Influence of maturity stage on nutritional and therapeutic potentialities of *Solanum anguivi* Lam berries (Gnagnan) cultivated in Côte d’Ivoire

Dan Chépo Ghislaine¹, *, Kouassi Kouakou Nestor¹, Ban Koffi Louis², Nemlin Gnopo Jean², Kouame Patrice Lucien¹

¹Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d’Ivoire, Abidjan
²Centre National de Recherche Agronomique, Abidjan, Côte d’Ivoire, 01 BP 1740 Abidjan

Email address: gisln78@yahoo.fr (D. C. Ghislaine), nestorkksi@yahoo.fr (K. K. Nestor), lbankoffi@yahoo.com (B. K. Louis), nemlinjn@yahoo.fr (N. G. Jean), kouame_patrice@yahoo.fr (K. P. Lucien)

**To cite this article:**

**Abstract:** *Solanum anguivi* Lam, collectively called Gnagnan in Côte d’Ivoire is an eggplant with nutritional and therapeutic potentialities. The present study was undertaken to analyze the chemical composition of berries at different stages of maturity. Data showed that at the first stage of maturity, green berries are rich in ascorbic acid (34.5 ± 1.7 mg / 100 g DM), phenolic compounds (956.7 ± 71.1 mg / 100 g DM), iron (467.7 ± 1.8 mg / 100 g DM), magnesium (404.6 ± 16.3 mg / 100 g DM) and potassium (2059.7 ± 22.3 mg / 100 g DM). However at the last stage of maturity, red berries are rich in proteins, cellulose, total sugars, fat and potassium with values of 22.53 ± 2 g / 100 g DM, 19.12 ± 0.4 g / 100 g DM, 3.7 ± 0.2 g / 100 g DM, 2.7 ± 0.2 g / 100 g DM and 2290.8 ± 22.2 mg / 100 g DM respectively. Thin layer chromatography revealed the presence of glucose, ribose, xylose, arabinose and fructose at all maturity stages. Excepted alkaloids and gallic tannins, the phytochemical sorting revealed that Gnagnan contain several pharmacological components. According to the maturity stages, orange and red berries showed a higher content in sterols and poly terpenes, flavonoids and saponins. The green berries contain most of polyphenols, catechin tannins and quinons. As to yellow berries, they are rich in polyphenols and catechin tannins. Data of our study may enhance clinical research on the nutritional and pharmacological properties of *S. anguivi* Lam.

**Keywords:** Gnagnan, Maturity Stage, Chemical Composition, Thin Layer Chromatography, Phytochemical Sorting

1. Introduction

*Solanaceae* is a plant family comprising about 2300 species, nearly one-half of which belong to the genus *Solanum* [1]. *Solanum anguivi* Lam a native of Africa, is a medicinal plant that has improved health both in ancient and modern times. The ethnobotanical and clinical surveys have revealed that *S. anguivi* Lam berries are used in the treatment of many diseases which are of public health concern [2-7]. It is one of the non-tuberous *Solanum* species which is widely distributed in non-arid areas of Africa notably in West Africa, Central Africa, East Africa as well as Southern Africa [3]. *S. anguivi* Lam is polymorphic with wide diversity in forms and agronomic characteristics [8] as shown with the wide diversity in local cultivars including fruit sizes, shapes, taste, color, plant height and branching ability [9]. It has the potential for wide cultivation and increased demand in Côte d’Ivoire due to the cultural importance involving the welcome of visitors into family houses especially in the Central geographical zone of the country. Currently, this preference extends increasingly in all regions of the country. In literature, no consensus exists on maturity stage of *S. anguivi* Lam berries. *S. anguivi* Lam berries or Gnagnan assumes different colors, from green to yellow and finally red during its ripening period [4]. But, other authors noticed that *S. anguivi* Lam globular green berries successively change color into yellow, orange to red after ten days [3]. The berries of *S. anguivi* Lam are collected and consumed as a vegetable and seem to contain many nutrients like most of vegetables and fruits [2]. The berries can be consumed fresh, semi-ripe, ripe, dried or ground into flour. *S. anguivi* Lam berries are
especially characterized by their bitterness due to the presence of various phenolic compounds conferring them antioxidant properties. The antioxidant profile (ascorbic acid, carotenoids and polyphenols) and antioxidant capacity of Gnagnan vary at three ripening levels (green, yellow and red) in Côte d’Ivoire [4]. Apart from this information on antioxidant properties of Gnagnan, little is known about its other chemical constituents. This complementary study was undertaken to determine nutritional and therapeutic potentialities of Gnagnan according to four maturity stage (green, yellow, orange and red).

2. Materials and Methods

2.1. Plant Materials

The berries of S. anguivi Lam were collected at the stage of green maturity from Yamoussoukro, political capital of Côte d’Ivoire, identified and authenticated at the Department of National Center of Floristic Research (Felix Houphouët-Boigny University, Cocody-Abidjan). They were conveyed to the laboratory at Nangu Abrogoua University where they were stored on a bench at room temperature (27 °C ± 3 °C) with a relative humidity of 70 ± 5% for 10 days. The first day, the ¼ of green berries collected were directly dried into an oven at 45 °C for 72 h. During the 10 days, the berries were sorted everyday by visual observation in regards to their color (yellow, orange and red) and stored in an oven under the same conditions. All the dried berries were grounded into a powdery (Grinder branded GLEN CRESTON) fine texture (100 µm) according to their color and stored at room temperature in air tight polythene bag prior to use for analysis.

2.2. Methods

2.2.1. Quantitative Evaluation of Nutritional Components

Five grams of the fresh sample of S. anguivi Lam was placed in an oven at 105°C until constant weight was attained. The percentage of dry matter was calculated as 100 % moisture. Ash, crude protein; fat and minerals were determined according to AOAC [10]. Phosphorus was determined as mentioned by Taussky and Shorr, 1953 [11]. Total sugars, fibers, phenolic compounds and ascorbic acid were carried out as described elsewhere [12-15].

2.2.2. Qualitative Evaluation of Sugars and Pharmacological Components

Sugars were revealed by thin layer chromatography as described by Bruckner [16]. The phytochemical sorting of pharmacological substances were determined according to previous studies [17]. Substance extractions were made with methanol. Sterols and polyterpenes were highlighted by Libermann's reaction. Polyphenols were proved by the reaction of iron chloride (FeCl3). Flavonoids highlighting was made by reacting with cyanamin. Catechol tannins were detected with Stiasny's reagent. Searching of gallic tannins was performed by reaction with sodium acetate. Quinonic substances were sought with Bornsträger's reagent. Alkaloids were highlighted by Bourchardat, Dragendorff, Mayer-Valser reagent and picric acid. Saponins have been identified by the foam reaction. Coumarins detection was performed by reaction with sodium hydroxide.

2.2.3. Statistical Analysis

Data analyzies were performed using the software STATISTICA 7 (Statsoft Inc, Tulsa, USA Headquarters) and XLSTAT- Pro7.5.2 (Addinsoft Sarl, Paris, France). Comparisons between the dependent variables were made by using analysis of variance (ANOVA) and Duncan's test at 5% level.

3. Results

3.1. Quantitative Evaluation of Nutritional Components

Results showed that maturity significantly (p ≤ 0.05) influenced the nutrients in S. anguivi Lam berries (Table 1). The dry matter, polyphenol, ascorbic acid and ash decreased with maturation while protein, total sugars, fat and fibers increased with Gnagnan maturation. Dry matter content of Gnagnan varied between 33.3 % DM (Green berries) to 22.1 % DM (Red berries). However, no statistically significance difference was observed between yellow and orange maturation stages in dry matter. During maturation proteins, fat, fiber, ash and polyphenols contents did not differed significantly between green to yellow berries and orange to red berries respectively. Ascorbic acid content (DM) decreased in all the maturation stages with the values of 34.5 ± 1.7 %, 25.6 ± 1.4 %, 20.7 ± 1.1 % and 13.8 ± 0.7 % at green, yellow, orange and red stages respectively. In Gnagnan, only red berries have higher total sugars contents (3.7 ± 0.2 % DM). S. anguivi Lam berries contained several minerals in which potassium has a higher content with the values of 2059.7 ± 22.3 mg / 100 g DM, 2189 ± 25.7 mg / 100 g DM, 2218.8 ± 23.7 mg / 100 g DM and 2290.8 ± 22.24 mg / 100 g DM respectively. No difference was observed in calcium, sodium and copper contents increased with maturation while magnesium, iron and manganese decreased with Gnagnan maturation.

3.2. Qualitative Evaluation of Sugars and Pharmacological Components

Development of sugars in S. anguivi Lam berries during ripening are presented in Figure 1. Data showed that Gnagnan contain many sugars such as glucose, ribose, arabinose, xylose and fructose. Fructose appears in yellow and orange berries while ribose and xylose are replaced by arabinose in red berries. There were no melibiose, raffinose
and lactose in Gnagnan whatever the stage of ripening was. 

*S. anguivi* Lam berries contain many pharmacological substances which are presented in Table 3. Except gallic tannins and alkaloids, Gnagnan contain sterols and polyterpenes, polyphenols, flavonoids, catechin tannins, quinons, saponins and coumarins. Saponins, flavonoids, sterols and polyterpenes increased during ripening while polyphenols, catechin tannins and quinons decreased during ripening. No variation was observed in coumarins during ripening. No variation was observed in coumarins during ripening while polyterpenes, polyphenols, flavonoids, catechin tannins, saponins, flavonoids, sterols and polyterpenes were rich in orange and red berries while polyphenols and catechin tannins were rich in green and yellow berries (Table 3).

4. Discussion

The dry matter, polyphenol, ascorbic acid and ash decreased with maturation while protein, total sugars, fat and fibers increased with Gnagnan maturation (Table 1). This observation is gradually explained by water variation in berries. Chemical, physiological and organoleptic changes occurring during ripening cause significant movement of water in the cell walls [18]. The decrease of dry matter in *S. anguivi* Lam berries during ripening is due to the loss of solutes (polyphenols, ascorbic acid and ash) provoked by the weakness of the berries tissues. Changes in membranes result in increasing ion permeability, increase leakage of solutes and cell decompartmentalization [19]. Compared to other studies, the dry matter content of *S. anguivi* Lam berries in this study is lower than those reported in *S. aethiopicum* [3] and similar to those of *S. melongena* [20] with the values of 9.4 % and 27.1 % respectively.

| Table 1. Progress of the chemical composition of Solanum anguivi Lam berries during different stages of ripening |
|------------------|------------------|------------------|------------------|------------------|
| Components       | Green berries    | Yellow berries   | Orange berries   | Red berries      |
| Dry matter (%)   | 33.3 ± 0.4a      | 27.9 ± 0.9b      | 27.3 ± 1.2c      | 22.1 ± 1.4d      |
| Proteins (%)     | 13.4 ± 1.9a      | 14.1 ± 1.9b      | 21.5 ± 0.7c      | 22.5 ± 2d        |
| Total sugars (%) | 2.4 ± 0.2a       | 2.9 ± 0.2b       | 3.4 ± 0.3c       | 3.7 ± 0.2d       |
| Fat (%)          | 1.4 ± 0.2a       | 1.6 ± 0.2b       | 2.4 ± 0.2c       | 2.7 ± 0.2d       |
| Fiber (%)        | 11.8 ± 0.7a      | 12.6 ± 0.9b      | 15.8 ± 0.5c      | 19.1 ± 0.4d      |
| Polyphenols (mg/100 g DM) | 956.7 ± 71.1a | 883.3 ± 39.2b | 666.8 ± 33.2c | 546.7 ± 35.4d |
| Ascorbic acid (mg/100 g DM) | 34.5 ± 1.7a | 25.6 ± 1.4b | 20.7 ± 1.1c | 13.8 ± 0.7d |
| Ash (%)          | 6.9 ± 0.1a       | 6.8 ± 0.1b       | 6.3 ± 0.1c       | 6.16 ± 0.0d      |

The means with different superscript letters within the same row indicate significant different at p<0.05.

| Table 2. Progress of minerals (mg/100 g DM) of Solanum anguivi Lam berries during different stages of ripening |
|------------------|------------------|------------------|------------------|------------------|
| Minerals         | Green berries    | Yellow berries   | Orange berries   | Red berries      |
| Calcium          | 544.8 ± 16.2a    | 559.9 ± 20.3a    | 580.4 ± 22.3b    | 680.9 ± 28.2c    |
| Sodium           | 268.4 ± 0.5a     | 324.1 ± 5.6b     | 352.1 ± 8.1c     | 451.8 ± 7.2d     |
| Potassium        | 2059.7 ± 23.3b   | 2189 ± 25.7b     | 2218.8 ± 23.7c   | 2290.8 ± 22.2a   |
| Magnesium        | 404.6 ± 16.3a    | 356.8 ± 22.6b    | 289 ± 14.2c      | 284.5 ± 21.2d    |
| Phosphorus       | 107.0 ± 13.4a    | 107.1 ± 12.7a    | 107.5 ± 15c      | 107.5 ± 7.7d     |
| Iron             | 467.7 ± 1.8a     | 457.7 ± 4.0b     | 341.8 ± 8.2c     | 323.3 ± 6.5b     |
| Copper           | 0.1 ± 0.0a       | 0.1 ± 0.0b       | 0.2 ± 0.0c       | 0.3 ± 0.0d       |
| Zinc             | 5.3 ± 0.4a       | 5.4 ± 0.3b       | 5.5 ± 0.5c       | 5.6 ± 0.2d       |
| Manganese        | 0.2 ± 0.0a       | 0.2 ± 0.0b       | 0.1 ± 0.0c       | 0.1 ± 0.0d       |

The means with different superscript letters within the same row indicate significant different at p<0.05.

The loss of dry matter is correlated with the loss of ash. During ripening, ash decrease with dry matter's [18]. The ash obtained is high compared to those of *S. melongena* (2 - 3.2 %) [20]. The ash of *S. anguivi* Lam berries are very rich in minerals such as calcium, sodium, potassium, magnesium, phosphorus and iron (Table 2) which are very important in metabolism and health. That is why, *S. anguivi* Lam is usually considered as fruits or legumes because of its richness in minerals. Its higher content in potassium regardless of ripening (2059.7 ± 22.3 - 2290.8 ± 22.2 mg/100g DM) is important for health. In fact, *S. anguivi* Lam berries could cover the daily needs of potassium which is 2000 mg/100 [21]. Potassium levels are higher than those reported in the literature. In fact, *S. melongena* [20] and *S.
**lycopersicum** [3] have potassium content of 238.1 - 245.4 mg/100 DM and 204 mg/100 g DM respectively. During ripening, magnesium declines because it is involved in the synthesis of enzymes required for the release of energy and protein synthesis [22]. Moreover, it decreases because it acts on carbohydrate and lipid metabolism that occur during ripening. **S. anguivi** Lam berries contain high level of magnesium compared to **S. lycopersicum** (10 mg) [3]. Also, it is richer in iron than **S. aethiopicum** [23] and **S. melongena** [3, 20] with the values of 1.5 - 2 and 2.8 mg / 100 g DM respectively.

Table 3. Development of pharmacological components of Solanum anguivi Lam berries during different stages of ripening

<table>
<thead>
<tr>
<th>Components</th>
<th>Green berries</th>
<th>Yellow berries</th>
<th>Orange berries</th>
<th>Red berries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterols and Polyterpenes</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Polyphenols</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoids</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Gallic tannins</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Quinins</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Alkaloids</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Saponins</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Coumarins</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Sterols and polyterpenes: + purple ring turning to the blue; ++ purple ring turning to the blue more marked
Polyphenols: + coloring blackish blue; ++ coloring blackish blue more pronounced
Flavonoids: + purplish coloring; ++ more marked purplish coloring
Gallic tannins: - absence of coloring black blue
Catechin tannins: + presence of flakes; ++ abundance of flakes
Quinins: + red coloring; ++ more marked red coloring
Alkaloids: - absence of tint
Saponins: + foam presence; ++ more foam
Coumarins: + transparent alkaline solution

**S. anguivi** Lam berries constitute a better source of vegetable protein compared to **S. melongena** with the value of 4.6 % [20] and can be used to prevent protein-energy malnutrition. Moreover, the high fibers content (11.8-15.4 %) of **S. melongena** [3] and scarlet eggplant [26] is lower compared to those of purple eggplants (11.8-15.4 %) of **S. melongena** [3] and scarlet eggplant (7.2 % DM) [20]. These sugars revealed by TLC are ribose, arabinose, xylose and fructose (Figure 1).

Data showed pharmacological substances such as sterols and polyterpenes, polyphenols, flavonoids, catechin tannins, quinons, coumarins and saponins (Table 3). That could explain the beneficial effect of the consumption of **S. anguivi** Lam berries for the treatment of several diseases. In fact, **S. anguivi** Lam berries have stimulant, antioxidant, anti-inflammatory and anti-carcinogenic properties because of these pharmacological substances [30, 4-7].

5. Conclusion

This study has highlighted that **S. anguivi** Lam berries or Gnagnan has high nutritional and pharmacological values. These potentialities depend on the stage of maturation of berries. It allowed showing the more or less important variations of the chemical composition of the berries of **S. anguivi** Lam during the various stages of ripening. Indeed, the rates of dry matter, phenolic compounds, ashes, vitamin C, magnesium, iron and manganese of the green berries are higher compared with those of the red berries. On the other hand, the rates of sugars, proteins, lipids, cellulose, calcium, sodium, potassium and zinc of red berries are superior to those of the green berries. The rates of phosphorus and copper in berries do not vary regardless of the stage of ripening. Besides, the loss of 40 % of vitamin C initial content stays the most important finding. Thin layer chromatography revealed ribose, arabinose, xylose, and fructose. The ribose and the xylose are replaced by the arabinose in red berries. Sterols, polyterpenes, flavonoids, saponins and coumarins seem to...
increase during the ripening contrary to polyphenols, catechic tannins and quinons. Furthermore, the absence of alkaloids in berries indicates that the consumption of this food is not hazardous. Our findings permit guidance on the choice of the berries of *S. anguivi* Lam according to their maturation stage for the prevention or the treatment of malnutrition and some public health diseases. Data elaborates on the attraction of this eggplant as a popular dish in Côte d'Ivoire.

**Acknowledgements**

The authors wish to thank the Centre National de Recherche Agronomique (CNRA) for the financial and technical supports of the study.

**References**


