

Full Length Research Paper

Biochemical characterization of four less exploited edible fruits in Congo-Brazzaville: *Passiflora edulis f. flavicarpa*, *Aframomum alboviolaceum*, *Saba comorensis* and *Clitandra cymulosa*

Josiane Enzonga*, Jean Paul Latran Ossoko, Yves Okandza, Arielle Makimouha-Kali and Mvoula Tsieri

Laboratoire de Contrôle et Qualité des aliments de l'Ecole Nationale Supérieure d'Agronomie et de Foresterie, Université Marien NGOUABI, BP 69 Brazzaville, Congo.

Received 22 August, 2019; Accepted 15 October, 2019

The aim of this study was to determine the biochemical characteristics (moisture, crude protein, crude lipids, ash, pH, titrable acidity, minerals and free sugars) of four popular edible fruits (*Passiflora edulis f. flavicarpa*, *Aframomum alboviolaceum*, *Saba comorensis* and *Clitandra cymulosa*), but less exploited. The pulp and seeds of *P. edulis f. flavicarpa* and *A. alboviolaceum* was also investigated in order to identify the nutritional quality of seeds which are by-products in juice and nectar production. The results showed that all the fruits had a high water content, which limited their conservation. The *P. edulis f. flavicarpa* contains significant protein content ($9.42 \pm 1.56\%$), and the lipid content of *P. edulis f. flavicarpa* (11.65%) and *A. alboviolaceum* (10.58%) was higher than that of the other two fruits. The pulps of *Saba comorensis* and *Clitandra cymulosa* were acidic with not negligible free sugar contents. The ashes of these four fruits contained minerals such as iron, phosphorus, calcium and magnesium, with the last two being the major elements. The comparative study of the seeds and pulps of *P. edulis f. flavicarpa* and *A. alboviolaceum* demonstrated the seeds nutritional quality. In view of these results, the four fruits as well as the *P. edulis f. flavicarpa* and *A. alboviolaceum* seeds could constitute an appreciable source of nutrient intake and also be valued in the food, pharmaceutical and cosmetic industry.

Key words: *Passiflora edulis f. flavicarpa*, *Aframomum alboviolaceum*, *Saba comorensis*, *Clitandra cymulosa*, mineral elements, biochemical characteristic, Republic of Congo.

INTRODUCTION

In the Republic of Congo, as in most developing countries, the problem of food security remains a major

*Corresponding author. E-mail: josiane0204@yahoo.fr.

challenge. Nutritional deficiencies are the cause of acute malnutrition affecting mostly women of childbearing age and children (OMS, 2009; Stevens et al., 2013; N'goran, 2014). One of the ways out of this impasse is the valuation of edible fruits including wild ones available but less exploited.

Fruits are considered as very good sources of minerals, vitamins, carbohydrates, phenolic compounds and antioxidants (Ahodegnon et al., 2018) and can contribute to a qualitative improvement in the health of populations (Kuhnlein, 1989).

For this reason, all scientists now agree that people who consume enough fruit are less likely to suffer from cardiovascular disease, obesity, cancer and diabetes (FAO/WHO, 2004). Fruits are an important link in the food chain both qualitatively and quantitatively. In terms of nutrition, fruits in general constitute an essential supplement of the basic diet consisting of cereals and starchy foods which are poor in mineral salts and vitamins (Kouyaté et al., 2009; Krishnamurthy and Sarala, 2012).

In the Republic of Congo, despite its usefulness in improving the nutritional status of populations, conventional fruits are still inaccessible to the middle class because of its high cost. This situation could lead to nutritional deficiencies that increase the risk of non-communicable diseases (NCDs). However, there are under-exploited pick fruits such as *Passiflora edulis f. flavicarpa*, *Aframomum albobviolaceum*, *Saba comorensis* and *Clitandra cymulosa* that are highly valued by urban and rural populations, which could be important sources of nutrients and thus play an important role in food security and the improvement of nutritional status of the populations.

Grenadilla (*P. edulis f. flavicarpa*), known as "sour passion fruit", native to South America (Koko et al., 2018; Carr, 2013), is a climbing plant in the Passifloraceae family (Hoff and Cremers, 2005) grown for its edible pulp fruits. The Passifloraceae family has more than 500 species divided into 18 genera among which the *Passiflora* genus (Corrêa et al., 2016). Its fruits have a round shape with a diameter ranging from 8 to 10 cm, a yellowish green skin when mature and contain multiple seeds surrounded by a gelatinous yellow pulp with a tangy taste and intense aroma (López-Vargas et al., 2013). The fruit is marketed worldwide with Brazil, Ecuador and Colombia as the largest producers (Cardoso et al., 2012). Its leaves are shiny on their upper surfaces and dull on their lower surfaces (Zas and John, 2016) with a thickness of 7.5 to 20 cm.

Maniguette (*Aframomum*), of African origin, is a plant that grows for example in Ivory Coast, Cameroon, Gabon, Congo, the DRC, Madagascar, and is found mostly in the undergrowth. *Aframomum* species are large herbaceous plants that reach 5-6 m (Ngakegni-Limbili et al., 2013). They are perennial and aromatic, and have large trumpet-shaped yellow or pink flowers, purple

petals and peduncles which are covered with sterile, superimposed bracts (Fankam et al., 2011). The pericarp, of variable woodiness, contains an edible whitish flesh dotted with dark brown seeds measuring 2-3 mm in diameter while the flesh has a very aromatic and refreshing taste (Herzog et al., 1994).

S. comorensis of the Apocynaceae family (Okullo et al., 2014) is a strong forest liana, up to 20 m long on other trees. It is used for its edible fleshy fruits in the form of berries (Ouattara et al., 2016). The fruits contain many almonds coated with orange-yellow pulp and are consumed during the lean season (Atato et al., 2011).

C. cymulosa (Benth) of the Apocynaceae family is native to tropical West Africa and has fruits in the form of berry containing almonds coated with red edible pulp (Mosango and Szafranski, 1985).

Despite the importance of these fruits in the food chain, very few studies on their biochemical characterization and their evaluation have been carried out up until now, to our knowledge. It is in this context that the present study was performed and is aimed at determining the biochemical characteristics of these four popular edible fruits in order to contribute to their evaluation.

MATERIALS AND METHODS

Biological materials

The biological materials used consist of fruits of *P. edulis f. flavicarpa* (yellow passion fruit), *A. albobviolaceum* (sweet maniguette), *S. comorensis* (Bojer) and *C. cymulosa* (Benth) presented in Table 1. They were bought fresh in the different markets of the city of Brazzaville (Republic of Congo).

Sample preparation

The fruits are washed and then cut in half with a kitchen knife (passion fruit, *S. comorensis* and *C. cymulosa*) or split longitudinally by pressing the fruit pod with both hands (*A. albobviolaceum*) to expose the fruit. The pulp and seeds or the pulp and almond are extracted with the spatula for the different analyses.

Chemical analyses

The four fruit samples, the pulp and seed of *P. edulis f. flavicarpa* and *A. albobviolaceum* were analyzed in triplicate for moisture, crude protein, crude lipids and ash using the standard AOAC methods (1995, 2005). Free sugars were determined from the pulp of *S. comorensis* and *C. cymulosa* by anthrone-sulfuric acid method (Yemm and Willis, 1954).

After mineralization of the different samples in the oven at 450°C, the ash was recovered, moistened with water and concentrated hydrochloric acid, and then minerals elements were determined employing standard methods. Phosphorus was assayed by the cold colorimetric method using Murphy and Riley's reagent. Calcium and magnesium were determined by atomic absorption under the following spectral conditions: calcium ($I = 5A$, $\lambda = 422.7$ nm) and magnesium ($I = 3A$, $\lambda = 285.2$ nm). Iron was determined by atomic absorption spectrometry (AAS). After plotting the calibration lines for each element, the concentrations read for the sample and blank

Table 1. Different samples used in this work.

Sample	Fruits	Seeds
1. <i>Passiflora edulis f. flavicarpa</i>		
2. <i>Aframomum alboviolaceum</i>		
3. <i>Saba comorensis</i> (Bojer)		
4. <i>Clitandra cymulosa</i> (Benth)		

were derived.

The pH was determined with *S. comorensis* and *C. cymulosa* pulp according to the potentiometric method using the electrode of a pH counter (55).

Titrateable acidity was determined according to the normalized method FP7n°245025 (AFTER, 2011) with some modifications. The acidity has been obtained according to the following formula:

$$\text{Acidity (mEq/100 g MF)} = N * V * \frac{50}{V_0} * \frac{100}{m}$$

where N is the normality of the soda used; V is the volume (ml), of the sodium hydroxide solution; m is the mass (g) of the sampled

product; 50 is the final volume of the solution in the volumetric flask; and V_0 is the volume (ml) of the aliquot test sample of the solution.

The titrateable acidity can also be expressed in grams of acids per 100 g of product, multiplied by a factor equivalent to the chosen acid. In our case, we used citric acid so this formula was multiplied by 0.07 (AFTER, 2011).

RESULTS AND DISCUSSION

Table 2 shows that, like most fleshy fruits, the four fruits analyzed (*P. edulis f. flavicarpa*, *A. alboviolaceum*, *S.*

Table 2. Chemical composition of four fruit (%).

Fruit	Moisture	Crude protein	Crude lipid	Ash
<i>Passiflora edulis f. flavicarpa</i>	68.77 ± 0.05	9.42±1.56	11.65	3.77 ± 0.33
<i>Aframomum alboviolaceum</i>	66.86 ± 1.66	5.78±0.83	10.58	3.84 ± 0.07
<i>Saba comorensis</i> Bojer	64.82±1.09	3.76 ± 0.06	0.72 ± 0.02	3.60 ±0.02
<i>Clitandra cymulosa</i> (Benth)	60.49±1.28	5.23 ± 0.13	0.79 ± 0.069	1.35±0.49

comorensis Bojer and *C. Cymulosa* (Benth) contained high water content.

These moisture contents were higher than the value found by Boamponsem et al. (2013) with *Saba senegalensis* fruits, similar to those obtained by Diop et al. (2010) in the pulps from *Detarium senegalense* J.F. Gmel fruits harvested in five localities of Senegal, and by Kone et al. (2018) in the fruit pulp of black plum (*Vitex doniana*) from Ivory Coast. However, our values were lower than those obtained by Corrêa et al. (2016) in the pulp of five species of *Passiflora* (72.93 - 95.6%).

Moisture content is important for the stability and quality of food. Fruits that contain a large amount of water are subject to rapid deterioration due to mold growth and insect damage (Boamponsem et al., 2013).

The *P. edulis f. flavicarpa* had the highest protein content while the *S. comorensis* had the lowest protein content. These protein levels were lower than those found by Ayessou et al. (2011) in five Senegalese forest fruits. However, these values were higher than those reported in the literature (Favier, 1993) on some pick fruits such as passion fruit (2.6%), cinnamon apple (1.8%), medlar (0.4%), desert date (1.8%), and *Aframomum* (1.1%) and by Corrêa et al. (2016) in five *Passiflora* species.

They were also close to the values obtained in the pulp of *Hippophae rhamnoides* fruit (Dhyani et al., 2007). These values could make these fruits a significant source of protein necessary for human nutrition compared to other fruits already valued or exploited.

From analysis of Table 2, the four fruits had a lipid content that varied between 0.72 ± 0.02% and 11.65%. *S. comorensis* and *C. cymulosa* had very low lipid content. However, the lipid contents of *P. edulis f. flavicarpa* and *A. alboviolaceum* were high and similar, and these values were close to those found in the pulp of *H. rhamnoides* fruit (Dhyani et al., 2007) making these two fruits a significant source of lipid.

Table 2 showed ash content between 1.35 ± 0.49% and 3.84 ± 0.07%. The ash content found in the pulp of *C. cymulosa* is lower compared to that obtained in *S. comorensis*, *P. edulis f. flavicarpa* and *A. alboviolaceum*. These values were similar to those obtained by Ayessou et al. (2011) in two Senegalese fruits (*F. gnaphalocarpa* and *S. latifolius*). In comparison with the work of Boamponsem et al. (2013) on the pulp of *S. senegalensis*, we noted that the pulp of *S. comorensis*

had higher ash content.

The composition of acidity and free sugars is given in Figure 1. From this figure, it can be observed that the pulp of two fruits contained low free sugar content. Nevertheless, the pulp of *C. cymulosa* (3.54%) was richer in reducing sugars than that of *S. comorensis* (2.52%). These values were close to those obtained by Diop et al. (2010) on the pulp of *D. senegalense* fruit (2.72 - 3.69%) already valued. In addition, our values were slightly lower than those obtained in wild *Spondias mombin* fruit available locally in Nigeria (Adepoju, 2009).

The pH of the *C. cymulosa* pulp (3.55) was higher than that of *S. comorensis* (3.2). These values were similar to those by Diop et al. (2010) who had worked on the pulp of *D. senegalense* (3.51) and superior to the results by Boamponsem et al. (2013) on the pulp of *S. senegalensis* (2.27). These results showed that the pulp of these fruits could give a juice with a favorable rate of acidity for the conservation against the degradation by the fungi.

Figure 1 showed that the pulp of *C. cymulosa* had titrable acidity expressed in citric acid equivalent content lower than that of *S. comorensis*. These results showed the concordance between the pH value and that of the acidity of the pulp of these two fruits.

Table 3 gives the results of mineral composition of *P. edulis f. flavicarpa*, *A. alboviolaceum* and *S. comorensis* Bojer fruits. The iron content was higher in the *S. comorensis* pulp compared to the two other fruits (*P. edulis f. flavicarpa* and *A. alboviolaceum*) with similar values. These values were higher than those found by Dike and Nnamdi (2012) with other fruits such as *Gambeya albida*, *Dialium guineense* and *Aframomum melegueta*. The *S. comorensis* fruit gave higher content of calcium, phosphorus and magnesium compared to the fruits of *P. edulis f. flavicarpa* and *A. alboviolaceum*.

In comparing our samples with four samples of Senegalese forest fruits and five Chinese jujube cultivars (Pareek, 2013) (Table 3) as well as three batches of jujube of Senegalese origin (Danthua et al., 2001), we could deduce that our samples constitute a source of mineral elements by their richness in magnesium, calcium and iron. Despite the low phosphorus content compared to the values of the literature (Ayessou et al., 2011), the consumption of these fruits could thus contribute to the satisfaction of the need of the human organism in terms of minerals and thus participate in a good growth, good metabolic process and prevention of

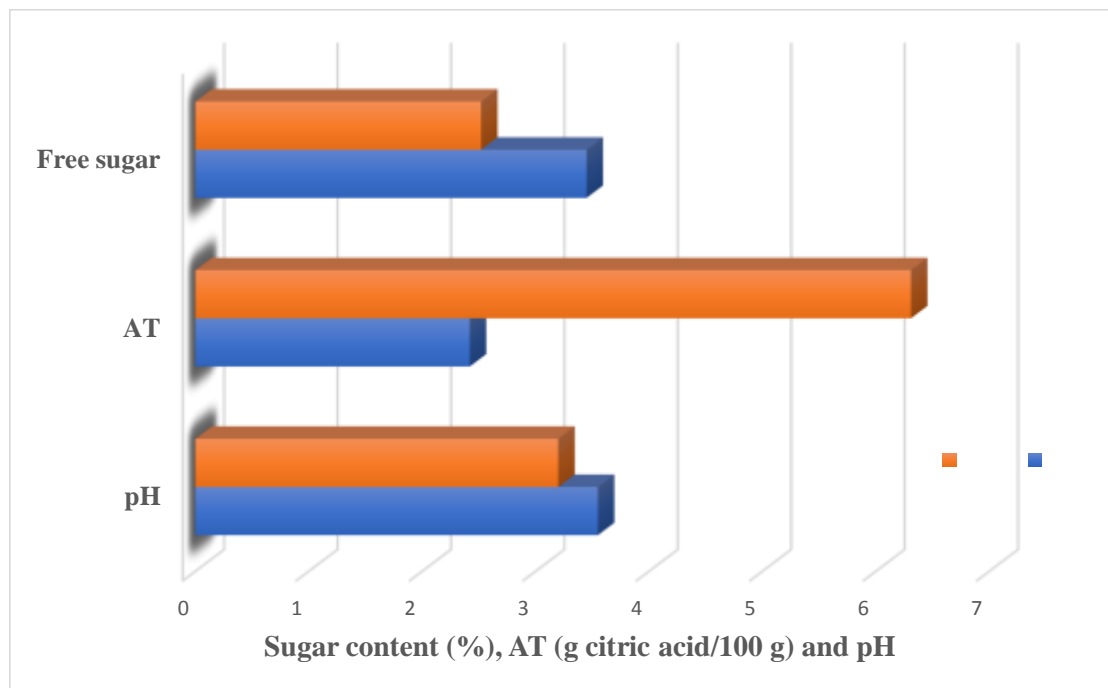


Figure 1. Contents of free sugar, AT and pH of *S. comorensis* and *C. cymulosa* fruit pulp.

Table 3. Comparison in mineral elements of studied fruits with other ones (mg/100 g).

Fruits	Fe	P	Ca	Mg
<i>Passiflora edulis f. flavicarpa</i> ^a	6 ± 0	24.5 ± 3.5	75 ± 7.07	65 ± 7.07
<i>Aframomum alboviolaceum</i> ^a	5.5 ± 0.7	17.5 ± 0.7	70 ± 14.14	170 ± 28.28
<i>Saba comorensis</i> Bojer ^a	25 ± 7.07	35 ± 7.07	460 ± 84.5	1090 ± 71
<i>Clitandra Cymulosa</i> (Benth) ^a	nd	nd	Nd	nd
<i>I. Senegalensis</i> ^b	8.1	172	612	210
<i>F. gnaphalocarpa</i> ^b	7.1	116	309	138
<i>C. pinnata</i> ^b	4.1	137	46	79
<i>S. lutifolius</i> ^b	5.4	214	470	154
<i>Jinsixiaozao</i> ^c	4.68	110	65.2	nd
<i>Yazao</i> ^c	6.93	59.3	91.0	nd
<i>Jianzao</i> ^c	6.42	72.3	45.6	nd
<i>Junzao</i> ^c	7.90	105	118	nd
<i>Sanbianhong</i> ^c	6.01	79.7	76.9	nd

Source: ^a This work; ^b Ayessou et al. (2011); ^c Pareek (2013).

certain diseases (FAO/WHO,2002). Magnesium is essential for the normal functioning of ATP (adenosine triphosphate) and glucose metabolism and therefore has extensive cellular effects. It is critical for normal ATP (adenosine triphosphate) function and glucose metabolism and therefore has widespread cellular effects. Magnesium is also important in cellular cytoskeleton contraction and at the myoneural junction (Moe, 2008).

Figures 2 and 3 showed the chemical composition of

seeds and pulps of *P. edulis f. flavicarpa* and *A. alboviolaceum*. In the analysis of Figure 2, except for the ash content which was higher in the two pulps ($3.82 \pm 0.04\%$ for *P. edulis f.* and $10.41\% \pm 0.02$ for *A. alboviolaceum*), the other nutrients (proteins and lipids) were present in high quantities in the seeds of two fruits. The seeds of *P. edulis f.* had the highest lipid content (17.86%), and this value was lower than that obtained by Malacrida and Jorge (2012) who worked on the same fruit, but native from Brazilia. In addition, this oil content

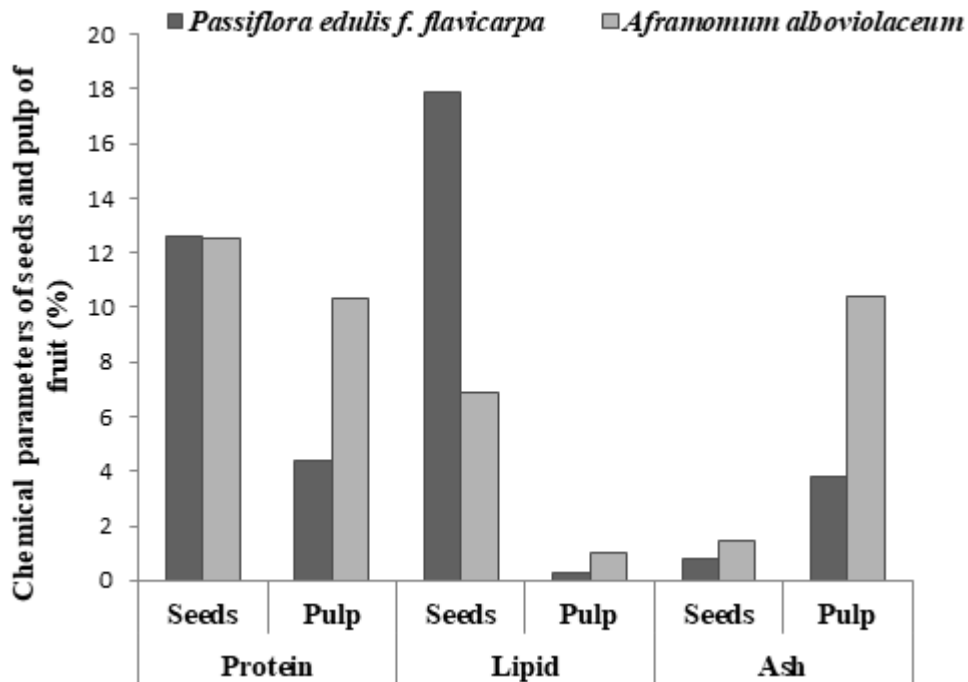


Figure 2. Chemical composition of seeds and pulp of *Passiflora edulis f. flavicarpa* and *Aframomum alboviolaceum*.

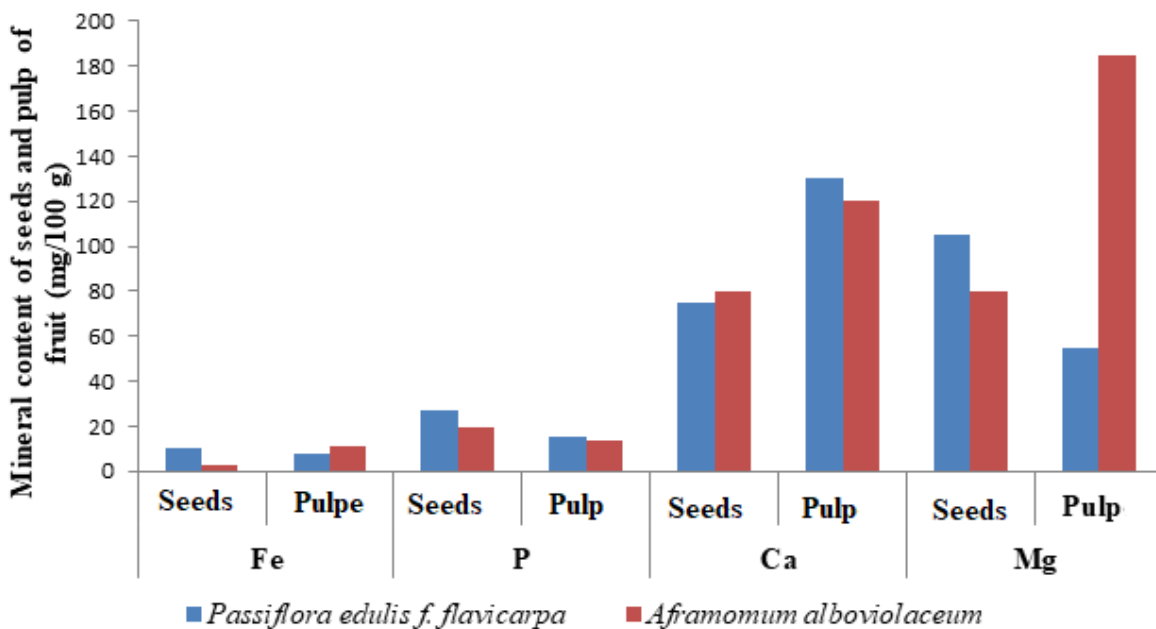


Figure 3. Mineral composition of seeds and pulp of *Passiflora edulis f. flavicarpa* and *Aframomum alboviolaceum*.

was similar to that obtained by Bireche et al. (2014) in *Citrullus colocynthis* seeds and by El Hachimi et al. (2015) in the seeds of two grenadier varieties. The seeds of *P. edulis f* also presented oil content higher than that

obtained both in the seeds of the prickly pear (El Hachimi et al., 2015) and the guava (Bourgeois et al., 1998).

Figure 3 shows the mineral content in the seeds and pulps of *P. edulis, f. flavicarpa* and *A. alboviolaceum*.

Concerning the *P. edulis f. flavicarpa* fruit, iron content (seeds: 10 ± 1.41 mg/100 g and pulp: 8 ± 1.41 mg/100 g), phosphorus (seeds: 27.5 ± 2.12 mg/100 g and pulp: 15.5 ± 0.7 mg/100 g) and magnesium (seeds: 105 ± 21.21 mg/100 g and pulp: 55 ± 7.07 mg/100 g) were higher in the seeds than in the pulp. However, calcium was more abundant in the pulp (130 ± 1.41 mg/100 g) than in the seeds (75 ± 7.07 mg/100 g). The magnesium and iron contents were similar to those found in guava seeds (Bourgeois et al., 1998) which already had values. With regard to the fruit of *A. alboviolaceum*, the analysis of Figure 3 showed, except the phosphorus which was more abundant in the seed (19.5 ± 2.12 mg/100 g) than in the pulp (14 ± 1.41 mg/100 g), iron (seeds: 3 mg/100 g and pulp: 11 mg/100 g), calcium (seeds: 80 mg/100 g and pulp: 120 mg/100 g) and magnesium (seeds: 80 ± 14.14 mg/100 g and pulp: 185 ± 21.21 mg/100 g) were present in greater quantity in the pulp than in the seeds. These results showed that the seeds of two fruits which were edible, but considered as waste during processing into juice or nectar had very interesting characteristics because of their essential nutrient composition. Thus, they could be valued in the same way as the pulp. These seeds could be used in human food by making flours utilized as a supplement in the formulation of infant flours and in cosmetology by extraction of essential oil.

Conclusion

This study allowed us, on the one hand, to determine the biochemical characteristics of the four (*P. edulis flavicarpa*, *A. alboviolaceum*, *S. comorensis* and *C. cymulosa*) popular edible fruits in the Republic of Congo and, on the other hand, to compare the pulp and seeds of *P. edulis f. flavicarpa* and *A. alboviolaceum*. The four fruits were characterized by a wealth of water and were a significant source of proteins, lipids, ashes and minerals. Nevertheless, *S. comorensis* and *C. cymulosa* presented very low lipid content. The pulp of *S. comorensis* and *C. cymulosa* were characterized by an important content of acidity and reducing sugar. Ashes contained iron, phosphorus, calcium and magnesium. All these mineral elements were in greater quantity in the pulp of *S. comorensis*. The comparative study of the seeds and pulps of *P. edulis f. flavicarpa* and *A. alboviolaceum* showed that the seeds contained higher levels of protein and lipids. The seeds of the passion fruit were rich in iron, calcium and magnesium. However, the values obtained in those of *A. alboviolaceum* were not negligible. These fruits including their seeds could be an important source of nutrients and are valued in the food, pharmaceutical and cosmetic industries. The encouraging results of this study deserve to be further investigated.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Adepoju OT (2009). Proximate composition and micronutrient potentials of three locally available wild fruits in Nigeria. *African Journal of Agricultural Research* 4(9):887-892.
- Ahodegnon DK, Gnansounou M, Bogninou RGS, Kanfon ER, Chabi B, Agbangnan Dossa PC, Anago EA, Ahoussi E, Wotto V, Sohounloulou DCK (2018). Biochemical profile and antioxidant activity of *Parkia biglobosa* and *Tamarindus indica* fruits acclimated in Benin. *International Journal of Advanced Research* 6(11):702-711.
- AOAC (1995). Official methods of analysis (16th edn) Association of Official Analytical Chemists. Virginia, USA.
- AOAC (2005). Association of Official Analytical Chemists, 18th ed. AOAC Official Methods of Analysis, Gaithersburg, MD.
- Atato A, Wala K, Dourma M, Bellefontaine R, Woegan YA, Batawila K, Akpagana K (2012). Espèces lianescentes à fruits comestibles du Togo. *Fruits* 67:353-368.
- Ayessou NC, Ndiaye C, Cissé M, Gueye M, Sakho M (2011). Nutritional Contribution of Some Senegalese Forest Fruits Running across Soudano-Sahelian Zone. *Food and Nutrition Sciences* 2:606-612.
- Bireche M, Bakchiche B, Maatallah M, Gherib A (2014). Propriétés physico-chimiques de lipide et quantification des protéines de graines des fruits *Citrullus Colocynthis* [Physicochemical properties of lipid and quantification of proteins of *Citrullus Colocynthis* seed oil]. *International Journal of Innovation and Applied Studies* 9(4):1944-1948.
- Boamponsem GA, Johnson FS, Mahunu GK, Awini-boyaya SF (2013). Determination of biochemical composition of *Saba senegalensis* (Saba fruit). *Asian Journal of Plant Science and Research* 3(1):31-36.
- Bourgeois P, Aurore GS, Abaul J, Joseph H (1998). Valorisation de la graine de goyave : huile de l'amande et poudre abrasive de coque. *Cahiers Agricoles* 7:105-109.
- Cardoso DOR, Docê RC, Sueli TBD (2012). Clarification of passion fruit juice by microfiltration: Analyses of operating parameters, study of membrane fouling and juice quality. *Journal of Food Engineering* 111:432-439.
- Carr MKV (2013). The water relations and irrigation requirements of passion fruit (*Passiflora edulis* Sims): A review. *Experimental Agriculture* 49(4):585-596.
- Corrêa RCG, Peralta RM, Haminiuk CWI, Maciel GM, Bracht A, Ferreira ICFR (2016). The past decade findings related with nutritional composition, bioactive molecules and biotechnological applications of *Passiflora* spp. (passion fruit). *Trends in Food Science and Technology* 58:79-95.
- Danthua P, Soloviev P, Totté A, Tine E, Ayessou N, Gaye A, Niang, Moussa Seck TD, Falle M (2002). Caractères physico-chimiques et organoleptiques comparés de jujubes sauvages et des fruits de la variété Gola introduite au Sénégal. *Fruits* 57 :173-182.
- Dhyani D, Maikhuri RK, Rao KS, Lalit Kumar, Purohit VK, Manju Sundriyal, Saxena KG (2007). Basic nutritional attributes of *Hippophae rhamnoides* (Seabuckthorn) populations from Uttarakhand Himalaya, India. *Current Science* 8(92):1148-1152.
- Dike MC, Nnamdi AE (2012). Comparative study of proximate, phytochemical and mineral compositions of edible plant fruits/seeds from Nigerian rainforest. *International Journal of Biological and Chemical Sciences* 6(4):1905-1909.
- Diop N, Dornier M, Dhuique Mayer C, Prades A, Munier Pantel S, Pélissier Y, Laroque M, Sock O (2010). Caractérisation d'un fruit sauvage du Sénégal: le Ditax (*Detarium senegalense* J.F. Gmel). Colloque international et interdisciplinaire sur les plantes alimentaires. Médicinales et Cosmétiques en Zone Sahélienne 9p.
- El Hachimi F, El Antari A, Boujnah M, Bendrisse A, Alfaiz C (2015). Comparaison des huiles des graines et de la teneur en acides gras de différentes populations marocaines de jujubier, de grenadier et de figuier de barbarie [Comparison of oils seed and fatty acid content of various Moroccan populations of jujube, grenadier and prickly pear]. *Journal of Materials and Environmental Science* 6(5):1488-1502.
- Fankam A, Kuete V, Voukeng I, Kuate J, Pages JM (2011). Antibacterial activities of selected Cameroonian spices and their synergistic effects with antibiotics against multidrug-resistant phenotypes. *BMC Complementary and Alternative Medicine* 11:104.
- FAO/WHO (2004). Fruit and Vegetables for Health. Rapport de

- collaboration FAO/OMS 46 p.
- Favier JC, Ireland Ripert J, Laussucq C, Feinberg M (1993). Table de composition des fruits exotiques, fruits de cueillette d'Afrique. Répertoire général des aliments, Paris ORSTOM, INRA, TEC and DOC Lavoisier 3:243.
- Food and Agriculture Organization (FAO)/World Health Organisation (WHO) (2002). Chapter 6 Vitamin C, In: human vitamin and mineral requirements. Agriculture and Consumer Protection, Rome pp. 73-87.
- Herzog F, Farah Z, Amadó R (1994). Composition and consumption of gathered wild fruits in the V-Baoulé, Côte d'Ivoire. *Ecology of Food and Nutrition* 32(3-4):181-196.
- Hoff M, Cremers G (2005). Le Jardin Guyanais Inventaire des plantes cultivées et des adventices des jardins de Guyane française. *Journal de Botanique de la Société de Botanique* 29:3-40.
- Koko CA, Kouamé BK, Diomandé M, Adjoua Boko CE, Nougou Assidj E, N'guessan Amani G (2018). Effets Des Technologies Membranaires Sur Les Caracteristiques Physicochimiques Des Extraits De Fruits De La Passion (*Passiflora Edulis*). *European Scientific Journal* 14(33):282-297.
- Kone HS, Kone KY, Akaki KD, Soro D, Elleingang FE, Assidjo NE (2018). Caractérisation Biochimique De La Pulpe des Fruits Du Prunier Noir (*Vitex Doniana*) De La Côte d'Ivoire. *European Scientific Journal* 14(3):252-270.
- Kouyaté AM, Van Damme P, De Meulenaer B, Diawara H (2009). Contribution des produits de cueillette dans l'alimentation humaine. Cas de *Detarium microcarpum*. *Afrika Focus* 22(1):77-88.
- Krishnamurthy SR, Sarala P (2012). Determination of nutritive value of *Ziziphus rugosa* Lamk: A famine edible fruit and medicinal plant of Western Ghats. *Indian Journal of Natural Products and Resources* 3(1):20-27.
- Kuhnlein HV (1989). Nutrient values in indigenous wild berries used by the Nuxalk people of Bella Coola, British Columbia. *Journal and Food Composition and Analysis* 2(1):28-36.
- López-Vargas JH, Fernández-López J, Pérez-Alvarez JA, Viuda-Martos M (2013). Chemical, physico-chemical, technological, antibacterial and antioxidant properties of dietary fiber powder obtained from yellow passion fruit (*Passiflora edulis* var. *flavicarpa*) co-products. *Food Research International* 51(2):756-763.
- Malacrida CR, Jorge N (2012). Yellow Passion Fruit Seed Oil (*Passiflora edulis* f. *flavicarpa*): Physical and Chemical Characteristics. *Brazilian Archives Archives of Biology and Technology* 55(1):127-134.
- Moe SM (2008). Disorders Involving Calcium, Phosphorus, and Magnesium. *Prim Care* 35(2):215-216.
- Mosango M, Szafranski F (1985). Plantes sauvages à fruits comestibles dans les environs de Kisangani (Zaïre). *Journal d'agriculture Traditionnelle et de Botanique Appliquée* 32:177-190.
- Ngakegni-Limbili CA, Zebib B, Cerny M, Tsiba G, Ndinga EMA, Mouloungui Z, Isabelle Fourastier I, Ouamba MJ (2013). *Aframomum stipulatum* (Gagnep) K. Schum and *Aframomum giganteum* (Oliv. & Hanb) K. Schum as Aroma Tincto Oleo Crops resources: essential oil, fatty acids, sterols, tocopherols, and tocotrienols composition of different fruit parts of Congo varieties. *Journal Sciences of Food and Agriculture* 93(1):67-75.
- N'goran P (2014). Sécurité alimentaire et nutritionnelle en Côte d'Ivoire: Etat des lieux, défis. Programme National de Nutrition 42 p.
- Okullo JBL, Omuja F, Bigirimana C, Isubikalu P, Malinga M, Bizuru E, Namutebi A, Obaan BB, Agea JG (2014). Ethno-Medicinal Uses of Selected Indigenous Fruit Trees from the Lake Victoria Basin Districts in Uganda. *Journal of Medicinal Plants Studies* 2(1):78-88.
- OMS (2009). Global prevalence of vitamin A deficiency in populations at risk 1995-2005. WHO global database on vitamin A Deficiency. Available: https://apps.who.int/iris/bitstream/handle/10665/44110/9789241598019_eng.pdf
- Ouattara ND, Gaille E, Stauffer FW, Bakayoko A (2016). Diversité floristique et ethnobotanique des plantes sauvages comestibles dans le Département de Bondoukou (Nord- Est de la Côte d'Ivoire). *Journal of Applied Biosciences* 98:9284-9300.
- Pareek S (2013). Nutritional composition of jujube fruit. *Emirates Journal of Food and Agriculture* 25(6):463-470.
- Stevens GA, Finucane MM, De-Regil LM, Paciorek CJ, Flaxman SR, Branca F, Ezzati M (2013). Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: a systematic analysis of population-representative data. *The Lancet Global Health* 1(1):16-25.
- Yemm EW, Willis AJ (1954). The estimation of carbohydrates in plant extracts by anthrone. *Biochemical Journal* 57:508-514.
- Zas P, John S (2016). Diabetes and Medicinal Benefits of *Passiflora edulis*. *World Journal of Pharmaceutical Research* 5(2):265-269.