

*Full Length Research Paper*

## **Biochemical composition of *Saba senegalensis* fruits from Burkina Faso**

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The aim of this study was to determine the biochemical characteristics of the fresh pulp and the dried hulls of *Saba senegalensis* fruits collected in seven localities of Burkina Faso. The biochemical composition of the samples was determined using standards methods. Results showed that the pulp presented mean values of 83.23%, 18.74%, 2.83 and 4.48 for moisture, Brix, pH and titratable acidity, respectively. Based on dry mater (DM), the pulp contained 5.9 g/kg of ashes, 144.2 g/kg of total carbohydrates, 11.5 g/kg of fat and 5.9 g/kg of proteins. The pulp contents (mg/kg) in minerals such as Fe, Zn, Mg, Ca and K were 25.4, 2.2, 1070.1, 1302.2 and 2535.7, respectively. The pulp has a potential energetic value of 704.2 kcal/kg for human consumption. *S. senegalensis* hulls presented higher mean values of proteins (30.8 g/kg), fat (150.6 g/kg), ashes (54.6 g/kg) and carbohydrates (637.8 g/kg). Hulls also displayed high contents in mineral elements such as Mg, K, Fe and Zn. This study demonstrated that pulps as well as hulls of *S. senegalensis* fruits from Burkina Faso have interesting nutritional potential which could be used to improve the diet of population.

**Key words:** *Saba senegalensis*, characterization, pulp, hull, nutrients, Burkina Faso.

### **INTRODUCTION**

*Saba senegalensis* is an indigenous climbing plant belonging to the Apocynaceae family. It is found as wild plant in many African countries such as Burkina Faso, Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Ghana, Mali, Niger, Senegal, and Tanzania (Diabagaté et al., 2019). It is one of the ten most important non-timber forest products in Burkina Faso with 79 454 tons of fruits

produced in 2012 according to the Agency for the Promotion of Non-Timber Forest Products (PNSAN, 2013). Fruits of *S. senegalensis* are called *zaban* (in Mali), *malombo* (in the Congo Basin), *maad* (in Senegal), *wèda* (in Burkina Faso) and *côcôta* (in Côte d'Ivoire). The fruit consists of a globular hull coating seeds with very soft and juicy yellow pulp (Kini et al., 2008;

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**Figure 1.** Map of Burkina Faso showing the seven sampling areas. Green circles indicate the localities and their names.

Kouakoua et al., 2019). Ripe fruit is tasty, sweet-sour with yellow pulp (Boamponsem et al., 2013) and is generally consumed fresh without any processing. However, the fruits could be processed into products such as juice, nectar or jam. It could also be used in other preparations such as cakes (Kouakoua et al., 2019). The fruit is rich in vitamin A, vitamin C, dietary fiber and contains minerals such as potassium, magnesium and calcium (Omale et al., 2010; Diabagaté et al., 2019). The presence of active compounds in *Saba* fruit could play an important role in the prevention and treatment of certain vitamin deficiencies and metabolic diseases (Kini et al., 2008). Despite its intrinsic qualities and its economic contribution, the valorization of the *S. senegalensis* fruit as most of climacteric fruits in Burkina Faso is limited by its seasonality and its high perishability. Indeed, the fruit harvesting period is three months (May to August) and once at maturity, the fruit storage time is very short and usually does not exceed three days (Lamien et al., 2010). In addition, the lack of methods of processing as well as methods of preserving the fruit results in its non-availability throughout the year. The objective of this study was to determine the biochemical composition of the pulp and the hull of *S. senegalensis* fruit for a better valorization in Burkina Faso.

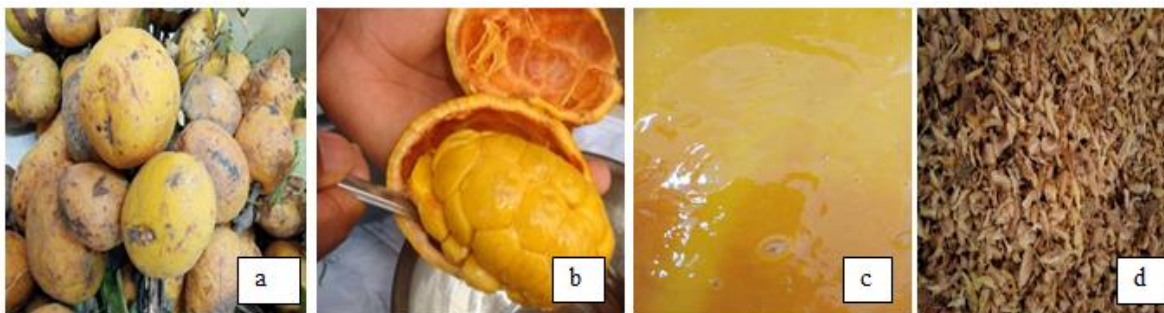
## MATERIAL AND METHODS

### Sampling

Fruits of *S. senegalensis* were collected from seven production areas in Burkina Faso (Figure 1): Boromo (Brm), Pô (Pô), Saponé (Sph), Houndé (Hnd), Nouna (Nna), Ouahigouya (Ohg) and Ouagadougou (Ogd). In each locality, 200 to 230 fruits (Figure 2a) were directly picked from randomly selected trees, pooled to form a composite sample of 30 to 35 kg. Each composite sample was divided into three equal parts. Three samples were then obtained per locality and a total of 21 samples was collected and transported to the pilot plant of Département Technologie Alimentaire (DTA/IRSAT/CNRST) for treatment before analyses.

### Samples treatment

Samples from each locality were first sorted and fruits of good quality and maturity were selected. The fruits were then washed with soap, disinfected with sodium hypochlorite (0.2%), rinsed twice and cutted into half with stainless steel knife. The seeds containing the pulp (Figure 2b) were then removed with stainless spoon. The pulp was extracted from the pulpy seeds without adding water using a mixer of mark SAYONA (NO: SZJ-LH 923B/AC 220V 50/60 Hz 500W) and a stainless sieve according to the diagram in Figure 3. The pulp obtained (Figure 2c) was collected in sterile freezer bags and stored at -18°C for the various analyses. The hulls of each sample were dried following the steps described in Figure 3. The



**Figure 2.** Ripe fruit of *S. senegalensis*. (a) Whole fruit; (b) open fruit, (c) pulp, (d) dried hulls.

obtained dried hulls (Figure 2d) were crushed using a porcelain mortar, then packaged in plastic boxes and kept at room temperature for analyses. After treatment, 21 samples of pulp and 21 samples of hull were obtained for the different analyses.

### Biochemical analysis

The pH and the titratable acidity were determined according to the AFNOR methods (1986) applicable to fruits and vegetables and derived products. Samples (5 g) were homogenized with 25 ml of distilled water. The pH of the homogenate was determined using a digital pH meter (Hanna, France) calibrated with standard buffer solutions pH 4.0 and 7.0. The solution used for measuring the pH was centrifuged at 3 500 rpm. The supernatant was collected for titrimetric assay.

The percentage of soluble dry matter or Brix level was determined using a digital refractometer (Abbe, France). The moisture content was determined by drying the sample at  $105 \pm 2^\circ\text{C}$  for 12 h according to the standard ISO 712 (2009). Ash content was determined by incineration at  $550^\circ\text{C}$  for 4 h according to the standard ISO 2171 (2007). Proteins content was determined by the Kjeldahl method after acid digestion according to the standard AFNOR NF V03 50 (1970). Fat content was determined with Soxhlet apparatus using n-hexane according to the standard ISO 659, (1998). Total carbohydrates content was estimated by the difference method according to the formula: % Total carbohydrates =  $100\% - (\% \text{moisture} + \% \text{proteins} + \% \text{fat} + \% \text{ash})$ . The energy value was calculated according to the Atwater coefficients. The determination of mineral elements was carried out by flame atomic absorption spectrometry (Perkin-Elmer model 303) according to AOAC (2005).

### Statistical analysis

The physico-chemical analyses were carried out in triplicate. Data were processed using Microsoft Excel 2013 for the calculation of averages and standard deviation.

## RESULTS AND DISCUSSION

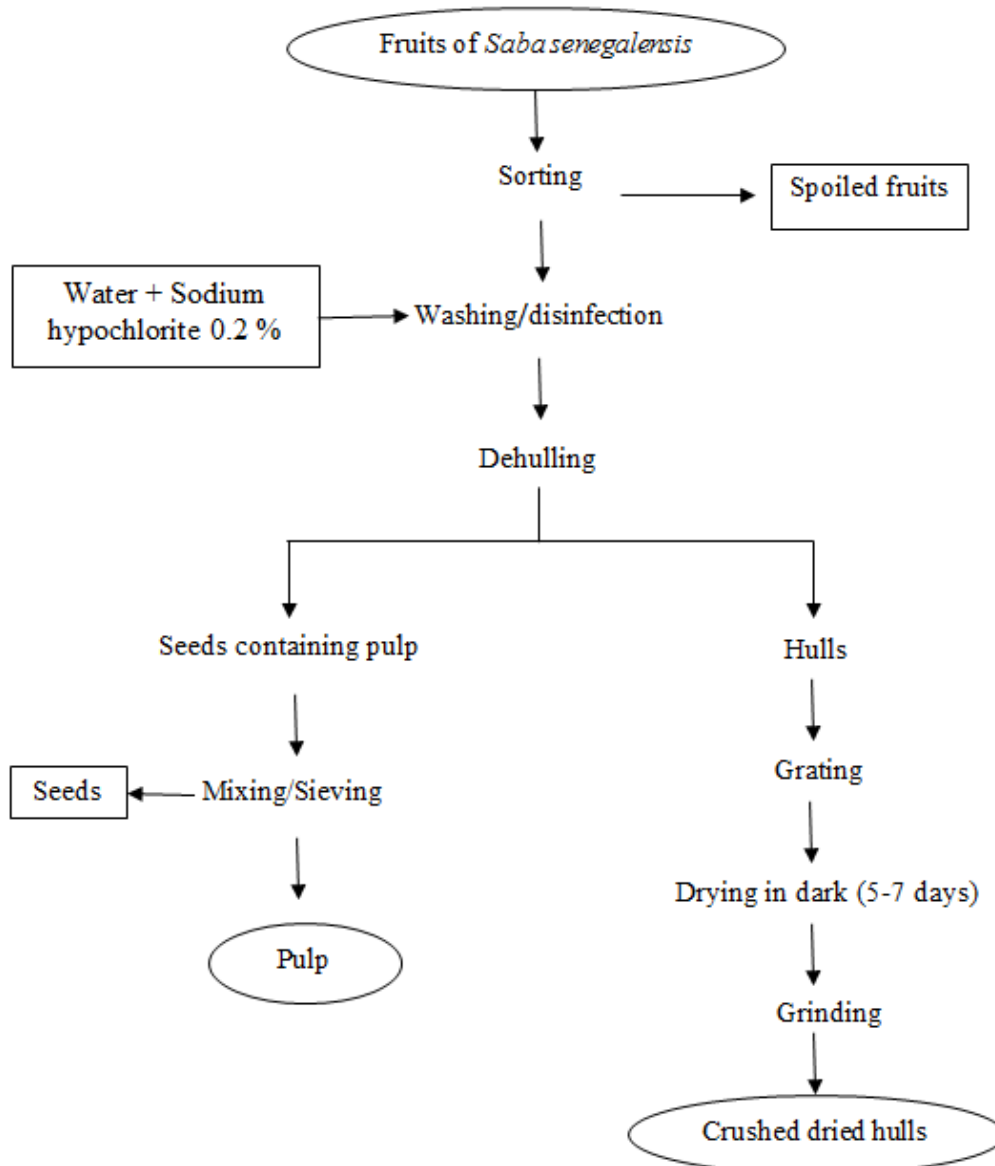
### Biochemical composition of *S. senegalensis* pulp

The biochemical composition of the pulp of *S. senegalensis* fruit on a dry matter (DM) basis is different among samples (Table 1). The moisture content of the

pulp ranged from  $80.94 \pm 0.04\%$  (Ogdp) to  $88.03 \pm 0.02\%$  (Nnap) with a mean value of  $83.23 \pm 2.39\%$ . This mean is higher than the value reported by Paget (2004) which was 80%. The moisture content is an important criterion for the stability of food. Fruits that contain a large amount of water are subject to rapid deterioration due to mold growth and insect damage (Boampossem et al., 2013). The variation in the moisture content of the different pulps could be explained by their ecological origin. Indeed, previous studies have reported that the humidity is not a varietal characteristic, but depends much more on soil and climatic conditions and therefore can be influenced by the effect of environment (Derrardji, 2014).

The pH of the pulps ranged from  $2.7 \pm 0.0$  (Spnp) to  $2.94 \pm 0.01$  (Brmp). The mean pH value for all samples was  $2.83 \pm 0.08$ , showing that *S. senegalensis* is an acidic fruit. This acidity could allow extending the shelf life of fresh fruit and inhibiting the multiplication of pathogenic microorganisms (Mudambi and Rajagopal, 2006). The mean pH of the *S. senegalensis* pulps from Burkina Faso was closed to those obtained by Kouakoua et al. (2019) from Côte d'Ivoire (pH 2.85) and Sarr et al. (2018b) from Senegal (pH 2.77). In contrast, Boampossem et al. (2013) reported a lower pH for the pulp harvested in Ghana. This difference could be justified by the differences in soil, climate and the level of the maturity of the fruit (Kouakoua et al., 2019).

Like pH, titratable acidity is also very important for the determination of the fruit pulp quality. Titratable acidity is related to the sour taste of food and expresses the quantity of organic acids (Diabagaté et al., 2019). In this study, the content of titratable acidity varied from  $3.53 \pm 0.12\%$  (Hndp) to  $5.29 \pm 0.49\%$  (Spnp) with an average of  $4.48 \pm 0.57\%$ . This average is higher than that (2.20%) reported by Kouakoua et al. (2019). The fruit being a climacteric fruit, this difference could be explained by ripeness and varietal differences among fruits. Indeed, during the ripening metabolism the reducing sugar contents increase and the sugar/acid ratio is consequently high. Therefore, the level of acidity is considered as an indicator of ripeness (Boampossem et al., 2013).



**Figure 3.** Diagram of extraction of the pulp and drying of the hulls of *S. senegalensis* fruits.

Samples Brix values ranged from  $13.4 \pm 0.00\%$  (Nnap) to  $22.1 \pm 0.00\%$  (Ogdp), with a mean value of  $18.74 \pm 0.00\%$ . The Brix level is one of the basic criteria used for the definition of fruit juice (Boamponsem et al., 2013). Theoretically, it is well known that the Brix value indicates the percentage of water-soluble dry matter in fruit juice. This soluble dry matter is mostly made up of sugar and minerals. Testing the brix level of fruits gives an idea of the fruit quality; high brix means better nutritional quality as well as better flavor (Boamponsem et al., 2013). It can depend on many factors including the variety of the fruit, the locality, the level of ripeness, etc. (Derrardji, 2014). This could explain the difference between that found from the present study and those from Boamponsem et al.

(2013) in Ghana, Sarr et al. (2018b) in Senegal and Kouakoua et al. (2019) in Côte d'Ivoire which were 14.10, 16.50 and 19.60%, respectively.

Ash contents of the pulps varied from  $2.5 \pm 0.1$  (Nnap) to  $10.4 \pm 1.18$  g/kg (Hndp) with an average of  $5.9 \pm 3.1$  g/kg. The average ash contents of *S. senegalensis* pulp from Burkina Faso is closed to that (4.6 g/kg DM) obtained by Diabagaté et al. (2019) for pulp from Côte d'Ivoire. However, Boamponsem et al. (2013) reported higher ash contents (28 g/kg DM) for *S. senegalensis* pulp from Ghana. The difference in ash contents may be due to the variety, the nature of the climate and the property of the soil on which the plant grows.

Protein contents ranged from  $3.7 \pm 0.0$  (Nnap) to  $7.9 \pm$

**Table 1.** Biochemical composition of the pulp of *S. senegalensis* fruit.

Sample	Moisture (%)	Ashes (g/kg DM)	Fat (g/kg DM)	Total Carbohydrates (g/kg DM)	Proteins (g/kg DM)	pH	Titrateable acidity (%)	Brix value (%)	Energy (kcal/kg DM)
Brmp	84.55±0.23	4.2±0.2	11.5±0.2	132.8±1.1	5.7±0.2	2.94±0.01	4.29±0.42	16.1±0.00	657.5
Hndp	82.09±0.17	10.4±1.18	12.5±0.8	148.1±1.0	7.9±1.5	2.83±0.02	3.53±0.12	19.9±0.00	736.5
Nnap	88.03±0.02	2.5±0.1	8.8±0.5	104.5±0.7	3.7±0.0	2.83±0.00	3.98±0.10	13.4±0.00	512
Ogdp	80.94±0.04	10.2±0.61	11.7±0.6	162.3±5.9	6.3±0.3	2.78±0.03	5.14±0.31	22.1±0.00	779.7
Ohgp	82.45±0.01	5.2±0.4	13.1±0.3	150.9±9	6.0±0.0	2.82±0.01	4.19±1.31	19.4±0.00	745.5
Pôp	81.76±0.20	5.8±0.1	11.7±0.3	158.8±1.5	5.8±0.4	2.89±0.00	4.02±0.45	20.4±0.00	763.7
Spnp	82.75±0.03	3.1±0.16	11.6±0.2	152.0±1.9	5.6±0.2	2.70±0.00	5.29±0.46	19.9±0.00	734.8
Mean	83.23±2.39	5.9±3.1	11.5±0.2	144.2±4.7	5.9±1.2	2.83±0.08	4.48±0.57	18.74±0.00	704.2

Brmp: Pulp from Boromo, Hndp: pulp from Houndé, Nnap: pulp from Nouna, Ogdp: pulp from Ouagadougou, Ohgp: pulp from Ouahigouya, Pôp: pulp from Pô, Spnp: pulp from Saponé.

1.5 g/kg (Hndp) with an average value of  $5.9 \pm 1.2$  g/kg. Thus, as for most fresh fruits, the pulps of *S. senegalensis* fruits from Burkina Faso were poor in proteins. The mean value of protein contents of the pulps is in agreement with the value (5 g/kg DM) reported by Boamponsem et al. (2013) but lower than the value reported by Diabagaté et al. (2019) which was 29.1 g/kg.

Regarding total carbohydrates content, the pulps of *S. senegalensis* fruit displayed a mean value of  $144.2 \pm 4.7$  g/kg. In previous studies, higher carbohydrates content (185 g/kg DM) of *S. senegalensis* pulp from Burkina Faso was reported by Zerbo et al. (2007) and PADEC (2018). The content of total carbohydrates in *S. senegalensis* pulp reported by other authors also varied (Kini et al., 2008; Nafan et al., 2013; Sarr et al., 2018a; Diabagaté et al., 2019). This variation could be explained by various conditions such as geographical localization, genetic constitution, pedological and climatic conditions, etc. (Diabagaté et al., 2019).

Fat content is known to provide high energy content and can be reservoir of fat-soluble vitamins. Pulps showed fat contents ranging from  $8.8 \pm 0.5$  g/kg (Nnap) to  $13.1 \pm 0.3$  g/kg (Ohgp) with a mean value of  $11.5 \pm 0.2$  g/kg. This average is in line with the fat content (14.8 g/kg) of *S. senegalensis* pulps from Côte d'Ivoire (Diabagaté et al., 2019). Food with low fat content may be interesting for obese people (Ayessou et al., 2009). The mean fat content of all the samples are nevertheless lower than that found by Boamponsem et al. (2013) which was 89.3 g/kg DM.

The potential calorific value of *S. senegalensis* pulp ranged from 512 kcal/kg (Nnap) to 779.7 kcal/kg (Ogdp) with an average of 704.2 kcal/kg. This low energy can be explained by the low contents of macronutrients in *S. senegalensis* pulps. However, the average potential nutritive value obtained for the pulp in this study is much lower than that reported by Boamponsem et al. (2013) which was 3793.2 kcal/kg. The high calorific content reported by these authors was due to the high fat content

(89.2 g/kg DM) found in their fruits compared to the fruits from Burkina Faso. Indeed, the calorific value is associated with the fat content. A high fat content necessarily influences the energy value because fat has a high calorific coefficient. Considering the average low energy value, *S. senegalensis* fruits collected in the seven localities of Burkina Faso could be recommended to the obese and diabetic patients or in overweight.

The composition in mineral elements expressed in mg/kg of dry matter (DM) of the pulps of *S. senegalensis* fruits from the 7 localities of Burkina is presented in Table 2. Results showed that the iron content ranged from  $3.7 \pm 0.0$  (Ogdp) to  $81 \pm 0.4$  (Brmp) with an average of  $25.4 \pm 0.3$  for all the samples. A weak content in zinc (Zn) was observed with an average of  $2.2 \pm 0.0$ . The lowest content ( $1.7 \pm 0.0$ ) was reported for the fruits of Boromo (Brmp) while the highest content ( $2.7 \pm 0.0$ ) was noted for the fruits of Saponé (Spnp). However, high percentage of magnesium, potassium, and calcium was found. For magnesium, the highest content ( $1622.5 \pm 6.6$ ) was obtained with Pô samples (Pop) and the lowest content ( $850 \pm 1.6$ ) with Houndé samples (Hndp). The mean value of Mg for all samples was  $1070.1 \pm 4.3$ . A variation of  $674.8 \pm 7.4$  (Nnap) to  $11062.4 \pm 72.7$  (Hndp) was observed for K and the average found was  $2535.7 \pm 27$ . Concerning Ca the content ranged from  $249.4 \pm 20.0$  (Pop) to  $2848.7 \pm 59.1$  (Ogdp). The mean value obtained for Ca was  $1302.2 \pm 25.1$ . Found data were comparable with those of Diabagaté et al. (2019) who showed that K ( $1169.6 \pm 20.6$  mg/kg DM) and Ca ( $366.1 \pm 27.9$  mg/kg DM) are the most abundant minerals in the pulp of *S. senegalensis* fruits from Côte d'Ivoire. Most pulps from the seven localities of Burkina Faso also presented higher content in Ca than that reported for the orange fruits ( $255 \pm 19.0$  mg/kg DM) by Dipak and Ranajit (2004).

Data showed that the pulp of *S. senegalensis* fruits from Burkina Faso were rich in minerals compared to other consumed fruits. The consumption of *S.*

**Table 2.** Mineral composition of the pulp of *S. senegalensis* fruit (mg/kg DM).

Sample	Fe	Zn	Mg	Ca	K
Brmh	81.0±0.4	1.7±0.0	892.9±2.5	384.8±12.5	955.3±25.7
Hndh	06.3±0.3	2.2±0.0	850.0±1.6	465.2±41.2	11062.4±72.7
Nnah	10.1±0.0	1.8±0.0	907.1±3.7	2160.2±4.9	674.8±8.7
Ogdh	03.7±0.0	1.8±0.0	1018.5±2.1	2848.7±59.1	1569.7±8.4
Ohgh	37.2±0.3	2.4±0.0	1143.3±3.7	4525±18.8	957.5±13.2
Pôh	27.1±0.3	2.6±0.0	1622.5±6.6	249.4±20.0	1591.2±46.5
Spnh	12.1±0.0	2.7±0.0	1056.2±1.1	2549.9±38.1	937.8±07.4
Mean	25.4±0.3	2.2±0.0	1070.1±4.3	1302.2±25.1	2535.7±27

Brmh: pulp from Boromo, Hndh: pulp from Houndé, Nnah: pulp from Nouna, Ogdh: pulp from Ouagadougou, Ohgh: pulp from Ouahigouya, Pôh: pulp from Pô, Spnh: pulp from Saponé.

**Table 3.** Biochemical composition of the hulls of *S. senegalensis* fruit.

Sample	Moisture (%)	Ashes (g/kg DM)	Total carbohydrates (g/kg DM)	Fat (g/kg DM)	Proteins (g/kg DM)	Titrateable acidity (%)	pH	Energy (kcal/kg DM)
Brmh	10.82±0.12	52.1±1.1	673.8±4.9	137.3±5.7	28.4±1.7	3.66±0.33	3.69±0.23	4044.5
Hndh	13.89±0.13	62.7±5.2	597.4±2.5	172.3±2.5	28.6±0.6	4.06±0.41	3.40±0.01	4054.7
Nnah	13.69±0.03	49.0±3.	619.5±5.1	165.8±1.0	28.6±1.0	2.61±1.25	3.55±0.03	4084.6
Ogdh	16.60±0.10	51.8±1.2	652.4±29.5	95.1±31.2	34.5±0.4	0.58±0.13	4.87±0.09	3603.5
Ohgh	13.35±0.07	55.7±1.9	667.7±92.2	108.7±94.2	34.3±0.2	0.30±0.20	5.01±0.23	3786.3
Poh	13.40±0.07	63.3±1.7	598.6±5.8	169.6±04.5 <sup>a</sup>	34.3±0.2	4.19±0.42	3.44±0.00	4058
Spnh	11.91±0.01	47.3±0.8	655.2±2.0	151.3±0.8 <sup>a</sup>	26.8±0.6	2.64±0.51	3.62±0.00	4089.7
Mean	13.38±1.80	54.6±1.5	637.8± 21.2	150.6±27.3	30.8±3.3	2.58±1.58	3.94±0.69	3960.1

Brmh: hulls from Boromo, Hndh: hulls from Houndé, Nnah: hulls from Nouna, Ogdh: hulls from Ouagadougou, Ohgh: hulls from Ouahigouya, Pôh: hulls from Pô, Spnh: hulls from Saponé.

*senegalensis* fruit could therefore contribute to cover the body's needs in minerals (Paget, 2004). Indeed, the mineral elements are involved in a wide range of functions in the organism such as mineralization, ion balance control, enzyme and hormonal systems, muscular system, nervous and immune systems. For example, there is no hemoglobin synthesis without Fe and no muscle contraction without Ca, K and Mg (Ciquel, 2013).

### Biochemical composition of *S. senegalensis* hulls

From the results, the moisture content of the hulls samples from the 7 localities ranged from 10.81 ± 0.12% (Brmh) to 16.60 ± 0.10% (Ogdh) with an average of 13.38 ± 1.80% (Table 3). The mean value of moisture content of the hulls corroborates the limit set by the Codex Alimentarius Commission (1991) for dried food which is 15%. The pH of the hulls ranged from 3.40 ± 0.01 (Hndh) to 5.01 ± 0.23 (Ohgh) with a mean value of 3.94 ± 0.69.

Concerning the titrateable acidity, it ranged from 0.12 ±

0.20% (Ogdh) to 4.19 ± 0.42% (Poh). The mean value obtained for titrateable acidity was 2.58 ± 1.58%. The biochemical composition of the hulls was different from those of the pulps. Ash contents varied from 47.3 ± 0.8 (Spnh) to 63.3 ± 1.7 g/kg (Poh) with an average of 54.6 ± 1.5 g/kg. It appears that the hulls contain higher percentage of ashes than the pulps. Hulls could therefore constitute a significant source of mineral elements, important for human consumption.

For the protein contents, they ranged from 26.8 ± 0.6 (Spnh) to 34.5 ± 0.4 g/kg (Ogdh) with an average of 30.8 ± 3.3 g/kg. *Saba senegalensis* fruit hull samples contain a high average protein content compared to pulp samples (5.9 ± 1.2 g/kg). The main function of proteins for the body is the building of new tissues and maintaining and repair of those already built. Synthesis of regulatory and protective substances such as enzymes, hormones and antibodies is also a function of food proteins.

Regarding the fat contents, they ranged from 95.1 ± 31.2 (Ogdh) to 172.3 ± 2.5 g/kg (Hndh). The mean content obtained was 150.6 ± 27.3 g/kg. This average is higher than that obtained for the pulp which was 11.5 ±

**Table 4.** Mineral composition of the hulls of *S. senegalensis* fruit (mg/kg DM).

Sample	Fe	Zn	Mg	Ca	K
Brmh	86.4±1.8	16.6±0.0	1870.5±4.5	3335.9±24.2	14703.3±65.9
Hndh	85.4±0.3	11.1±0.0	1154.3±1.6	161.3±31.7	857.5±10.8
Nnah	28.0±0.3	5.5±0.5	1882.2±5.2	80.6±7.7	9544.4±89.9
Ogdh	46.8±0.3	3.8±0.0	1920.1±6.3	161.6±10.9	14306.6±60
Ohgh	35.6±0.3	3.5±0.0	1387.2±3.2	453.1±18.4	12894±9.3
Poh	28.6±0.3	9.3±0.0	1082.8±2.9	157.3±0.7	8389.9±26.2
Spnh	79.7±0.9	11.4±0.0	1093±3.3	231.5±14.6	10024.2±8.9
Mean	56.1±1.2	8.8±0.1	1484.3±4.7	654.5±16.5	10103.1±38.8

Brmh: Hulls from Boromo, Hndh: hulls from Houndé, Nnah: hulls from Nouna, Ogdh: hulls from Ouagadougou, Ohgh: hulls from Ouahigouya, Pôh: hulls from Pô, Spnh: hulls from Saponé.

0.2 g/kg, meaning that *S. senegalensis* hulls is a good source of fat. Fats are concentrated sources of energy, carriers of fat, soluble vitamins and a source of essential fatty acids (Mudambi and Rajagopal, 2006).

The total carbohydrate contents of the hulls ranged from 597.4 ± 2.5 (Hndh) to 673.8 ± 4.9 g/kg (Brmh) with an average of 637.8 ± 21.2 g/kg. It appeared that the hulls had higher mean value of total carbohydrates than the pulps (144.2 ± 4.7 g/kg). The chief function of carbohydrates is to provide energy needed by our body.

The hulls samples presented energetic value ranging between 3603.5 and 4089.7 kcal/kg with an average of 3960.1 kcal/kg. Hulls therefore have very good nutritive value which is attributed to the high carbohydrates and fats content.

The mineral content (expressed in mg/kg of DM) of the dried hulls is shown in Table 4. The highest Fe value was obtained with Boromo fruits hulls (86.4 ± 1.8) and the lowest value with Nouna fruits hulls (28 ± 0.3) with an average of 56.1 ± 1.2. The content of Mg ranged from 1082.8 ± 2.9 (Pôh) to 1920.1 ± 6 (Ogdh) with a mean value of 1484.3 ± 4.7. Regarding the Zn content, the highest content was found in Brmh samples (16.6 ± 0.0) and the lowest content in Ohgh sample (3.5 ± 0.0) with a mean value of 8.8 ± 0.1. Concerning Ca, the content ranged from 80.6 ± 7.7 (Nnah) to 3335.9 ± 24.2 (Brmh) with an average of 654.5 ± 16.5. The content of K ranged from 857.5 ± 10.8 (Hndh) to 14703.3 ± 65.9 (Brmh). The mean K concentration obtained for all the hull samples was 10103.1 ± 38.8. Except for the Ca, the contents of all the determined mineral elements in the hulls are higher than those found in the pulps.

In summary, the results showed that the hull samples contain interesting contents of macronutrients (carbohydrates, fats, ashes) and micronutrients (Fe, Ca, Mg, K) which highlight the nutritional potential of the hulls of *S. senegalensis* fruit analyzed. In Burkina Faso, the dried hulls are generally ground, mixed with water, sieved and used as acidifier in the preparation of certain foods. With regards to their nutritional potential, the consumption of *S. senegalensis* hulls could be encouraged as a food

supplement to improve the diet of population.

## Conclusion

This study highlighted the biochemical composition and nutritional potential of *S. senegalensis* fruits (pulp and hull) from Burkina Faso. The results showed that the pulp is a nutritionally rich food for human consumption. The results also demonstrated that the contents in macronutrients and minerals of the hulls were much higher than those of the pulp. The hulls of *S. senegalensis* may therefore be considered as cheap source of nutrients for particularly rural consumers. Further studies will assess the influence of geographical localization on the biochemical composition of *S. senegalensis* fruit. In addition, identifying appropriate technologies for preserving and processing the *S. senegalensis* fruit will make this resource available out of season and add its value.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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