

Biochemical Characterization and Nutritional Profile of Jam and Syrup from *Saba senegalensis* fruit in Côte d'Ivoire

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Abstract

Saba senegalensis is a plant to the family of Apocynaceae and its fruit called Saba is mainly used as food. For better valorisation, this study aimed to evaluate the nutritional potential of jam and syrup derived of this fruit. The study was carried out on the fruit of *Saba senegalensis* harvested in the north of Côte d'Ivoire. After jam and syrup formulation, pH, dry matter, ash, macronutrients, vitamins, minerals, phytonutrients, anti-nutritional factors and nutritional profile have been determined. The results showed that jam and syrup of Saba were acidic with respective pH of 3.11 ± 0.01 and 3.65 ± 0.05 . They contained higher in carbohydrates with respective rates of 56.53 ± 0.24 % and 66.27 ± 1.08 %. Vitamin C rate in jam and syrup was respectively about 20.01 ± 0.01 mg/100 g and 18.33 ± 2.22 mg/100 g. The most important mineral was potassium which rate is 136.71 ± 4.08 mg/100 g and 241.76 ± 5.9 mg/100 g in jam and syrup respectively. They also contain phytonutrients such as polyphenols (respectively 103.18 ± 0.69 mg/100 g and 3.29 ± 0.02 mg/100 g) and antinutritional factors such as oxalates (respectively 102.01 ± 6.93 mg/100 g and 19.96 ± 0.01 mg/100 g). Nutritional profile has classified *Saba Senegalensis* jam and syrup to the group 4 of foods, foods that must be eaten occasionally. The transformation of Saba in jam and syrup could be a good way to valorise this fruit and also ensuring its consumption through the year.

Keywords: jam, syrup, nutritional profile, nutritional value, *Saba senegalensis*

1. Introduction

Fruits are essential for the alimentation. They have high nutritional value and serve to supplement the nutrients provided by cereals, starchy foods, vegetables (Ojure & Quadri, 2012). Fruits have generally low content of lipids, sodium, calories and are an important source of many important nutrients such as dietary fiber, vitamin C, minerals and phytonutrients such as phenols and flavonoids. These compounds protect the body against oxidative stress and degenerative diseases by developing the body's ability to defend against external attacks (Yoshikawa, Toyokuni, Yamamoto & Naito, 2000; Ena, Shalini, Pragati, Reena, & Rai, 2016). However, the fruits have higher water content, which makes them susceptible to biological and chemical degradation agents such as microorganisms and oxidation reactions (Nout, Hounhouigan, & Boekel, 2008). The fruits are therefore very perishable and can only be kept fresh for a few days at room temperature, hence the need to transform them. It is in this context that our work is based on the fruit *Saba senegalensis* better known under the name of c ô c ô ta in Côte d'Ivoire, W à da in Burkina Faso, Madd in Senegal or Saba in French.

Saba senegalensis is a wild liana which pushes in African savannahs (Diabagaté Traor é Cissé Soro, & Brou 2019). The effects of *Saba senegalensis* in local traditional medicine are varied. From fruit, to roots, to leaves and latex, everything is usable (Burkill, 2000; Bandoma, 2009; Dari 2013; Sarr *et al.*, 2018). According to Sarr *et al.* (2015), the crushed leaves of Saba are used for the care of wounds and the roots against female sterility. According to B â Dalp é and Guissou (1996), the latex of *Saba senegalensis* combats cough and tuberculosis. In addition, its coagulation gives a natural rubber for various local uses. Nutritionally, the pulp of fruit of *Saba*

senegalensis is a true source of β -carotene ($189.62 \pm 1.33 \mu\text{g}/100\text{g}$) which would play a significant role in the prevention of cancer (Diabagat *et al.*, 2019). These authors also showed that the pulp was acidic ($\text{pH} = 3.03 \pm 0.01$) and rich in total phenolic ($264.76 \pm 4.54 \text{ g}/100\text{g}$), vitamin C ($36.67 \pm 2.22 \text{ g}/100\text{g}$), and minerals like potassium ($116.96 \pm 2.06 \text{ mg}/100\text{g}$) and calcium ($36.61 \pm 2.79 \text{ mg}/100\text{g}$). Moreover, according to Attah *et al.* (2012) and James, Rotimi, and Bamaiyi (2015), the indigenous fruits are appropriate to be transform into products like juice, jam, syrup and wine that could ameliorate not only the nutrition and health of population, but also livelihoods. Indeed, the processing of these fruits could improve the financial incomes of poor families.

The fruit of *Saba senegalensis* is a seasonal fruit and therefore not always available. The necessity to transform this fruit into jam and syrup could be one of the ways to valorise the fruit of *Saba senegalensis*, improve the acceptability of this astringent fruit and ensure its consumption through the year in Côte d'Ivoire. The aim of this study was to determine the nutritional potential of jam and syrup of *Saba senegalensis* for better valorisation in Côte d'Ivoire.

2. Material and Methods

2.1 Material

The plant material used in this study is the fruit of *Saba senegalensis* harvested in the village of Warani é located about 5 km from the city of Korhogo. Warani é is located at the North of the Côte d'Ivoire between the parallels $8^{\circ}26'$ and $10^{\circ}27'$ of Northern latitude and $5^{\circ}17'$ and $6^{\circ}19'$ of longitude Western. The ripe fruits of *Saba Senegalensis* were harvested between May and July 2019 from lianas in the region of Korhogo. The fruits were identified and monitored until the maximum maturity stage. About 10 and 15 healthy orange-yellow fruits were harvested at randomly from each tree.

2.2 Methods

2.2.1 Jam Preparation

The extraction of raw pulp of Saba was carried out according to the method of Diabagat *et al.* (2019). The *Saba Senegalensis* fruits (10 kgs) were cutted into half. The pulp with seeds was removed with stainless spoon and were put into the mixer of mark ilux (NO: LX-176P/AC: 220-240V 50Hz 350W) for mixing. The mixture was put into the stainless-steel sieve and blended manually to separate the seeds from the pulp. The pulp obtained was stored at -20°C for analysis. About 500 g of raw pulp of *Saba Senegalensis* were mixed with 400 g of white sugar. The whole was brought to cooking until thickening of the mixture (105°C about 20 min). After cooking, the jam was stored in airtight containers.

2.2.2 Syrup Preparation

The seeds covered of pulp were soaked for 1 hour in water then kneaded and sieved. The sugar (750g) was added to 500 ml of the juice. The mixture was boiled approximately for 10 min until the sugar was completely dissolved. After cooling, the mixture was stored in airtight containers.

2.2.3 Chemical Composition of Products Derived from Saba

pH measurement

The pH was determined according to Le Coque (1955) method. It was carried out on the filtrate obtained by grinding 2g of sample with 28 ml of distilled water and centrifuged at 3000 rpm for 10 min. The pH is determined using a pH meter (Consort pH meter P 107).

Titrateable acidity

Titrateable acidity was determined according to Kimaryo, Massawi, Olasupo, and Holzapfel (2000) method. Sample (2 g) was mixed in distilled water (28 ml) and centrifuged at 3000 rpm for 10 min. The filtrate (10 ml) was dosed with a 0.1 N sodium hydroxide (NaOH) solution and 2 to 3 drops of phenolphthalein ($\varphi\varphi$) were added until it turns pink.

Dry matter content

Dry matter was determined according to the method of Association of Official Analytical Chemists (AOAC) (1990). The sample was dried with the drying oven (Mettler 854 Schwabach) during 24 h, to 105°C and was cooled in a desiccator during 1 h, then weighed and the dry matter was determined.

Ash content

Ash content was obtained according to AOAC (1990) method. Each jam and syrup (about 5 g) was introduced into porcelain capsules and placed in a muffle furnace (JP S Æcta SA 313066) for electric heating for 6 h at 550°

C. After heating, the samples was cooled in a desiccator for 2 h and the ash were expressed as a percentage of the initial weight of the samples.

Total carbohydrate content

Total carbohydrate content was determined by difference method:

$$[100 \% - (\% \text{ moisture} + \% \text{ ash} + \% \text{ fat} + \% \text{ protein})] \quad (1)$$

Determination of total sugars

The total sugars were determined according to the method of Dubois, Gilles, Hamilthon, Rebers, and Smith (1956). One hundred (100) μl of the juice extract were placed in a test tube. Two hundred (200) μl of phenol (5%, w / v) and one (1) ml of concentrated sulfuric acid were added successively to the reaction medium. After homogenization of the reaction medium, the optical density is determined using a spectrophotometer (GENESYS 5) at 490 nm against a control containing no sweet extract. Optical densities were converted into the amount of total sugars using a calibration line obtained from a glucose solution (1 mg / ml).

$$\% \text{ total sugar} = D_{0490} / a \quad (2)$$

a: director coefficient of the calibration line = 9.525

Determination of reducing sugars

Reducing sugars were determined by the method of Bernfeld (1955) using dinitrosalicylic acid (DNS). In this method, pentose and hexose, under the effect of heat, transform into furfural compounds. These compounds, in the presence of DNS, produce a specific staining with reducing sugars. The reaction medium was composed of:

- 0.1 ml of sugar extract solution;
- 0.9 ml of distilled water;
- 0.5 ml of DNS.

The mixture was heated in a boiling water bath for 5 min, then allowed to cool for 10 min at room temperature. Then, 3.5 ml of distilled water are added to the reaction medium. The optical density is read at 540 nm in the presence of a control. This value is converted into mg of reducing sugars using a calibration curve obtained from a solution of glucose at 1 mg / ml.

$$\% \text{ reducing sugars} = D_{0540} / a \quad (3)$$

a: director coefficient of the calibration line = 10.056

Quantitative determination of Vitamin C

The method used for the determination of vitamin C was described by Pelletier (1985). The samples (10g) (ME) were diluted in 40 ml of metaphosphoric acid-acetic acid (2 %; w / v). The mixture was centrifuged at 3000 rpm for 20 minutes and the supernatant was made up to 50 ml with boiled distilled water. A 10 ml sample placed in a vial was titrated with 2.6 DCPIP at 0.5 g / L until a persistent pink color was obtained for 30 s. The vitamin C content was given as a percentage according to the following expression:

$$\text{Vitamine C (\%)} = \frac{(0,5 \times V \times 10^{-3}) \times 5}{\text{ME}} \times 100 \quad (4)$$

Beta-carotene Content

Total carotenoids were extracted according to Rodriguez-Amaya (1999) method. Samples were crushed and homogenized. About 5 g of sample was homogenized with 100 ml of methanol: petroleum ether (1: 9, v / v), the mixture was transferred to a separatory funnel. The petroleum ether layer was filtered through sodium sulfate, transferred to a volumetric flask to a volume of 100 ml, made up with petroleum ether. Finally, the total carotenoid content was measured by a spectrophotometer at the wavelength of 450 nm.

The results were expressed in β -carotene equivalents (μg / 100 g of fresh material).

Fat content

The fat was extracted according to the method of AOAC (1995). Five grams (5 g) of sample was added to a Whatman cartridge and the whole placed in the extractor of soxhlet. The fat was extracted with 60 ml of hexane at reflux for 6 hours at the boil. The hexane was evaporated using a rotary evaporator. The previously tared extraction flask was dried in an oven at 60 °C. for 30 min and was cooled in desiccator. The fat content was

expressed as a percentage of the initial weight of the sample.

Fibbers Content

Crude fibbers were determined according to AOAC (1990). In 2g of sample, were added 50 ml of 0.25 N sulfuric acid and the mixture was boiled for 30 min under reflux. About 50 ml of 0.31 N sodium were added and the whole brought to the boil for 30 min under cooling agent. The extract obtained was filtered through Whatman filter paper and the residue washed until complete elimination of the alkalis. The residue obtained was incinerated in an oven at 550 °C for 3 h, cooled in a desiccator and the ash obtained were weighed.

Mineral content

Ash (0.1g) was weighed in platinum crucibles to which was added 1 ml of distilled water. In each crucible, 5 ml of hydrofluoric acid 50 % and 2 drops of sulphuric acid (v / v) were added, homogenized and heated at 100 °C until fully evaporated. Residue obtained was dissolved in 10 ml of 50 % hydrochloric acid. Solution was left to stand for 10 minutes on the bench and the final volume was brought to 100 ml (Diabagat *et al.*, 2019). The contents of sodium, magnesium, phosphorus, potassium, calcium and iron were determined by atomic absorption spectrophotometry at their specified wavelengths at 589.3 nm; 285.2 nm; 410 nm; 766.5 nm; 422.7 nm and 510 nm.

2.2.4 Phytonutrients

Polyphenols content

Total polyphenols content were estimated by the Folin-Ciocalteu method (Scalbert, Monties, & Janin, 1989). About 200 µl of sample were mixed with 800 µl of Folin-Ciocalteu reagent. The mixture was kept for 2 minutes in the dark at room temperature and 1 ml of sodium carbonate (75 g.l-1) was added. The mixture was placed in a water bath maintained at 50 °C for 15 minutes and cooled. The absorbance was measured at 760 nm using of a UV 1205 spectrophotometer and the results expressed in mg / 100 g.

Flavonoids content

The flavonoid content was determined according to Meda, Lamien, Romito, Millogo and Nacoulma (2005). In a flask contening 0.5 ml of sample, were successively added 0.5 ml of 10 % aluminum chloride, 0.5 ml of 1N potassium acetate and 2 ml of distilled water. The mixture was left for 20 minutes in the dark. Optical density was read at 415 nm against a reference.

2.2.5 Antinutritionals Factors

Tannin content

The tannin content was determined by the method described by Bainbridge, Tomlins, Wellings, and Westby (1996). One 1 ml of sample was added 5 ml of vanillin reagent. The mixture was left for 20 min in the dark and the optical density (OD) was read at 500 nm against a blank. The amount of tannins was determined using a standard range established from a stock solution of tannic acid (2 mg / ml) under the same conditions as the test.

$$\text{Tannins (mg/100)} = \frac{\text{DO500} \times 103}{3,11 \times \text{me}} \quad (5)$$

Calibration line: OD500 = 3.11 mass (mg) Tannic acid

me: mass (g) of the sample.

Phytate content

The phytate content was determined by the method described by Mohammed, Ponnampereuma, and Youssef (1986). About 0.5 g of the sample was homogenized in 25 mL of 3 % (w / v) trichloroacetic acid (TCA). The mixture was centrifuged at 3500 rpm for 15 min. The supernatant was mixed with 3 mL of 1 % (w / v) ferric chloride. The solution obtained was heated in boiling water bath for 45 min. After cooling, the solution was centrifuged at 3500 rpm for 10 min. The supernatant was mixed with 5 mL of hydrochloric acid (0.5 N). To the mixture obtained, 5 ml of sodium hydroxide (1.5 N) were added and the whole was taken to a boiling water bath for 15 min. The solution obtained was centrifuged at 3500 rpm for 10 min. To the supernatant (1 mL) , 4.5 mL of boiled, air-cooled distilled water and 4.5 mL of orthophenantroline reagent were added. The mixture was left for 1 hour before reading the optical density (OD) at 470 nm against a blank. A standard range was established from a stock solution of Mohr's salt (10 µg iron / mL) under the same conditions as the test for the determination of the amount of phytate-ferric in the sample.

$$\text{Phytates (mg/100)} = \frac{DO_{470} \times 4}{0.033 \times m_e} \quad (6)$$

Calibration line: OD (470) = 0.033 mass (μg) Phytate sodium

me: mass (g) of the sample.

Oxalic acid

The oxalic acid (OA) content was determined according to the method described by AOAC (1995). About 0.5 ml of sample was added to 100 ml of potassium hydroxide (0.1N KOH). The mixture was boiled for 30 min at 80 °C. After cooling, the solution was filtered and 5ml of concentrated sulfuric acid (H₂SO₄) was added. The filtrate is heated to the temperatures at 60 °C to 70 °C for 10 min then titrated with 0.1N potassium permanganate solution (KMnO₄) until a persistent pink color. The content of oxalic acid was determined by the following relationship:

$$\% \text{ OA} = \frac{V \times 0.45 \times 2}{P_e} \quad (7)$$

Pe: The test sample (0.5 g)

V: burette drop (KMnO₄) or volume of KMnO₄ poured

0.45 = quantity of oxalic acid corresponding to 1 liter of 0.1N solution of KMnO₄

2.2.6 Nutritional Profile

Food nutrient profile was calculated according to Darmon, Vieux, Maillot, Volatier, and Martin (2009) system. This system is based on two (2) indicators: the SAIN score, based on qualifying nutrients (ie, positive nutrients), and the LIM score, based on disqualifying nutrients (ie, the nutrient to be limited).

The SAIN score was an unweighted arithmetic mean of the percentage adequacy for Five (5) positive nutrients. It was calculated for 100 kcal of food, as follows:

$$\text{SAIN} = \frac{\frac{\text{Vitamin C}}{\text{RNI Vitamin C}} + \frac{\text{Iron}}{\text{RNI Iron}} + \frac{\text{Calcium}}{\text{RNI Calcium}} + \frac{\text{Protein}}{\text{RNI Protein}} + \frac{\text{Fiber}}{\text{RNI Fiber}}}{5} \times 100 \times 100 \quad (8)$$

RNI (Recommended Nutritional Intake)

The LIM score was the mean percentage of the maximal recommended values for 3 nutrients, the intakes of which should be limited in a healthy diet.

The LIM score was calculated for 100 g of food as follows:

$$\text{LIM} = \frac{\frac{\text{Na}}{3153} + \frac{\text{SFA}}{22} + \frac{\text{Added sugar}}{50}}{3} \times 100 \quad (9)$$

SFA= Saturated Fatty Acid

The recommended nutritional intake are based on French and European nutritional recommendations. In particular, the daily maximal recommended value for SFAs and added sugars corresponded to 10 % of 2000 kcal, ie, 22 and 50 g, respectively, and that of sodium corresponded to a daily intake of 8 g NaCl (ie, 3153 mg Na). The 2000-kcal value was chosen as a reference for energy intake because it is close to the mean observed energy intakes in the French population. Overall, the SAIN, LIM system was based on 8 basic nutrients (5 included in the SAIN plus 3 included in the LIM) (Darmon *et al.*, 2009).

Based on reference daily energy intake of 2000 kcal, the optimum value for the SAIN was 100 % for 2000 kcal, which was equivalent to 5 % for 100 kcal food. The SAIN value ≥ 5 indicated, therefore, a good nutrient density. Unlike the SAIN, the LIM was calculated for 100 g. Thus, the reference value used to derive the threshold value for the LIM score was based on food intake rather than on energy intake. Because the mean daily food intake (including solid foods only) observed in the French population was ≈ 1330 g/d, the maximal value for the LIM score was 100 % for 1330 g, which was equivalent to 7.5 % for 100 g food. A LIM value < 7.5 indicated, therefore, a low content of limited nutrients (Darmon *et al.*, 2009).

Based on SAIN and LIM score values, each food was classified into 1 of 4 possible SAIN and LIM groups (Darmon *et al.*, 2009):

Group 1: SAIN ≥ 5 and LIM < 7.5 (Foods recommended for health)

Group 2: SAIN < 5 and LIM < 7.5 (Neutral foods)

Group 3: SAIN ≥ 5 and LIM ≥ 7.5 (Foods recommended in small quantities or occasionally)

Group 4: SAIN < 5 and LIM ≥ 7.5 (Foods to limit).

2.2.7 Statistical Analysis

Results made in triplicate measurements were expressed as means with standard deviation. A one-way ANOVA was performed and means were separated using Tukey test ($p \leq 0.05$) with Statistica 7.1 software.

3. Results

3.1 Biochemical Composition of Jam and Saba Syrup

3.1.1 pH, Titratable Acidity, Ash and Dry Matter

The pH, titratable acidity, ash and dry matters contents of jam and syrup of Saba were given in Table 1. Results showed that pH, titratable acidity, ash and dry matters differ significantly to the jam and syrup of Saba. The jam and the syrup have low pH values (respectively 3.11 ± 0.01 and 3.65 ± 0.05) with a titratable acidity respectively of 0.23 ± 0.01 % and 0.09 ± 0.01 %. On the other hand, the dry matter contents was higher than 50 %. Also, they contained respectively 0.63 ± 0.05 % and 1.06 ± 0.09 % of ash.

Table 1. Compositions in pH, titratable acidity, ash and dry matter

	Contents	
	Jam	Syrup
pH	3.11 ± 0.01^b	3.65 ± 0.05^a
Titratable acidity	0.23 ± 0.01^a %	0.09 ± 0.01^b %
Ash	0.63 ± 0.05^b %	1.06 ± 0.09^a %
Dry matters	58.08 ± 0.37^b %	67.47 ± 1.45^a %

Values are means \pm standard deviations of three measures ($n = 3$). The same letter subscripted in the same line indicates that there is no significant difference between samples for the parameter concerned ($p < 0.05$).

3.1.2 Macronutrient Content

Macronutrient content were significantly different ($P < 0.05$) in the jam and the syrup of *Saba Senegalensis* (Table 2). Results showed that the jam and the syrup had low lipid contents (respectively 0.92 ± 0.06 % and 0.13 ± 0.01 %). On the other hand, the syrup (66.27 ± 1.08 %) was higher total carbohydrate content than the jam (56.53 ± 0.24 %). The total sugars contents of the jam and the syrup were respectively 13.36 ± 0.14 % and 17.35 ± 0.30 %.

Table 2. Macronutrient compositions of Jam and Saba Syrup

	Contents (%)	
	Jam	Syrup
Lipids	0.92 ± 0.06^a	0.13 ± 0.01^b
Total carbohydrates	56.53 ± 0.24^b	66.27 ± 1.08^a
Total sugar	43.36 ± 0.14^b	47.35 ± 0.30^a
Reducer sugar	3.05 ± 0.34^a	0.28 ± 0.02^b

Values are means \pm standard deviations of three measures ($n = 3$). The same letter subscripted in the same line indicates that there is no significant difference between samples for the parameter concerned ($p < 0.05$).

3.1.3 Vitamins and Minerals

The Table 3 presented the vitamin C, β -carotene and minerals contents of jam and syrup of *Saba senegalensis*. Results showed the significant difference between the parameters studied. The vitamin C rate was highest in the jam (20.00 ± 0.01 mg/100 g) that in the syrup (18.33 ± 2.22 mg/100 g). In addition, β -carotene rate of the jam was 174.34 ± 3.01 μ g/100 g while its content in the syrup was in the traces form.

Concerning minerals contents, potassium was the most abundant mineral in jam and syrup with respective values of 136.71 ± 4.08 mg/100 g and 241.76 ± 5.9 mg/100 g. The formulated products contained a significant amount of calcium (53.46 ± 3.96 mg/100 g and 87.49 ± 5.42 mg/100 g). Nevertheless, they were low in iron contents (1.01 ± 0.21 mg/100 g and 3.11 ± 0.87 mg/100 g).

Table 3. Vitamins and minerals contents

	Contents	
	Jam	Syrup
Vitamins		
Vitamin C	20.00 ± 0.01 ^a mg/100 g	18.33 ± 2.22 ^b mg/100 g
β-carotene	174.34 ± 3.01 ^a µg/100 g	Traces
Minerals		
	Jam (mg/100 g)	Syrup (mg/100 g)
Sodium (Na)	5.25 ± 0.31 ^b	18.80 ± 1.08 ^a
Magnesium (Mg)	16.19 ± 0.21 ^b	34.49 ± 0.54 ^a
Phosphorus (P)	14.19 ± 0.44 ^b	40.46 ± 1.32 ^a
Potassium (K)	136.1 ± 4.08 ^b	241.76 ± 5.90 ^a
Calcium (Ca)	53.46 ± 3.96 ^b	87.49 ± 5.42 ^a
Iron (Fe)	1.01 ± 0.21 ^b	3.11 ± 0.87 ^a

Values are means ± standard deviations of three measures (n = 3). The same letter subscripted in the same line indicates that there is no significant difference between samples for the parameter concerned (p<0.05).

3.2 Phytonutrients and Anti-nutritional Factors

The phytonutrients content and antinutritional factors content were shown in Table 4. Results were significantly different (p<0.05) on phytonutrients and anti-nutritional factors in each formulated products. Polyphenols were more abundant in *Saba Senegalensis* jam (103.18 ± 0.69 mg/100g) than in syrup (3.29 ± 0.02 mg/100g). In addition, phytates were more abundant in Saba jam (102 ± 6.93 mg/100g). Results also showed that flavonoids content were lower in jam and syrup of Saba with respective values of 19.00 ± 0.99 mg/100g and 0.20 ± 0.02 mg/100g.

Table 4. Phytonutrients contents and antinutritional factors

	Contents (mg/100g)	
	Jam	Syrup
Phytonutrients		
Total polyphenols	103.18 ± 0.69 ^a	3.29 ± 0.02 ^b
Flavonoids	19.00 ± 0.99 ^a	0.20 ± 0.02 ^b
Antinutritional Factors		
Tannins	78.51 ± 0.14 ^a	1.08 ± 0.04 ^b
Phytates	102 ± 6.93 ^a	19.96 ± 0.01 ^b
Oxalates	19.87 ± 0.01 ^a	6.62 ± 0.21 ^b

Values are means ± standard deviations of three measures (n = 3). The same letter subscripted in the same line indicates that there is no significant difference between samples for the parameter concerned (p<0.05).

3.3 Nutritional Profile

The Figure 1 showed the SAIN and LIM scores for jam and syrup of *Saba Senegalensis*. The SAIN score of the jam was 2.88 and LIM score was 54.70. The SAIN score of the syrup was 3.85 and LIM score was 97.39.

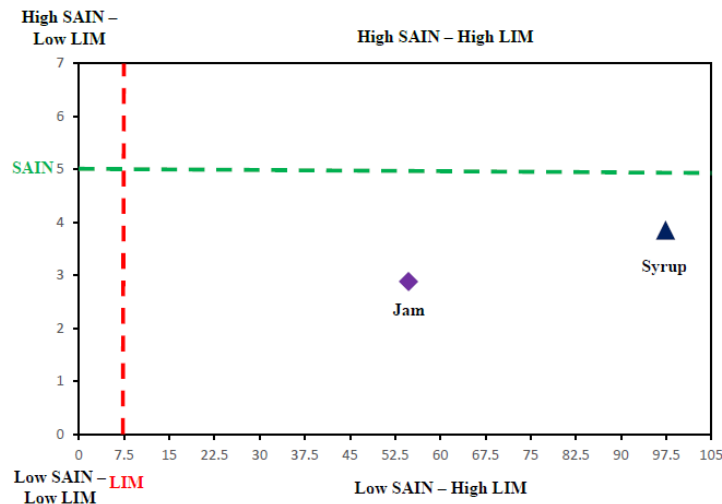


Figure 1. Nutritional profile of jam and syrup of Saba

4. Discussion

The aim of this study was to evaluate the nutritional potential of jam and syrup of *Saba senegalensis* for better valorisation of this fruit. The pH value showed that jam and syrup was acidic. It was established that acidity is one of the main parameters that determine the quality of food and it is due to the presence of organic acids (Ouchemoukh, Louaileche, & Schweitzer, 2007). The acid content of the jam and the syrup of *Saba Senegalensis* obtained in this result indicated that *Saba Senegalensis* fruit could contain organic acids. Due to the high acidic content, jam and syrup of *Saba senegalensis* could be able to tolerate microbial activities, especially pathogenic germs and will have a long shelf life. According to Vondruskova, Slamova, Trckova, Zraly, and Pavlik (2010), organic acids have the ability to lower pH and thereby reduce the growth of certain pathogenic bacteria. The dry matter corresponds to the mass of sample after complete evaporation of the free water. The dry matter content in jam and syrup of *Saba Senegalensis* was higher than 50 %. This property would indicate that the jam and the syrup could resist a long time against the microbial growth. Dry matter contents was higher than those obtained by Badarou and Sanni (2014) in tamarind jam $\approx 54 \pm 1.79$ % and pineapple syrup ≈ 21.40 %. Carbohydrates content in this result were higher than 50 %. The high carbohydrate content in jams can be associated to the large presence of sugar (> 50 g/ 100g) as observed from the nutrition labelling on its packaging (Whitney & Rolfes, 2005; Naeem *et al.*, 2017). The total sugars contents (43.36 ± 0.14 %) obtained in this result were lower than those of Parkouda, Oboulbiga, and Sawadogo-Lingani (2015) in the Saba jam in Burkina Faso (65.36 ± 0.92 %). The difference of sugars obtained in this result and those of Parkouda *et al.* (2015) could be explained either by the different varieties of the fruit or by the technological treatments applied.

According to Khalil and Saleemullah (2004), carotenoids is the biological antioxidants and play an important role in human health. β -carotene was converted into retinol (vitamin A) in the human body with a better yield estimated at 1/6 (Favier *et al.*, 1993; Diabagat *et al.*, 2019). Vitamin A was involved in growth, vision, and resistance to infection and its deficiency is a major contributor to infant and child mortality (Tee, 1992; Diabagat *et al.*, 2019). *Saba Senegalensis* jam could thus contribute to the recommended nutritional intake of carotenoids, especially in children. The β -carotene content of Saba syrup was in the form of traces. The great loss of carotenoids in the syrup could be explained by the method of manufacture of the Saba juice used for the formulation of the syrup and by the cooking method. Indeed, according to Alvarez-Jubete and Tiwari (2013), cooking influences the carotenoid content with varying degrees of stability between the different compounds. *Saba Senegalensis* jam and *Saba Senegalensis* syrup have high content of vitamin C. According to the Institute of Medicine (2005) for the consumption of vitamin C, the Accepted Daily Intake (ADI) permitted is 110 mg/days. Due to the high content of vitamin C, the consumption of jam and syrup of Saba could be contribute to attain the requirement daily of vitamin C. In this study, the ash content obtained was higher than that reported by Parkouda *et al.* (2015) in Saba jam from Burkina Faso, which was 0.35 ± 0.01 %. The difference of ash contents obtained in this result and those of the literature could be explained either by the different varieties, the geographical locations of Saba studied or by the technological treatments applied. The ash contents in food explain that it contain a significant amount of minerals.

Minerals are extremely important because they are responsible to several metabolic reactions in body (Traoré Assemang, Digbeu, Kouadio, & Brou, 2018). This result showed that potassium was abundant in jam and syrup of *Saba Senegalensis*. As far as potassium, the potassium content of Saba jam was higher than that obtained by Ajenifujah-Solebo and Aina (2011) in plum jam (90.42 ± 0.01 mg/100g). Moreover, the potassium content of *Saba senegalensis* syrup (241.76 ± 5.90 mg/100g) were higher than those obtained by Agence Nationale de Sécurité Sanitaire, alimentation, Environnement et travail (ANSES) (2013) in pineapple syrup (105 mg/100 g). Potassium is well known for its important role in regulating heart rate and neurotransmission (Alinnor & Akalezi, 2010). As the importance of these potassium contents, jam and syrup of Saba could be appropriate to help solve the problems of sodium-related diseases. The calcium contents in Saba jam (53.46 ± 3.96 mg/ 100g) and the Saba syrup (87.49 ± 5.42 mg/100 g) were respectively higher than those of papaya jam (36.00 ± 1.00 mg/100 g) reported by Ena, Shalini, Pragati, Reena, and Rai, (2016) and date syrup (44.41 mg/100g) reported by Farahnaky, Mardani, Mesbahi, Majzooobi, and Golmakani (2016). The relatively high levels of calcium in the two products suggest that they could have therapeutic value in a hypocalcaemia state such as osteoporosis. Indeed, calcium is a major factor in ossification and plays a role in muscle contraction, and absorption of vitamin B12 (Mensah, Okoli, Ohaju-Obodo, & Eifediyi 2008). The studies carried out by Onwuliri and Obu (2002) have showed that the minerals were important for their absolute involvement in vital physiological functions such as the regulation of osmotic pressure, regulation of electrolyte flows between the intra-and extracellular medium (by Na / K pump) (Traoré *et al.*, 2018). Due to the high potassium content, jam and syrup of *Saba senegalensis* could be recommended in diet.

As for as the antinutritional factor, results showed the high level of phytates and tannins in jam and syrup of *Saba senegalensis*. Indeed, the high content of phytates and tannins in diet could be responsible for the unavailability of certain minerals such as iron, Zinc, magnesium and calcium (Traoré *et al.*, 2018). In addition to the antinutritional factor, the jam and syrup of *Saba senegalensis* contained phytonutrients, which play the role of antioxidants. In previous studies, Weiguang, Joan, and Casimir (2005) demonstrated that polyphenols was considered as powerful antioxidants against radical phenomena leading to tissue or cellular degeneration. Furthermore, Sarni-Manchado and Cheynier (2006) showed that they are able to activate the natural anti-cancer defences. The flavonoid content of Saba jam (19.00 ± 0.99 mg/100g) was higher than that of strawberry jam (14.08 ± 0.99 mg/100g) reported by Branka, Danijela, Martina, and Dragović-Uzelac (2012). Moreover, the total phenolic content (103.18 ± 0.69 mg/100g) of the jam was higher than that obtained by Patras, Brunton, Tiwari, and Butler (2011) for strawberry jam (83.71 ± 0.90 mg/100g). The total phenolic and flavonoid contents of jam and syrup of Saba could give those potential therapeutic or preventive properties.

With regard to nutritional profile, results showed that jam and syrup of Saba have low score SAIN (SAIN <5) and high LIM score (LIM > 7.5). The SAIN and LIM scores have classified the jam and syrup of *Saba senegalensis* belong to the group 4 of foods, foods that must be consumed with moderation and therefore occasionally. For a better consumption of the syrups and jams of *Saba senegalensis*, it will be interesting to produce them without added sugar. The results were in agreement with those of Darmon *et al.* (2004) who classified products rich in sugar as foods to limit in consumption. For a better consumption of foods from this group, it will be interesting to produce jams and syrup of *Saba senegalensis* without added sugar. Contrary to these results, several studies classified cowpea seeds in food of group 1, recommended foods for health because cowpea seeds have high score SAIN higher than 5 and low score LIM lower than 7.5 (Traoré *et al.*, 2018; Traoré *et al.*, 2020).

5. Conclusion

The present study showed that jam and syrup of *Saba senegalensis* were an important source of minerals such as magnesium, potassium, calcium and phosphorus. In addition, jam and syrup of Saba contained high rate of carbohydrates, total sugars, phenolic compounds and vitamin C whose presence facilitates the absorption of minerals. The nutritional profile showed that jam and syrup of Saba belong to the group of foods who must be consumed moderately. For a better consumption, it is desirable to produce jam and syrup of *Saba Senegalensis* fruit without added sugar. This study has shown that Saba jam and Saba syrup have a high nutritional value and could thus contribute to the improvement of the population's diet and these products would offer interesting possibilities of the economic market.

Statement of competing interests

The authors have no competing interest in relation to their work.

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