

Nutraceutical Potentiality of Fruits of Red Variety of *Pseudospondias microcarpa* (A. Rich) Engl.

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Abstract

The red fruits of *Pseudospondias microcarpa* (A. Rich) Engl. are widely consumed by the populations of northern Congo for their sweet and tangy flavor as well as for their characteristic smell. The objective of this study was to show the food potential of the fruits of this plant for their valorization. Organic solvent extracts were prepared and subjected to phytochemical screening to determine the nutrients and phytonutrients of this fruit. Raw juice was extracted by trituration without adding water and subjected to physicochemical and biochemical analyses in order to determine its quality and its antiradical activity. The raw juice obtained is moderately acidic (pH 3.28), very cloudy and colored (turbidity of 1019 NTU). It has a dry matter content of $3.771\% \pm 0.013\%$ reflecting the 70% dominance of water in the weight of the fruit and the presence of dissolved organic matter in its juice. Energy nutrients (sugars, amino acids), carotenoids, coumarins, tannins, flavonoids, terpenes and sterols have been highlighted as nutrients with therapeutic potential commonly called phytonutrients of this fruit. The juice presented a dominance in polyphenols (134.8500 ± 0.0023 mg gallic acid/100 g) than in carotenoids (5.100 ± 0.010 mg carotene/100 g), high levels of mineral macroelements (calcium: 3570.00 ± 2.05 mg and potassium: 4576.00 ± 9.49 mg) and trace elements (copper: 11.13 ± 0.10 mg, iron: 3.02 ± 0.03 mg and zinc: 2.57 ± 0.08 mg). These compounds exhibited good antioxidant activity. The presence of these nutrients and phytonutrients in these fruits is interesting for the proper functioning of certain organs and the prevention of certain diseases. This fruit is therefore an energizing and functional food that can compete with conventional fruits whose juices are marketed.

Keywords

Alicament, Fruit Juice, *Pseudospondias microcarpa*, Phytochemistry

1. Introduction

The human, social and economic costs of hunger, food insecurity and malnutrition for society as a whole are considerable in terms of lost productivity, health, well-being, reduced ability to learn and limitation of human potential. If current conditions persist, the Sustainable Development Goal of ending hunger by 2030 will not be achieved. Indeed, unless we make our food systems more nutrition-sensitive, large segments of the population, especially in sub-Saharan Africa and South Asia, will remain undernourished in 2030 and even 2050 [1]. However, most of these countries benefit from favorable eco-geographical conditions for the development of a rich and varied flora including a significant potential in food, oilseed, aromatic and medicinal plants, a large part of which is endemic. This endemic character gives them the advantage of producing new natural assets with added value; this is the case of plants with edible fruits whose fruits are highly appreciated for their flavor. The exploitation of this floristic richness is still unconventional, due to still embryonic physicochemical data [2] [3]. Among this richness is the species *Pseudospondias microcarpa* (A. Rich) Engl., a plant of the Anacardiaceae family, which is generally found in tropical and subequatorial climates. It exists in nature in two forms: the variety with red fruits and the variety with blue-blackish fruits when ripe. Its fruits are edible and highly appreciated by populations as well as chimpanzees for their sweet and tangy taste. Many studies confirm some of the medicinal properties attributed to this plant, including antispasmodic, antimicrobial, antioxidant, analgesic, anticonvulsant, antidepressant, anxiolytic properties. Some phytochemical studies of this plant have revealed the presence of several major phytochemical families such as triterpenes, polyphenols, flavonoids, alkaloids, tannins, steroids, saponosides, cardiac glycosides and sugars, as well as certain fruit nutrients of the blue-blackish variety [4] [5] [6] [7].

In Congo, vegetable oil analysis of the fruit seeds of *Pseudospondias microcarpa* (A. Rich) Engl. delivered several compounds including twelve major compounds, namely oleic acid, palmitic acid, stearic acid, β -Sitosterol, α , γ and δ -tocopherol [8]. That of the essential oils of the pulps, stones, shells and seeds of these fruits made it possible to identify 67 compounds, the most important of which are vaccenic acid, ascorbic acid, 2,6-dihexadecanoate and α -terpineol [9]. To our knowledge, no study reports the nutritional value of the fruits and fruit juices of this plant. However, the valorization of these products requires a precise knowledge and justifies this work of determination of the chemical composition, in order to highlight a possible specificity.

2. Material and Methods

1) Collection of plant material

About 50 kg of ripe fruits of *Pseudospondias microcarpa* (A. Rich) Engl. were harvested along the Kouyou River in Owando, a town located in the central Cuvette department in northern Congo. The botanical identification of the fruit

was carried out at the Center for the Study of Plant Resources (CERVE in french). The species was registered under number 8957 on 7/08/1961.

2) Physical characteristics of harvested ripe fruit

The weights of fruits, pericarp, pulp and seeds were measured using an electronic scale and expressed in grams (g). The peel/pulp ratio was determined by taking the ratio between the peel weight and the pulp weight. The fruit color was recorded using the LEROUX color chart. The fruit length and width were measured using a digital caliper and expressed in millimeters (mm) [10].

3) Determination of dry matter and water content

The dry matter content is evaluated according to the AOC method [11]. This method corresponds to the loss in mass after complete drying at 105°C, for approximately 2 to 4 hours, in an isothermal oven until a constant mass is obtained. The dry matter content is calculated by formula (1).

$$MS(\%) = \frac{M_f - M_c}{M_i - M_c} \times 100 \quad (1)$$

or

DM: Dry matter (%);

Mc: Mass of the empty capsule (g);

Mf: Final mass (g) of the dish containing the sample after staving;

Mi: Initial mass (g) of the capsule containing the sample before staving.

The humidity (or water content) denoted H, is determined from formula (2).

$$H = 100 - MS \quad (2)$$

4) Obtaining fruit juice

The fruit juice was obtained by crushing ripe fruit. 1.5 kg of fresh fruit were manually pressed to collect the pure juice without adding water.

5) Determination of nutrients and phytonutrients

a) Preparation of extracts

A few grams of pulped fresh fruit had been macerated only in ethanol. At the same time, 1 g of dry pulp was subjected to extraction with different solvents, in ascending order of polarity, namely: hexane, chloroform, ethylacetate and water.

b) Screening of chemical families of extracts

The screening of the chemical families was carried out by thin layer chromatography (TLC) and by tube reactions according to the methods described in the literature. The operating conditions of the chemical families sought by TLC are listed in **Table 1**. The saponosides were determined by the mouse index and the reducing sugars by the Fehling test [12] [13].

c) Physico-chemical and biochemical analyzes of raw fruit juice

The Nutritional potential of raw fruit juice was determined according to standards and methods described in the literature. The operating conditions for measuring of pH, turbidity, density, titratable acidity and °Brix; and determination of water contents, dry matter, ash, total carotenoids, total polyphenols, total flavonoids, tannins, total sugars and dietary fibers as well as the assessment of antiradicaire activity are inscribed in **Table 2**.

Table 1. Operating conditions for chemical screening by TLC.

| Families wanted | Types of extracts, elution systems and method of revelation used | | |
|-----------------------------------|--|---|---|
| | Extract Types | Elution systems | Revelation/Observation |
| Flavonoids | Ethylacetate (P3) and aqueous (P5) extracts | Butanol/ AcOH/H ₂ O (12/1/1) | Neu, Observation reagent at visible and UV 365 nm |
| Tannins | Ethylacetate extract (P3) | Butanol/ AcOH/H ₂ O (12/1/1) | 2% FeCl ₃ Visible observation |
| Coumarins | Hexane (P1), chloroform (P2), ethylacetate (P3) extracts | Toluene/ AcOEt/AcOH (1/1/1) | 10% KOH in ethanol Observation at UV 365 nm |
| Sugars | Ethanollic extract (P4) | Butanol/AcOH/AcOEt/H ₂ O (9/6/3/2) | Anisaldehyde + heating to 100°C Visible observation |
| Amino acids | Ethanollic extract (P4) | Butanol/AcOH/AcOEt/H ₂ O (9/6/3/2) | Ninhydrin + heating to 100°C Visible observation |
| Terpenes, Sterols and Carotenoids | Hexane (P1), chloroform (P2), ethylacetate (P3) extracts | Hexane/AcOEt (7/3) | Antimony chloride + heating to 110°C Visible observation |

Table 2. operating conditions for physicochemical and biochemical analyzes.

| Analyzes | Analysis method and type of device | | |
|--|------------------------------------|---|------------|
| | Methods | Material | References |
| Dry matter (%) | Drying at 105°C, 2 hours | Oven (Memmert, ULE 500, Germany) | [16] |
| Ash (mg/100g) | Incineration at 550°C, 4 hours | Moufle oven (Carbolite, OAF 11/1, England) | [17] |
| pH at 25°C | pH-metry | pH meter (Hanna Instruments, HI 223, USA) | [18] |
| Turbidity | Turbidimetry | Turbidimeter | |
| Volumic mass | Weighing | Pycnometer | |
| Titrateable acidity (mEq/100g) | Titrimetry | Potentiometer titrator (SI Analytics, TitroLine easy, Germany) | [19] |
| BRIX (%) | Refractometry | Refractometer | |
| Dietary fiber (%) | Gravimetry | Common laboratory equipment | [20] |
| Total sugars (g/100g) | Luff-Schoorl after hydrolysis | Common laboratory equipment | [21] |
| Total carotenoids (mg carotene/100g) | Spectrophotometry | UV/Visible Spectrophotometer (Analytik Jena, Specord 200 plus, Germany) | [22] |
| Total polyphenols (mg gallic acid/100g) | Follin-Ciocalteu | UV/Visible Spectrophotometer (Analytik Jena, Specord 200 plus, Germany) | [23] |
| Total Tannins (mg tannic acid/100g) | Follin -Denis | UV/Visible Spectrophotometer (Analytik Jena, Specord 200 plus, Germany) | [24] |
| Flavonoids (mg catechin acid/100g) | Colorimetric | UV/Visible Spectrophotometer (Analytik Jena, Specord 200 plus, Germany) | [25] |
| Antioxidant activity (% inhibition) at 0.1 mg/L sample | DPPH | UV/Visible Spectrophotometer (Analytik Jena, Specord 200 plus, Germany) | [25] |

Calcium, iron, copper and zinc were determined using an inductive coupling optical emission spectrophotometer (ICP-OES) according to the AOC method, n° 984.27 [14]. Potassium was determined using an atomic flame absorption spectrophotometer (AAS) according to the AOC method, n° 975.03 [15].

3. Results and Discussion

1) Physical characteristics of *Pseudospondias microcarpa* (A. Rich) Engl. fruits

The weight of harvested *Pseudospondias microcarpa* (A. Rich) Engl. varies from 2 to 8 g with a constant pulp/mesocarp-kernel ratio. The size of these fruits varies from 1 to 2 cm in central diameter and 1 to 2.5 cm in length. The color chart allows us to say that the fruit ripening color ranges from yellow to red (final stage). The Observation of the fruits of this plant with the naked eye is reminiscent of those of *Spondias mombin* L. and *Prunus laurocerasus* L. in terms of morphology (shape, size and weight) [24] [25] [26] [27].

2) Water, dry matter and fruit juice content

The water and dry matter contents of this fruit are respectively 69.99% and 31.11%. These results show that the weight of the fruit is dominated by water; which is consistent with the usual content of fleshy fruits described in the literature.

In addition, out of 1500 g of the fruits, 350 mL of raw juice was obtained; i.e. a content of 23.33% of the pure juice in the fruit without adding water. This content makes it possible to classify these fruits among citrus fruits or melons [28].

3) Highlighting nutrients and phytonutrients in fruits

Five extracts were obtained from the fruit pulp. These extracts made it possible to observe by TLC the spots of green, brown, blue (fluorescent), green, yellow, orange, red and gray color characteristic of the presence of two nutrients (sugars and amino acids) and six phytonutrients (carotenoids, coumarins, flavonoids, tannins, terpenes and sterols) (Chromatograms 1 to 7). The use of special reagents and elution systems as well as control compounds made it possible to differentiate them according to the results described in the literature.

Chromatograms 1 and 2 show that this fruit could contain energizing compounds namely glucose, fructose, maltose and histidine or their derivatives. The presence of glucose, fructose and maltose in the ethanolic extract confirms the abundance of reducing sugars observed with the Felling test. We also note in this fruit a diversified phytonutrient profile (Chromatograms 3 to 7).

4) Physicochemical and biochemical characteristics of raw fruit juice

Table 3 groups together the physicochemical and biochemical characteristics of the raw fruit juice of *Pseudospondias microcarpa* (A. Rich) Engl. with those of two varieties of Anacardiaceae taken as references. The juice showed contents of $3.771\% \pm 0.013\%$ and 0.6047 ± 0.0629 mg/100g respectively for dry matter and ash. These values show that the weight of the juice is more than 95% represented by water. It can be a source of water, an essential element for the functioning of the body. This juice is denser than water ($\rho_{\text{juice}} = 1.255$ g/cm³), very cloudy and colored (turbidity of 1019 NTU); which reflects a high rate of dissolved

Table 3. Physico-chemical and biochemical quality of *Pseudospondias microcarpa* fruit juice.

| Settings | Physicochemical and biochemical quality of pseudospondia <i>Pseudospondias microcarpa</i> (A. Rich) juice compared to that of <i>Spondias mombin</i> L. and <i>Irvingia gabonensis</i> (A.-L.) Baill. | | |
|---|---|---------------------------|---|
| | <i>Pseudospondias microcarpa</i> (A. Rich) Engl. | <i>Spondias mombin</i> L. | <i>Irvingia gabonensis</i> (A.-L.) Baill. |
| Dry matter (%) | 3.771 ± 0.013 | 19.44 | 12.00 |
| Ash (mg/100g) | 0.6047 ± 0.0629 | 5.40 | 1.50 |
| Turbidity (NTU) | 1019 | - | - |
| Density (g/cm ³) | 1,255 | - | - |
| pH at 25°C | 3,286 | 2.35 | 4.00 |
| Titrateable acidity (mEq/100g) | 4.05 | 0.46 | 0.04 |
| BRIX (%) | 12,533 | 5.58 | 10.00 |
| Total sugars (g/100g) | 8.700 ± 0.141 | 11.61 | 7.72 |
| Dietary fiber | 0.17 | 0.64 | 0.98 |
| Total carotenoids (mg carotene/100g) | 5.100 ± 0.010 | 0.095 | 1,056 |
| Total polyphenols (mg Eq. Gallic acid/100g) | 134.8500 ± 0.0023 | 155.126 | 272.00 |
| Tannins (mg Eq. tannic acid/100g) | 99.4100 ± 0.0019 | - | - |
| Flavonoids (mg Eq. Catechin acid/100g) | 8,009 | 139.00 | 395.00 |
| Copper Cu (mg) | 11.13 ± 0.10 | 0.125 | - |
| Iron Fe (mg) | 3.02 ± 0.03 | 0.48 | 1.30 |
| Calcium Ca (mg) | 3570.00 ± 2.05 | 13.04 | 160.00 |
| Zinc Zn (mg) | 2.57 ± 0.08 | 130.42 | 1.90 |
| Potassium K (mg) | 4576.00 ± 9.49 | 276.27 | 598.00 |
| Antioxidant activity (% inhibition) | 3.935 ± 1.015 | 38.72 | - |

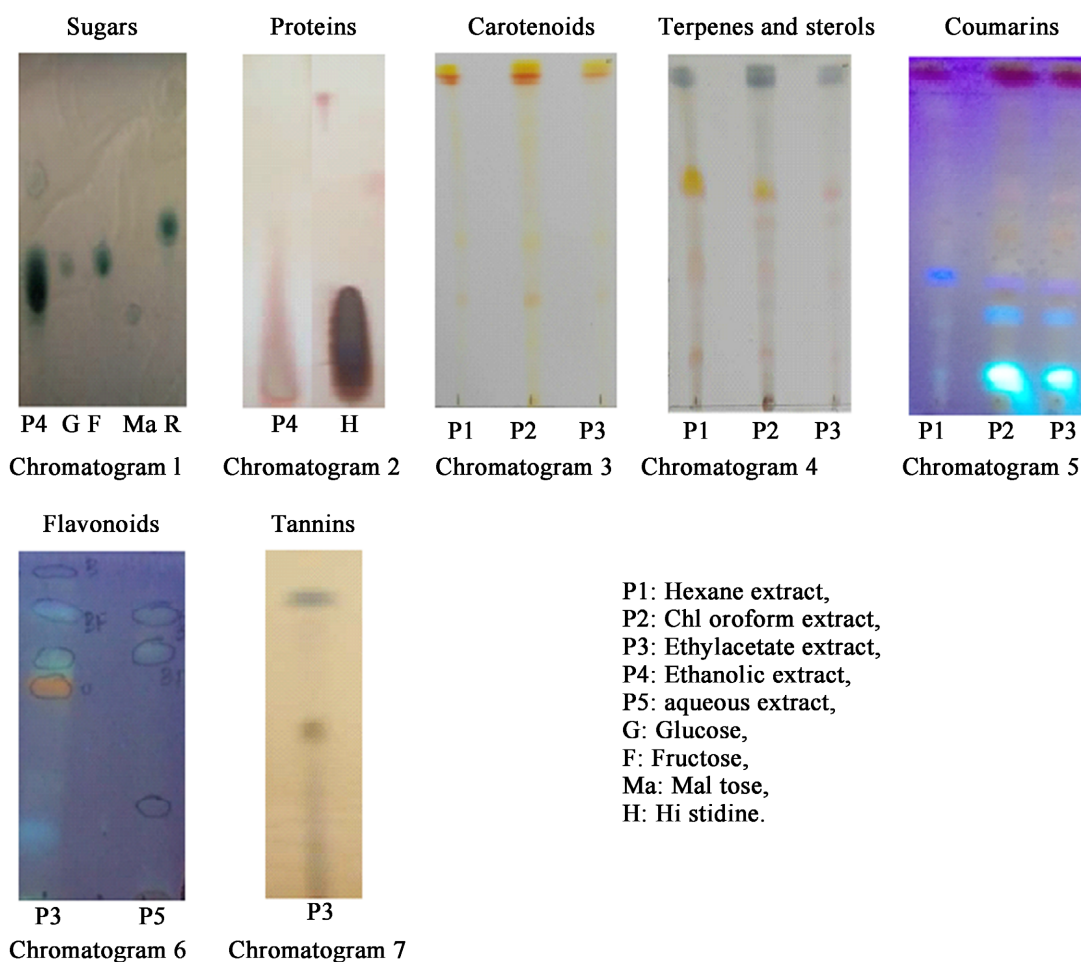
organic matter such as carotenoids. It is moderately acidic (pH 3.28); an acidity approaching that of its Anacardiaceae counterparts taken as examples [29] [30]. The value of °BRIX (12.533%) in the juice is high; which also reflects the high sugar content (8.700 ± 0.141 g/100g juice). This fruit is a more energizing nutrient than that of *Irvingia gabonensis* whose °BRIX is 10.00%.

In this juice, polyphenols (134.8500 ± 0.0023 mg gallic acid/100g) are the most abundant phytonutrients than carotenoids (5.100 ± 0.010 mg carotene/100g). These phytonutrients are known for their antioxidant power and their provitamin A property. The presence of these phytonutrients in this juice proves inter-

esting in the prevention of cataracts, age-related macular degeneration, cardiovascular diseases and various cancers such as lung cancer and prostate cancer [31].

Five mineral elements have been determined and quantified in this juice, namely: copper, iron, calcium, zinc and potassium. Calcium (3570.00 ± 2.05 mg/100g) and potassium (4576.00 ± 9.49 mg/100g) contents are high in the juice because these nutrients are macronutrients. This trend is the same observed with mango juice containing calcium (150.00 mg/100g) and potassium (598.00 mg/100g). The presence of calcium in this juice is therefore important because it gives this juice a power of growth and hardness of bones and teeth. The three other elements identified as, for example, iron and copper are essential for the synthesis and functioning of hemoglobin, the functional role of which is to ensure the transport of respiratory gases. The deficiency of these mineral elements in the body leads to decalcification, rickets, tetany, muscle spasm, fatigue, anemia, growth retardation, pallor, reduced resistance to disease [32]-[37].

The juice of this fruit has an important antioxidant power characterized by the low percentage of inhibition ($3.935\% \pm 1.015\%$). This significant activity could be due to the presence of phytonutrients such as phenolic compounds and carotenoids in the juice. This result confirms the use of this fruit for food purposes.



4. Conclusion

The physicochemical and biochemical characterization of *Pseudospondias microcarpa* (A. Rich) Engl. fruits made it possible to identify functional nutrients and phytonutrients and to quantify carotenoids (5.100 ± 0.010 mg carotene/100g) and polyphenols (134.8500 ± 0.0023 mg gallic acid/100g) as well as five essential mineral elements namely copper, iron, calcium, zinc and potassium with the respective contents 5.100 ± 0.010 mg, 3.02 ± 0.03 mg, 3570.00 ± 2.05 mg, 2.57 ± 0.08 mg and 4576.00 ± 9.49 mg. In addition, these compounds exhibited good antioxidant activity. The presence of these nutrients and phytonutrients militates to give it a status of health food for new technological routes.

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Conflicts of Interest

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

References

- [1] FAO, FIDA, OMS, PAM et UNICEF (2019) L'État de la sécurité alimentaire et de la nutrition dans le monde 2019. Se prémunir contre les ralentissements et les fléchissements économiques. FAO, Rome, 253 p.
- [2] Loubelo, E. (2012) Impact des produits forestiers non ligneux (PFNL) sur l'économie des ménages et la sécurité alimentaire: Cas de la République du Congo. Thèse de doctorat, Université de Rennes 2, Rennes, 261 p.
<https://tel.archives-ouvertes.fr/tel-00713758/document>
- [3] Malela, K.E., Miabangana, E.S., Petit, J., N'zikou, J.M. and Scher, J. (2016) Enquête ethnobotanique sur les fruits comestibles de la flore spontanée de la République du Congo. *International Journal of Pure & Applied Bioscience*, **4**, 346-357.
- [4] Bouquet, A. (1969) Féticheurs et médecines traditionnelles du Congo (Brazzaville). Mémoires ORSTOM (36), 282 p.
https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers4/13972.pdf
- [5] Wewura Adongo, D., Kolibea Mante, P., Kwami Edem Kukuia, K., Kwaku Benneh, C., Biney, R.P., Boakye-Gyasi, E., Akinwale Titiloye, N. and Woode, E. (2018) Toxicological Assessment of *Pseudospondias microcarpa* (A. Rich.) Engl. Hydroethanolic Leaf Extract in Rats: Haematological, Biochemical, and Histopathological Studies. *The Scientific World Journal*, **2018**, Article ID: 4256782.
<https://doi.org/10.1155/2018/4256782>
- [6] Malebo, H.M., Tanja, W., Cal, M., Swaleh, S.A.M., Omolo, M.O., Hassanali, A., Séquin, U., Hamburger M., Brun, R. and Ndiege, I.O. (2009) Antiplasmodial, Anti-Trypanosomal, Anti-Leishmanial and Cytotoxicity Activity of Selected Tanzanian Medicinal Plants. *Tanzania Journal of Health Research*, **11**, 226-234.
<https://doi.org/10.4314/thrb.v11i4.50194>
- [7] Yondo, J., Komtangi, M.C., Wabo, J.P., Bilong Bilong, C.F., Kuate, J.R. and Mpoame, M. (2017) *In Vitro* Effects of *Schumanniphyton magnificum*,

- Pseudospondias microcarpa* and *Rauvolfia vomitoria* Stem Barks Extracts, on Free Larval Stages of *Heligmosomoides bakeri* (Nematoda, Heligmosomatidae). *Asian Journal of Biomedical and Pharmaceutical Sciences*, **7**, 19-25.
<https://www.alliedacademies.org/articles/in-vitro-effects-of-schumanniphyton-magnificum-pseudospondiasmicrocarpa-and-rauwolfia-vomitoria-stem-barks-extracts-on-free-larva.pdf>
- [8] Nkounkou Loumpangou, C., Douniama Lönn, G.V., Ngakegni-Limbili, A.C., Mpele, S.R., Bonazaba Milandou, J.C., Elouma Ndinga, A.M., Cerny, M., Moutsabote, J.M. and Ouamba J.M. (2018) Caractérisation chimique des graines de *Pseudospondias microcarpa* (A. rich) Engl. *Annales de l'Université Marien N'gouabi*, **18**, 21-27.
<https://dicames.online/jspui/bitstream/20.500.12177/2620/1/Nkounkou%20-%202019%20-%20Caract%20chimique%20des%20graines%20de%20Pseudospon.pdf>
- [9] Baboungolo, S.-G., Nkounkou Loumpangou, C., Dao, E., Simon, V., Elouma Ndinga, A.M. and Ouamba, J.-M. (2021) Variability in Aromatic Composition of Different Fruit Parts of *Pseudospondias microcarpa* (A. Rich) Engl from Congo. *Journal of Essential Oil Bearing Plants*, **24**, 421-430.
<https://doi.org/10.1080/0972060X.2021.1936203>
- [10] Dey, K., Ghosh, A., Dey, A.N., Bhowmick, N. and Bauri, F.K. (2016) Evaluation of Nutritive and Mineral Value in Ripe Fruits of Indian Hog Plum (*Spondias pinnata* Linn.) from Four Different Location of Northern Parts of West Bengal. *Vegetos*, **29**, 11-16. <https://doi.org/10.5958/2229-4473.2016.00094.X>
- [11] AOAC (1990) Official Methods of Analysis. 15th Edition, Association of Official Analytical Chemists, Washington DC, 771 p.
- [12] Wagner, H., Blatt, S. and Zgainski, E.M. (1983) Plant Drug Analysis. Springer-Verlag, Berlin, 314 p. <https://doi.org/10.1007/978-3-662-02398-3>
- [13] Waksmundzka-Hajnos, M., Sherma, J. and Kowalska, T. (2008) Thin Layer Chromatography in Phytochemistry. CRC Press, Boca Raton, 888 p.
<https://doi.org/10.1201/9781420046786>
- [14] Poitevin, E., Nicolas, M., Graveleau, L., Richoz, J., Andrey, D. and Monard, F. (2009) Improvement of AOAC Official Method 984.27 for the Determination of Nine Nutritional Elements in Food Products by Inductively Coupled Plasma-Atomic Emission Spectroscopy after Microwave Digestion: Single-Laboratory Validation and Ring Trial. *Journal of AOAC International*, **92**, 1484-1518.
<https://doi.org/10.1093/jaoac/92.5.1484>
- [15] AOAC (2005) Official Method Analysis 975.03. Metals in Plants and Pets Food Atomic Absorption Spectrophotometric Method.
- [16] AFNOR (1982) Détermination de la teneur en eau, NF V18-109.
- [17] AFNOR (1972) Fruits, légumes et produits dérivés-Minéralisation des matières organiques-Méthode par incinération, NF V05-113.
- [18] AFNOR (1990) Produits dérivés des fruits et légumes-Mesurage du pH, NF V05-108.
- [19] AFNOR (1974) Produits dérivés des fruits et légumes-Détermination de l'acidité titrable. Association Française de Normalisation, NF V 05-101, Paris, 1-4.
- [20] AOAC (1996) Fiber (Crude) in Animal Feed and Pet Food. AOAC 978.10-1979, 2.
- [21] Dekker, K.D. (1950) The Luff-Schoorl Method for Determination of Reducing Sugar in Juices, Molasses and Sugar. *South African Sugar Journal*, **34**, 157-171.
- [22] McMurry, J. (2008) Organic Chemistry. 7th Edition, Brooks/Cole Publishing Com-

- pany, Pacific Grove, 504 p.
- [23] Georgé, S., Brat, P., Alter, P. and Amiot, M.J. (2005) Rapid Determination of Polyphenols and Vitamin C in Plant-Derived Products. *Journal of Agricultural and Food Chemistry*, **53**, 1370-1373. <https://doi.org/10.1021/jf048396b>
- [24] Glick, Z. and Joslyn, M.A. (1970) Food Intake Depression and Other Metabolic Effects of Tannic Acid in the Rat. *The Journal of Nutrition*, **100**, 509-515. <https://doi.org/10.1093/jn/100.5.509>
- [25] Kim, D.-O., Chun, O.K., Kim, Y.J., Moon, H.-Y. and Lee, C.Y. (2003) Quantification of Polyphenolics and Their Antioxidant Capacity in Fresh Plums. *Journal of Agricultural and Food Chemistry*, **51**, 6509-6515. <https://doi.org/10.1021/jf0343074>
- [26] Oladunjoye, A.O., Adeboyejo, F.O., Okekunbi, T.A. and Aderibigbe, O.R. (2021) Effect of Thermo-sonication on Quality Attributes of Hog Plum (*Spondias mombin* L.) Juice. *Ultrasonics Sonochemistry*, **70**, Article ID: 105316. <https://doi.org/10.1016/j.ultsonch.2020.105316>
<https://oxfamibrary.openrepository.com/bitstream/handle/10546/114101/bp91-ca-using-hunger-240706-fr.pdf;jsessionid=A24C773A40A7E09CC74A3B41F9777788?sequence=2>
- [27] Ayad, M. (2017) Contribution à l'étude des différentes variétés de cerisier (prunus) cultivées dans la région de tlemcen, Master en Science agronomie. Université Abou Bekr Belkaid Tlemcen, Algérie, 80 p.
- [28] Lozano, J.E. (2006) Fruit Manufacturing. Springer Sciences, Berlin, 230 p.
- [29] Coolborn, A.F., Esther, B.B., Akinsola, A.F. and Afolabi, O.B. (2016) Antioxidant, Physicochemical and Mineral Evaluations of *Spondias mombin* Crude Fruit Juice. *Acta Biologica Szegediensis*, **60**, 171-176. <http://abs.bibl.u-szeged.hu/index.php/abs/article/view/2905>
- [30] Mattietto, R.A. and Matta, V.M. (2011) Cajá (*Spondias mombin* L.). In: Yahia, E.M., Ed., *Postharvest Biology and Technology of Tropical and Subtropical Fruits*, Elsevier, Amsterdam, 330-351, 352e-353e. <https://doi.org/10.1533/9780857092762.330>
- [31] Akubor, P.I. (2017) Evaluation of the Quality of Juice Prepared from African Bush Mango (*Irvingia garbonensis* Var. *garbonensis*) Fruit Pulp. *Asian Research Journal of Agriculture*, **6**, 1-9. <https://doi.org/10.9734/ARJA/2017/36476>
- [32] Chung, S.Y. and Landau, J.M. (2000) Effects of Tea Consumption on Nutrition and Health. *The Journal of Nutrition*, **130**, 2409-2412. <https://doi.org/10.1093/jn/130.10.2409>
- [33] Pérez-Vizcaino, F., Ibarra, M., Cogolludo, A., *et al.* (2002) Endothelium Independent Vasodilator Effects of the Flavonoid Quercetin and Its Methylated Metabolites in Rat Conductance and Resistance Arteries. *Journal of Pharmacology and Experimental Therapeutics*, **302**, 66-72. <https://doi.org/10.1124/jpet.302.1.66>
- [34] Heber, D. (2000) Colorful Cancer Prevention: α -Carotene, Lycopene and Lung Cancer. *The American Journal of Clinical Nutrition*, **72**, 901-902. <https://doi.org/10.1093/ajcn/72.4.901>
- [35] Herzog, F., Farah, Z. and Amado, R. (1994) Composition et consommation de fruits sauvages cueillis dans le V-Baoulé, Côte d'Ivoire. *Écologie de l'alimentation et de la Nutrition*, **32**, 181-196. <https://doi.org/10.1080/03670244.1994.9991399>
- [36] Liu, T.P.S.L., Brandão Costa, R.M.P., de Vasconcelos Freitas, D.J., Oliveira Nascimento, C., de Souza Motta, C.M., Bezerra, R.P. and Porto, A.L.F. (2016) Tannase from *Aspergillus melleus* Improves the Antioxidant Activity of Green Tea: Pu-

rification and Biochemical Characterisation. *International Journal of Food Science & Technology*, **52**, 652-661. <https://doi.org/10.1111/ijfs.13318>

- [37] Moudon, L. (1989) Le rôle des vitamines et des oligoéléments dans l'organisme. In: *La Méthode Kousmine*, Jouvence édit. Onex/Genève, 1, 61-64.