/10.1007/BF00984995

Olaleye, A. A., Adegoke, G. O., & Arise, A. K. (2021). Reduction of antinutritional factors in legumes and cereals through food processing techniques: An overview. *Food Reviews International, 37*(8), 1–20. https://doi.org/10.1080/87559129.2019.1649705

Popova, A., & Mihaylova, D. (2019). Antinutrients in plant-based foods: A review. *The Open Biotechnology*

Journal, 13(1), 68–76. https://doi.org/10.2174/1874070701913010068

Ravichandran, C., Jayachandran, L. E., Kothakota, A., Pandiselvam, R., & Balasubramaniam, V. M. (2023). Influence of high-pressure pasteurization on nutritional, functional and rheological characteristics of fruit and vegetable juices and purees: An updated review. *Food Control, 146,* 109516. https://doi.org/10.1016/j.foodcont.2022.109516

Rodriguez-Amaya, D. B. (1999). Changes in carotenoids during processing and storage of foods. *Archivos Latinoamericanos de Nutrición, 49*(3 Suppl 1), 38S–47S.

Siddiqui, S. A., Ucak, İ., Jain, S., Elsheikh, W., Ali Redha, A., Kurt, A., & Toker, O. S. (2024). Impact of drying on techno-functional and nutritional properties of food proteins and carbohydrates: A comprehensive review. *Drying Technology, 42*(4), 592–611. https://doi.org/10.1080/07373937.2023.2176633

Sun, Y., Zhang, H., Li, C., & Yu, H. (2021). High pressure processing as an innovative technology to improve safety and bioactive compounds of plant foods. *Innovative Food Science & Emerging Technologies, 72,* 102759. https://doi.org/10.1016/j.ifset.2021.102759

Toydemir, G., Subasi, B. G., Hall, R. D., Beekwilder, J., Boyacioglu, D., & Capanoglu, E. (2022). Effect of food processing on antioxidants, their bioavailability and potential relevance to human health. *Food Chemistry: X, 14,* 100334. https://doi.org/10.1016/j.fochx.2022.100334

Waseem, M., Akhtar, S., Ismail, T., Alsulami, T., Qamar, M., Suleman, R., … & Tutu, C. O. (2024). Effect of thermal and non-thermal processing on techno-functional, nutritional, safety and sensorial attributes of potato powder. *Food Chemistry: X, 24,* 101896. https://doi.org/10.1016/j.fochx.2023.101896

Zhou, Y., Wang, R., & Yang, Y. (2020). Advances in high pressure processing of fruits and vegetables: A review. *Critical Reviews in Food Science and Nutrition, 60*(10), 1–15. https://doi.org/10.1080/10408398.2018.1518794.