African food tradition revisited by research

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African Food Tradition rEvisited by Research

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Literature review and Background information of

Bissap

(*Hibiscus sabdariffa* L.)

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Abstract

Production area. Introduced in the country in the XIXth century, *Hibiscus sabdariffa* L. is grown throughout the territory of Senegal, particularly in the Kaolack, Djourbel, Thies, Saint-Louis and Louga regions.

Varieties. Several varieties of red *H. sabdariffa* calyx are cultivated in Senegal. Four main varieties namely Vimto, Koor, CLT 92 and Thai can be distinguished. It appears that there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*. These operations are performed under unsuitable conditions leading to the deterioration of the quality of the *H. sabdariffa* calyx.

Composition. The red calyxes are the most commonly used and are characterised by their concentration of anthocyanin, which can reach 1.5 $g.kg^{-1}$ of dry matter. Delphinidin 3-sambubioside and cyanidin 3-sambubioside are the major anthocyanins comprising 70 and 29 % of total anthocyanins respectively. Organic acids, minerals and amino acids are present in the calyx,

Transformation. The main processing activities of the *H. sabdariffa* calyx are crushing and the production of drinks and concentrate. The manufacture of beverages, the main method of transformation, carried out under the direction of women's groups, has remained virtually traditionnal.

Markets. With a support program of the Senegalese state, the increase in the cultivated areas and the number of actors, *H. sabdariffa* occupies an important place in the marketing of agricultural products in Senegal. The export of dried calyx of *H. sabdariffa* to Europe and the United States at prices ranging between 1,000 and 2,500 $\$US.t^{-1}$ is increasing year by year.

Introduction

Hibiscus sabdariffa L. is a herbaceous plant, cultivated largely in tropical and subtropical areas of both hemispheres. It belongs to the family of Malvaceae and is known by different names such as Guinea sorrel or bissap in Senegal, karkadé in North Africa, roselle or sorrel in Asia and flora of Jamaica in Central America (Morton & Roselle, 1987; Glew et al., 1997; Lorenzo et al., 2000 ; McClintock.& El Tahir, 2004 ; Babalola et al., 2001 ; Nyarko et al., 2006 ; Cisse et al., 2009a; Cisse et al., 2009b)

In Senegal, *H. sabdariffa* was introduced in the 19th century (Kerharo & Adam, 1974) and is now grown throughout the territory; mainly in the Kaolack, Diourbel, Thies, Saint-Louis and Louga regions (**Figure 1**). In these areas, a dozen varieties are grown including Vimto, Koor, Thai and CLT 92. Indeed, with the decline of traditional crops, especially peanut, many producers are now growing bissap to improve their income.

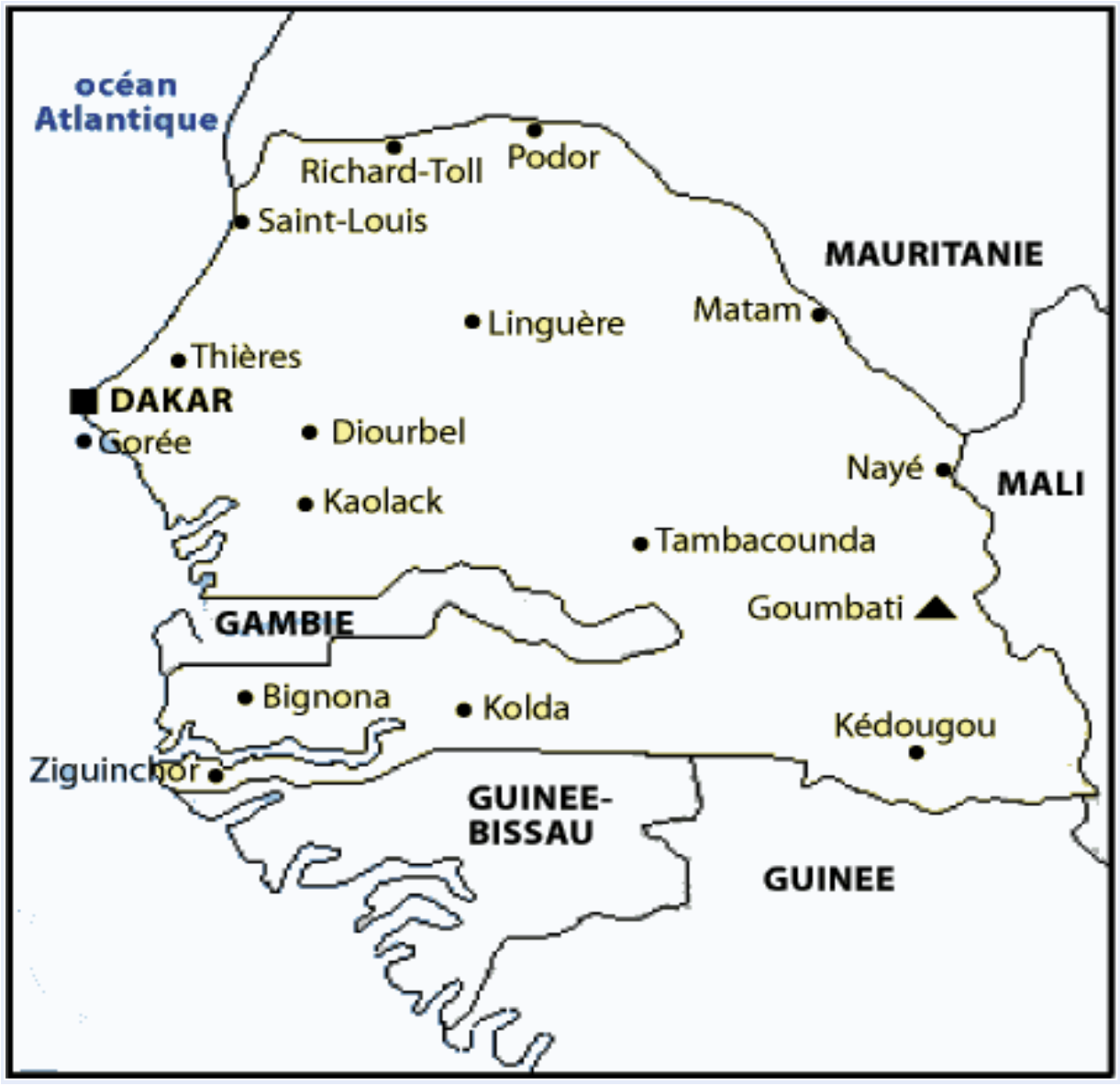

Figure 1. Main areas of *Hibiscus sabdariffa* cultivation

1. Traditional processing of the product

In Senegal, traditional processing of the *H. sabdariffa* calyx has been greatly improved by the establishment of many small enterprises.

1.1. Raw materials and additives used and their handling

H. sabdariffa is cultivated mainly for its calyx. The traditional processing activities of the calyx are for the production of jam, concentrates and particularly of drinks/beverages.

The drink is made from an extract obtained by aqueous extraction from a solid-to-solvent ratio. The extraction operation is carried out at temperatures between 25 and 100°C. After filtration, sugar and other ingredients, such as other fruit juices, flavorants and fruit pieces (pineapple, strawberry and ginger) may be added.

The consumption of this drink is widespread in Africa and Asia. In Senegal, where it is very popular, its consumption is highest during the month of Ramadan. In Mali, Côte d'Ivoire and Burkina Faso, the drink is called “da Bilenni”. In Egypt, it is known as the "drink of the Pharaohs." In Sudan the name is "tea Karkade”. This beverage is consumed cold or hot , depending on the season.

1.2. Description and variability/similarity of processing methods

The description and processing methods used for *H. sabdariffa* calyx in Senegal are represented in **Figure 2**. Variability is closely related to similarity between producers (Cissé et al. 2009a)

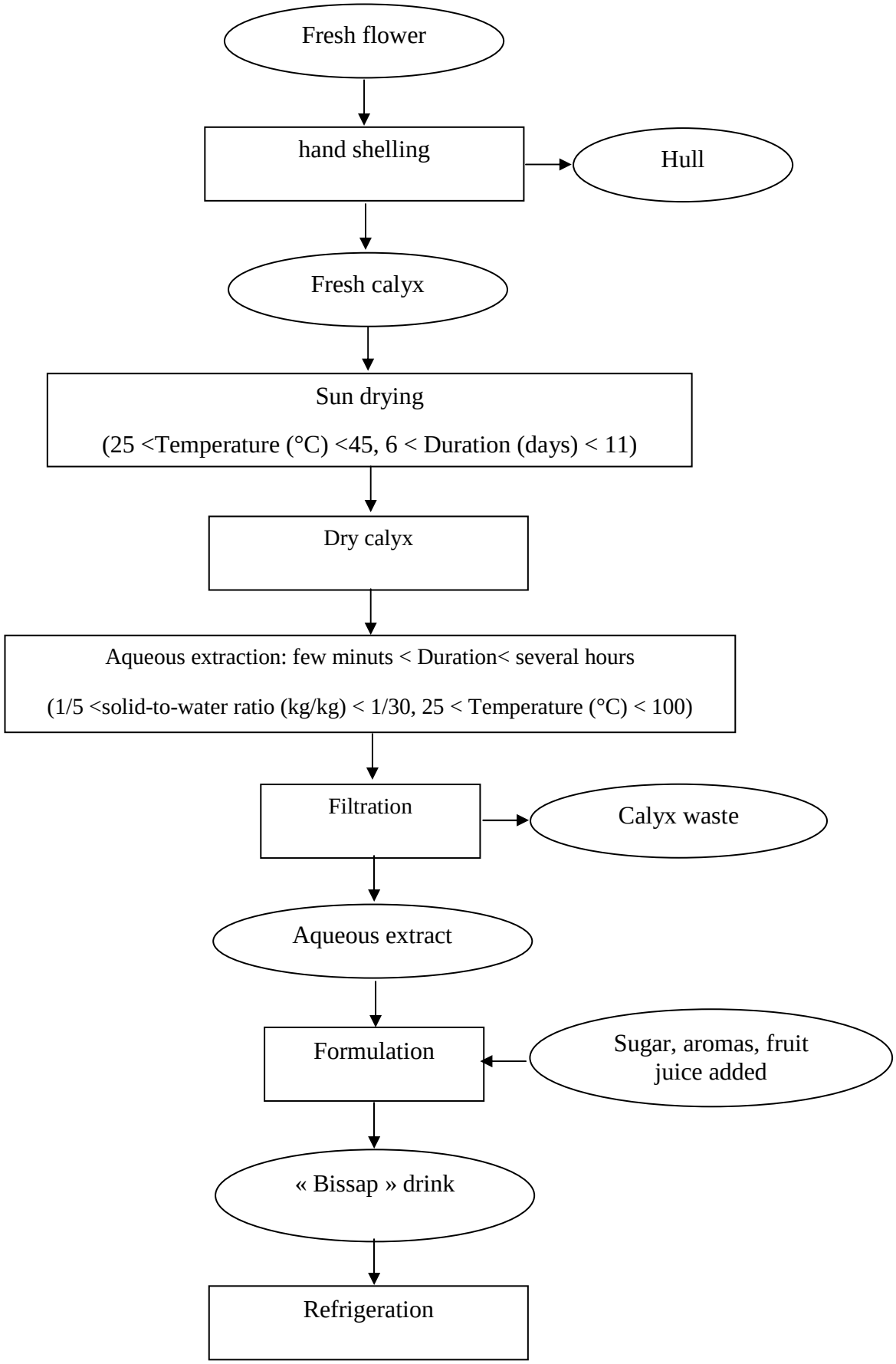

Figure 2: Flow diagram of traditional processing of *Hibiscus sabdariffa* drink in Senegal

1.3. Major problems associated with processing methods

The operations of shelling and drying are carried out manually. These operations lead to a raw material of heterogeneous quality.

During the production of *H. sabdariffa* drink, the main problem is the lack of adequate technical resources. The women rely on their knowhow and experience to determine the end of each step. This could result in a heterogeneous production process and in medium or poor quality beverages.

1.4. Storage methods, maximum duration and problems associated with storage

According to producers and traders, the red color of calyx turns brown or black after 3 months of storage. In fact, there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*.

After production, the drinks are stored in plastic bottles at 4 °C for 4-10 days. Usually no treatment is applied to stabilise the finished product. More significant degradation of anthocyanins has been noted during heat treatment (Cisse et al., 2009).

2. Socio-economic importance

2.1. Production, processing, handling and storage zones identified in the country

2.1.1. Production

In Senegal, the cultivation of *H. sabdariffa* is an ancient activity, usually conducted by extensive farming in the Kaolack, Diourbel, Thies, Louga and Saint Louis regions (**Figure 1**).

In the northern regions of Louga and Saint-Louis, Hibiscus is cultivated mainly in lines on the boundaries of rice plots. In these regions Hibiscus is cultivated also in association with millet, maize and groundnuts crops.
In the central regions of Kaolack and Diourbel, *H. sabdariffa* is grown mainly in association with groundnut or millet. However, monoculture of *H. sabdariffa* is becoming more and more frequent because of the exports opportunities of the dried calyx..

The increase of *H. sabdariffa* cultivation is encouraged by the support of non-governmental organizations such as ASNAPP (Agribusiness in Sustainable Natural African Plant Products). The Hibiscus was selected from twelve products as a minor crop in Senegal, but with great potential to improve the income for producers.

2.1.2. Postharvest treatment

After harvesting, dried calyx of *H. sabdariffa* undergoes the steps of shelling, drying, packaging and storage.

Decortication

Scouring is a delicate manual operation, and requires a skilled workforce. It involves taking the fruit between two hands and then making a vertical incision with both thumbs to separate the capsule and calyx (**Photo n°1**). It is often difficult and painful because of the pressure required to separate the calyx and capsule and for some varieties, the presence of irritating stinging hairs.

Photo n°1. Manual scouring of *Hibiscus sabdariffa*

Some operators cut the base of the flower stalk with a knife to release the capsule and get a circular closed calyx. This method can damage the capsule which then opens slightly and releases the seeds. Significant losses are incurred by breaking the sepals with a knife. To reduce these losses some farmers dissect the flowers only 24 hours after harvest. A real need for mechanization of this step is obvious. It constitutes a major obstacle to the development of the *H. sabdariffa* industry.

Drying

Drying is carried out after shelling. It reduces the moisture content of the calyx from 86% to 16% or 14% for improved preservation. Currently drying is traditionally performed by direct exposure of the calyx to the sun. Calyxes are spread on mats or plastic sheets placed directly on the ground.

This method has major disadvantages, such as the important risk of microbiological contamination, presence of sand and debris, anthocyanins degradation, losses of nutritional compounds. The duration of drying is between 6 and 10 days.

Studies on drying kinetics and the impact on the quality of calyx should be envisaged to better control this step.

Packaging

The dried calyxes are harvested and sold in bulk or in individual packages. For export, dried calyxes are baled in batches of 50 kg in woven polypropylene bags. Packaging dried calyx in polypropylene bags is the most widely used because of the good ventilation allowed by this type of packaging and the low cost. The price per bag varies between 50 and 100 FCFA (0.08 and 0.15 euro). This conditioning is used both by producers and collectors.

Transport and storage

Transportation of dried calyx of *H. sabdariffa* between production areas and urban centers is performed by truck with a capacity from 15 to 30 t. *H. sabdariffa* can be transported at the same time as other crops such as groundnuts, millet and corn. The price depends on distance and is between 10 and 20 $CFA.kg^{-1}$ (0.015-0.03 euro). We have noted the lack of appropriate structures for the storage of dried packaged calyx.

The packaged products or bulk products are stored outdoors or under cover in major urban markets or in a facility where other products are stored. The storage time varies and depends on the consumption or marketing. The calyx can be kept until the next harvest. However, according to producers and traders, the red color of calyx turns brown or black after 3 months of storage.

In conclusion, it appears that there are no appropriate structures for the shelling, drying, packaging and storage for the calyx of *H. sabdariffa*. These operations are performed under unsuitable conditions which lead to the deterioration in the quality of *H. sabdariffa* calyx.

2.2. Socio-economic profile of the actors

Producers of *H. sabdariffa* can be divided into two main groups. The first one represents about 70% of producers and consists of traditional producers who grow Hibiscus around crop fields. The other emerging group, about 30% of producers, consists of women's groups and economic interest groups cultivating plots of Hibiscus on areas ranging from 1 to 5 ha in size.

Processors of *H. sabdariffa* in Senegal can be divided into two groups: small-scale processors and industrial transformers. The small-scale processors do not have adequate technical capacity.

Many large industrial Senegalese companies have investigated the transformation of *H. sabdariffa* calyx, but up to now, only two companies, Kirene and Laiterie du berger, offer drinks made from *H. sabdariffa* calyx. Two main constraints have been identified: inhomogeneity of the raw material and problems of discoloration of the beverage over time.

2.3.Socio-economic importance of the product

With an average acreage between 5000 and 6500 ha for a domestic production of 1200 to 3000 t (per year) and an estimated 30 000 to 40 000 producers, *H. sabdariffa* currently holds an important place in the marketing of agricultural products in Senegal. (Cisse et al., 2009a). Crops of *H. sabdariffa* provide substantial income to producers. The marketing of calyx is provided by producers, street vendors and wholesalers established most often at urban markets. These wholesalers supply exporters of dried calyx. The price offered to growers varies between 750 and 1000 F CFA (1.14 – 1.53 euros) per kg of calyx.?.

2.4. Commercialisation of the product

National market requirements for calyx for household and artisanal processing are estimated to be 700 t (per year). In Senegal, in most cases, the *H. sabdariffa* calyxes are sold in two units of measurement: a basin corresponding to a capacity of 5 kg and a tin with a capacity of 250 g. The price of dried calyx varies by location of sale and time of year. Thus, in the weekly markets, the sale price of the basin ranged from 2000 FCFA in October (beginning of harvesting) to 5000 FCFA for the month of May; either 400 to 1000 FCFA. kg^{-1} of calyx. The price of a tin generally varies from 125 to 175 FCFA and 500 to 700 FCFA.kg^{-1} over the same period. On national roads and in the large urban areas, prices charged are usually higher than those observed at the weekly markets.

Exports of *H. sabdariffa* calyx are mainly to the United States and Europe, including, notably France and Germany (Anonym, 2000; Gueye, 2005) , which constitutes 80% of the European

market which is estimated at 3000 t/year. Calyxes are exported for the food and cosmetics industry. Very little data is available on export quantities. Limited data is available at the computer center of the Senegalese customs which reported export quantities of 923 and 312 t in 2000 and 2001 respectively. Highest annual exports were recorded in 2003 and 2004 with respective quantities around of 1000 and 1400 t.

The quantities currently exported are far from satisfying international demand. Indeed, with agreements of the African Growth and Opportunity Act (AGOA), the needs of the American market are estimated at 30 000 t/year. The prices on the world market show large fluctuations. The average market price is between 1000 and 2500 U.S. $.t^{-1}. These prices obviously depend on the quality of the product which is judged primarily on the variety of Hibiscus, varietal purity and rate of whole calyx (Cisse et al., 2009a).

3. Quality characteristics of the product

3.1. Nutritional quality

The composition of *H. sabdariffa* calyx is highly variable (**Table 1**).

Table 1. Minimum ,maximum and average values, of the different characteristics of *Hibiscus sabdariffa* calyx (Kerharo & Adam, 1974; Morton & Roselle, 1987; Wong et al., 2002; D'Heureux–Calix & Badrie, 2004; Cisse et al., 2009b)

	Units	**Minimum**	**Average**	**Maximum**
Moisture	g.100g^{-1}	84.5	86.3 (8)	89.5
Protein		0.9	6.6 (8)	17.9
Lipid		0.1	2.3 (7)	3.9
Fibers		2.5	8.8 (6)	12.0
Ash		4.5	5.6 (5)	6.8
Carbohydrates		3.3	8.1 (4)	12.3
Malic acid		0.12	1.36 (3)	2.70
Calcium	mg.100g^{-1}	1.3	94.0 (9)	213.0
Iron		2.9	17.2 (9)	37.8
Phosphorus		40.0	191.1 (6)	312.6

Ascorbic acid	6.7	72.0 (6)	141.1
Anthocyanin	150	350 (5)	1500

() Number of values taken into account in calculating the average

Except for moisture and fat, differences between the minimum and maximum values are significant. This variability may be due to several factors such as conditions of crop, soil type, rainfall and country of origin of the calyx (Kerharo & Adam, 1974; Morton & Roselle, 1987). Variety and compositional differences major components were also observed by Babalola et al. (2001). The calyx of *H. sabdariffa* is rich in organic acids. Succinic, oxalic, tartaric and malic acids are present at respective concentrations of 0.51, 0.43, 0.17 and 0.12 g.100 g^{-1} (Dafallah & al-Mustafa, 1996; Babalola et al., 2001; Wong et al., 2002). Sugars present in calyx of *H. sabdariffa* are glucose, fructose and sucrose. The glucose, with nearly 40% of total sugars, was the most important sugar (Wong et al., 2002).

The presence of β-carotene and lycopene at respectively concentrations of 1.9 mg.100 g^{-1} and 164.3 mg.100 g^{-1} of fresh material has been reported in the calyx of *H. sabdariffa* (Wong et al., 2002). These flowers also contain mucilages and pectins (Forsyth & Simmonds, 1954; Tsai, 1995; Chen et al., 1998) and all essential amino acids (Morton & Roselle, 1987; Glew et al., 1997) (**Table 2**).

Table 2. Amino acid composition (mg.g^{-1} dry matter) of *Hibiscus sabdariffa* calyx

Amino acid	**Calyx**	
	Morton & Roselle, 1987	**Glew et al., 1997**
Arginine	3.60	4.48
Cysteine	1.30	0.87
Histidine	1.50	1.19
Isoleucine	3.00	2.70
Leucine	5.00	4.21
Lysine	3.90	2.77
Methionine	1.00	0.65
Phenylalanine	3.20	2.32
Threonine	3.00	2.36
Tryptophane	-	0.45
Tyrosine	2.20	1.44
Valine	3.80	3.33
Aspartame	16.30	10.50

Glutamine	7.20	8.85
Alanine	3.70	3.46
Glycine	3.80	2.47
Proline	5.60	5.82
Serine	3.50	2.65

One of the characteristics of *H. sabdariffa* is its high anthocyanin content that can reach 1.5 $g.kg^{-1}$ of dry calyx. This content is comparable to that of blackberry and superior to most other edible plants (Mazza & Miniati, 2000) (**Table 3**). The calyx contains two main anthocyanins: delphinidin-3-sambubioside or delphinidin-3-xylosylglucoside or hibiscin and cyanidin-3-sambubioside or cyanidin-3-xylosylglucoside or gossypicyanin, and two minor anthocyanins, delphinidin-3-glucoside and cyanidin-3-glucoside. The delphinidin-3-sambubioside represents 70% of the total content of anthocyanins. The anthocyanins represent the largest group of water soluble pigments in the plant. They are highly valued in the food industry for their coloring properties, which can give food various hues of red and violet (Francis, 1990; Wang et al., 2000). The calyx of *H. sabdariffa* also contains other polyphenolic compounds including protocatechic acid (Herrera-Arellano et al.,, 2004; Dickel et al., 2007). However, anthocyanins of *H. sabdariffa* are known for their instability (Esselen & Sammy, 1975; Tsai & Ou, 1996; Mazza & Miniati, 2000; Chen et al., 2005). The anthocyanins are easily degraded during heat treatments or during storage at room temperature. After heating, the red color gradually changes in brown. This instability is also evident in aqueous solutions and is the main factor limiting the use of extracts of *H. sabdariffa* as colorant in complex food formulations. Greater stability of anthocyanin will permit the market entry as natural colorant which is 940 million US $ (per year), and is growing at the rate of about 5% annually compared to artificial colorant (400 million US $), which increases by only 2-3 % per year (Sarni-Manchad & Cheynier, 2006).

3.2. Microbiological quality

Generally no microbiological problems are noted in the *H. sabdariffa* calyx or in beverages prepared from it (Cisse et al.2009b).

3.3. Product quality perception/requirement by consumers

For drinking, two criteria are essential for consumers, namely the red color of the drink and its acidity. This drink is consumed during hot weather and especially during the month of Ramadan. It can be drunk at any time of day.

Table 3. Some fruits with their major anthocyanins and their content in mg.100g^{-1} of fresh material (Mazza & Miniati, 2000)

Fruits	Anthocyanin	Content (mg.100 g^{-1})
Black chokeberry (*Aronia melanocarpa*)	Cy 3-galactoside Cy3-arabinoside Cy 3-syloside	1050
(*Prunus avium var. Bigareau*)	Cy 3-rhamnoglucoside Cy 3-glucoside Peonidin 3-rutinoside	350-450
Sweet cherry(*Prunus cerasus L. var. Montmorency*)	Pn 3-rutinoside Cy 3-glucoside Cy 3-rutinoside Cy 3-sophoroside Cy 3-2^{G}glucosylrutinoside	35-82
Prune (*Prunas salicina cv. Sordum*).	Cy 3-rhamnoglucoside Cy 3-glucoside	29.5
Blueberry (*Vaccinium corynbasum L.*)	Dp 3-galactoside Dp 3-arabinoside Mv 3-galactoside Mv-arabinoside	25-495
Cranberry (*Vaccinium macrocarpon Ait*)	Pn 3-galactoside Pn 3-arabinoside Cy 3-galactoside Cy 3-arabinoside	78
Black raspberry (*Rubus spp. Var Cumberland*)	Cy 3-glucoside Cy 3-rutinoside Cy 3-sambubioside Cy 3-xylosylrutinoside	428
Strawberry (*Fragaria spp.*)	Pg 3-glucoside Cy 3-glucoside	450-700
Grappe (*Vitis vinifera L.)*	Mv 3-monoglucoside Pn 3-monoglucoside Dp 3-monoglucoside Mv 3-monoglucoside-p-coumarate Pn 3-monoglucoside-p-coumarate	30-750
Hibiscus sabdariffa	Dp 3-xylosylglucoside Cy 3-xylosylglucoside Dp 3-glucoside Cy 3-glucoside	150
Blackberry (*Rubus fruticosus L.*)	Cy 3-glucoside Cy 3-rutinoside	67-230
Blood orange (*Citrus sinensis L., Rutaceae*)	Cyanidin 3-glucoside cyanidin 3-(4”-acetyl)-glucoside	70-100

Conclusion

The *Hibiscus sabdariffa* industry has large potential in Senegal through the increasing market for its producers and exporters. However, it suffers from a lack of organization, information and support to improve its productivity. The industry is also facing several problems such as low availability of certified seeds, poorly controlled post-harvest technology and the lack of industrial or semi-industrial products manufactured locally.

The perspectives on research and required research innovations can be declined in different ways:

- More appropriated scouring, drying and aqueous extraction methods are still needed to obtain higher quality of calyx and drinks;
- To my knowledge no research has been done on the possible increase in value of bioactive components such as anthocyanins by processing technology;
- A research study investigating the stabilization of local drink production from *H. sabdariffa* must be performed. These results will increase the shelf-life of the *H. sabdariffa* drinks and will boost the economic profit for enterprises in this area for exportation possibility.
- A research study focused on a new product such as a natural colorant will also be performed.

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