Journal of
Plant Development Sciences
Meerut, India

SHORT COMMUNICATION

QUALITY ASSESSMENT OF TRIPHALACHOORNAM: EVALUATION OF HEAVY METAL CONTAMINATION AND MICRONUTRIENT COMPOSITION

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Received-26.05.2025, Revised-10.06.2025, Accepted-24.06.2025

Abstract: Triphalachoornam, a classical Ayurvedic polyherbal formulation composed of the dried fruits of *Emblica officinalis*, *Terminalia bellirica*, and *Terminalia chebula*, is well known for its therapeutic properties. Given increasing concerns over heavy metal contamination in herbal preparations, this study evaluated ten commercial samples of Triphalachoornam for their heavy metal and micronutrient profiles using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). Eleven elements were quantified—six essential micronutrients (Ca, Mg, Fe, Mn, Zn, Cu) and five potentially toxic heavy metals (Cd, Cr, Ni, Pb, Hg)—and compared against WHO/FAO safety limits. Sixty percent of the samples complied with permissible levels, while the remaining 40% exceeded limits for Chromium and Nickel. These findings highlight the need for stringent quality control and regulatory surveillance in the herbal product industry to safeguard consumer health and ensure product integrity.

Keywords: Triphalachoornam, Heavy metals, Micronutrients, Elemental profiling, Herbal formulation safety

INTRODUCTION

Triphalachoornam is a renowned polyherbal Ayurvedic formulation traditionally comprising equal parts of *Emblica officinalis* (Amla), *Terminalia bellirica* (Bibhitaki), and *Terminalia chebula* (Haritaki). As per ancient Ayurvedic texts such as the *Charaka Samhita* and *Sushruta Samhita*, Triphala is reputed for its antioxidant, detoxifying, immunomodulatory, and anti-inflammatory activities (Manjeswar *et al*., 2007; Chouhan *et al*., 2013).

However, growing safety concerns stem from reports of heavy metal contamination in herbal products, attributed to environmental pollution, adulteration, or improper processing (Saper *et al*., 2004; Gupta and Reddy, 2020). Chronic exposure to toxic metals like lead, cadmium, mercury, and nickel poses serious health hazards.

Due to the fruit origin of Triphala, it is also expected to provide beneficial micronutrients. Therefore, this study aims to evaluate both toxic heavy metals and essential elements in ten marketed Triphalachoornam samples using ICP-OES.

MATERIALS AND METHODS

Sample collection

Ten Triphalachoornam samples, including branded and non-branded products, were purchased from local herbal vendors and online sources to represent market diversity. Brand identities were anonymized and coded as TC-01 to TC-10.

Sample preparation

Each sample was oven-dried at 70°C, finely powdered using a stainless-steel grinder, and sieved (0.5 mm mesh). Subsamples (0.5 g) were digested using a diacid mixture (HNO_3: $HClO_4$ = 9:4) by wet digestion. The digested samples were diluted to 50 mL with ultrapure water, filtered, and analyzed using ICP-OES. Quality control included reagent blanks and certified reference materials. Mercury analysis followed a modified ICP-OES method (Erjavec *et al*., 2024).

ICP-OES analysis

Instrument: **Optima 8000, Perkin Elmer**

Operating parameters:

- RF Power: 1500 W
- Plasma Gas Flow: 12 L/min
- Nebulizer Flow: 0.7 L/min
- Auxiliary Gas Flow: 0.2 L/min
- Sample Flow Rate: 1 mL/min

Elemental wavelengths (nm)used:

- Cd: 228.802
- Cr: 267.716
- Pb: 220.353
- Ni: 231.604
- Hg: 253.652

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Other elements (Ca, Mg, Fe, Mn, Zn, Cu) were analyzed as per standard ICP-OES protocols.

RESULTS AND DISCUSSION

Heavy metal contamination

Table .1. Summarizes are elemental concentrations of ten tested samples. According to WHO/FAO guidelines, the permissible limits for toxic elements in herbal products are: Pb<10 mg/kg, Cd <0.3 mg/kg, Cr <2 mg/kg, Ni <1.5 mg/kg, and Hg <0.5 mg/kg (WHO, 2007; Codex Alimentarius, 2003).The study revealed that (Table.1 and Table.2) with respect to the toxic heavy metal content, few samples were safe for consumption but the rest unsafe.

- **Safe Samples**: TC-01 to TC- 06 (60%) complied regulatory standards for heavy metals and hence proved safe for consumption.
- **Non-Compliant Samples:** TC-07 to TC-10 (40%) was unsafe for consumers due to the presence of Cadmium and Nickel above regulatory limits.

Presence of heavy metals in herbal drugs were reported in earlier studies. Variations in mineral concentrations across samples may arise from environmental, geographic, or manufacturing differences. Research done by Kantamreddi *et al*. (2017) used WD-XRF spectrometry to quantify both essential and non-essential elements in 5 commercial Triphalachurna samples and found that lead levels were above permissible limit in some samples. Princy *et al*. (2018) also tested few Triphlachoornam samples and found that they contained lead and cadmium within safe limits. Our findings align with prior reports indicating persistent risks of contamination in commercial preparations.

Micronutrient composition

Essential elements such as **iron (Fe), zinc (Zn), calcium (Ca), magnesium (Mg), manganese (Mn) and copper (Cu)** serve pivotal roles in maintaining human health. They act as cofactors in numerous enzymatic systems, support antioxidant defenses, and contribute to immunological homeostasis. The presence of these micronutrients in Triphalachoornam, due to its fruit ingredients, not only adds to its nutritional value but may also potentiate its traditional therapeutic properties (Tomar, 2006; Tomar, 2022 and Tomar 2024).

Essential elements including Fe, Zn, Ca, Mg, Mn, and Cu were detected in all samples, although concentrations varied significantly—likely reflecting differences in raw material sources and processing. Range of the elemental load is given in Table.1 and as per the profile, highest levels were scored as below.

- **Highest Ca:**In TC-04 (2196 mg/kg)
- **Highest Mg:**In TC-10 (1422 mg/kg)
- **Highest Fe:**In TC-08 (1032 mg/kg)
- **Highest Mn:**In TC-04 (29.8 mg/kg)
- **Highest Zn and Cu:**In TC-01

Kantamreddy *et al*. (2017) studied the elemental profile of five Triphalachoornam samples and found that samples contained Ca (Range:1888-2729mg/kg), Mg (Range 948-998mg/kg), Cu (Range 4.2-7.5mg/kg), Zn (Range 16.1-19.6mg/kg), Mn (Range 22.8 - 45.2mg/kg) and Fe (Range 357-1026mg/kg) in varying amounts. Present study also aligns with this earlier report with variation in contents.

The mineral and heavy metal content of Triphalachoornam reported herein may not be the same as earlier reports because of the variation in the source materials and the analytical procedures employed.

Table 1. Elemental profile of Triphalachoornam samples (mg/kg)

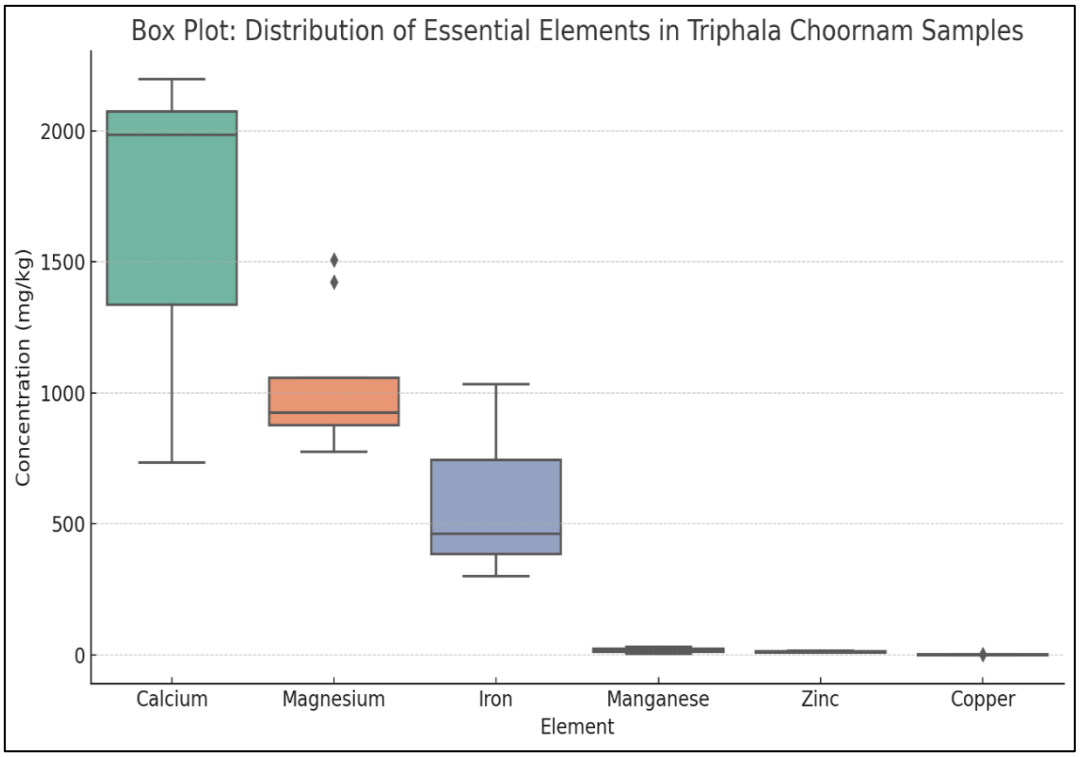
Elements (mg/kg)	WHO/FAO Permissible limit (mg/kg dry weight)	Coded Triphalachoornam (TC)samples										**Range**
		TC-01	**TC-02**	**TC-03**	**TC-04**	**TC-05**	**TC-06**	**TC-07**	**TC-08**	**TC-09**	**TC-10**	
Calcium	NA	2160	1497	1982	2196	2066	2076	735	1284	973	1989	735-2196
Magnesium	NA	870	872	938	1058	909	889	1508	1052	775	1422	775-1422
Iron	NA	368	675	768	1024	451	471	301	1032	387	385	301-1032
Manganese	NA	14.8	14.4	25.8	29.8	29.6	18.2	9.0	13.0	3.6	7.2	3.6-29.8
Zinc	NA	17.0	13.2	9.4	8.8	15.8	14.4	12.8	9.0	10.6	11.2	8.8-17
Copper	NA	1.8	0.6	0.8	BDL	0.4	BDL	BDL	BDL	BDL	BDL	BDL -1.8
Cadmium	<0.3	0.15	0.04	0.08	0.07	BDL	0.30	0.87	0.89	0.99	0.98	BDL-0.99
Chromium	<2	0.15	0.15	0.52	0.62	0.14	0.15	0.23	0.27	0.19	0.46	0.14-0.62
Nickel	<1.5	0.68	0.41	BDL	BDL	0.51	0.54	1.7	2.6	2.1	0.35	BDL-2.6
Lead	<10	8.37	3.9	2.44	7.4	3.96	1.52	3.5	1.8	2.6	BDL	BDL-8.37
Mercury	<0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Note: BDL - Below Detection Limit, NA: not applicable, FAO-Food and agricultural organization

Table 2: Compliance summary of Triphala samples to regulatory limits
This table shows which samples complied or violated permissible limits for heavy metals

Sample Code	Cd	Cr	Ni	Pb	Hg	Status
TC-01	✓	✓	✓	✓	✓	Safe
TC-02	✓	✓	✓	✓	✓	Safe
TC-03	✓	✓	✓	✓	✓	Safe
TC-04	✓	✓	✓	✓	✓	Safe
TC-05	✓	✓	✓	✓	✓	Safe
TC-06	✓	✓	✓	✓	✓	safe
TC-07	×	✓	×	✓	✓	Unfit
TC-08	×	✓	×	✓	✓	Unfit
TC-09	×	✓	×	✓	✓	Unfit
TC-10	×	✓	✓	✓	✓	unfit

Note: ✓ Within permissible limit, × = Exceeds permissible limit



The box plot above gives the distribution of essential elements (Ca, Mg, Fe, Mn, Zn, Cu) across the 10 Triphalachoornam samples. It explains that

- **Iron, Calcium and Magnesium** show wide variability, suggesting different raw material sources or formulation practices.
- **Manganese and Zinc** are moderately variable.
- **Copper** is mostly at or near zero in most samples, with only TC-01 having a significant value.

CONCLUSION

The study revealed that while most Triphalachoornam samples are safe for consumption, a notable proportion (40%) exceeded permissible levels of Chromium and Nickel. The presence of beneficial micronutrients confirms Triphala's nutritional value, though variability in elemental content emphasizes the need for standardization and rigorous quality control. Regulatory oversight and batch-wise testing are essential to ensure consumer safety and maintain the credibility of herbal medicines.

These findings also offer a basis for utilizing Triphala formulations in functional food development or mineral biofortification strategies. Future studies should evaluate pharmacological effects linked to elemental variability and broaden sample coverage for better national-level representation.

ACKNOWLEDGEMENT

Authors are grateful to the financial assistance extended from All India Coordinated Research Project on Medicinal, Aromatic Plants & Betelvine, ICAR-DMAPR, Anand, Gujrath and to Kerala Agricultural University for providing the research facilities.

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