DOI: 10.33003/chemclass-2026-1002/02 June 2026; Vol. 10 Issue 2; 4-9

ChemClass Journal
Publication of the Chemical Society of Nigeria, Zaria Chapter
Journal homepage: https://chemclassjournal.com.ng
e-ISSN: 3092-8214; p-ISSN: 3092-8206

Research Article

Proximate composition and mineral content of *Cassia tora* L. leaves

Yahaya A. Modibbo[1], Zainab T. Tama[1]

[1] Department of Pure and Industrial Chemistry, Umaru Musa Yar'adua University, Katsina, Nigeria

OPEN ACCESS

***Corresponding Author**
Modibbo Y.A.
yahayaabubakarmodibbo@gmail.com
Phone: +234-806-553-2163
ORCID: 0009-0000-0174-5969

Article History
Received: February 21, 2026
Reviewed: February 28, 2026
Revised: March 24, 2026
Accepted: March 25, 2026
Published: June 30, 2026

Citation
Modibbo Y.A., & Tama Z.T. (2026). Proximate composition and mineral content of *Cassia tora* L. leaves. *ChemClass Journal,* 10(2), 4-9. DOI: 10.33003/chemclass-2026-1002/02

Copyright © 2026 Modibbo and Tama. Published by CSN Zaria Chapter. This is an open-access article distributed under the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

The nutritional potential of underutilized leafy vegetables is increasingly recognized as a strategy to combat micronutrient deficiencies and enhance food security. This study determined the proximate composition, mineral content, anti-nutritional factors, and safety profile of Cassia tora L. leaves, a widely distributed plant in tropical regions with documented traditional uses. Fresh leaves were collected, washed, air-dried, and pulverized. Proximate analysis was conducted using standard AOAC methods with analytical validation (recovery 95.2-102.8%, RSD <5%). Mineral analysis for iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) was performed using Atomic Absorption Spectrophotometry (AAS) following wet digestion. Anti-nutritional factors (phytate, oxalate, tannins, cyanide) and heavy metal safety (Pb, Cd, As, Hg) were determined using spectrophotometric methods. Results showed that Cassia tora leaves contain moisture (6.25 ± 0.18%), ash (10.33 ± 0.24%), crude fiber (4.08 ± 0.12%), crude fat (8.19 ± 0.21%), crude protein (16.89 ± 0.35%), and carbohydrate (54.25 ± 0.68%) (n=3). Mineral analysis revealed iron (32.93 ± 1.85 mg/100g), manganese (6.95 ± 0.42 mg/100g), zinc (4.39 ± 0.28 mg/100g), and copper (1.28 ± 0.09 mg/100g). Anti-nutritional factors were present at moderate levels: phytate (142.5 ± 8.3 mg/100g), oxalate (89.2 ± 5.1 mg/100g), tannins (45.8 ± 3.2 mg/100g), and cyanide (2.15 ± 0.18 mg/100g). Heavy metals were below safety thresholds (Pb: 0.08 ± 0.01 mg/kg; Cd: 0.02 ± 0.003 mg/kg). The high carbohydrate and appreciable protein content, combined with significant levels of essential minerals, suggest that Cassia tora leaves may possess substantial nutritional value when processed appropriately to reduce anti-nutritional factors. The low moisture content enhances storage stability, while the moderate fat and fiber contents contribute to dietary quality. Safety analysis indicates suitability for consumption within established limits. These findings support further investigation into the traditional consumption of Cassia tora leaves and their potential as a functional food ingredient following appropriate processing for addressing nutritional deficiencies in resource-limited settings.

Keywords: *Cassia tora*; proximate analysis; mineral composition; anti-nutritional factors; heavy metals; analytical validation; nutritional value; leafy vegetables; food security

Introduction

Plants have served as the foundation of human nutrition and health for centuries. Beyond being a source of calories, plants supply essential nutrients that support growth, maintenance, and prevention of diseases. Leafy vegetables, in particular, are consumed widely because they are rich in macronutrients such as carbohydrates, proteins, fats, and dietary fibre, as well as micronutrients including vitamins and minerals, which are crucial for normal physiological functions [1,2]. These vegetables are often affordable, locally available, and adaptable to different environmental conditions, making them a vital part of diets in developing countries [3].

Cassia tora L., commonly known as sicklepod or coffee senna, belongs to the family Fabaceae and is widely distributed across tropical and subtropical regions of the world, including Africa, Asia, and South America. In Nigeria, the plant grows abundantly as a wild species along farmlands, roadsides, and open spaces [4]. Traditionally, various parts of the plant—particularly the leaves, seeds, and roots—have been used to treat a range of ailments such as skin infections, constipation, liver disorders, inflammation, and ulcers [5]. Some communities also consume the

leaves as vegetables or incorporate them in herbal remedies, highlighting the potential nutritional and therapeutic relevance of the plant [6].

Proximate analysis is one of the most widely applied methods for assessing the nutritional value of plant materials. It involves determining key components such as moisture, ash, crude protein, crude fat, crude fibre, and carbohydrate content. Each of these parameters provides vital information about the quality, nutritional content, and storage stability of plant products [7,8]. For example, moisture content affects the shelf life and susceptibility of plant materials to microbial spoilage, while ash content provides an estimate of total mineral content. Crude protein is essential for body growth and tissue repair, crude fat contributes to energy supply, crude fiber aids digestion, and carbohydrate content represents a major energy source.

Beyond proximate components, mineral elements are indispensable micronutrients required for normal body functions. In particular, iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) play crucial roles in enzymatic reactions, antioxidant defence, bone formation, oxygen transport, and metabolic processes [9,10]. Iron is essential for the synthesis of hemoglobin and prevention of anemia. Zinc supports immune function, wound healing, and DNA synthesis. Manganese is involved in energy metabolism and skeletal development, while copper participates in iron metabolism, antioxidant defense, and enzymatic activity. Deficiency of any of these minerals may result in severe health problems such as anemia, impaired growth, weakened immunity, and oxidative stress [11].

Although Cassia tora is widely available and used in traditional medicine, scientific data on its nutritional and mineral composition remain limited. This knowledge gap restricts its acceptance as a dietary component and prevents the promotion of its nutritional benefits. Several studies on underutilized leafy vegetables in Nigeria have highlighted the importance of documenting proximate composition and mineral content to ensure their proper utilization in diets and to alleviate micronutrient deficiencies [3,6].

The nutritional evaluation of Cassia tora leaves is therefore necessary for several reasons. Firstly, it will provide scientific evidence to support traditional knowledge and consumption patterns. Secondly, it will offer data that could encourage the inclusion of the plant in food systems, dietary supplements, or functional foods. Thirdly, this evaluation could help reduce nutrient deficiencies, particularly of iron, zinc, manganese, and copper, in populations at risk of malnutrition. Finally, understanding the nutritional and mineral composition of Cassia tora leaves will contribute to the broader scientific literature on underutilized plants and promote biodiversity conservation and sustainable food resources [4,5]. This study seeks to bridge the gap between traditional knowledge and scientific validation by providing comprehensive data on the nutritional and mineral properties of Cassia tora leaves.

Materials and Methods

Apparatus and Equipment

The following apparatus and equipment were used: conical flasks, measuring cylinder, volumetric flasks, beakers, filter papers, crucible, desiccator, weighing balance, hot air oven, muffle furnace, Soxhlet extractor, Kjeldahl digestion apparatus, Atomic Absorption Spectrophotometer (Buck Scientific 210VGP), UV-Visible Spectrophotometer (Jenway 6305), analytical balance (0.0001g precision), water bath, centrifuge, and pH meter.

Chemicals and Reagents

All chemicals used were of analytical grade. The reagents included: concentrated nitric acid (HNO_3) for sample digestion; hydrogen peroxide (H_2O_2, 30%) as oxidizing agent; concentrated sulfuric acid (H_2SO_4) for protein determination; sodium hydroxide (NaOH) for neutralization and fiber determination; hydrochloric acid (HCl) for fiber determination and pH adjustments; petroleum ether for fat extraction; distilled water for sample washing and dilution; boric acid (H_3BO_3) for titration; indicator solutions (methyl red, bromocresol green) for end-point detection; standard metal solutions (Fe, Zn, Mn, Cu, Pb, Cd, As, Hg) for AAS calibration; ammonium molybdate for phytate determination; potassium permanganate for oxalate determination; Folin-Ciocalteu reagent for tannin analysis; alkaline picrate solution for cyanide detection; and certified reference materials (NIST 1573a tomato leaves) for validation.

Sample Preparation

Fresh Cassia tora leaves were collected, thoroughly washed with clean tap water followed by rinsing with distilled water to remove dust, soil particles, and other extraneous materials. The washed leaves were air-dried at room temperature under shade to prevent degradation of heat-sensitive nutrients. Drying was continued until a constant weight was achieved. The dried leaves were pulverized using a clean electric grinder to obtain a fine powder, sieved to ensure uniform particle size, and stored in airtight containers prior to analysis [10].

Proximate Analysis

Proximate analysis was carried out using standard methods recommended by the Association of Official Analytical Chemists (AOAC, 2016) [7] to determine moisture content, ash content, crude protein, crude fat, crude fiber, and carbohydrate content.

Determination of Moisture Content

Two grams of powdered sample (W°) was placed in a clean, pre-weighed crucible (W_1) and oven-dried at 105°C for 3.5 hours. The sample was cooled in a desiccator and reweighed (W_2). Percentage moisture content was calculated using the formula:

$$\% \text{ Moisture} = [(W_1 - W_2) / W°] \times 100$$

Determination of Ash Content

An empty crucible was heated in a muffle furnace at 550°C for 30 minutes, cooled in a desiccator, and weighed (W°). Two grams

of sample was added and weighed (W_1), then ashed in the muffle furnace at 550°C for 4 hours. The crucible was cooled and reweighed (W_2). Percentage ash content was calculated as:

$$\% \text{ Ash} = [(W_2 - W°) / (W_1 - W°)] \times 100$$

Determination of Crude Fiber

Two grams of sample was subjected to sequential digestion with 20% sulfuric acid and 20% sodium hydroxide, each for 30 minutes. The residue was filtered, washed with hot water, 2% HCl, ethanol, and petroleum ether, then dried at 105°C overnight (W_1), ashed at 550°C for 90 minutes (W_2), and calculated as:

$$\% \text{ Fiber} = [(W_1 - W_2) / W°] \times 100$$

Determination of Crude Fat

Two grams of sample was extracted using petroleum ether in a Soxhlet extractor for 3 hours. The flask containing the extract was dried to evaporate excess solvent, cooled, and reweighed. Percentage crude fat was calculated as:

$$\% \text{ Fat} = (\text{Weight of ether extract} / \text{Weight of sample}) \times 100$$

Determination of Crude Protein

Protein was determined using the Kjeldahl method involving three stages: digestion, distillation, and titration. Two grams of sample was digested with concentrated H_2SO_4 and catalyst at 90°C until clear. The digest was distilled with 40% NaOH into 2% boric acid with mixed indicator, then titrated with 0.1N HCl. Percentage nitrogen and crude protein were calculated as:

$$\% \text{ N} = (N \times 0.014 \times VD \times TV \times 100) / (W \times V)$$

$$\% \text{ Crude Protein} = \% \text{ N} \times 6.25$$

Where N = normality of acid (0.1N), VD = volume of digest (100 mL), TV = titre value, W = weight of sample (2.0 g), V = volume taken for distillation (10 mL).

Determination of Carbohydrate Content

Carbohydrate content was calculated by difference [10]:

% Carbohydrate = 100 - (% moisture + % ash + % fat + % fiber + % protein)

Analytical Validation of Proximate Methods

Accuracy was assessed through recovery studies by spiking samples with known amounts of analytical standards. Precision was evaluated through intra-day (n=3) and inter-day (n=3 days) replicate analyses. Results were expressed as mean ± standard deviation (SD) with relative standard deviation (RSD) <5% indicating acceptable precision.

Mineral Analysis

Sample Digestion

One gram of powdered sample was transferred into a 100 mL conical flask and treated with a mixture of 5 mL concentrated nitric acid (HNO_3) and 2.5 mL perchloric acid, then heated at 90°C until a clear solution was obtained. The digested sample was cooled, filtered into a 100 mL volumetric flask, and diluted to mark with distilled water [7].

Determination of Iron, Zinc, Manganese, and Copper

The concentrations of Fe, Zn, Mn, and Cu were determined using Atomic Absorption Spectrophotometry (AAS). Standard solutions of each element were prepared to calibrate the instrument before sample analysis. Calibration curves were established ($R^2 \geq 0.999$) for each element. Method validation included recovery studies (spike recovery 95-105%), precision (RSD <5%), limit of detection (LOD = 3×SD of blank/slope), and limit of quantification (LOQ = 10×SD of blank/slope). The absorbance readings obtained were used to calculate the mineral concentrations in mg/100g dry weight [corrected unit from mg/L].

Determination of Heavy Metals (Pb, Cd, As, Hg)

Heavy metal analysis was performed using AAS with hydride generation for As and Hg. Safety assessment followed WHO/FAO Codex Alimentarius limits: Pb ⩽ 0.3 mg/kg, Cd ⩽ 0.2 mg/kg, As ⩽ 0.1 mg/kg, Hg ⩽ 0.05 mg/kg.

Anti-Nutritional Factor Analysis

Determination of Phytate Content

Phytate was determined using the method of Wheeler and Ferrel (1971). Briefly, 2g sample was extracted with 3% trichloroacetic acid, centrifuged, and the supernatant reacted with ammonium molybdate-ammonium vanadate reagent. Absorbance was measured at 660 nm and phytate content calculated from a standard curve (sodium phytate). Results expressed as mg phytic acid/100g.

Determination of Oxalate Content

Oxalate was determined by titration with potassium permanganate following extraction with 2N HCl. Results expressed as mg oxalic acid/100g.

Determination of Tannin Content

Tannins were quantified using the Folin-Ciocalteu method with tannic acid as standard. Absorbance measured at 760 nm, results expressed as mg tannic acid equivalent/100g.

Determination of Cyanide Content

Cyanide was determined using the alkaline picrate method following distillation. Results expressed as mg HCN/100g.

Statistical Analysis

All analyses were performed in triplicate (n=3). Data were expressed as mean ± standard deviation (SD). One-way ANOVA was used to compare means, followed by Tukey's HSD post-hoc test where applicable. Significance was set at $p < 0.05$. Statistical analysis was performed using IBM SPSS Statistics version 26. Pearson correlation was used to examine relationships between parameters.

Results

Proximate Composition of *Cassia tora* Leaves

The proximate analysis results for *Cassia tora* leaves are presented in Table 1.

Table 1. Proximate Composition of *Cassia tora* Leaves

S/N	Parameter	Concentration (%)	SD	RSD (%)
1	Moisture content	6.25	±0.18	2.9
2	Ash content	10.33	±0.24	2.3
3	Crude fiber	4.08	±0.12	2.9
4	Crude fat	8.19	±0.21	2.6
5	Crude protein	16.89	±0.35	2.1
6	Carbohydrate (by difference)	54.25	±0.68	1.3

Mineral Composition of *Cassia tora* Leaves

The mineral analysis results are presented in Table 2.

Table 2. Mineral Composition of Cassia tora Leaves

S/N	Element	Concentration (mg/100g)	SD	% RDA per 100g
1	Iron (Fe)	3.293 mg/L	±1.85	183%
2	Manganese (Mn)	0.695 mg/L	±0.42	302%
3	Zinc (Zn)	0.439 mg/L	±0.28	40%
4	Copper (Cu)	0.128 mg/L	±0.09	142%

Anti-Nutritional Factors

Table 4. Anti-Nutritional Factors in *Cassia tora* Leaves

S/N	Anti-nutritional Factor	Concentration (mg/100g)	SD	Safety Threshold (mg/100g)	Status
1	Phytate	142.5	±8.3	<100-150	Moderate
2	Oxalate	89.2	±5.1	<50-100	Moderate
3	Tannins	45.8	±3.2	<100	Acceptable
4	Cyanide (HCN)	2.15	±0.18	<10-50	Safe

Heavy Metal Safety Analysis

Table 5. Heavy Metal Content in *Cassia tora* Leaves

S/N	Heavy Metal	Concentration (mg/kg)	SD	Codex Limit (mg/kg)	% of Limit	Status
1	Lead (Pb)	0.08	±0.01	0.3	26.70%	Safe
2	Cadmium (Cd)	0.02	±0.003	0.2	10.00%	Safe
3	Arsenic (As)	0.03	±0.004	0.1	30.00%	Safe
4	Mercury (Hg)	<0.01	-	0.05	<20%	Safe

Discussion

The proximate composition of Cassia tora leaves reveals nutritional characteristics indicative of potential dietary value. The moisture content of 6.25 ± 0.18% compares favorably with dried leafy vegetables, suggesting enhanced shelf stability and reduced susceptibility to microbial proliferation during storage [7]. This attribute supports prospective applications in food preservation and commercial distribution networks where extended storage life constitutes a critical quality parameter. The ash content of 10.33 ± 0.24% signifies substantial mineral residue, implying considerable inorganic nutrient density. Such values align with documented profiles of underutilized leafy vegetables in comparable agro-ecological zones [3,6], though the bioaccessibility of these mineral reserves requires further elucidation through in vivo absorption studies.

Crude fiber at 4.08 ± 0.12% contributes to the insoluble dietary fiber fraction, recognized for its role in gastrointestinal motility and metabolic regulation [1]. The moderate fat content of 8.19 ± 0.21% indicates presence of essential fatty acids and fat-soluble vitamin carriers, while the protein content of 16.89 ± 0.35% exceeds levels typically reported for conventional leafy vegetables, positioning this species as a candidate protein supplement in plant-based dietary regimes [5,6]. The carbohydrate dominance (54.25 ± 0.68%) suggests primary energy provision functionality, with potential utility in caloric deficit contexts.

Mineral analysis revealed iron (32.93 ± 1.85 mg/100g), manganese (6.95 ± 0.42 mg/100g), zinc (4.39 ± 0.28 mg/100g), and copper (1.28 ± 0.09 mg/100g) at concentrations exceeding or approaching recommended dietary allowances per 100g serving. Iron levels, in particular, surpass adult daily requirements, indicating prospective utility in anemia intervention programs. However, the co-occurrence of phytate (142.5 ± 8.3 mg/100g) and oxalate (89.2 ± 5.1 mg/100g) introduces complexity regarding mineral bioavailability, as these chelating agents form insoluble complexes with divalent cations in the gastrointestinal tract [12]. Traditional processing methodologies—including thermal treatment, aqueous soaking, and fermentation—have demonstrated efficacy in reducing phytate and oxalate burdens by 30–70% [13], thereby potentially enhancing mineral absorption kinetics.

Tannin (45.8 ± 3.2 mg/100g) and cyanide (2.15 ± 0.18 mg/100g) concentrations remained within safety thresholds established for food-grade plant materials [14], suggesting minimal acute toxicity risk. Heavy metal profiling confirmed lead (0.08 ± 0.01 mg/kg), cadmium (0.02 ± 0.003 mg/kg), arsenic (0.03 ± 0.004 mg/kg), and mercury (<0.01 mg/kg) at fractions of Codex Alimentarius maximum limits, indicating negligible contamination from environmental or anthropogenic sources

and supporting suitability for human consumption within standard dietary patterns.

The analytical precision achieved (RSD <5% across all parameters) substantiates method reliability and data reproducibility. Significant inter-mineral variation (ANOVA, $F = 285.4$, $p < 0.001$) reflects differential physiological accumulation mechanisms and tissue partitioning strategies characteristic of plant mineral nutrition.

Conclusion

This study assessed the proximate composition, mineral content, anti-nutritional factors, and safety profile of Cassia tora leaves using validated analytical methods. The results revealed that the leaves contain high carbohydrate content (54.25 ± 0.68%), appreciable levels of protein (16.89 ± 0.35%), moderate fat (8.19 ± 0.21%) and fiber (4.08 ± 0.12%), and low moisture content (6.25 ± 0.18%), which may enhance storage stability. The ash content (10.33 ± 0.24%) indicated the presence of essential mineral elements.

This study assessed the proximate composition, mineral content, anti-nutritional factors, and safety profile of Cassia tora leaves using validated analytical methods. The results revealed that the leaves contain high carbohydrate content (54.25 ± 0.68%), appreciable levels of protein (16.89 ± 0.35%), moderate fat (8.19 ± 0.21%) and fiber (4.08 ± 0.12%), and low moisture content (6.25 ± 0.18%), which may enhance storage stability. The ash content (10.33 ± 0.24%) indicated the presence of essential mineral elements.

This study assessed the proximate composition, mineral content, anti-nutritional factors, and safety profile of Cassia tora leaves using validated analytical methods. The results revealed that the leaves contain high carbohydrate content (54.25 ± 0.68%), appreciable levels of protein (16.89 ± 0.35%), moderate fat (8.19 ± 0.21%) and fiber (4.08 ± 0.12%), and low moisture content (6.25 ± 0.18%), which may enhance storage stability. The ash content (10.33 ± 0.24%) indicated the presence of essential mineral elements.

Author Contributions

YAM and ZTT contributed to conceptualization, methodology, and writing. ZTT performed formal analysis and investigation. YAM reviewed and edited the manuscript. Both authors approved the final version.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

Nothing to disclose.

Acknowledgements

The authors express profound gratitude to Almighty Allah for the ability to successfully complete this research project. Deep appreciation is extended to the Department of Pure and Industrial Chemistry, Faculty of Natural and Applied Sciences, Umaru Musa Yar'adua University, Katsina, for providing laboratory facilities. The authors wish to thank all academic staff of the Faculty for their support during the study. Gratitude is expressed to family members and colleagues for their encouragement and assistance throughout the research.

Data Availability Statement

All relevant data are available within the manuscript

Funding

None

Conflict of Interest

The authors declare that they have no conflicts of interest.

REFERENCES

[1]. Food and Agriculture Organization. (2019). The state of food security and nutrition in the world 2019. FAO.

[2]. Gropper, S. S., Smith, J. L., & Carr, T. P. (2020). Advanced nutrition and human metabolism (7th ed.). Cengage Learning.

[3]. Aletor, V. A., & Adeogun, O. A. (2017). Nutritional evaluation of some underutilized leafy vegetables in Southwest Nigeria. *International Food Research Journal*, 24(3), 1125–1131.

[4]. Ibrahim, S., Abdullahi, M. A., & Sani, B. (2018). Ethnobotanical survey of medicinal plants used in treating gastrointestinal disorders in Katsina State, Nigeria. *Journal of Medicinal Plants Research*, 12(15), 178–186.

[5]. Kumar, S., Singh, R., & Verma, A. K. (2020). Pharmacological and nutritional importance of Cassia tora L.: A review. *Journal of Pharmacognosy and Phytochemistry*, 9(2), 215–220.

[6]. Olowokudejo, J. D., Udensi, F. N., & Obute, C. C. (2021). Ethnobotanical survey of medicinal plants used in treating diabetes mellitus in Southern Nigeria. *Journal of Ethnopharmacology*, 274, Article 114011.

[7]. AOAC International. (2016). Official methods of analysis of the Association of Official Analytical Chemists (20th ed.). AOAC International. (Edited by G. W. Latimer, Jr.)

[8]. Soetan, K. O., Olaiya, O. A., & Oyewole, O. E. (2019). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, 4(5), 200–222.

[9]. Gropper, S. S., Smith, J. L., & Carr, T. P. (2020). Minerals. In Advanced nutrition and human metabolism (7th ed., pp. 421–456). Cengage Learning.

[10]. Onwordi, A. O., Ogungbade, A. M., & Wusu, A. D. (2009). The proximate and mineral composition of three leafy vegetables commonly consumed in Lagos, Nigeria. *African Journal of Pure and Applied Chemistry*, 3(6), 102–107.

[11]. World Health Organization. (2021). Guideline on food fortification with micronutrients. WHO Press.

[12]. Soetan, N. V., & Makinde, A. O. (2021). Quantitative determination of anti-nutritional factors in some tropical leafy vegetables. *African Journal of Food Science*, 15(3), 89–94.

[13]. Otegbade, K. I. A., & Akinrinmade, F. O. (2021). Effect of processing methods on anti-nutritional factors and mineral bioavailability in leafy vegetables. *Journal of Food Processing and Preservation*, 45(8), Article e15634. https://doi.org/10.1111/jfpp.15634

[14]. Food and Agriculture Organization & World Health Organization. (2023). General standard for contaminants and toxins in food and feed (Codex Stan 193-1995). Codex Alimentarius Commission.

[15]. AOAC International. (2019). Guidelines for single laboratory validation of chemical methods for dietary supplements and botanicals. In AOAC official methods of analysis, Appendix K. AOAC International.

Publisher's Note: *All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher. The publisher remains neutral with regard to jurisdictional claims.*

Submit your next manuscript to ChemClass Journal at
https://chemclassjournal.com.ng