


# Biochemical and Nutritional Characterization of *Cymbopogon citratus* (DC.) Stapf Leaves

Assetou Kamissoko<sup>1\*</sup>, Zoumana Traore<sup>2</sup>, Mamadou Abdoulaye Konaré<sup>3</sup>, Keloua Kourouma<sup>4</sup>, Adama Moussa Sakho<sup>1,5</sup>

<sup>1</sup>Department of Chemistry, Gamal Abdel Nasser University, Conakry, Guinea

<sup>2</sup>Centre for Research and Training in Light and Textile Industries, Ségou, Mali

<sup>3</sup>Laboratory of Biosciences and Applications (LBA), University of Sciences, Technologies of Bamako (USSTTB), Bamako, Mali

<sup>4</sup>High School of Tourism and hotel industry, Conakry, Guinea

<sup>5</sup>Laboratory Techniques Department, Mamou Higher Institute of Technology, Mamou, Guinea

Email: \*assetoukamissoko@gmail.com

**How to cite this paper:** Kamissoko, A., Traore, Z., Konaré, M.A., Kourouma, K. and Sakho, A.M. (2026) Biochemical and Nutritional Characterization of *Cymbopogon citratus* (DC.) Stapf Leaves. *Food and Nutrition Sciences*, 17, 348-358.  
<https://doi.org/10.4236/fns.2026.173025>

**Received:** February 7, 2026

**Accepted:** March 8, 2026

**Published:** March 11, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).  
<http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

*Cymbopogon citratus* constitutes an important source of energy and is highly valued for its therapeutic properties. In this study, the physicochemical parameters (Dry matter, total ashes) and macronutrients levels of dried leaves were determined using standardized methods. The mineral contents were assessed by X-ray fluorescence (XRF) spectroscopy. The results revealed that the dried leaves of *C. citratus* could be conserved easily based on its relatively low level of moisture ( $11.17\% \pm 1.44\%$ ). Furthermore, the species was found to be rich in proteins ( $9.25\% \pm 0.12\%$ ) and carbohydrates ( $72.37\% \pm 1.39\%$ ). In opposite, lower levels of fats were recorded ( $0.95\% \pm 0.00\%$ ). The spectroscopy highlighted the richness of these leaves in various mineral led by potassium (2.528%), silicon (1.578%), calcium (0.980%), sulfur (0.250%), and phosphorus (0.174%). This study has confirmed the nutritional advantages of *C. Citratus*.

## Keywords

*Cymbopogon citratus*, Physicochemical, Dried Leaves, Nutritional

## 1. Introduction

Adequate nutrition continues to represent a major global public health challenge. In this context, medicinal plants have garnered increasing scientific interest due to their diverse biological activities and their potential applications in both human and animal nutrition. When incorporated into animal feed, these plants may serve as natural growth promoters and probiotics, thereby enhancing animal perfor-

mance and health. Owing to their bioactive constituents, medicinal plants are widely utilized in veterinary and human medicine. In addition, they are considered promising natural alternatives to synthetic pesticides in agricultural production systems, as well as in post-harvest handling and the preservation of food and feed products [1].

Among these species, *Cymbopogon citratus* (DC.) Stapf occupies a prominent position. It is extensively valued by local populations in West Africa, particularly in Guinea, where it is traditionally used for both nutritional and therapeutic purposes. Commonly referred to as lemongrass, *C. citratus* belongs to the family Poaceae, a taxonomic group widely distributed worldwide that comprises more than 635 genera and approximately 9000 species. The genus *Cymbopogon* includes over 140 cultivated species, of which 52 have been reported in Africa, representing nearly 37% of the genus diversity on the continent [2]. *C. citratus* is an aromatic species primarily cultivated for its recognized therapeutic properties [3]. As aromatic and medicinal species, *C. citratus* is potential sources of natural antioxidants due to their content of secondary metabolites such as polyphenols, carotenoids, and essential oils [2] [4] [5]. Certain natural compounds, such as polyphenols, possess strong antioxidant and antibacterial properties. Polyphenols are natural antioxidants and antimicrobial agents present in almost all parts of plants [6]. *C. citratus* is commonly consumed as a tea or infusion prepared from its fresh or dried leaves. It is widely used in various cultures for its health-promoting effects, including stimulating digestion, lowering cholesterol levels, eliminating body toxins, and improving blood circulation. In India, the plant is traditionally used in the management of gastrointestinal disorders. In India, it is traditionally employed for the treatment of gastrointestinal disorders, whereas in China, it is consumed for its anxiolytic properties. In other countries, such as Brazil, it is valued for its antispasmodic, analgesic, and anti-inflammatory effects [7]-[9]. Although *C. citratus* (DC.) Stapf, particularly the variety cultivated in Guinea, is widely used in traditional Guinean medicinal practices in the form of herbal teas due to its moderate cost, its industrial exploitation in the beverage sector. Similar studies have been reported elsewhere, particularly on other varieties of this species, highlighting their interesting profiles in terms of mineral composition, bioactive constituents, and pharmacological activities [10] [11]. The local market remains largely dominated by simple synthetic formulations in the form of decoctions.

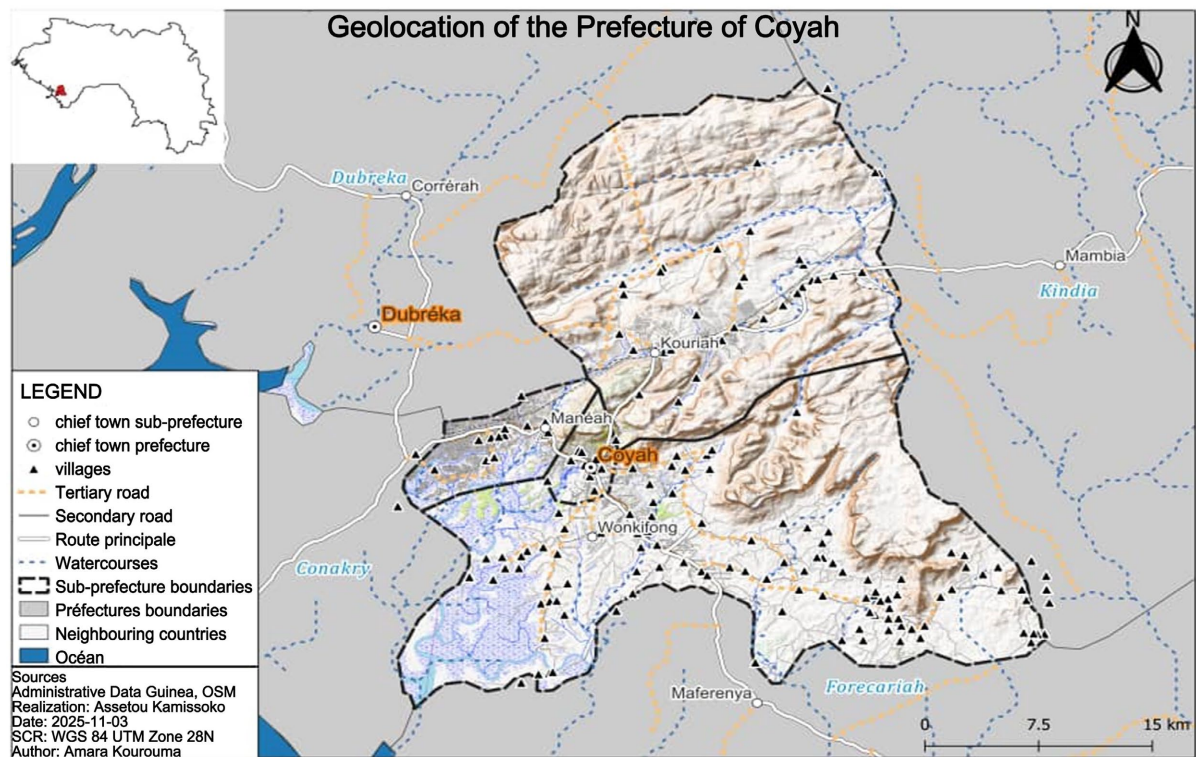
Despite these socioeconomic and therapeutic advantages offered by *C. citratus*, very limited local scientific data on its biochemical and nutritional characteristics are available to the best of our knowledge. To fill this gap, this work aimed to conduct a physicochemical and nutritional analysis of extracts from this variety of *C. citratus* found in the prefecture of Coyah (Republic of Guinea).

## 2. Materials and Methods

### 2.1. Study Area

The Coyah Prefecture, located in western Guinea within the Maritime Guinea nat-

ural region, is part of the Kindia administrative region. It covers an area of approximately 2166 km<sup>2</sup> and lies about 50 km from the capital city, Conakry. Its geographical coordinates are 9°42'N and 13°23'W. In 2016, the population was estimated at 281,757 inhabitants, with a population density of approximately 130 inhabitants per km<sup>2</sup>. The prefecture's administrative and economic center is the town of Coyah. The landscape of Coyah is characterized by mountainous terrain, including Mount Kakoulima, the highest point in the region. Administratively, the prefecture is divided into four sub-prefectures: Coyah-Centre, Kouriah, Manéah, and Wonkifong. The main ethnic groups are the Soussous, Peuls, and Malinkés. Coyah benefits from a strategic location due to its road network connecting Conakry to the inland regions of Guinea and to Sierra Leone (**Figure 1**).



**Figure 1.** Map of Coyah Prefecture (Source: Amara Kourouma).

## 2.2. Study Framework

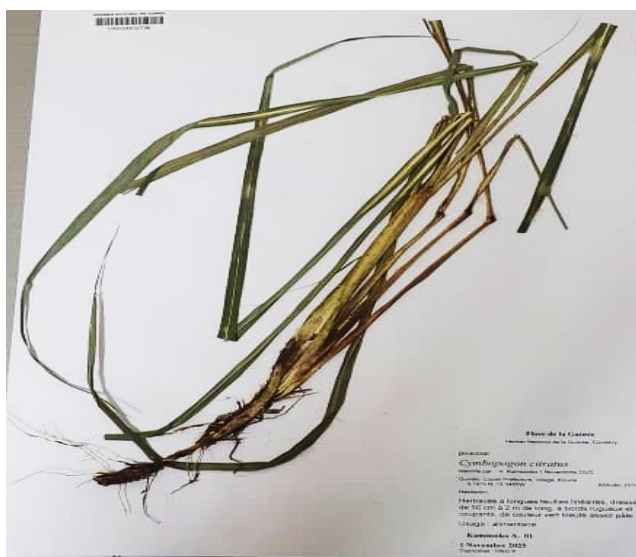
The study was conducted at the Laboratory of Plant and Food Biochemistry and Biotechnologies (LBVA\_B), Faculty of Sciences and Techniques (FST), University of Sciences, Techniques and Technologies of Bamako (USTTB), Bamako, Mali.

## 2.3. Sample Collection

The plant material consisted of *C.citratus* leaves (**Figure 2**) collected in Coyah Prefecture in August 2024. The species was taxonomically authenticated, and a voucher specimen was deposited at the National Herbarium of Guinea under the reference number HNG0002736 (**Figure 3**).



**Figure 2.** Image of *C. citratus*. (Source: Assetou Kamissoko)



**Figure 3.** Image of *C. citratus* specimen. (Source: Assetou Kamissoko)

The collected leaves were air-dried in the shade at ambient temperature (25°C - 30°C) for 10 days. Subsequently, the dried material was pulverized using a Floria® grinder, yielding a fine powder that was employed for extract preparation and all subsequent physicochemical and nutritional analyses.

## 2.4. Determination of Physicochemical Parameters of the Leaves

### ❖ Determination of Dry Matter and Moisture Contents

The determination of moisture content was performed based on the gravimetric loss of mass of a known quantity of powdered sample upon oven drying at 105°C for 24 hours. A test sample (Pe) of 10 g (or 10 mL) was placed in a pre-weighed crucible (P<sub>0</sub>) and subjected to drying in an oven maintained at 105°C for 24 hours. Following oven treatment, the crucible and its contents were cooled in

a desiccator containing a desiccant, such as calcium chloride or phosphorus pentoxide, and subsequently weighed ( $P_1$ ). The moisture content (%) was calculated from the difference in mass before and after drying according to the following equation:

$$\text{Dry Matter (\%)} = \frac{\text{Weight of crucible after oven drying (g)} - \text{Weight of empty crucible (g)}}{\text{Sample weight (g)}} \times 100$$

The moisture content, expressed as a percentage, was calculated using the following formula [11]:

$$\text{Moisture (\%)} = 100 - \text{Dry Matter (\%)}$$

#### ❖ Determination of Total Ash Contents

A test sample ( $P_e$ ) of 10 g was placed in a pre-weighed crucible ( $P_0$ ). The crucible and its contents were then incinerated in a furnace (Vecstar Ltd.) at 550 °C for 3 hours. After cooling in a desiccator containing a desiccant (calcium chloride or phosphoric anhydride), the crucible was weighed again ( $P_1$ ). The ash content was calculated from the mass difference.

$$\text{Ash Mass (g)} = P_1 - P_0$$

The total ash content, expressed as a percentage, was calculated using the following formula [12]

$$\text{Total Ashes (\%)} = \frac{\text{weight of ashes (g)}}{\text{sample weight (g)}} \times 100$$

## 2.5. Determination of Nutritional Composition

#### ❖ Determination of Total Protein Content

The protein content of our samples was determined using the Kjeldahl method [12]:

Approximately 0.2 g of powdered sample was weighed and placed into a 300 ml digestion flask. Then, 5 g of a mixed catalyst and 10 mL of concentrated 0.1 N  $H_2SO_4$  were added. The mixture was digested in a Kjel-Digester (K-446) at 400 °C for 15 minutes. Following digestion, the solution was distilled for 4 minutes using the automatic mode. The distillate was transferred into a beaker under continuous agitation by an HPLC apparatus, which sequentially aspirated 32% NaOH and 4%  $H_3BO_3$  to facilitate nitrogen determination. The nitrogen content obtained was then multiplied by 6.25 (the nitrogen-to-protein conversion factor) to calculate the total protein content of the samples.

The nitrogen content of the sample, expressed as g/100 g, was calculated using the following formula:

$$\text{Nitrogen (\%)} = \frac{(V - V.\text{Blanc}) \times [H_2PO_4] \times 14.0067 \times 0.1}{\text{sample weight (g)}}$$

$$\text{Protein (\%)} = \text{Nitrogen (\%)} \times 6.25$$

- **V:** Volume of  $H_2SO_4$  added;
- **V-blank:** Volume of the blank;

#### ❖ Determination of Total Fat Contents.

Total lipid (fat) extraction was performed according to the AOAC standard method [13]. Briefly, 10g of sample was placed in a tube, and 100 ml of hexane (or petroleum ether) was added. The mixture was vortexed for 5 min and then centrifuged. The supernatant was collected, and the extraction was repeated once more. The combined supernatants were discarded, and the residue was recovered on filter paper. After air-drying for approximately 30 min, the residue was weighed.

$$\text{Total lipid content (\%)} = \frac{\text{sample weight (g)} - \text{Residue weight (g)}}{\text{sample weight (g)}} \times 100$$

#### ❖ Determination of Total Carbohydrate Content

Total carbohydrate content was calculated using the following formula [14]:

$$\% \text{Carbohydrate} = 100 - [\% \text{Moisture} + \% \text{Protein} + \% \text{Fat} + \% \text{Ash}]$$

#### ❖ Determination of Energy Value

The energy value was calculated using the specific Atwater factors for protein, fat, and carbohydrates [15].

$$\text{Energy value (Kcal/100g)} = \text{\%proteins} \times 4 \text{ Kcal} + \text{\%carbohydrates} \times 4 \text{ Kcal} + \text{\%lipids} \times 9 \text{ Kcal}$$

#### ❖ Minerals

Mineral content was determined using X-ray fluorescence (XRF) spectroscopy, a non-destructive analytical technique. Portable analyzers X-50 and X-200 were employed for the measurements.

##### Principle:

X-ray fluorescence (XRF) spectroscopy is an analytical technique used for elemental analysis. In this method, the sample is irradiated with X-rays, causing the ejection of inner-shell electrons from the atoms, a process known as the absorption phase. The resulting electron vacancies create an unstable electronic state, and the atoms undergo electronic rearrangement to restore stability.

## 2.6. Statistical Analyses

Statistical analyses were performed using advanced Excel.

## 3. Results

### 3.1. Sample Quality Control

#### 3.1.1. Physicochemical Characteristics

The results of the physicochemical parameters are summarized in **Table 1**. Mineral elements and their contents are presented in **Table 2**, while the macronutrient contents of *C. citratus* leaves are shown in **Table 3**.

**Table 1.** Physicochemical parameters of *C. citratus* leaves.

Samples	Total Ash (%)	Moisture (%)	Dry Matter (%)
Leaves	6.27 ± 0.12	11.17 ± 1.44	88.83 ± 1.44

### 3.1.2. Nutritional Characteristics

**Table 2.** Mineral element contents.

Mineral Elements		Contents (%)	RDI (g)
Name	Sigles		
Aluminum	Al	0.126	
Arsenic	As	0.004	
Calcium	Ca	0.980	1.30
Chromium	Cr	0.002	
Copper	Cu	0.003	
Iron	Fe	0.061	0.018
Potassium	K	2.528	4.70
Manganese	Mn	0.003	0.42
Molybdenum	Mo	0.006	
Niobium	Nb	0.005	
Nickel	Ni	0.000	
Phosphorus	P	0.174	1.25
Lead	Pb	0.003	
Rubidium	Rb	0.004	
Sulfur	S	0.250	
Silicon	Si	1.578	
Strontium	Sr	0.004	
Tungsten	W	0.001	
Zinc	Zn	0.005	
Zirconium	Zr	0.003	

RDI: Reference Daily Intakes recommendations for adults and children  $\geq 4$  years [15] [16].

**Table 3.** Macronutrient contents of *C. citratus* leaves.

Samples	Total Proteins	Total lipids	Total Carbohydrates	Energy value (kcal/100g)
Leaves	9.25 $\pm$ 0.12	0.95 $\pm$ 0.00	72.37 $\pm$ 1.39	335.02 $\pm$ 6.02
DRV (g)	50	78	275	

\*DRV: Daily reference values based on the reference caloric intake of 2000 calories for adults and children aged 4 years and older [15] [16].

## 4. Discussion

The moisture content of the dried leaves (11.17%) (**Table 1**) indicates that the drying process was generally effective, although it is slightly higher than the optimal threshold for good preservation, typically around 10% [17] [18]. This minor increase in moisture may be attributed to factors such as the initial water content of the leaves, the drying method employed, leaf thickness, drying duration, ambient environmental conditions, or relatively low drying temperatures. The dry mat-

ter content observed in this study ( $88.83\% \pm 1.44\%$ ) is comparable to the value reported by Prince *et al.* [19], confirming a low residual moisture level favorable for post-harvest preservation ( $13\% \pm 2.92\%$ ).

Regarding total ash, the value obtained in this study ( $6.27\% \pm 0.12\%$ ) was slightly lower than that reported by Unuigbe *et al.* [20] ( $7.63\% \pm 0.23\%$ ). This variation may reflect differences in mineral composition or the pedoclimatic conditions of the plant's growth environment. Moderate ash content is generally considered indicative of a balanced mineral composition while limiting excessive accumulation of inorganic compounds [21].

Analysis of mineral elements (Table 2) revealed that *C. citratus* leaves contain significant amounts of essential minerals important for human health. Potassium was the predominant macroelement in this study, with a concentration of  $2.528\% \pm 0.00\%$ , highlighting its essential physiological roles in osmoregulation and nerve impulse transmission [22]. Silicon, the second most abundant element ( $1.578\% \pm 0.00\%$ ), may contribute to the strengthening of plant cell walls, although it is often not included in standard dietary intake assessments. Phosphorus, present at  $0.174\% \pm 0.00\%$ , is crucial for energy metabolism (ATP) and nucleic acid synthesis. Copper, an essential trace element, was detected at  $0.003\% \pm 0.00\%$ , remaining within the required thresholds for enzymatic functions [22]. In contrast, aluminum was present at  $0.126\% \pm 0.00\%$ , which warrants attention as it is not essential to human metabolism and may exert toxic effects when accumulated [23]. Sulfur, a key element involved in the synthesis of sulfur-containing amino acids such as cysteine and methionine, as well as certain B vitamins (B<sub>1</sub> and biotin), was found at 0.250%. This reflects the leaves' richness in sulfur compounds, which may contribute to both their nutritional value and their antioxidant and antimicrobial activities [24]. Calcium, an essential macronutrient involved in cellular signaling, bone metabolism, membrane stability, and blood coagulation [25], was present at 0.980%, indicating a significant nutritional contribution. The total protein content ( $9.25\% \pm 0.12\%$ ) is considerable, suggesting that *C. citratus* leaves could serve as a valuable source of amino acids, particularly for populations relying predominantly on plant-based diets. These protein levels are comparable to those reported by Connor *et al.* [26] for certain edible green leafy vegetables. Combined with their carbohydrate content, these leaves may play an important role in preventing protein-energy malnutrition. Conversely, the low fat content (0.95%) indicates that this plant may be suitable for low-fat dietary regimens.

Overall, these findings demonstrate that *Cymbopogon citratus* leaves possess a balanced nutritional profile, characterized by substantial protein and essential mineral content, while maintaining a low lipid fraction. This nutritional composition underscores their potential as a valuable resource for human nutrition and for agro-food valorization.

## 5. Conclusions

*Cymbopogon citratus* represents a valuable source of essential nutrients and bio-

active compounds, characterized by a physicochemical composition that supports both nutritional and therapeutic applications. Proximate analysis demonstrates a relatively high carbohydrate and protein content, accompanied by a low lipid fraction, thereby conferring appreciable energetic value while maintaining a favorable nutritional profile. Such a composition may be advantageous in the formulation of balanced dietary products aimed at energy supply without excessive fat intake. Beyond its macronutrient composition, *C. citratus* contains significant levels of essential minerals, including calcium, iron, potassium, and phosphorus. These micronutrients play pivotal roles in numerous physiological and metabolic processes. Calcium and phosphorus are essential for bone mineralization and skeletal integrity; iron is fundamental for hemoglobin synthesis and oxygen transport; and potassium contributes to electrolyte balance, neuromuscular function, and blood pressure regulation. The presence of these elements enhances the plant's nutritional relevance and supports its traditional use in phytotherapy.

Moreover, the combined nutritional and mineral profile of *C. citratus*, together with its documented antioxidant potential, strengthens for the development of nutraceutical formulations and functional foods. Its incorporation into dietary interventions could contribute to improving nutritional status, mitigating micronutrient deficiencies, and reducing the risk of pathologies associated with oxidative stress and metabolic imbalance. Consequently, *C. citratus* emerges as a multifunctional botanical resource with significant potential in preventive nutrition and health.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### References

- [1] Aćimović, M., Kiprovski, B. and Gvozdenac, S. (2020) Application of *Cymbopogon citratus* in Agro-Food Industry. *Journal of Agronomy, Technology and Engineering Management*, **3**, 423-436. <https://www.fimek.edu.rs/jatem>
- [2] Machraoui, M., Kthiri, Z., Ben Jabeur, M. and Hamada, W. (2018) Notes ethnobotaniques et phytopharmacologiques sur *Cymbopogon citratus* (D.C.) Stapf. *MaisonAgro-Technologie et Biotechnologie*, **55**, Article No. 5.
- [3] Dabire, T.G., Bonzi, S., Somda, I. and Legreve, A. (2016) Antifungal Activity of *Cymbopogon citratus* (D.C.) Stapf., *Eclipta alba* (L.) Hassk. and *Portulaca oleracea* (L.) Aqueous Extracts against the Main Seed-Borne Fungi of Onion (*Allium cepa* L.) in Burkina Faso. *International Journal of Innovation and Applied Studies*, **17**, 804-812.
- [4] Coulibaly, B., Daou, C., Konaré, M., Samaké, F. and Sanogo, R. (2024) Zonal Effect on the Essential Oil Profile from *Cymbopogon citratus* (Lemongrass) Leaves and *Citrus sinensis* (Orange) Peels Harvesting in Mali. *Journal of Food and Nutrition Sciences*, **12**, 246-254. <https://doi.org/10.11648/j.fns.20241205.16>
- [5] Kamissoko, A., Kourouma, K., Traore, Z., Diallo, A. and Sakho, A.M. (2025) Phytochemical Study and Evaluation of the Antioxidant Activity of *Cymbopogon citratus* by Different Tests (TAC, DPPH, ABTS). *Journal of Agricultural Chemistry and En-*

- vironment*, **14**, 295-306. <https://doi.org/10.4236/jacen.2025.143020>
- [6] Sarr, S., Fall, A., Gueye, R., Diop, A., Diatta, K., Diop, N., *et al.* (2015) Etude de l'activité antioxydante des extraits des feuilles de *Vitex doniana* (Verbenacea). *International Journal of Biological and Chemical Sciences*, **9**, 1263-1269. <https://doi.org/10.4314/ijbcs.v9i3.11>
- [7] Zhou, Q., He, D., Yu, H., Yang, J., Wu, K., Duan, X., *et al.* (2022) Increased Antioxidant and Antimicrobial Activities of Lemongrass and Cinnamon Essential Oils with Tea Polyphenols and Its Application in the Preservation of Marine Fish. *International Journal of Food Science & Technology*, **58**, 3996-4008. <https://doi.org/10.1111/ijfs.16177>
- [8] Kassahun, T., Girma, B., Joshi, R.K., *et al.* (2020) Ethnobotany, Traditional Use, Phytochemistry and Pharmacology of *Cymbopogon citratus*: Review Article. *International Journal of Herbal Medicine*, **8**, 80-87.
- [9] Kusuma, I.Y., Perdana, M.I., Vágvölgyi, C., Csupor, D. and Takó, M. (2024) Exploring the Clinical Applications of Lemongrass Essential Oil: A Scoping Review. *Pharmaceuticals*, **17**, Article No. 159. <https://doi.org/10.3390/ph17020159>
- [10] Miguel, A.E.-E., Sonia, E.P.-D. and Glenda, I.A.-H. (2023) Bioactives of Lemongrass Used in the Industry. *Revista Mexicana de Ciencias Agrícolas*, **14**, 1.
- [11] Nimenibo-Uadia, R. and Nwosu, E.O. (2020) Phytochemical, Proximate and Mineral Elements Composition of Lemongrass (*Cymbopogon citratus* (DC) Stapf) Grown in Ekosodin, Benin City, Nigeria. *Nigerian Journal of Pharmaceutical and Applied Science Research*, **9**, 52-56.
- [12] Konare, M.A., Cisse, C., Diarra, N., Somda, M.K., Wele, M. and Sanogo, R. (2022) Nutritional Composition of Four Underexploited Wild Fruits in Mali. *Food and Nutrition Sciences*, **13**, 26-40. <https://doi.org/10.4236/fns.2022.131004>
- [13] Turner, A.D., Norton, D.M., Hatfield, R.G., Morris, S., Reese, A.R., Algoet, M., *et al.* (2009) Refinement and Extension of AOAC Method 2005.06 to Include Additional Toxins in Mussels: Single-Laboratory Validation. *Journal of AOAC International*, **92**, 190-207. <https://doi.org/10.1093/jaoac/92.1.190>
- [14] Guindo, F., Konaré, M.A., Daou, C. and Kouyaté, A.M. (2022) Influence des Types de Coupe Sur Les Caractéristiques Physico-Chimiques et Organoleptiques Des Feuilles de Baobab. *International Journal of Progressive Sciences and Technologies*, **34**, Article No. 170. <https://doi.org/10.52155/ijpsat.v34.2.4620>
- [15] Food and Drug Administration (FDA) (2012) Recommendations Food Labeling: Revision of the Nutrition and Supplement Facts Labels: Guidance for Industry Small Entity Compliance Guide Office of Nutrition and Food Labeling Nutrition Programs Staff. HFS-830 Center for Food Safety and Applied Nutrition Food and Drug Administration 5001 Campus Drive College Park, MD. <http://www.fda.gov/FoodGuidances>
- [16] Konaré, M., Diawara, Y., Diakité, M., Tounkara, F. and Sissoko, S. (2024) Technological and Nutritional Properties of Four Varieties of Sorghum Grains Used in Mali. *International Journal of Nutrition and Food Sciences*, **13**, 291-305. <https://doi.org/10.11648/j.ijnfs.20241306.16>
- [17] Al-Hamdani, A., Jayasuriya, H., Pathare, P.B. and Al-Attabi, Z. (2022) Drying Characteristics and Quality Analysis of Medicinal Herbs Dried by an Indirect Solar Dryer. *Foods*, **11**, Article No. 4103. <https://doi.org/10.3390/foods11244103>
- [18] Diarra, M.L., Haidara, M., Dénou, A., *et al.* (2019) Physicochemical Control of Leaves of Cultivated *Lippia Chevalieri* Moldenke. *European Scientific Journal*, **15**,

- <http://dx.doi.org/10.19044/esj.2019.v15n33p274>
- [19] Sasu, P., Attah-Kotoku, V., Anim-Jnr, A.S., Osman, A., Adjei, O., Adjei-Mensah, B., et al. (2023) Comparative Nutritional Evaluation of the Leaves of Selected Plants from the Poaceae Family (Bamboos and Grasses) for Sustainable Livestock Production in Ghana. *Frontiers in Sustainable Food Systems*, **7**, Article ID: 1087197. <https://doi.org/10.3389/fsufs.2023.1087197>
- [20] Unuigbo, C., Enahoro, J., Erharuyi, O. and Okeri, H.A. (2019) Phytochemical Analysis and Antioxidant Evaluation of Lemon Grass (*Cymbopogon citratus* DC.) Stapf Leaves. *Journal of Applied Sciences and Environmental Management*, **23**, Article No. 223. <https://doi.org/10.4314/jasem.v23i2.4>
- [21] Rees, W.J. and Sidrak, G.H. (1956) Plant Nutrition on Fly-Ash. *Plant and Soil*, **8**, 141-159. <https://doi.org/10.1007/bf01398816>
- [22] FAO/WHO (2001) Human Vitamin and Mineral Requirements. Report of a Joint FAO/WHO Expert Consultation, Bangkok, Thailand. Food and Agriculture Organization of the United Nations.
- [23] Exley, C. (2003) A Biogeochemical Cycle for Aluminium? *Journal of Inorganic Biochemistry*, **97**, 1-7. [https://doi.org/10.1016/s0162-0134\(03\)00274-5](https://doi.org/10.1016/s0162-0134(03)00274-5)
- [24] Takahashi, H., Marsolais, F., Cuypers, A. and Kopriva, S. (2023) Sulfur Metabolism: Actions for Plant Resilience and Environmental Adaptation. *Journal of Experimental Botany*, **74**, 3271-3275. <https://doi.org/10.1093/jxb/erad164>
- [25] Wdowiak, A., Podgórska, A. and Szal, B. (2024) Calcium in Plants: An Important Element of Cell Physiology and Structure, Signaling, and Stress Responses. *Acta Physiologiae Plantarum*, **46**, Article No. 108. <https://doi.org/10.1007/s11738-024-03733-w>
- [26] Balfany, C., Gutierrez, J., Moncada, M. and Komarnytsky, S. (2023) Current Status and Nutritional Value of Green Leaf Protein. *Nutrients*, **15**, Article No. 1327. <https://doi.org/10.3390/nu15061327>