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# Determination of mineral composition of traditional plant-based bicarbonates: A case study of *Eicchornia crassipes*, *Elaeis guineensis*, and *Musa x paradisiaca*

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**ABSTRACT**

Poor nutrition can lead to malnutrition due to micronutrient deficiencies, posing serious public health issues. Promoting traditional foods is one approach, with a sustainable impact on addressing micronutrient deficiencies, being explored in the Democratic Republic of Congo. This study aimed to determine and compare the mineral profile of three types of traditional bicarbonate produced from the leaves and spadices of the oil palm (*Elaeis guineensis*), the leaves of the water hyacinth (*Eicchornia crassipes*), and the peels of plantains (*Musa x paradisiaca*). Samples were analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES). Data analysis revealed that these three types of traditional bicarbonate have notable mineral contents, with varying levels of calcium, sulfur, magnesium, iron, zinc, manganese, and copper. The noteworthy concentrations of these nutritionally relevant minerals suggest that these three types of traditional bicarbonate could serve as good sources of essential minerals for preventing malnutrition due to micronutrient deficiencies and potentially helping prevent non-communicable chronic diseases.

**Keywords:** Malnutrition, Traditional bicarbonate, Minerals, Democratic Republic of the Congo

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## Introduction

The food history of the Democratic Republic of Congo reflects a rich of culinary practices shaped by various cultural contexts (Bonkena *et al.*, 2018). Before colonization, dietary customs varied across regions and ethnic groups, influenced by natural environments—such as forests, savannas, and water bodies—highlighting local cultural distinctions (Mbiye *et al.*, 2015; Ngbolua *et al.*, 2021). However, the colonial era marked the beginning of intensified cultural mixing driven by urbanization, the rise of the middle class, and the influence of Western dietary practices (WHO, 2013; Kabena *et al.*, 2020). This shift often led to the abandonment of traditional recipes and ingredients, particularly among the elite and urban populations (Bonkena *et al.*, 2018; Mukuta *et al.*, 2017).

A striking example of this transition is the gradual replacement of traditional bicarbonate, produced from plant ashes, with synthetic alternatives (Plumey, 2018). Used in local dishes to tenderize meats or for its medicinal properties, this traditional bicarbonate has recently garnered renewed interest, especially due to its potential richness in micronutrients (WHO, 2020; CAADP, 2013).

Studies report a "hidden hunger" caused by micronutrient deficiencies, affecting 30% of the global population through iron-deficiency anemia and 20% with zinc deficiency (Menga *et al.*, 2023, 2021; Mbaye, 2019). In the DRC, iron deficiencies reportedly affect 50% of women and children (Menga *et al.*, 2023). Some researchers attribute these deficiencies to abandoning traditional foods, which historically contributed to our ancestors' resilience against certain diseases (Mbemba, 2013; Kabena *et al.*, 2024).

This study aims to analyze the mineral composition of three types of traditional Congolese bicarbonate derived from plant substrates such as palm leaves, water hyacinth, and plantain peels. By exploring their potential role in combating micronutrient deficiencies, this research seeks to contribute to preserving and valorizing this local knowledge (WHO, 2013; Katunda *et al.*, 2023).

## Materials and Methods

### *Drying and calcination of samples*

Samples from these three species were dried separately in the open air under sunlight for 20 days, then traditionally calcined in a pot over high heat until ash was obtained. After cooling, these samples were separately packed in containers and coded for further analysis.

### *Chemical analysis by ICP-OES*

The ICP analysis was conducted following the method detailed by (AOAC, 2019).

*Principle*

In Optical Emission Spectrometry, one approach for wet metal analysis begins with the sample being heated and mineralized with hydrochloric and nitric acids. The sample is then filtered, and quantification is performed using an inductively coupled plasma optical emission spectrometer (ICP-OES). Plasma is generated by induction within a torch placed inside a coil and initiated with an electric discharge, producing free electrons and argon ions. These ions are subjected to the magnetic field generated by the induction coil. Electrons accelerate in the magnetic field, creating an induced current.

Collisions with ions sustain the plasma, causing atomization, excitation, and ionization of the sample, which is introduced into the plasma. Metals are atomized at temperatures up to 10,000 K, emitting light energy at wavelengths specific to each element. This emitted light is dispersed by a diffraction grating, and its intensity is measured using a solid-state multi-channel detector. Element concentrations in solution are determined by comparing the light intensities of the sample with those of standard solutions. Results are then reported as mg/kg of the sample.

*Working conditions*

Analyses were conducted under the following ICP-OES conditions:

- Instrument: ICP-OES
- Power: 1500 W
- Plasma gas flow rate: 8 L/min
- Nebulizer flow rate: 0.70 L/min
- Auxiliary gas flow rate: 0.2 L/min
- Plasma combustion height: 5–22 mm
- Reading time: 1–5 s (max 45 s)
- Flow time: 1 s (max 10 s)
- View: Radial

*Preparation of ash solution*

- Dissolve the ash obtained in 2 mL of concentrated $HNO_3$, then heat gently for 1 min.
- Cool, filter through Whatman No. 42 filter paper into a 50 mL volumetric flask, and bring to volume with triple-distilled water.
- Prepare a blank using a similar experimental procedure. Maintain three replicates of each species analyzed.

*Mineral analysis*

Calibration of the ICP-OES was conducted using a working standard prepared from a commercially available multi-element standard solution 3, at two concentrations (1 mg $L^{-1}$ and 2.5 mg $L^{-1}$). The appropriate wavelength, gas flow, plasma stabilization, and other ICP-OES parameters for each metal/mineral were selected, with measurements taken within the linear range of the working standards used for calibration.

## Results and Discussion

Although needed only in trace amounts, minerals and trace elements are essential and play roles in various metabolic reactions and hormonal activities that support proper bodily functions. This study explored the mineral benefits humans may obtain through the consumption of traditional bicarbonates.

ICP-OES analyses revealed the presence of several minerals and trace elements in different samples of these traditional bicarbonates, as outlined in Tables 1 and 2.

Table 1. Mineral contents in different bicarbonate samples (ppm).

| Elements | B.El | B. Mu | B.Ei |
|---|---|---|---|
| Ca | 50003.1 | 23301.1 | 2792 |
| S | 4857.61 | 5171.36 | 4807 |
| Mn | 424.83 | 449.36 | 582 |
| Na | - | - | 9091 |

*Legend*:

- *B. El: Bicarbonate from the leaves and inflorescences of oil palm (Elaeis guineensis)*
- *B. Mu: Bicarbonate from plantain banana peels (Musa paradisiaca)*
- *B. Ei: Bicarbonate from water hyacinth leaves (Eichhornia crassipes)*
- *nd: Not determined*

Table 1 shows that the three types of traditional bicarbonate contain notable concentrations of calcium (Ca), sulfur (S), and manganese (Mg), with the sodium (Na) content only present in bicarbonate derived from water hyacinth leaves.

Table 2. Trace element contents in different bicarbonate samples (ppm).

| Chemical elements | B. E1 01 | B. Mu 02 | B. Ei 03 |
|---|---|---|---|
| Fe | 5572.82 | 2371.06 | 31770 |
| Cu | 63.36 | 63.41 | 40 |
| Mn | 424.83 | 449.36 | 582 |
| Zn | 197.9 | 244.716 | 231 |

*Legend: Same as above.*

Table 2 demonstrates that the three types of traditional bicarbonate contain trace elements in varying concentrations, with significant differences observed for iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu).

***Calcium Content***

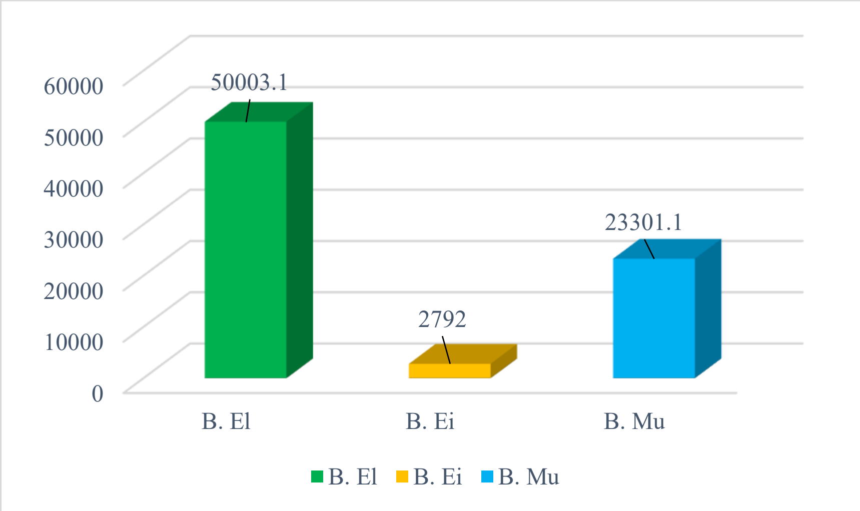


Fig. 1. Calcium Content in Traditional Bicarbonates.

Calcium is a major component of bones and teeth, playing roles in muscle contraction, blood coagulation, cell exchanges, membrane permeability, hormone release, and nerve impulse transmission (Mbemba, 2013). Figure 1 indicates that bicarbonate derived from oil palm leaves and inflorescences contains a notably higher calcium level, followed by the plantain banana peel bicarbonate, while water hyacinth-based bicarbonate shows the lowest concentration.

***Magnesium Content***

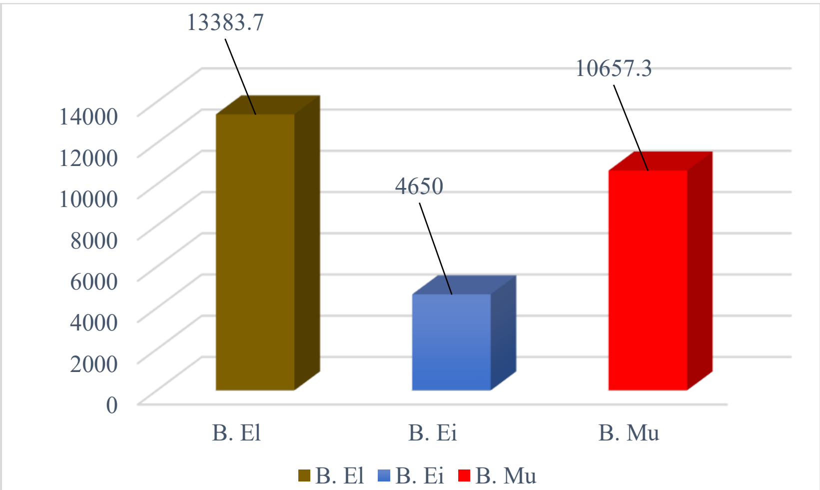


Fig. 2. Magnesium Content in Traditional Bicarbonates.

Magnesium is essential for intracellular enzymatic reactions and is also involved in neuromuscular transmission. Deficiency or excess magnesium can cause fatigue, bloating, discomfort, hypertension, tingling, and cramps. The recommended daily intake (RDI) is 300 mg or 6 mg $kg^{-1}$ of body weight, with higher needs for pregnant women, athletes, those with depression, and more (Lewis, 2022). The magnesium content is highest in oil palm-based bicarbonate, followed closely by plantain peel bicarbonate, with water hyacinth-based bicarbonate containing the lowest amount.

**Sulfur Content**

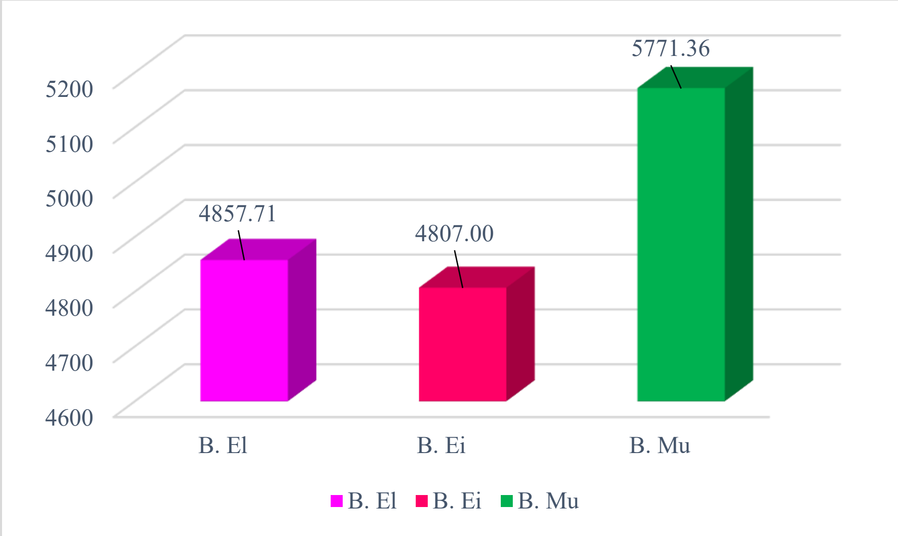


Fig. 3. Sulfur Content in Traditional Bicarbonates.

Sulfur is critical in protein structure through disulfide bonds and is a detoxifying agent, as it conjugates with toxic compounds. It is provided by cystine, cysteine, and methionine in mammals, and by sulfates in plants, which convert it into sulfur-containing amino acids before incorporating it into various organic molecules (Mbemba, 2013). Figure 3 shows that sulfur levels in all three bicarbonates are similar.

***Iron Content***

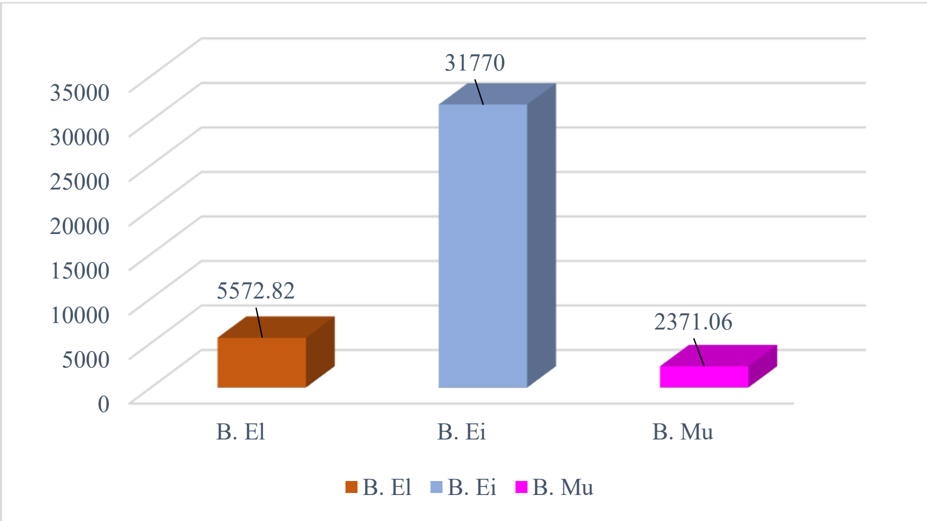


Fig. 4. Iron Content in Traditional Bicarbonates.

Iron is a component of heme proteins like haemoglobin and cytochromes. It is recycled from red blood cell breakdown and is more susceptible to deficiency in women, particularly during menstruation and pregnancy. Low iron can impair oxygen transport, causing fatigue, decreased intellectual performance, and, in severe cases, anemia. Pregnant women are particularly vulnerable (Mbemba, 2013). Figure 4 indicates that water hyacinth-based bicarbonate has the highest iron content, followed by oil palm-based bicarbonate, with plantain peel bicarbonate showing the lowest amount.

***Zinc Content***

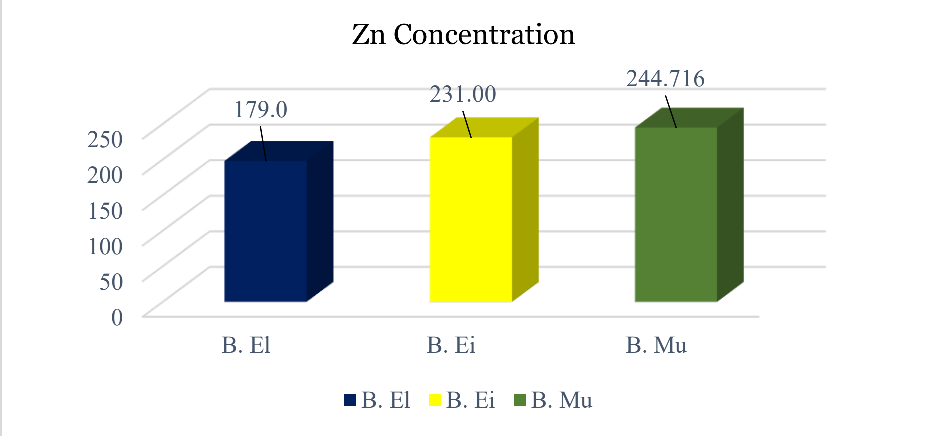


Fig. 5. Zinc Content in Traditional Bicarbonates.

Zinc is vital for immune function, protein synthesis, DNA creation, and enzyme activation. It serves as a cofactor for many enzymes and acts as a neurotransmitter. Zinc deficiency can lead to stunted growth, diarrhoea, impotence, hair loss, skin and eye lesions, appetite loss, immune decline, and in severe cases, stunted growth in children (Mbemba, 2013). Figure 5 shows a slightly higher zinc level in plantain peel-based bicarbonate compared to water hyacinth-based bicarbonate, while oil palm-based bicarbonate has the lowest zinc content.

***Copper Content***

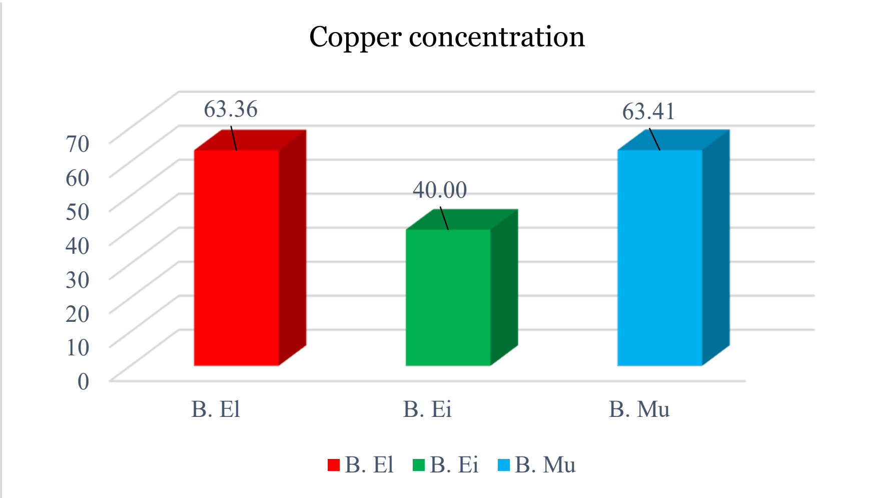


Fig. 6. Copper Content in Traditional Bicarbonates.

Copper is an essential trace element for numerous enzymes, oxygen transport, cartilage maintenance, infection resistance, heart function, and bone health. Foods rich in copper include oysters, liver, chocolate, potatoes, nuts, raisins, lentils, and beans. Copper deficiency is rare but can lead to anemia, osteoporosis, and cardiovascular issues (Mbemba, 2013). Figure 6 shows that the highest copper level is found in plantain peel bicarbonate, with values close to those in oil palm-based bicarbonate. The lowest copper level is observed in water hyacinth-based bicarbonate.

Scheideker *et al.* (1958) found respective values of 2.68%, 1.04%, 0.73%, and 0.37% for Na, K, Ca, and Mg in oil palm leaves, whereas the values in the inflorescences were 0.62%, 0.20%, 0.20%, and 0.09%, respectively. These findings align in some respects with the current study, though calcium content is notably higher here. César *et al.* (2019) reported lower mineral concentrations in water hyacinth leaves and stems than those found in this study, except for Mg and Ca, which had higher values.

To our knowledge, there is limited research on the mineral profile of plantain banana peels. The differences observed may result from genetic, edaphic, climatic, or environmental factors unique to each region.

The presence of these nutritionally significant minerals in substantial amounts across different types of traditional bicarbonates supports the hypothesis that they serve as valuable sources of minerals (Mg, Ca, S) and trace elements (Fe, Zn, Cu). Consequently, they could help prevent deficiencies when consumed, supporting their use in malnutrition prevention and possibly reducing the risk of certain chronic non-communicable diseases due to micronutrient deficiencies.

## Conclusion and perspectives

At the end of this work, it has been demonstrated that the different types of traditional bicarbonate contain interesting levels of micronutrients, particularly mineral elements, making these traditional foods good sources of mineral substances for the prevention of malnutrition due to micronutrient deficiencies and/or the prevention of non-communicable chronic diseases. The results obtained indicate more or less considerable differences in concentrations depending on the mineral element measured in the different types of traditional bicarbonate analyzed.

This would justify a diversified use of these different types of traditional bicarbonates to balance mineral intake in dietary habits. In light of these results, nutritional education combined with these traditional knowledge systems would be necessary, especially in urban areas, to preserve traditional eating habits to protect against these chronic non-communicable diseases that are on the rise in poor and/or developing African countries. From a perspective, it would be interesting to continue this study by evaluating their potential biological activities and determining the proportions to use in dish formulations to avoid excessive consumption of these minerals and their health consequences.

### *Conflicts of interest*

The authors report that there is no conflict of interest.

## References

AOAC. 2019. Official Methods of Analysis, 18th Edition, Association of Official Analytical Chemists, Washington, DC, USA. pp. 61-73. https://doi.org/10.1093/jaoac/92.1.61

Bonkena, P., Mbiye, G. and Kavira, M. 2018. Culture et alimentation en RDC: Une A historical and sociological approach. University Presses of Congo, Democratic Republic of the Congo. 39p.

CAADP. 2023. Detailed program for the development of African agriculture. Malnutrition and food security in sub-Saharan Africa. Comprehensive African Agricultural Development Programme, South Africa. 75p.

César, C.O., Bongo, G.N., Freddy, B., Gafuene, G.N. Ngbolua, K. and Kasali, J.L. 2019. Bioaccumulation of heavy metals in *Eichhornia crassipes* used as a potential substrate for the cultivation of edible mushrooms. *Int. J. Life Sci. Engin.* 3(2): 87-95.

Kabena, O.N., Yasombe, Y.K., Amogu, J.J.D. Mubigalo, F.F., Mukania, J.M., Nzembo, F.M., Mpungi, O.K., Asamboa, L.S. and Iteku, J.B. 2024. Micrographic profiling and bio-optimisation of the antibacterial and antioxidant activities of *Solanum lycopersicum* L. (1753) by combining it with *Curcuma longa* L. (1753) extract. *Orapuh J.* 5(2): e1117. https://dx.doi.org/10.4314/orapj.v5i2.17

Kabena, O.N., Nyakembe, N.E., Amogu, J.J.D., Asamboa, L.S., Lengbiye, E.M., Mboloko, J.E., Mpiana, P.T. and Lukoki, F.L. 2020. Spermicidal and antibacterial effects of *Oncoba welwitschii* Oliv. (Salicaceae). *European J. Medi. Plants.* 31(17): 59-67. https://doi.org/10.9734/ejmp/2020/v31i1730336

Katunda, R., Amogu, J.J., Nzundu, J.P., Mukeba, F., Dianzuangani, D., Mutwale, P., Kabena, O. and Lukoki, F. 2023. Phytochemical and mineral profiling of anti-fertilizer plants used by pygmy women in the town of Mbandaka in the Democratic Republic of the Congo: Case of *Ipomoea involucrata* P.Beauv. and *Piptadeniastrum africanum* (Hook.f.) Brenan. *Int. J. Agril. Res. Innov. Tech.* 13(2): 64-69. https://doi.org/10.3329/ijarit.v13i2.70858

Menga, P., Mundabi-fal, I., Amogu, J.J., Ngbolua, J.P.K.N., Makengo, G. and Lukoki, F. 2023. Étude ethno-botanique, chimique et activité glycophage in vitro de *Synsepalum dulcificum* et *S. stipulatum* en RD Congo. *Rev. Mar. Sci. Agron. Vét.* 11(4): 499-507. https://doi.org/10.5281/zenodo.10466506

Lewis, J. 2022. The MSD Manual, 1899 revised in July 2022. pp. 1731–1742.

Mbaye, N. 2019. Micronutrients: Challenges and Solutions for Central Africa. Nutrition Studies. 40p.

Mbiye, G., Ekoko, L. and Mutombo, K. 2015. Culinary Practices in Congo Before Colonization: Current State and Perspectives. Kivu Press. 77p.

Mbemba, F.T. 2013. Aliments et denrées alimentaires traditionnels du Bandundu en R.D. Congo : Répertoire et composition en nutriments. L'Harmattan.

Mukuta, T., Simpson, P.V., Vaughan, J.G., Skelton, B.W., Stagni, S., Massi, M., Koike, K., Ishitani, O. and Onda, K. 2017. Photochemical processes in a rhenium (I) tricarbonyl N-heterocyclic carbene complex studied by time-resolved measurements. *Inorganic Chem.* 56(6): 3404-3413. https://doi.org/10.1021/acs.inorgchem.6b02936

Mutombo, K. 2021. Impact of modernization on traditional culinary practices in the DRC. *African J. Sociol.* 4(1): 41-49.

Ngbolua, J.P.K.N., Molongo, M.M., Libwa, M.T.B., Amogu, J.J.D., Kutshi, N.N. and Masengo, C.A. 2021. Enquête ethnobotanique sur les plantes sauvages alimentaires dans le Territoire de Mobayi-Mbongo (Nord-Ubangi) en République Démocratique du Congo. *Rev. Mar. Sci. Agron. Vét.* 9(2): 259-265.

Plumey, L. 2018. Role of traditional foods in nutrition and health. University Presses of Paris, France. 96p.

Scheideker, D., Chollet, M. and Bouloux, M. 1958. Carbohydrates and mineral elements in the oil palm. *General Rev. Bot.* 65: 186-215.

WHO. 2013. World Health Statistics. World Health Organization of United Nations, Geneva, Switzerland. 172p.

WHO. 2020. WHO Guidelines on physical activity and sedentary behaviour. World Health Organization of United Nations, Geneva, Switzerland. 93p.