

Physicochemical, Biochemical and Phytochemical Characterisation of Ripe Fruit of the Mombin Plum (*Spondias mombin*) from Côte d'Ivoire

Paul Rodolphe Kouamé Tanou^{1,*}, Kouamé Mathias Koffi¹

Laboratoire de Biotechnologie, Agriculture et Valorisation des Ressources Biologiques, UFR Biosciences,
Université Félix HOUPHOUËT BOIGNY de Cocody (UFHB) Abidjan, CÔTE D'IVOIRE

*Corresponding author: tpaulrodolphe@yahoo.fr

Received September 25, 2023; Revised October 22, 2023; Accepted October 29, 2023

Abstract *Spondias mombin* is a tropical fruit widely consumed in several tropical countries. In Côte d'Ivoire, the fruits of *Spondias mombin* are consumed by the population without much interest. This is due to the lack of knowledge of the qualities of this fruit because there are few studies on its biochemical and physicochemical characteristics. This study therefore aims to determine the nutritional potential of the fruit. The analyzes showed that the fruit pulp is acidic with a pH between 2.20 and 2.97. It is also rich in sugar and has a quantity of soluble solids between 11 and 13° Brix. There are also proteins between 2.09 and 3.06 %, flavonoids from 2.09 to 3.41 mg/100 g, polyphenols from 25.40 to 38.22 mg/100 g, tannins from 69.64 to 142.61 mg/100 g and an energy value between 29.58 and 32.40 Kcal/100 g. Given the nutritional qualities of this fruit, the hog plum is a very interesting fruit to consider in the prevention of certain dietary imbalances and shows a real potential for use in the food processing industry.

Keywords: hog plum, *Spondias mombin*, biochemical and physicochemical characteristics, nutritional potential, Côte d'Ivoire

Cite This Article: Paul Rodolphe Kouamé Tanou, and Kouamé Mathias Koffi, “Physicochemical, Biochemical and Phytochemical Characterisation of Ripe Fruit of the Mombin Plum (*Spondias Mombin*) from Côte d'Ivoire.” Journal of Food and Nutrition Research, vol. 11, no. 10 (2022): 652-659. doi: 10.12691/jfmr-11-10-7.

1. Introduction

Côte d'Ivoire, like all tropical countries, has a great biodiversity that allows access to countless species of fruits. From the food point of view, the fruit is defined as a food of plant origin, generally with a sweet flavor and eaten raw [1]. Indeed, fruits contain many essential elements for the proper functioning of the body. They are rich in vitamins as well as antioxidant compounds such as polyphenols, flavonoids, carotenoids and are significant sources of dietary fiber necessary for a healthy digestive system. Fruits are also involved in reducing the risk of certain diseases such as cancer, obesity and cardiovascular disease [2,3].

Given the importance of fruit in the human diet, the “5 a Day” program has encouraged the population since 1988 to consume at least five fruits and vegetables per day. However, 3.9 million deaths worldwide in 2017 were due to insufficient consumption of fruits and vegetables [4].

To remedy this problem, the promotion of local food products and more specifically wild forest fruits which have a nutritional potential and an almost free availability also accessible to all social strata would be an asset.

The fruit of the plum mombin or yellow mombin (*Spondias mombin*), whose nutritional, medical and commercial values are not negligible [5] could satisfy this requirement. This fruit is well known and consumed by the local populations of countries such as Guyana, Brazil and Nigeria where it is more produced and industrialized [6,7]. Similarly, the fruit pulp of the mombin plum tree is used in the preparation of various drinks and is used in the preparation of sorghum porridges in Togo [8]. Also, the pulps of this fruit are rich in vitamins A and C and antioxidant compounds [9].

In Côte d'Ivoire, the mombin plum tree is best known for its bark and leaves used in traditional medicine in the treatment of certain diseases such as digestive disorders, vomiting, nausea, post and prenatal hemorrhage [10,11]. Also, the fruit of the mombin plum tree, despite its availability and accessibility, remains little known and little exploited [12,13]. It is consumed mainly by the populations of the forest regions and the wooded savannah. However, there are no data on the nutritional and nutritional potential of this fruit in Côte d'Ivoire. Hence the need for this study.

Therefore, the objective of this work is to determine the physicochemical and biochemical characteristics in order to provide information on the composition of the fruits of

the mombin plum tree to better orient their possible valorization.

2. Material and Methods

2.1. Material

The plant material used consists of ripe plum mombin (*Spondias mombin*) fruits, yellow in color and ovoid and rounded shapes from three different regions of Côte d'Ivoire (Figure 1). These regions are: the N'Zi region, the Moronou region and the Gbêkê region. The fruits were collected in the morning at the foot of the trees.



Figure 1. Ripe fruits of plum mombin (*Spondias mombin*)

2.2. Methods

2.2.1. Sample Preparation

The batches of ripe fruit were washed three times with tap water and then sorted to obtain only fruit in good condition. Then they were put in three different plastic jars depending on where they came from. Finally, the samples (one sample of fruit for each region) of fruit were kept at -18°C until the time of the analyzes to avoid the proliferation of spoilage microorganisms.

2.2.2. Juice Extraction

The ripe fruits, once thawed, were separated from their epicarp, then kneaded by hand to obtain the pulp in the form of juice containing fibrous residues (Figure 2).



Figure 2. Pulp of ripe mombin plum fruits

2.2.3. Physicochemical Analysis

Brix degree

The Brix degree is the percentage of matter soluble in water. It is determined using a **SODIAL(R) brand refractometer** by depositing a drop of the juice sample from the pulp of *Spondias mombin* on the prism of the instrument then directing it to a light source. The eye in contact with the indicator makes it possible to observe two separate zones. The graduation corresponding to the limit which separates the two zones corresponds to the Brix degree of the sample. The tests were carried out three times for each sample [14].

pH

The pH is used to determine the concentration of H^+ ions in the sample. It is determined by direct measurement in 5 mL of the pulp using a **pH meter (HANNA HI 8424)** previously calibrated at pH 4.0 and 7.0. Measurements were made three times for each sample [14].

Moisture rate and dry matter rate

The moisture content was determined by difference in weighing the samples before and after passing through the oven [14]. About 5 grams (g) of pulp (Pe) are weighed in a crucible (P0) then placed in an oven at 105°C. for 24 hours. The crucibles containing the samples are then cooled in a desiccator and then weighed (Pf) again. The tests were carried out three times for each sample. The percentage of the moisture content is obtained according to the following formula:

$$\%H = \frac{Pe - (Pf - Po)}{Pe} \times 100 \quad (1)$$

Titrateable acidity

titrateable acidity (in mEq /L) is a value which makes it possible to know the number of acid equivalents contained in the yellow mombin pulp. It was determined according to the colorimetric method described by [15]. 45 mL of distilled water are added to a volume of 5 mL of pulp juice. After 5 min of homogenization using a magnetic stirrer. Then, 10 mL (V0) of the mixture is taken and poured into a jar. The titration is finally carried out with sodium hydroxide (NaOH at N1=0.1N) after addition of 2 drops of phenolphthalein. Let V1 be the volume of the NaOH solution poured at equivalence. The tests were carried out three times for each sample. The titrateable acidity (A) is obtained according to the formula of the equation:

$$N \text{ (mEq /L)} = (N1.V1 / V0.f) \times 100 \quad (2)$$

Density

Density is the ratio between the density (mass of a unit volume) of a substance (ρ_{echan}) and the density (mass of the same unit volume) of a reference substance. Density is a ratio and therefore has no unit [16]. In the majority of cases, the reference substance is water (ρ_{water}) for liquids or air for gases. Take 10mL of pulp juice in a test tube and weigh. Calculate the density of the pulp juice according to the equation:

$$d = \rho_{\text{sample}} / \rho_{\text{water}} \quad (3)$$

Ash content

Ash content was determined by [14]. Mineral matter or total ash is the residue obtained after the destruction of organic compounds by calcination. They are determined after oven-drying at 105°C for 24 hours of samples of 5g of yellow mombin pulp. Then calcined in a muffle furnace for 12 hours at 550°C. and the ashes inside the crucibles are cooled in a desiccator to room temperature then the crucibles are weighed after cooling. The tests were carried out three times for each sample. The ash content is given by the following formula:

$$Tc (\%) = (Mc / Ms) \times 100 \quad (4)$$

2.2.4. Biochemical Characterization

Vitamins C

2,6- dichlorophenolindophenol (2,6-DCPIP) titration method [17]. The method consists of reduction of 2,6-DCPIP and oxidation of ascorbic acid to dehydroascorbic acid. It therefore allows a determination of the vitamin C content in its reduced form (ascorbic acid). Once the oxidation of ascorbic acid is complete, 2,6-DCPIP serves as a color indicator and its presence in solution gives a characteristic pink color [18]. For the preparation of the metaphosphoric acid / acetic acid solution, 30 g of solid HPO₃ are dissolved in 80 ml of acetic acid and 240 ml of distilled water. The volume is then brought to 1000 mL by adding distilled water. As metaphosphoric acid is slowly transformed into H₃PO₄, the solution obtained is stored for a maximum of one week in a refrigerator at 4°C. Concerning the 2.6 DCPIP solution, 250 mg of 2.6 DCPIP sodium salt are dissolved in 250 mL of distilled water containing 210 mg of sodium carbonate (NaHCO₃) and then mixed vigorously. The volume is then brought to 1000 mL by adding distilled water, then filtered before being stored in the refrigerator at 4°C. As for the standard solution of ascorbic acid, 50 mg of ascorbic acid is accurately weighed and diluted with metaphosphoric acid/acetic acid solution in a 50 mL volumetric flask protected from light. For the assay, 2 mL of standard solution are assayed with 2,6-DCPIP as well as 2 mL of the sample.

The expression of vitamin C is as follows:

$$C = \frac{(V_e - V_0) \times 20 \times 100}{(V_S - V_0) \times 10} \quad (5)$$

C: Concentration of vitamin C in the sample (mg/100 mL)

V_e: Volume (mL) of 2,6- dichlorophenol indophenol (2,6-DCPIP) poured in to neutralize the sample solution (mL)

V_S: Volume (mL) of 2,6-DCPIP poured in to neutralize standard vitamin C solution

V₀: Volume (mL) of 2,6-DCPIP poured to neutralize the metaphosphoric acid/acetic acid solution

Reducing sugars

The reducing sugars were assayed which uses 3,5- dinitro - salicylic acid (DNS) as reagent [19]. The principle is based on the reducing property of simple sugars. Indeed, pentoses and hexoses are transformed into furfural under the effect of heat. Furfural in the presence of phenolic derivatives such as DNS, produces a specific coloring of reducing sugars whose intensity is proportional to the quantity of reducing sugars in the medium. First, the preparation of the DNS solution consisted in dissolving 2 g of DNS (salt of 3,5- dinitro - salicylic acid) and 3.2 g of soda in 70 mL of distilled water. To this mixture, with heating stirring, were added 60 g of sodium and potassium double tartrate. The volume was made up to 200 mL with distilled water. Thus, the prepared DNS solution is ready for use. Then, for the reaction medium, a volume of 1 mL of water-soluble sugar extracts was introduced into a test tube and supplemented with 0.5 mL of distilled water and 0.5 mL of DNS solution. The mixture was heated in a boiling water bath for 5 min. The tests were carried out three times for each sample. After cooling, 2 mL of distilled water were added and then the optical density (OD) of the solution was read at 540 nm on a spectrophotometer (PU 8600). The egg white without water-soluble sugars was treated under the same conditions as the tests. A standard range was established under the same conditions from a stock solution of glucose (1 mg/ mL). The quantity of reducing sugars contained in the samples was determined from the equation of the regression line established using the standard range.

Total sugars

The total sugar content is determined using the sulfuric phenol method described by [20]. The principle of this method is based on the hydrolysis of the glycosidic bonds of sugars in a hot acidic medium for the formation of furfural derivatives. The aldehyde function and its furfural derivatives then condense with the hydroxyl of a phenolic compound to give reddish-colored acetals whose intensity is proportional to the concentration of sugars in the medium.

A volume of 100 µL of water-soluble sugar extracts is introduced into a test tube. Then, 200 µL of 5% (w/v) phenol and 1 mL of concentrated sulfuric acid are added thereto successively. After cooling away from light, a volume of 5.7 mL of distilled water is added to the mixture and the optical density (OD) is read on a spectrophotometer (SHIMADZU) at 490 nm against a blank without water-soluble sugar extract prepared under the same conditions as the tests.

A standard range is produced from a stock glucose solution of 1 mg/mL. The quantity of total sugars of each sample is obtained from the equation of the regression line established using the standard range.

Fiber content

The fiber content was determined according to the method described by [21]. Two (2) grams of yellow mombin pulp sample (P₀) were introduced into a flask and then 50 mL of sulfuric acid (0.25 N) was added. The resulting mixture was homogenized and boiled for 30 min

under reflux condenser. After 30 min, 50 mL of sodium hydroxide (0.31 N) was added to the contents and boiled again under reflux for 30 min. Thus, the extract obtained was filtered on Whatman No. 4 filter paper and the residue was washed until complete elimination of the alkalis. The residue was dried in an oven at 105° C. for 8 hours. After cooling in a desiccator, the residue was weighed (P1) then incinerated in an oven at 550° C. for 3 hours. After cooling, the ashes obtained were weighed (P2). The crude fiber content was obtained in g per 100 g of fresh material according to the relationship:

$$\text{Fiber (\%)} = (P1 - P2) / P0 \times 100 \quad (6)$$

Lipid levels

The lipid content was determined according to the method using the SOXHLET by the French standard [22]. Extraction of the fat under reflux with hexane was carried out using a Soxhlet. Thus, 5g of yellow mombin (Me) pulp sample was placed in a cellulose extraction cartridge and plugged with cotton to prevent the sample from being carried over during the extraction. An empty glass flask of mass (M1) was also weighed and 250 mL of hexane was poured into it. The flask was positioned on the extraction apparatus and the cartridge introduced into the reservoir of the Soxhlet. Lipid extraction was carried out by an ebb and flow system for 6 hours at boiling. The heating was carried out using heating caps. After 6 h of extraction, the solvent (n-hexane) was recovered using a rotary evaporator. The flask was brought to an oven at 105° C. for 1 hour to eliminate all traces of hexane. Then, the flask containing the fat was left to cool in a desiccator for 5 min and weighed again (M2). The lipid level expressed in g/100 g of dry matter was obtained by the following formula:

$$\text{Lipid (\%)} = (M2 - M1) / M_e \times 100 \quad (7)$$

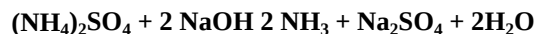
Total proteins

The protein level is determined according to the KJEDAH method [15]. This method makes it possible to control the protein value of foods by measuring the total nitrogen. It includes a phase of mineralization followed by a phase of distillation and finally a phase of titration with sulfuric acid. Firstly, **the mineralization** which is the transformation of the raw sample into ammonium sulphate in the presence of concentrated sulfuric acid is given according to the following reaction:



A mass of 1 g of yellow mombin pulp was taken from a digestion tube. Then a pinch of the catalyst (Selenium) and 20 mL of concentrated sulfuric acid were successively added. The tube was covered with a vapor collector and carried under a hood. Mineralization was carried out at 400 °C for 3 hours in a BUCHI brand digester. After cooling the tube to ambient temperature, the clear coloring mineralisate was transferred to a 100 mL volumetric flask

and filled up to the mark with distilled water. Two blank tubes containing all reagents except the yellow mombin pulp juice sample were run simultaneously with the assays. Then comes **distillation** which is the step that converts ammonium sulfate $[(NH_4)_2SO_4]$ into ammonia in the presence of sodium hydroxide:



The distillate is recovered as follows: $2NH_3 + H_3BO_3 \rightarrow (NH_4)_2B_2O_3 + 3H_2O$

After complete cooling, a volume of 10 mL of 35% NaOH (350 g/L) was added to 10 mL of mineralized product and the mixture was placed in the tank of the distiller (**VELP SCIENTIFICA**, model: **UDK**). The extension of the distiller's condenser was then immersed in a beaker containing 20 mL of 4% boric acid to which was added a mixed indicator consisting of 200 mL of bromocresol green (1 g/L in ethanol) and 14 mL of methyl red (1 g/L in ethanol). The distillation was carried out for 10 min until a purple distillate was obtained. Finally, during the titration or the determination of the total nitrogen, the distillate was dosed with a 0.1 N hydrochloric acid solution contained in a digital burette. The end of the titration was marked by the transition from the violet color to the green color. Under the same conditions as the test, a blank was carried out with distilled water. The total protein content (QP) was determined by applying the conversion factor of nitrogen into protein according to the following relationship:

$$Q_p = 14,007 \times NHCl \times (V1 - V0) \times m_e \times 100 \times d \times f$$

$$Q_N = 14 \times NHCl \times (V1 - V0) \times m_e \times 100$$

Total carbohydrate content and energy value

The total carbohydrates were evaluated by calculation following the method recommended by the [23]. This method took into account moisture, fat, protein and ash contents. The total carbohydrate content was expressed as a percentage by mass as follows:

$$\text{Glucides totaux (\%)} = 100 - [\text{Proteins (\%)} + \text{Humidity (\%)} + \text{Lipids (\%)} + \text{Ash (\%)}]$$

The calculation of the energy value expressed in kilocalories per 100 g of food was carried out according to the following relationship:

$$\text{Energy value (kcal/100g)} = [(4 \times \% \text{ proteins}) + (9 \times \% \text{ Lipids}) + (4 \times \% \text{ Carbohydrate})] \quad (8)$$

2.2.5. Phytochemical Characterization

Total polyphenols

The determination of total phenols was carried out according to the method of [24]. In an alkaline medium, the Folin - Ciocalteu reagent oxidizes phenols to phenolate ions and partially reduces its hetero-polyacids, hence the formation of a blue complex [25]. One (1) mL of methanolic extract was introduced into a test tube and then 1 mL of Folin - Ciocalteu's reagent was added to this

content. Then the tube was left to stand for 3 min at room temperature ($28 \pm 0.2^\circ\text{C}$) and 1 mL of sodium carbonate solution (20%, w/v) was added. The tube was placed in the dark for 30 min and the optical density reading was taken at 745 nm against a blank. A standard range established from a stock solution of gallic acid (1 mg/ mL) under the same conditions as the test made it possible to determine the quantity of phenols in the fruit pulp of *Spondias mombin*.

Flavonoid content

The method for determining the level of flavonoids is that of [26]. The principle of this method is based on the fact that in the presence of potassium acetate, the flavonoids react with the aluminum chloride to give a complex of yellow color whose intensity is proportional to the quantity of flavonoids present in the medium. A volume of 0.5 mL of methanolic extract was introduced into a test tube. To the contents of the tube were successively added 0.5 mL of distilled water, 0.5 mL of aluminum chloride, 0.5 mL of potassium acetate and 2 mL of distilled water. The tube was allowed to stand for 30 min in the dark and the optical density (OD) was read at 415 nm against a blank. A calibration range carried out under the same conditions as the test using a quercetin stock solution at 0.1 mg/ mL made it possible to determine the flavonoid content of the samples of mombin plum fruit pulp.

Tannin content

The dosage of tannins was carried out according to the method described by [27] whose principle is stated as follows: tannins react in an acid medium with vanillin to give a yellow-colored complex whose intensity is proportional to the quantity of tannins present in the medium. One (1) mL of methanolic extract was added to a test tube. To the contents of the tube are added 5 mL of 1% (w/v) vanillin reagent. The tube was left to stand for 30 min in the dark and the optical density (OD) is read at 500 nm against a blank. The quantity of tannins in the samples was determined using a standard range established from a stock solution of tannic acid (2 mg/ mL) produced under the same conditions as the test.

2.4. Statistical Analysis

The data was first entered in the Excel spreadsheet, then the STATISTICA 7.1 software was used to perform the statistical processing. A descriptive analysis of the variables (physicochemical, biochemical and phytochemical) measured made it possible to calculate the means and standard deviations.

3. Results and Discussion

3.1. Results

The physicochemical, biochemical and phytochemical compositions after the analyzes carried out on each sample are presented in Tables 1, 2, and 3.

Table 1 show that the pH obtained for the fruit pulp of the mombin plum tree is less than 3 and therefore acid regardless of the region of origin. Thus the pH of the pulps of the Gbekê region (2.97 ± 0.03) and Moronou

(2.87 ± 0.01), the results of titratable acidity revealed slightly higher levels of 223.33 ± 5.77 mEq / L and 213 ± 11.55 mEq / L respectively for the regions of Moronou (MT) and Gbekê (MB) compared to that of N'Zi (MD) which is 166.67 ± 11.55 mEq / L; the soluble dry extract expressed in degree Brix showed that the content of the N'Zi region (13° Brix), the Moronou region (12° Brix) and the Gbekê region (11° Brix); the ash content of the mombin plum fruit pulp is 0.65% and 0.60% respectively for the Gbekê and Moronou regions and that of the N'Zi region has the maximum value with 0.90. %; the moisture content of the fruit pulp of the mombin plum tree 93.28%; 92.02%; 92.60% respectively for the regions of Gbekê, N'Zi and Moronou show that they are rich in water.

Table 1. Physicochemical characteristics of the pulp of the ripe fruit of the mombin plum tree

Settings	Gbeke region (MB)	N'Zi region (MD)	Moronou region (MT)
pH	2.97 ± 0.03 a	2.20 ± 0.08 b	2.87 ± 0.01 a
Brix	11 ± 2 a	13 ± 2 a	12 ± 2 a
Titratable acidity in mEq / L	213.00 ± 11.55 a	166.67 ± 11.55 b	223.33 ± 5.77 a
Humidity	93.28 ± 1.98 a	92.02 ± 0.97 a	92.60 ± 0.92 a
Density	0.99 ± 0.00 a	1.01 ± 0.00 a	1.01 ± 0.01 a
Ash (%)	0.65 ± 0.07 a	0.90 ± 0.14 b	0.60 ± 0.14 a

Table 2. Biochemical characteristics of the pulp of ripe mombin plum fruits

Settings	Gbeke region (MB)	N'Zi region (MD)	Moronou region (MT)
Fiber content (%)	0.25 ± 0.00 a	0.25 ± 0.00 a	0.25 ± 0.00 a
Fat content (%)	1.06 ± 0.00 a	1.02 ± 0.00 a	1.04 ± 0.00 a
Protein content (%)	2.09 ± 0.07 a	2.40 ± 0.00 a	3.06 ± 0.06 b
Reducing sugar content (mg/100g)	3.04 ± 1.27 a	3.81 ± 0.21 b	3.78 ± 0.00 b
Content Total sugars (mg/100g)	4.04 ± 0.2 b	4.85 ± 0.3 a	4.82 ± 0.11 a
Total carbohydrate content (%)	7.92 ± 0.95 a	6.66 ± 1.02 b	7.70 ± 1.02 a
Vitamin C content (mg/100g)	25.67 ± 0.33 b	23.34 ± 0.1 a	23.14 ± 0.27 a
Energy value (Kcal/100g)	29.58 ± 3.94 a	33.44 ± 4.10 b	32.40 ± 3.96 b

Table 2 show that the levels of reducing sugars and total sugars in the pulp of the mombin plum tree are higher in fruit pulp from the N'Zi (3.81 mg/100g and 4.85 mg/100g) and Moronou (3.78 mg/100g and 4.82 mg/100g) regions; the vitamin C content of fruits varies between 23.14 ± 0.27 mg/100g and 25.67 ± 0.33 mg/100g. The region with the highest content is that of Gbekê (25.67 ± 0.33 mg/100g); the rate of proteins collected in the different regions studied has low averages and oscillates between 2.09 and 3.06% (a value of $3.06 \pm 0.062\%$ for the region of Moronou which is higher and those of the regions of N'Zi 2.40% and Gbekê $2.09 \pm 0.071\%$); the total lipid contents are very low, around 1% in the pulp of the fruits collected in the different regions studied (Gbekê 1.06%; N'Zi 1.02% and Moronou 1.04%). Our study found a proportion of 0.25% of fiber obtained for fruit pulp from all regions. Regarding the total carbohydrate content, the highest content is recorded in fruit pulp from the Gbekê region (7.92%). The energy value of the fruit pulp of the plum mombin from the collection regions is

29.58%, 33.44%, 32.40 respectively for the regions of Gbekê, N'Zi and Moronou.

Table 3 show that the polyphenol content of mombin plum fruit pulp are between 25.40 and 38.21 mg/100g. For the flavonoid contents, the fruit pulp from the regions of Gbekê (3.41mg/100g), Moronou (3.07mg/100g) and N'Zi (2.09mg/100g). The tannin contents of the fruits are 69.64 ± 0.45 ; 105.36 ± 10.27 ; 142.61 ± 6.70 mg/100g respectively for the regions of Gbekê, N'Zi and Moronou.

Table 3. Phytochemical characteristics of the pulp of ripe mombin plum fruits

Settings	Gbeke region (MB)	N'Zi region (MD)	Moronou region (MT)
Flavonoid content (mg/100g)	3.41±0.07 a	2.09±0.07 a	3.27±0.08 a
Polyphenol content (mg/100g)	38.22±0.47 a	25.40±0.57 b	30.22±0.29 c
Tannin content (mg/100g)	69.64±0.45 a	105.36±10.27 b	142.61±6.70 c

3.2. Discussion

The pH results obtained are similar to that of [9] who obtained 2.83 ± 0.0 . On the other hand, fruit pulp from the N'Zi region has a pH of 2.20 ± 0.08 , which is in accordance with the Brazilian standard [28]. In addition, this pH value is similar to the results of the work carried out by [29]. It should be noted that pH is an indicator of fruit maturity. In fact, one of the advantages of acidic fruits such as those of the mombin plum tree in the diet is their ease of assimilation by the body because they only take an hour to be digested.

For titratable acidity, the results revealed slightly higher levels of 223.33 ± 5.77 mEq/L and 213 ± 11.55 mEq/L respectively for the regions of Moronou (MT) and Gbekê (MB) compared to that of N'Zi (MD) which is 166.67 ± 11.55 mEq /L. Indeed, titratable acidity is an important parameter in determining fruit maturity. This maturity is one of the essential indicators in the evaluation of fruit flavor.

The results of the soluble dry extract expressed in degree Brix showed that the content of the N'Zi region (13° Brix), the Moronou region (12° Brix) and the Gbekê region (11° Brix) are high compared to that of the mombin plum fruit pulps studied by [30] which is 10.09° Brix. It should also be noted that the soluble solids content is a good marker for identifying specific stages of development and ripening of fruits and is a major aid in predicting the acceptance or preference of consumers of these fruits.

These results of ash content are similar to that of [9] which is 0.76%. Obtaining the ashes makes it possible to assess the content of inorganic matter contained in the fruits.

The results on the level of the moisture content of the fruit pulp of the mombin plum are superior at 90%. These results are superior to those obtained by [31,32]. Indeed, these high water contents define the freshness of the fruits and possibly their good juice yield. In fact, the precautions to be taken for their storage and their transport must be greater, because they are very quickly perishable and favorable to the growth of certain spoilage microorganisms.

The levels of reducing sugars and total sugars in the pulp of the mombin plum tree are higher in fruit pulp from the N'Zi (3.81 mg/100g and 4.85 mg/100g) and Moronou (3.78 mg/100g and 4.82 mg/100g) regions. Our results are lower than those obtained by [32,33] which are 8.80% and

9.90% respectively. This difference in the results obtained could be due to the different geographical and climatic characteristics of the regions and also to the probable fermentation of our fruits.

The vitamin C content of fruits varies between 20 and 26 mg/100g. The region with the highest content is that of Gbekê (25.67 ± 0.33 mg/100g) which is substantially equal to that of [33] who obtained (25.93 ± 1.65). These values are higher than the results of [34] (13.7 ± 0.16 mg/100g) and are lower than the values found by [32] (34.86mg/100g).

The proteins percentage obtained are inferior at 3.06%. These results are superior to that of [30] which is 0.82%. Although the amount of protein is low in the pulps of mombin plum fruits, however, it is higher than that of other fruits like mango 0.63% ([35], papaya 0.60% [36]. Moreover, note that 1 gram of protein is equivalent to an energy of 4 kilocalories. So, the fruits of the mombin plum tree provide more calories than these two other fruits.

The total lipid contents are very low, around 1% in the pulp of the fruits collected in the different regions studied. This low lipid content correlates with most fruits like mango and guava [9]. Our results obtained are superior to those [32] which is 0.26% and lower than that of Nigerian mombin plum fruit pulps equivalent to 2% [37].

Our study found a proportion of 0.25% of fiber obtained for fruit pulp from all regions. This proportion is lower than those of the fruit pulps of the mombin plum tree, of 30 different genotypes from three different regions of Brazil [38]. This dissimilarity could be due to the soil of the areas where the fruits were collected and also to the low quantity of dry matter of the fruits of these regions. Note that fibers are essential for the proper functioning of intestinal transit and the overall health of humans, because they are metabolized by intestinal bacteria into products that influence all of our metabolisms and all of our major functions, such as, immunity, the various hepatic metabolisms, brain function and satiety.

Regarding the total carbohydrate content, the highest content is recorded in fruit pulp from the Gbekê region (7.92%). Our results obtained are lower than those of [39].

The high energy value of the fruit pulp from the collection regions is 33.44%. These energy values are lower than those obtained in the fruit pulps of the mombin plum tree studied by [9] and that given by [40] which is 65.42%. Moreover, it is identical to that of lemon, strawberry, pomelo, grape fruit and more excellent than that of watermelon [41].

Polyphenol content of mombin plum fruit pulp are between 25.40 and 38.21 mg/100g. Our results are lower than those of [42,43]. However, it should be noted that the polyphenol content of fruit pulp from these regions is higher than that of orange 8.85 mg/100g [44] and grapefruit 1.25 mg/100g [45]. These polyphenols which have antioxidant effects can improve the survival of body cells and pro-oxidant effects can prevent tumor growth. In addition, they prevent against oxidative stress, that is to say the attack on cells by free radicals. As a result, these polyphenols can be extracted from the fruits of the mombin plum tree and used as additives in the food industries.

For the flavonoid contents, the authors [43] obtained higher values (6.9mg/100g) than those obtained in fruit

pulp from the regions of Gbekê (3.41mg/100g), Moronou (3.07mg/100g) and N'Zi (2.09mg/100g). On the other hand, they are identical to the results of [46]. These authors obtained flavonoid contents of 1 to 5 mg/100 g. Indeed, flavonoids are pigments responsible for the coloring of flowers and fruits but also for the acidity of the environment. Also, they act mainly as primary antioxidants, stabilizing peroxide radicals and are bioactive compounds in many beverages such as red wine, beer. This implies that the ripe fruits of the mombin plum tree could be fermented for the production of beer.

The tannin contents of the fruits of different regions are between 70 and 143 mg/100g. These values obtained are lower than those of the fruits studied by [30] which is 299.81mg/100g and much higher than those of the Brazilian fruits studied by [47] which are between 3 and 17 mg/100 g. This difference could be due to the climate or to the origin of our fruits. Indeed, tannins can be destroyed by heat and are responsible for the bitterness and astringency of fruits. In addition, tannins can bind to toxic substances and "neutralize" them in the gastrointestinal tract and then reject them through the stool.

4. Conclusion

The objective of this work was to characterize the ripe fruits of the plum mombin specifically pulps. To achieve this, it was a question of determining the physicochemical, biochemical and phytochemical characteristics of the pulps of ripe fruits of the mombin plum tree from different regions of Côte d'Ivoire which are Gbekê, N'Zi and Moronou. The results obtained allow us to conclude that the pulps of ripe fruits of the mombin plum tree from these three regions are full of protein, fiber, antioxidant compounds (polyphenols, flavonoids, tannins) and a higher energy value compared to certain tropical fruits such as pomelo or grapefruit. These potentials presented by the pulp of ripe fruits of the mombin plum tree could arouse an interest for the agro-food industries, breweries, in the confection of jam, juice, jelly, alcoholic beverages and additives for biscuits and chocolate. In addition, this aspect could raise the economy of Côte d'Ivoire from farmers to industries, through retail traders and wholesalers.

References

- [1] Kader, AA. "Perspective Flavor quality of fruits and vegetables". *Journal of the Science of Food and Agriculture* (88), 1863–1868. 2008.
- [2] Ridgewell, J. "Examining food and nutrition". Oxford University Press, London 58p. 1998.
- [3] USDA. Why is it important to eat fruit? 2019. http://www.mypyramid.gov/pyramid/fruits_why.html. Accessed 29/12/2020.
- [4] WHO. Increasing fruit and vegetable consumption to reduce the risk of non-communicable diseases. 2019 https://www.who.int/elena/titles/fruit_vegetables_ncds/en/Accessed d 29/12/2020.
- [5] Sameh S., Al- Sayed E, Labib, RM and Singab, AN. "Genus Spondias: A Phytochemical And Pharmacological Review". *Evidence-Based Complementary and Alternative Medicine*, 1-13. 2018.
- [6] Joas J. "Mombins: Interesting technological possibilities". *Fruit*. 11(37): 727-729. 1982.
- [7] Mishra P, Brahma A. and Seth D. "Physicochemical, functionality and storage stability of hog plum (*Spondias pinnata*) juice powder produced by spray drying". *Journal of Food Science and Technology*, 54: 1052-1061. 2017.
- [8] Kpemiassi-Amana E. "The Anacardiaceae of Togo: Botanical, ecological studies and antifungal properties". Doctoral thesis in pharmaceutical sciences, plant biology from the University of Reims Champagne-Ardenne, France, p198. 2007.
- [9] Tiburski JH, Rosenthal A., Deliza R., de Oliveira GRL, and Pacheco S. "Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp". *Food Research International*, 44: 2326-2331. 2011.
- [10] Diby SB, Koné M. and Yapo A. "Pharmacological potential of stem barks of *Spondias mombin* L. (Anacardiaceae) on in vitro motricity of rabbit duodenum; a medicinal plant used in the traditional treatment of digestive disorders". *Pharmacognosy* 10: 306-312. 2012.
- [11] Béné K., Camara D, Fofie NB Y, Kanga Y, Yapi A. B, Yapo Y. C, Ambe S. A and Zirihi GN. "Ethnobotanical study of medicinal plants used in the Department of Transua, District of Zanzan (Côte d'Ivoire)". *Journal of Animal & Plant Sciences*, 2(27): 4230-4250. 2016.
- [12] N'Dri KMT and Gnahoua GM. "Spontaneous alimentary trees and lianas of the department of Gagnoa (center-west of the Ivory Coast) Volume IV". *Woods and forests of the tropics*, 298: 10p. 2008.
- [13] Ouattara ND, Galle E., Stauffer FW and Bakayoko, A. "Floristic and ethnobotanical diversity of wild edible plants in the Department of Bondoukou (North-East of Côte d'Ivoire)". *Journal of Applied Biosciences*, 98: 9284 – 9300. 2016.
- [14] AOAC (Association of Official Analytical Chemists), 932.12., 934.06., 940.26., 981.12. Official methods of analysis of the association of official analytical chemists: Arlington, USA, 15th edition vol II: 35p 1990.
- [15] AOAC 942.15. Official method Acidity (Titrable) of fruit products read with AOAC official method. 17th edition Preparation of test sample 2000.
- [16] FAO/INFOODS. FAO/INFOODS Database - Density Database - version 2.0, Rome, 20p. 2015.
- [17] Pongracz G. "Neue potentiometrische Bestimmungsmethoden für Ascorbinsäure und dessen Verbindungen Fresenius Z". *Anale de Chemistry* 253: 271–274. 1971.
- [18] AOAC. Official methods of Analysis. Association of official Analytical chemists. Washington. D.C., USA: 584p. 1984.
- [19] Bernfeld P. "Amylase and Proteases". In *Methods in Enzymology*, Colswick SP, Kaplan NO (eds). Academic Press: New York, USA; 149–154. 1955.
- [20] Dubois M., Gilles K., Hamilton, JK, Rebers, PA. and Smith F. "Colorimetric methods for determination of sugars and related substances". *Analyse chemical*, 28: 350 - 356. 1965.
- [21] Van, SPS. "Use of detergents in the analysis of fibrous feeds II- A rapid method for the determination of fiber and lignin". *Journal of Association of Official Analytical Chemistry*, 46: 829-835. 1963.
- [22] ISO 734:2015. "Oilseed meals-Determination of oil content-Method by extraction with hexane (or petroleum ether)" 2nd edition, 7p.
- [23] FAO. "Food energy-methods of analysis and conversion factors". FAO paper on food and nutrition 77. Report of a technical workshop Rome, 97 p. 2002.
- [24] Singleton VL, Orthofer R. and Lamuela-Raventós RM. "Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent". *Methods in Enzymology*, 299: 152-177. 1999.
- [25] Daels, RD. "Phenolic extracts of hawthorn, cola and rosehip". Doctoral thesis, University of Lille-II, France. 1999.
- [26] Meda A., Lamien CE, Romito M., Millogo J. and Nacoulma, OG "Determination of the total phenolic, flavonoid and proline contents in Burkina Faso honey, as well as their radical scavenging activity". *Analytical, Nutritional and Clinical Methods, Food Chemistry* 91: 571–577. 2005.
- [27] Bainbridge Z., Tomlins K. and Wetby A. "Laboratory methods. In: Bainbridge Z, Tomlins K and Wetby A (eds). *Methods for assessing quality characteristics of non-grain starch staples*, Part 3". Natural Resources Institute, Chatham, UK, pp 27-29. 1996.
- [28] Brazil 2000. "Ministry of Agriculture Pecuaría and Abastecimento. Instrução Normativa n. 01, from 07 from janeiro. Regulations técnico Geral para fixação dos padrões de identidade e qualidade para polpa de fruta". *Diário Oficial of the Republic Federativa do*

- Brasil, Brasília, DF, Seção I, Ministério da Agricultura. p. 54-58. 10 de janeiro 2000.
- [29] Cordeiro SF, Marcia MLS, Inácia SIM, Souza CD, Danielle STP and Matilde SAA "Comparative Study of Fruit Bioactivity of Spondias". International Journal of Advanced Engineering Research and Science (IJAERS), 1(6): 184-187. 2019.
- [30] Mattietto RA, Lopes AS and Menezes, HC, "Characterization física e físico - química Dos frutos da cajazeira (*Spondias mombin* L.) e de suas polpas obtained por must tipos de extractor". Brazilian Journal of Food Technology, 13(3): 156-164. 2010.
- [31] Sacramento CK and Souza FX. "Caja". In: Santos- Serejo, et al. (Eds.), Fruticul - tura Tropical. Species regionais e exóticas, Brasil, pp 85-105. 2009.
- [32] Dias, DR, Schwan, RF and Lima, LCO "Methodology for elaboração de fermentado de cajá (*Spondias mombin* L.)". Ciência e Tecnologia de Alimentos, Campinas, 3(23): 342-350. 37. 2003.
- [33] Souza VR, Aniceto A., Abreu JP, Montenegro J., Boquimpani B., Jesus VA, Campos MBE, Marcellini PS, Freitas SO, Cadena R. and Teodoro AJ "Fruit-based drink sensory, physicochemical, and antioxidant properties in the Amazon region: Murici (*Byrsonima crassifolia* (L.) Kunth and *verbascofolia* (L.) DC) and tapereba (*Spondias mombin*)". Food Science & Nutrition, 8: 2341-2347. 2020.
- [34] Carvalho J. M., Geraldo A. M., Valquíria, VAF and Rodrigues P. H. S. S., "Effect of processing on physicochemical composition, bioactive compounds and enzymatic activity of yellow mombin (*Spondias mombin* L.): tropical juice". Journal of Food Science and Technology 52(2): 1182-1187. 2015.
- [35] Saeed A., Muhammad R., Anwaar A. and Atif N. "Physico - chemical, microbiological and sensory stability of chemically preserved mango pulp". Pakistan Journal of Botany, 42(2): 853-862. 2010.
- [36] Krishna, KL, Paridhavi, M. and Patel JA. "Review on nutritional, medicinal and pharmacological properties of papaya (*Cacrica papaya* Linn.)". Natural Product Radiance, 7 (4): 364-367. 2008.
- [37] Adepoju, OT. "Proximate composition and micronutrient potentials of three locally available wild fruits in Nigeria". African Journal of Agriculture Research, 4(9): 887-892. 2009.
- [38] Pinto, WS, Dantas, ACVL; Fonseca, AAO, Ledo, CAS, Jesus, SC, Calafange, LP and Andrade, EM. "Characterization física, físico - química and química de fruits de genótipos de cajazeiras". Pesquisa Agropecuária Brasileira, Brasília, 9(38): 1059-1066. 2003.
- [39] Bora, PS, Narain, N., Holschuh, HJ and Vasconcelos, MAS. "Postharvest Respiratory activity and Changes in Physical and Chemical Composition during Maturation of Yellow Mombin (*Spondias mombin*) fruits". Food Chemistry, Oxford, 3(41): 341-348. 1991.
- [40] USDA. "Composition of foods, raw, processed, prepared. USDA national nutrient database for standard reference", release 20: USDA_ARS, Beltsville Human Nutrition Research Center, Nutrient Data Laboratory, Beltsville, Maryland. 2008.
- [41] FAO 1968. "Nutritional value of foods commonly used in Africa".
- [42] Alia- Tejacal I., Maldonado- Astudillo YI, Núñez-Colín CA, Valdez-Aguilar LA, Bautista Baños S., García-Vázquez E., Ariza - Flores R. and Rivera-Cabrera F. "Characterization of Ciruela fruit _ Mexicana (*Spondias purpurea* L.) del Sur de México: Revista". Fitotecnica. Mexicana, 35: 21-26. 2014.
- [43] Rufino, MSM, Alves, RE, Brito, ES, Pérez, JJ, Saura- Calixto, F. and Mancini FJ. "Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil". Food Chemistry, 121: 996-1002. 2010.
- [44] Iglesias-Carres, L., Mas- Capdevila, A., Bravo, FI, Aragonès, G., Muguerza, B. and Arola Arnal, A. "Optimization of a polyphenol extraction method for sweet orange pulp (*Citrus sinensis* L.) to identify phenolic compounds consumed from sweet oranges". PLOS ONE, 14(1): 1-17. 2019.
- [45] Ramful, D., Tarnus, E., Aruoma, OI, Bourdon, E. and Bahorun, T. "Polyphenol composition, vitamin C content and antioxidant capacity of Mauritian citrus fruit pulps". Food Research International, 44: 2088-2099. 2011.
- [46] Gomes, SFV, Melo, SS, Cabral, SGC, Mendonça, RMN, Alves, RE and Dantas, AL. "Bioactive compounds and antioxidant activity in fruits of clone and ungrafted genotypes of yellow mombin tree". Ciência Tecnológica Food, 32: 685-695. 2012.
- [47] Lavrinha, STL, Silva, EP, Asquieri, ER, Vieira, ECS, Silva, JS, Alves, SF and Damiani, C. "Physicochemical characterization and behavior of biocompounds of caja-manga fruit (*Spondias mombin* L.)". Food Science Technology, 38: 399-406. 2018.

