Scientific Research Publishing

Open Journal of Physical Chemistry, 2025, 15(1), 20-25
https://www.scirp.org/journal/ojpc
ISSN Online: 2162-1977
ISSN Print: 2162-1969

Physico-Chemical Characterisation of Bissap Tea (*Hibiscus sabdariffa* L.)

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How to cite this paper: Yehe, M.D., Dadje, J.C. and Kouame, J.K. (2025) Physico-Chemical Characterisation of Bissap Tea (*Hibiscus sabdariffa* L.). *Open Journal of Physical Chemistry*, **15**, 20-25.
https://doi.org/10.4236/ojpc.2025.151002

Received: November 23, 2024
Accepted: February 8, 2025
Published: February 11, 2025

Abstract

Hibiscus sabdarrifa flowers are known the world over. In Cote d'Ivoire, they are commonly known as "bissap" and are of great interest to local people, who use them to make an eponymous herbal tea. This drink has potential medicinal and nutritional value (Khan *et al.*, 2022). Nine (9) samples of dried flowers of the plant, packaged in 3 g sachets of a local Kuinafo brand, were used for physico-chemical analyses. Heavy metals, mineral salts, ash and moisture content were determined using methods adapted from the Association of Official Analytical Chemists (AOAC). The results showed the presence of heavy metals at levels whose intake should take into account the weight of the consumer in the case of mercury and arsenic (0.5 mg/Kg and 0.7 mg/Kg respectively). Apart from lead, whose level was not compliant (1.310 mg/Kg for a CSHPF standard of 0.5 mg/Kg), cadmium had a regulatory level (0.18 mg/Kg for a CSHPF standard of 0.20 mg/Kg). Nutrient intakes were significant (calcium, iron and potassium respectively at 1.79 g/100g; 17.27 mg/100g and 1.76 g/100g of dried *Hibiscus sabdarrifa* flowers) and the moisture content suggested that the dried flowers were better preserved. The study of the physico-chemical characteristics of *Hibiscus sabdarrifa* flowers has enabled us to highlight the importance of quality control and the need to prevent any adverse effects on consumer health.

Keywords

Hibiscus Sabdariffa, Herbal Tea, Physicochemical

1. Introduction

Plants have the particularity of having a very large reservoir of potential bioactive compounds [1]. They may contain harmful substances such as heavy metals

absorbed from the soil [2]. In West Africa, particularly Cote d'Ivoire, *Hibiscus sabdariffa* is used by local units to produce consumer products made from the plant's dried flowers, commonly known as "bissap" [3]. The non-quality of consumer products not only caused a loss of around 17 billion CFA francs to the Ivorian economy between 2016 and 2023, but also posed a serious threat to consumer health [4]. To reduce the impact of this non-quality, the government has set up the National Committee to Combat Counterfeiting (CNLC) [4]. Therefore, due to a lack of knowledge about quality control of dried bissap flowers and in order to support the NCLC, the objective of our study was to contribute to the quality control of "Kuinafo" brand bissap flowers, popular among the population and produced locally for the preparation of herbal teas. The literature makes no mention of studies on the characterisation of bissap flowers produced in the north of Côte d'Ivoire and the need to protect the health of consumers (by analysing the heavy metals) of this product by drawing up an Ivorian standard.

2. Materials and Methods

2.1. Method for Determining Heavy Metals and Minerals

The determination of heavy metals (Hg, Ars, Cd and Pb) and minerals (Fe, Ca and K) is carried out using the AOAC 999.11 method, which is characterised by three (3) stages.

Step 1/3: Mineralisation of the sample

2 g of dried plant flowers were placed in the oven to dry at 102˚C to 105˚C for 1 hour. After cooling in the desiccator, the sample was heated in an oven using a temperature gradient. 250˚C for 2 hours, then 550˚C for 4 hours.

Step 2/3: Preparation of standard solutions

It begins with the preparation of a standard range of 0.5 mg/l, 1 mg/l, 3 mg/l and 6 mg/I from a standard solution of 1000 mg/l. This is done for each heavy metal and mineral to be measured. The calibration line is checked with a quality control (QC) of 5 mg/l. The standard solutions were used to draw the calibration lines needed to determine the concentration of the chemical elements considered by the Beer-Lambert law.

Step 3/3: Dosage

The ash obtained in the mineralisation step was recovered with 2 ml of 0.1 N hydrochloric acid in a 50 ml flask. Distilled water was added up to the mark. The mixture obtained is taken to an atomic absorption spectrophotometer (AAS) to determine the element in question.

2.2. Method for Determining Ash Content

The ash content indicates the proportion of minerals in our sample. Its determination involves several stages.

Step 1/2: Obtaining the ash

2 g of dried bissap flowers are weighed into a tared crucible. The mixture is baked in an oven at 550 C for 4 hours.

Step 2/2: Calculating the ash content

After cooling in a desiccator for 45 minutes, the crucible is weighed and the ash content is calculated using the following formula:

$$TC = (M2 - M0/M1 - M0) * 100.$$

With M0: weight of the empty crucible. M1: weight of the crucible + test sample. M2: weight of crucible + calcined residue.

The level represents the mineral fraction of bissap. This fraction can be composed of mineral salts such as calcium, potassium, sodium and various trace elements (Ouadfel S, 2018).

2.3. Method for Determining Moisture Content

The moisture content is used to assess the product's suitability for preservation. It is determined in 2 stages.

Step 1/2: Drying

The empty crucible and the 2 g of sample are weighed. The crucible and the weighed sample are placed in an oven at 103 ± 2 C for 1 hour.

Step 2/2: Calculating the moisture content

After cooling in a desiccator for 45 minutes, the crucible is weighed and the moisture content is calculated using the following formula :

$$H\% = (M1 - M2/M1 - M0) * 100.$$

With H: water content expressed as a percentage; MO: mass (g) of the empty crucible; M1: mass (g) of the empty capsule + test sample before heating; M2: mass (g) of the empty capsule + test sample after heating.

3. Results

3.1. Results for the Determination of Heavy Metals

Table 1 presents the content of heavy metals studied in the bissap flower sample.

Table 1. Heavy metal contents in our sample.

Parameters	Results (mg/Kg of dried flowers)	Standards (µg/Kg(b.w.)/dr)
Arsenic (As)	<1	0.3 (US EPA)
Cadmium (Cd)	0.18	0.35 (EFSA)
Mercury (Hg)	<1	0.5 (EFSA)
Lead (Pb)	1.310	0.3 (ANSES)

3.2. Results for Mineral Determination

Table 2 presents the content of minerals studied in the bissap flower sample.

3.3. Results for Determining Ash Content

The ash content is the mineral fraction in bissap flower samples. The ash content determined in our sample was 9.39 ± 0.05%.

Table 2. Mineral content in our sample.

Parameters	Units	Results	Standards (WHO/FAO, 2004)
Calcium (Ca)	g/100g	1.79	769 mg/day
Iron (Fe)	mg/Kg	172.71	6 mg/day
Potassium (K)	g/100g	1.76	2000 mg/day

3.4. Results for Determining Moisture Content

The water content is the fraction of water in the bissap flower samples. The water content measured in our sample was 7.21 ± 0.02%.

4. Analysis

The lead content measured in our sample was 1.310 mg/kg of dried *Hibiscus sabdarrifa* flowers. The ANSES standard sets a maximum daily amount at 0.3 ug/kg (of body weight). Tiani *et al.* [5], obtained a value of 0.69 mg/kg from dried *Hibiscus sabdarrifa* flowers. This value is lower than ours. Since the ANSES standard sets a maximum daily quantity of 0.3 µg/kg (of body weight), for example, an adult weighing 60 kg would need to consume at least five (5) sachets (one sachet contains 3 g of dried Hibiscus sabdarrifa flowers) of Hibiscus *sabdarrifa* herbal tea over the course of the day for his or her health to be at risk.

The cadmium value obtained in our study was 0.18 mg/kg of dried *Hibiscus sabdarrifa* flowers. The EFSA standard defines a maximum daily intake of 0.35 ug/kg (of body weight). The value of 0.67 mg/kg of dried flowers obtained by [5] in their study on *Hibiscus sabdarrifa* flowers is higher than ours. This difference could be explained by the fact that *Hibiscus sabdarrifa* flowers are harvested from a plot (Gounti Valley) not far from a landfill area and small industries in Niger; these areas being known sources of lead [6]. As with lead, if these figures are based on a consumer's weight, they would have to consume more than ten (10) sachets (one sachet contains 3 g of dried Hibiscus sabdarrifa flowers) of Hibiscus *sabdarrifa* tea to be exposed to cadmium.

The mercury analysis in our study yielded 0.5 mg/kg of dried Hibiscus *sabdarrifa* flowers. The EFSA standard sets a maximum daily amount at 0.5 ug/kg (of body weight). The weight of the consumer must be taken into account. For example, an adult weighing 60 kg would need to consume at least ten (10) sachets (one sachet contains 3 g of dried *Hibiscus sabdarrifa* flowers) of *Hibiscus sabdarrifa* tea over the course of the day for his or her health to be threatened by the presence of mercury.

For arsenic, a value of less than 1 mg/kg of *Hibiscus sabdarrifa* flowers was determined. The US EPA standard sets a maximum daily intake of 0.3 µg/kg (of body weight). An adult weighing 55 kg would, therefore, need to consume at least five (5) sachets (one sachet contains 3 g of dried *Hibiscus sabdarrifa* flowers) of *Hibiscus sabdarrifa* tea per day for the daily arsenic dose to be exceeded.

In particular, the manufacturer should draw up a table of data suggesting the maximum daily quantity of herbal tea permitted, and make it available to consumers

to warn them of any adverse effects of heavy metals on health.

Given the accumulation of heavy metals in the body (a long-term threat to consumer health), the quantities of dried flowers used for herbal tea should be respected [7].

The potassium content measured was 1.76 g/100g (*i.e.* 0.05 g/sachet of *Hibiscus sabdarrifa* herbal tea). As the WHO health safety limit is 2 g/day, our sample does not present any danger to consumers. The value obtained is close to that found by [8] in their study of bissap flowers, which was 2.02 g/100g. The study focused on traditional pharmacopoeia [8]. This may be due to the proximity of the production areas in northern Côte d'Ivoire and Mali.

Calcium is a substance involved in bone mineralisation. Its content in our sample of *Hibiscus sabdarrifa* flower is 1790 mg/100g (*i.e.* 53.7 mg/sachet of *Hibiscus sabdarrifa* tea). A sachet of *Hibiscus sabdarrifa* tea does not meet the average nutritional requirement for calcium, which the WHO/FAO (2004) estimates at 769 mg/day. The value obtained in our study is close to that of Kerharo and Adam (1583 mg/100g) who carried out work on bissap flowers [8]. The value obtained calcium levels of 3 mg/100g of dried bissop flowers in Asia [9]. These values, which differ from ours, could be explained by various factors such as soils and climatic conditions, which differ from one continent to another.

The iron content determined in our sample was 172.71 mg/kg (*i.e.* 0.5 mg of iron per sachet of *Hibiscus sabdarrifa* tea). The standard is set at 6 mg/day by the French Food Safety Agency. The value obtained is different from that of 8330 mg/kg (of dried flowers), obtained by [10]. This difference could be explained by various factors such as cultivation practices.

The results of the ash content showed values of 9.49% in our study. This value differs from the 6.9% obtained by Mahadevan *et al.* (2008) in their studies of bissap flowers in Asia. The differences observed could be due to factors such as growing conditions and the country of origin of the bissap flowers (Morton *et al.* 1987).

The water content in our sample was 7.21%. This value complies with the standard, which sets the water content at less than 15% (CODEX standard 154-1985). The authors, in their work on *Hibiscus sabdarrifa* flowers, obtained a value of 9% [9]. This is in line with ours. The low water content obtained in our sample means that there is less risk of micro-organisms developing, thus ensuring good preservation of the product.

5. Conclusions

People consume dried *Hibiscus sabdarrifa* flower tea. The physico-chemical analysis of Kuinafo brand bissap, produced and sold on the local market, showed that apart from lead, the heavy metals (Ars, Hg and Cd) were in compliance with standards. In addition, dried bissap flowers had significant nutritional value (iron, calcium and potassium) and the low water content measured in the sample favoured the preservation of bagged *Hibiscus sabdarrifa* flowers in the form of herbal tea. The study highlighted the importance of quality control for *Hibiscus* sabdarrifa-

based herbal teas in order to prevent any adverse effects that this product might have on consumer health.

We suggest that Ivorian bissap quality control standards be drawn up, as the characteristics of this plant vary from one region to another. This standard would be adapted to local realities and would make it possible to objectively determine the quality of bissap. The standard could, for example, define the permitted carbohydrate content (to determine, for example, whether it should be consumed by diabetics), pH (to assess its acidity), protein, vitamin C or fat content (nutritional values).

It would be wise to define the maximum daily quantities of sachets that can be used to prepare herbal teas on the product packaging, according to the weight of the consumer, in order to protect the consumer's health.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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