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Research Article

Evaluation of the Nutritional Potential of Irvingia Gabonensis Kernels Harvested in Sibiti in the Lekoumou Department of the Republic of Congo

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Abstract

Irvingia gabonensis, commonly known as wild mango, "Peke" or "Mawiki" in the Republic of Congo, is a tropical forest plant also found wild in savannahs. Belonging to the *Irvingiaceae* family, it is used in traditional medicine to treat ailments such as hernias, infertility, and dysentery. In Congo, outside of the main departments where it is found, the plant remains little known to the population and has so far been subject to low consumption. The objective of this study was to promote the value of *Irvingia gabonensis* kernels. A series of analyses were conducted to assess their nutritional potential. These analyses allowed us to determine that the almonds of the fruit of *Irvingia gabonensis* are rich in carbohydrates (50.41%), fat (39.2%), and a little less in proteins (8.33%), with a water content of 2.5%. The analysis of the chemical indices of the oil gave us respectively 4.84 mg KOH/g for the Acid Index, 196.32 mg KOH/g for the Saponification Index, 0.75 meq of O /Kg for the Peroxide Index, 4.1 for the Iodine Index and 191.48 for the Ester Index. The ash content was estimated at 2.06%. Among the minerals identified are Phosphorus: 1.39%, Sodium: 0.04%, Calcium: 0.10%, Magnesium: 0.19%, and Potassium: 0.33%. The calculated energy value is 587.76 Kcal / 100g.

Keywords

Irvingia gabonensis, Nutritional Value, Almonds, Characterization

1. Introduction

The Republic of Congo, with its humid tropical climate and ten million hectares of arable land, is one of the African nations with great potential in both agriculture and forestry. Unfortunately, it is clear that, despite this great potential, the

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country remains dependent on food imports to meet its population's needs.

Indeed, according to GUOT data for the first half of 2024 [1], Congo spends approximately 195.68 billion CFA francs per semester on importing basic necessities, more than 70% of which are foodstuffs.

On the other hand, despite these high imports, numerous food surveys have shown that the Congolese population faces significant difficulties in obtaining healthy and nutritious food. Indeed, according to Ms. Yannick Ariane Rasoarimanana, FAO representative in Congo, nearly 51.7% of Congolese people are exposed to severe food insecurity due to a lack of access to an adequate and balanced diet.

Aware of the precariousness of the situation, fueled among other things by the insufficiency and limited diversity of food resources, the Congolese scientific community is working to find alternatives to the current shortage. That said, in recent years, there has been a renewed interest in unconventional crops, which offer potential benefits both for the development of local populations and for industry [2].

The use of local plants as sources of lipids, proteins, or carbohydrates sometimes leads to rare specimens for in-depth studies. *Irvingia gabonensis*, the subject of our study, is one of the plants that grows wild in Congo-Brazzaville.

Used in traditional medicine as an antidiarrheal and antiulcer agent, the plant is consumed nationwide by only a minority of the population, who incorporate its kernels into some dishes.

A tree of African rainforests [3], *Irvingia gabonensis*, also known as "wild mango," is a tree with juicy and sweet fruit, possessing kernels very rich in mucilaginous substances, hence their use as a thickener for sauces [4-6]. This work aims to contribute to the understanding of the true nutritional potential of *Irvingia gabonensis* kernels in order to encourage their consumption and promotion nationwide.

2. Materials and Methods

2.1. Plant Material

The plant material in our study consists of kernels extracted from the pods of *Irvingia gabonensis*, collected in Sibiti, in the Lékoumou department of the Republic of Congo.

Figures 1, 2, 3 below show the whole fruits, fresh kernels, and dried and then ground kernels of *Irvingia gabonensis*, respectively.

Figure 1. *Whole fruit of I. gabonensis.*

Figure 2. *Fresh almonds of I. gabonensis.*

Figure 3. *Ground almonds from I. gabonensis.*

2.2. Methods

The methods used in this study are described below:

1. Determination of Moisture Content (M) [7]

The moisture content was determined as follows: 2 g of ground almonds extracted from the ripe fruit were placed in a pre-weighed dish and placed in an oven (Memmert, Germany) at 70 C until the mass became constant.

2. Determination of Lipid Content (LPC)

The lipids contained in the dried and ground almonds were extracted using the press method, following the protocol used by Matouba in 2013 [8].

3. Determination of Some Fat (Oil) Characteristics

The acid (AI), iodine (II), peroxide (PI), and saponification (SI) values were determined in accordance with AOAC 969.17, 1997 [9]; AOAC 993.20, 1997 [10]; AOAC 965.33, 1997 [11]; AOAC 920.160, 1997 [12] respectively.

The ester index (EI) was calculated based on the analytical data using the formula: EI = IS – IA (1).

4. Determination of protein content (P) [13]

Approximately 0.1 g of ground almond meal was used to determine the crude protein content based on the Kjeldahl method for determining total nitrogen. The protein content was obtained by multiplying the total nitrogen content by a conventional factor of 6.25.

5. Determination of crude ash and mineral content (C and M) [13]

Two grams of ground and deoiled almond meal were used to determine ash content using the gravimetric method. The samples were incinerated in a muffle furnace at 550 C for 6 hours. The ash content obtained after incineration was then calculated. Phosphorus, calcium, sodium, potassium, and magnesium were measured using the cold colorimetric method, atomic absorption spectrometry (AAS), and flame emission spectrometry.

6. Determination of Total Carbohydrate (G) Content [13]

Carbohydrate (G) content was estimated using the difference method. According to this method, it was calculated by subtracting the sum of moisture (M), fat (F), protein (P), and ash (A) contained in the sample from 100.

7. Determination of Energy Value (EV)

The total energy value was calculated using the method of Manzi (1999) cited by Diallo Koffi et *al.* in 2015 [14].

It was determined using the following formula: EV (Kcal/100g) = (CHO x 4) + (CL x 9) + (CP x 4) with CHO =% carbohydrate, CL =% fat, and CP =% protein.

3. Results and Discussion

3.1. Results

The table below summarizes all the results obtained after analyzing *Irvingia gabonensis* kernels.

Table 1. *Average physicochemical composition of Irvingia gabonensis kernels.*

Water content	**2.5 ±0.03%**
Fats content	39.2 ±0.5%
Proteins content	8.33 ±0.09%
Ashs content	2.06% ±0.03
Carbohydrates content	50.41% ±0.06
Energy value	587.76 Kcal/100g

Ash analysis identified the following mineral elements: phosphorus, sodium, calcium, magnesium and potassium. The results are: Phosphorus: 1.39%, Sodium: 0.04%, Calcium: 0.10%, Magnesium: 0.19%, and Potassium: 0.33%.

The results of the characterization of *Irvingia gabonensis* kernel oil are shown in the table below:

Table 2. *Chemical index of Irvingia gabonensis kernel oil.*

Acid Number (mg KOH/g of oil)	**4.84±0.51**
Saponification index (mg KOH/ g of oil)	196.32±0.18
Peroxide index (meq of O2/kg of oil)	0.75±0.01
Oil index	4.1±0.01%
Calculated ester index	191.48

3.2. Discussion

1. Water Content

The water content of the *Irvingia gabonensis* kernels studied was estimated at an average of 2.5%. This value is relatively low compared to those obtained by Ejiofor et *al.* in 1987 (11.90%) [15], Ibezim 2015 (8.28%) [16], and Ezeabara and Ezeani in 2016 (11.54%) [17]. This may be explained by the fact that the seeds were stored for approximately three months at room temperature before analysis, thus causing natural drying.

The water content obtained, however, is quite close to that found by Eka 1980 (2.10%) [18], as well as Elah 2010 [19], and Ogunsina et *al.* in 2012 [20], both of whom obtained 2.55%. These authors report having purchased the analyzed kernels in state markets, which makes the hypothesis of natural drying plausible. However, since the moisture content of fresh kernels generally varies between 10 and 14%, it is necessary to dry them beforehand after harvesting for better preservation.

2. Lipid Content and Chemical Indices

The various tests conducted to determine the lipid content of the *Irvingia gabonensis* kernels studied yielded an average value of 39.2% ±0.5. This result falls within the range proposed by Silou et *al.* in 2004 [2] and Matos et al. in 2009 [21], who found 36.75% and 34.55%, respectively. The superiority of our result (39.2%) compared to these authors can be explained by the force applied at the time of pressing and the quality of the device used. It should be noted that this value (39.2%) obtained using the press extraction method indicates a much higher actual oil content. Indeed, in general, press extraction is recognized as the least profitable method compared to the various other methods. Statistical data generally show a gap of at least 20% between press extraction and organic solvent extraction using the Soxhlet. This is the case, for example, of the data obtained by I. A. AMOUKOU et *al.* in 2013 [22] on *Sesamum indicum* L. oil, which had an average rate of 28.05% for the manual press, compared to 50.20% for the organic solvent method; a gap of approximately 22%. The results of oil extraction from *Irvingia gabonensis* using organic solvents obtained by E. DAHOUENON-AHOUSSI et *al.* in 2012 (65.45% ± 2.53) [23], Idowu et *al.* in 2013 (67.69%) [24] and Ibezim in 2015 (69.34%) [16] corroborate this argument.

The oil content obtained by pressing in this work is slightly higher than that of some conventional oilseed varieties such as peanuts 37.9 to 56.3% [25] and 18% for palm oil [26].

The results relating to the chemical indices of the oil from *Irvingia gabonensis* almonds demonstrate interesting potential. The Acid Index obtained in this work (4.84 ± 0.51 mg KOH/g) is relatively close to that of Matos et *al.* in 2009 (4.68 mg KOH/g) [21] who worked on almonds of the same origin as ours. A substantially identical result was obtained by Etong et *al.* in 2014 (4.70 mg KOH/g) [27]. On the other hand, much lower values (2.72 mg KOH/g) were obtained by Ogunsina et *al.* in 2012 [20] as well as Okoronkwo et *al.* in 2014 (3.18 mg KOH/g) [28]. Concerning the peroxide value, the data obtained (0.75 meq of O /Kg) were lower than those of Matos et al. in 2009 (1.90 meq of O /Kg), Etong et *al.* in 2014 (1.80 meq of O /Kg), Okoronkwo et *al.* in 2014 (2.67 meq of O /Kg). This result indicates a low oxidation state of the analyzed oil.

The saponification (196.32 mg KOH/g) and iodine (4.1) indices were lower than those of Matos et *al.* 2009 (199.50 mg KOH/g and 4.30), Ogunsina et *al.* in 2012 (256.50 mg KOH/g and 8.20), Okoronkwo et al. 2014 (230.95 mg KOH/g and 13.40). The values obtained are higher than the saponification indices of conventional commercial oils such as soybean (189 - 195 mg KOH/g), peanut (187 - 196 mg KOH/g) and cotton (189 - 198 mg KOH/g) [29] of type C18. These data are compatible with the composition of C12:0 and C14:0 fatty acids, known to enhance the foaming character highly sought after in detergents and soap making. [30].

The calculated Ester index (191.48) is lower than that of Nakavoua et *al.* in 2023 (236.11) [31].

All these results make *Irvingia gabonensis* a real asset for the food sector, particularly in the production of fats. Indeed, due to its high oil content and relatively high saponification and ester indices, *Irvingia gabonensis* has good potential and can be used in oil mills as a raw material for the production of vegetable oil for food and cosmetic use.

However, due to the solid nature of its oil at room temperature, extraction by mechanical press can only be profitable if the oil's fluidity is guaranteed until packaging.

3. Protein Content

The kernels of the *Irvingia gabonensis* fruit studied had an average protein content of 8.33% ± 0.09. This value is perfectly within the range of the works of Eka (1980) [18], Matos et al (2009) [21], Ogunsina et *al.* in 2012 [20], Idowu et *al.* in 2013 [24], Ibezim (2015) [16] who obtained respectively: 8.60%; 8.71%; 8.90%; 8.10%; 8.81%. It is nevertheless lower than those obtained by some authors such as Ejiofor et *al.* in 1987 (9.24%) [15] and Koumba Ibinga et *al.* in 2022 (13.0%) [32]. This slight difference in composition can be justified by the origin of the analyzed almonds and by the analytical protocol used. *Irvingia gabonensis* also has a low protein value compared to certain legumes such as *Pteridium aquilinum* (20.33 ± 0.58%) [33] or other almonds such as *Tetracarpidium conophorum* with 33.95% [34].

However, the value obtained turns out to be significant when considering its proximity to that of certain reference cereals such as corn (7.9%) [35] and wheat (9.15%) [36].

We can therefore affirm that the seeds of *Tetracarpidium conophorum* are therefore protein. That said, its oilcakes can be an excellent protein supplement and can be used in the preparation of sauces and dishes of all kinds. Subject to the analysis of essential amino acids and vitamins, it is possible to use these de-oiled cakes as seasonings, without altering their nutritional value. This operation will have the advantage of diversifying the by-products and giving added value to the previously extracted fat [23].

4. Ash Content and Main Minerals

Ash is a good indicator of the concentration of mineral elements in a sample. Analysis of *Irvingia gabonensis* cake allowed us to obtain 2.06 ± 0.03%. This value is consistent with those obtained by Matos et al. in 2009 [21], Ejiofor et al. in 1987 [15], Onimawo et al. in 2003, and Ogunsina et *al.* in 2012 [20], with, respectively: 2.06%; 2.46%; 2.26%; and 2.32%.

The value obtained is also lower than that of Idowu et *al.* in 2013 (3.35%) [24] and Ibezim in 2015 (4.52%) [16]. Since ash content is primarily influenced by the almond variety and growing conditions, the few variations observed are perfectly logical.

An almond is generally considered high in ash when its ash content is greater than 3.5%. Since the ash content of the *Irvingia gabonensis* almonds studied is significant, it justifies the mineral levels obtained in this study. (Phosphorus: 1.39%, Sodium: 0.04%, Calcium: 0.10%, Magnesium: 0.19%, and Potassium: 0.33%).

Minerals are essential for a balanced diet. Indeed, calcium and phosphorus are involved in teething and ossification. Magnesium enables the activation of certain enzymes and is involved, for example, in carbohydrate breakdown, protein synthesis, nerve impulse transmission, and muscle contraction [23]. The analyzed almonds showed a higher concentration of phosphorus than all other identified minerals.

The data obtained for phosphorus, sodium, calcium, potassium, and magnesium are considerably lower than those reported by Silou et *al*. in 2004; this could be related to the different nature of the soils and possibly to genetic variation orchestrated over time. The results obtained in this study suggest the presence of other undetermined minerals in these ashes, as the sum of the values found is less than 2.06%.

5. Carbohydrate Content

Carbohydrates are the body's primary source of short-term energy. They provide the fuel needed by cells, particularly the brain and muscles. They also play a role in energy storage (glycogen) and cellular structure (fiber).

The carbohydrate content obtained in this study is 50.41 ± 0.06%. This value is significantly higher than that found in the literature and is similar to those of other unconventional, high-carbohydrate almonds such as *Tetracarpidium conophorum* (51.18%) [37] and *Passiflora edulis f. flavicarpa* (48.94%) [38].

Given this result, a thorough analysis of the carbohydrates present in *Irvingia gabonensis* kernels, combined with research on their nutritional properties and appropriate utilization strategies, could open new perspectives for the country's diet, health, and economic development.

6. Energy Value (EV)

The energy value obtained for the kernels studied was 587.76 Kcal/100g. This value is lower than that obtained by Idowu et *al.* in 2013, Onyeike and Acheru in 2002 [39]; Matos et *al.* in 2009 [21], Dosumu et *al.* in 2012 [40]; and Giami et *al.* in 1994 [41], who respectively found: 684.5 Kcal; 688.00 Kcal; 729.36 Kcal; 595.05 Kcal; and 682 Kcal per 100g. This gap is simply explained by the fact that these different authors obtained lipid contents higher than those of this current study. Indeed, we know that one gram of lipids corresponds on average to 9 kcal of energy compared to 4 kcal for carbohydrates, the energy value of these almonds studied being calculated by numerical application, naturally resulting in a lower result.

However, the result obtained in this study remains higher than that of certain authors who have worked on other almonds such as Ossoko et *al.* in 2019 [42] for *Borassus aethiopum* (224.36 kcal/100g) and M. A. HALIDOU et *al.* in 2022 for *Sclerocarya birrea* (382.68 kcal).

Considering an average energy requirement of 2600 kcal for an adult male [43], 500g would be more than enough to meet this requirement. The almonds of the fruit of *Irvingia gabonensis* are therefore a very good source of energy.

4. Conclusion and Outlook

This study highlighted the significant nutritional potential of *Irvingia gabonensis* kernels, a still underexploited local resource in the Republic of Congo. The results revealed a rich composition of carbohydrates, lipids, and essential minerals, as well as a high energy value, making these kernels a potentially valuable food for combating food insecurity.

Analysis of the chemical indices of the oil extracted from the kernels also confirms their quality and potential for various industrial applications. The ash content and mineral composition highlight the importance of these kernels as a source of essential nutrients.

These results encourage the development of *Irvingia gabonensis* on a national scale, not only to improve food security but also to diversify the income sources of local populations. Further studies could further explore the functional properties of these kernels and develop innovative food products based on *Irvingia gabonensis*. In conclusion, the development of *Irvingia gabonensis* represents a promising opportunity to strengthen food security and promote sustainable development in the Republic of Congo.

Abbreviations

AOAC	Association of Officical Analytical Chemists
CFA	Communauté Financière Africaine / African Financial Community
FAO	Food and Agriculture Organisation
g	Gram
GUOT	Guichet Unique des Opérations Transfrontalières / Single Window for Cross-border Operations
Kcal	Kilocalorie
Kg	Kilogram
KOH/g	Milligrams of Potassium Hydroxide per Gram
meq	Milliequivalent
mg	Milligram
O/Kg	Oxygen per Kilogram

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Guichet Unique des Opérations Transfrontalières, Bulletin statistique 1er semestre 2024., ed N 005.

[2] Silou T., Biyoko S., Heron S., Tchapla A., Maloumbi M. G. (2004). Caractéristiques physico-chimiques et potentialités technologiques des amandes de Irvingia gabonensis. La Rivista italiana dell grasse (LXXXI): 49-56.

[3] Ainge L., Brown N. (2004). Bush mango (Irvingia gabonensis and I. wombulu). In: Clark L. E. & Sunderland T. C. H. (eds.): The Key Non-Timber Forest Products of Central Africa (state of the knowledge). Technical paper; 122: 15 - 36.

[4] Lapido D. 0. (2000). Le développement de normes de qualité pour l'Ogbono (amandes d'Irvingia gabonensis et d'Irvingia wombulu): les efforts pour encourager le développement d'un commerce international des produits forestiers non ligneux en Afrique de l'ouest et en Afrique centrale. In: Sunderland T. C. H., Clark L. E. & Vantomme P. (eds.): Les produits forestiers non ligneux en Afrique centrale, recherches actuelles et perspectives pour la conservation et le développement. Rome, CARPE-FAO, pp. 261 -266.

[5] Profizi J. P, Makita Madzou J. P Milandou J. C, Karanda N. C, Motom M et Bitsindou I, 1993:< Ressources végétales non ligneuse des forêts du Congo> Rapport d`études pour l`élaboration du PAFT Congo Brazzaville 67 P.

[6] Wilks C., Issembe Y. (2000). Les arbres de la Guinée équatoriale: Guide pratique d'identification, Région continentale. CUREF, 545 p.

[7] AOAC 950.01-1950. Water (Total) in fertilizers.

[8] MATOUBA Excellent Vincent de Paul (2013). Valorisation de quelques plantes de consommation courante au Congo Brazzaville: la qualité des lipides], Thèse de Doctorat Unique, Domaine: Sciences exactes, naturelles et de l'ingénieur, Spécialité: Chimie et Technologie Alimentaires, Faculté des Sciences, Université Marien NGOUABI, 139 pages.

[9] AOAC 969.17 (1997). Valeur d'acide des matières grasses. Méthode titrimétrique.

[10] AOAC 993.20 (1997). Indice d'iode des graisses et huiles, méthode Wijs (solvant cyclohexane-acide acétique). Méthode IUPAC-AOCS-AOAC.

[11] AOAC 965.33 (1997). Indice de peroxyde des huiles et graisses.

[12] AOAC 920.160 (1997), Saponification Number (Koettstorfer Number) of Oils and Fats.

[13] OAC (1984) Official Methods of Analysis. Association of Official Analytical Chemists. 14th Edition, AOAC, Arlington.

[14] Diallo Koffi Séraphin, Koné Kisselmina Youssouf, Soro Doudjo, Assidjo Nogbou Emmanuel, Yao Kouassi Benjamin, Gnakri Dago (2015). Caractérisation Biochimique et Fonctionnelle des Graines de Sept Cultivars de Voandzou [VignaSubterranea (l.) Verdc. Fabaceae] Cultivés en Côte d'Ivoire. European Scientific Journal. vol. 11, No. 27. 2-17 p.

[15] Ejiofor, M. A. N., S. Onwubuke, and J. Okafor (1987). Developing improved methods of processing and utilization of kernels of Irvingia gabonensis (var. gabonensis and var. excelsa). International Tree Crops Journal 4 (4): 283–90. https://doi.org/10.1080/01435698.1987.9752829

[16] Ibezim, G. N. U. (2015). Chemical constituents of dikanut and soyabean seeds. Time Journals of Medicinal Plant Sciences and Pharmacology 3 (2): 17–22.

[17] Ezeabara, C. A., and D. S. Ezeani. (2016). Comparative study of phytochemical and nutrient contents of various parts of Irvingia gabonensis (Aubry-Lecomte ex O' Rorke) Baill. and Irvingia wombolu Vermoesen. Scientia Agriculturae 14 (3): 284–8.

[18] Eka, O. U. (1980). Proximate composition of seeds of bush mango tree and some properties of dika fat. Nigerian Journal of Nutrition Science 1: 33–36.

[19] Elah, E. (2010). Markets and market chain analysis for bush mango (Irvingia sp.) in the South West and East regions of Cameroon. PhD diss., University of Buea.

[20] Ogunsina, B. S., A. S. Bhatnagar, T. N. Indira, and C. Radha. (2012). The proximate composition of African bush mango kernels (Irvingia gabonensis) and characteristics of its oil. Ife Journal of Science 14 (1): 177–83.

[21] L. Matos, J. M. Nzikou, E. Matouba, V. N. Pandzou-Yembe, T. Guembot Mapepoulou, M. Linder and S. Desobry, (2009). Studies of Irvingia gabonensis Seed Kernels: Oil Technological Applications. Pakistan Journal of Nutrition, 8: 151-157. https://doi.org/10.3923/pjn.2009.151.157

[22] Amoukou I. A., Boureima S. et Lawali S. (2013). Caractérisation agro-morphologique et étude comparative de deux méthodes d'extraction d'huile de sésame (Sesamum indicum L.). Agronomie Africaine 25(1): 71-82.

[23] Ahoussi-Dahouenon, E.; Adjou, E. S.; Lozes, E.; Yehouenou, L. L.; Hounye, R.; Famy, N.; Soumanou, M. M.; Sohounhloue, D. K. C., (2012). Nutritional and microbiological characterization of pulp powder of locust bean (Parkia biglobosa) used as a supplement in infant feeding in Northern Benin. Int. J. Biol. Chem. Sci. 6(5): 2263-2273.

[24] Idowu, M. A., Omoniyi, S. A., Henshaw, F. O. and Olayiwola, I. O. (2013). "Sensory acceptability of partially defatted dikanut (Irvingia gabonensis) flour in "ogbono" soup", Journal of Culinary Science and Technology, Vol. 11 No. 4, pp. 346-355.

[25] Mora-Escobedo R., Hermandez-Luna P., Joaquin-Torres I. C., Ortiz-Moreno A. and Robles-Ramirez M. Del C. (2015). Physicochemical properties and fatty acid profile of eight peanut varieties grown in Mexico. CyTA-Journal of Food, 13, 2: 300-304.

[26] Yao, R., & Kamagate, D. (2011). Production du palmier à huile (Elaeis guineensis Jacq.) et taux d'extraction dans des conditions climatiques marginales au Nord-Est de la Côte d'Ivoire. Agronomie Africaine, 22(2). https://doi.org/10.4314/aga.v22i2.68363

[27] Etong, D. I., Mustapha, A. O. and Taleat, A. A. (2014). "Physicochemical properties and fatty acid composition of dikanut (Irvingia gabonensis) seed oil", Research Journal of Chemical Sciences, Vol. 4 No. 12, pp. 70-74.

[28] Okoronkwo, C. U., Agoha, E. E. C., Ogodo, A. C. and Nwachukwu, N. O. (2014). "Physical and chemical characteristics of the African bush mango (Irvingia gabonensis var garbonensis) seed oil", International Journal of Advances in Engineering and Management, Vol. 1 No. 6, pp. 28-31.

[29] Codex Alimentarius Commission (1993). Graisses et huiles végétales, division 11, Version abrégée FAO/WHO. Codex Stan 20-1981, 23-1981.

[30] Nzikou, J. M., Mvoula-Tsier, M., Matos, L., Matouba, E., Ngakegni-Limbili, A. C., Linder, M. and Desobry, S. (2007). "Solanum nigrum L. seeds as an alternative sources of edible lipids and nutrients in Congo Brazzaville". Journal of Applied Sciences, Vol. 7 No. 8, pp. 1107-1115.

[31] Nakavoua A., Dzondo G., Loumouamou A., Matos L. and Figueredo G. (2023). Irvingia Fat Ageing: Study of Chemical Characteristics Related to MIR Spectroscopy. Spectral Analysis Review, 7, 1-12. https://doi.org/10.4236/sar.2023.71001

[32] Koumba Ibinga, Sidrine Kerthy, Muriel Cerny, Eric Lacroux, Jean-François Fabre, Romain Valentin, Othmane Merah, Raphaël Bikanga, and Zéphirin Mouloungui (2022). "Extraction and Physicochemical Composition of Irvingia gabonensis Almond Oil: A Potential Healthy Source of Lauric-Myristic Oil" Separations 9, no. 8: 207. https://doi.org/10.3390/separations9080207

[33] Arnaud, W. G. Tamba Sompila, J. E. Moussounga, A. B. Madiélé Mabika, N. P. G. Pambou-Tobi, P. Diakabana, B. D. E. Miakayizila, M. Dzondo-Gadet and Silou, T.(2019). Conservation and Analysis of the Physicochemical Parameters of a Congo Food Plant Alicamentary [Pteridium aquilinum (L.) Kuhn]. Int. J. Curr. Microbiol. App. Sci. 8(9): 247-256. https://doi.org/10.20546/ijcmas.2019.809.030

[34] Ossoko Jean Paul Latran; Dzondo Gadet Michel; B. D. E. Miakayizila Blaise Divin Emmanuel; Mvoula Tsieri Michel Didace (2021). Assessment of the Nutritional Potential of the kernels of the Seeds of Tetracarpidium conophorum collected in Lékana in the Department of Plateaux in the Republic of Congo. J. Bio. Innov. 10 (4), pp: 1102- 1110. ISSN: 2277-8330 (Electronic).

[35] FranceAgriMer / ARVALIS - Institut du végétal / Enquête qualité collecteurs 2018 N 47 – Février 2019.

[36] Gebregewergis A (2021). Review on the Protein Content of Different Wheat Varieties Collected from Pakistan and Ethiopia. Adv Crop Sci Tech 9: 466.

[37] Suara, K. O., Azubuike, C. P., Okubanjo, O. O. & Igwilo, C. (2016). Neutraceuticals and antibacterial properties of methanol extract of (Plukenetia conophora Müll.-Arg.) family Euphorbiaceae leaves and physical properties of its cream formulations. Nigerian Journal of Pharmaceutical and Applied Science Research. 5(1): 91–98.

[38] J. P. L. Ossoko, Y. Okandza, J. Enzonga Yoca, B. F. Mbété, M. G. Dzondo, M. D. Mvoula Tsieri. (2020). Biochemical Passion Fruit Seeds Characterization (Passiflora edulis F. Flavicarpa Denger) Cultivated in Republic of Congo. IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB). ISSN: 2455-264X, Volume 6, Issue 1 (Jan. – Feb. 2020), PP 48-54 www.iosrjournals.org

[39] Onyeike, E., and G. Acheru (2002). Chemical composition of selected Nigerian oil seeds and physicochemical properties of the oil extracts. Food Chemistry 77 (4): 431–7. https://doi.org/10.1016/S0308-8146(01)00377-6

[40] Dosumu, O., O. Oluwaniyi, G. Awolola, and O. Oyedeji (2012). Nutritional composition and antimicrobial properties of three Nigerian condiments. Nigerian Food Journal 30 (1): 43–52. https://doi.org/10.1016/S0189-7241(15)30012-6

[41] Giami, S. Y., Okonkwo, V. I., & Akusu, M. O. (1994). Chemical composition and functional properties of raw, heat-treated and partially proteolysed wild mango (Irvingia gabonensis) seed flour. Food Chemistry, 49(3), 237–243. https://doi.org/10.1016/0308-8146(94)90166-x

[42] J. P. L. Ossoko, Y. Okandza, J. Enzonga Yoca, M. G. Dzondo, M. D. Mvoula Tsieri (2019)."Caractérisation Biochimique des Amandes du Rônier (Borassus aethiopum) de la Sous-Préfecture de Mbamou en République du Congo." IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB) 5.3 (2019): 65-71.

[43] Comité des besoins en calories de l'Organisation des Nations Unies pour l'Alimentation et l'Agriculture. "Les besoins en calories." Annales de La Nutrition et de l'alimentation, vol. 11, no. 2, 1957, pp. 53–101. JSTOR, http://www.jstor.org/stable/45122205 Accessed 24 Feb.2025