Discoveries in Agriculture and Food Sciences - Vol. 13, No. 03
Publication Date: June 17, 2025
DOI:10.14738/tnc.1303.18946.
Makalao, M. M. & Massamngue, A. (2025). Nutritional Composition of Sorrel Chalices (*Hibiscus sabdariffa* L.) of Green Type and Red -Type Sorrel Chalices Consumed in the City of Bongor (Chad). *Discoveries in Agriculture and Food Sciences*, 13(03). 117-134.

Nutritional Composition of Sorrel Chalices (*Hibiscus sabdariffa* L.) of Green Type and Red -Type Sorrel Chalices Consumed in the City of Bongor (Chad)

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ABSTRACT

Green and red type sorrel calyxes are vegetables consumed by a barn part of the population. The objective of this work aims to determine the nutritional composition of sorrel chalices (*Hibiscus Sabdariffa* L.) of green type and red -type sorgers consumed in Bongor (Chad) with a view to providing nutritional knowledge on the consumption of these vegetables. Specifically, it is a question of collecting information on green and red type sorrel caly tall in five (5) districts of the city of Bongor and to determine the nutrients of red sorrel calyxes and green sorrel chalices. An investigation was first carried out using survey sheets with 150 people chosen at random. Then, the physicochemical analyzes were carried out such as the determination of water, ashes, proteins, lipids and total carbohydrates. The survey noted the following results: then, the Physicochemical Analyzes Were Carried Out Such as the determination of Water, Ashes, Proteins, Lipids and Total Carbohydrates. The Survey noted the following results: Sorough cultivation is evaluated at 46% for the green type and 33.33% for the red type. Consumption of chalices is 100% for the green type and 96% for red. Green chalices are consumed most often in the form of 80%sauce, in an occasional way at 91%. The consumption of these chalices is much more consumed during the dry season at 76%. The green chalices are used in the form of tea and juice (juice: 57.33% and tea-just: 29.33%). Physicochemical analyzes have shown that red reddish chalices contain (water: 86.34%; ashes: 43.64%and; Proteins: 0.77%), the red -red calyxes contain (water: 5.59%; ashes: 14.67%; proteins: 6.12%, lipids: 0.50%; carbohydrates: 73.12% and energy value: 321.46 kJ), green cost chalices contain (water: 88.34%; ashes: 7.03% and protein: 1.44%), and dry green chalices contain (water: 7.65% ashes: 14.48%; proteins: 5.44%, lipids: 0.89%; carbohydrates: 71.4% and energy value: 315.37 kJ). All these results show that this vegetable is a good source of nutrients that can be made available to the population.

Keywords: sorrel (*Hibisus Sabdariffa* L.), chalices, nutritional composition, Bongor (Chad).

INTRODUCTION

Resources of plant origin constitute foods consumed largely by populations. Among these plant resources used, the leafy vegetables occupy a good place in the food of the populations (Jean et al., 2022). Leaf vegetables occupy an important place in the diversification of food regimes of

developing populations and constitute one of the main sources of nutrients (Anin et al., 2012). In addition to their nutritional importance, leafy vegetables have a significant economic and social interest due to their relatively low cost, the ease and speed of their preparation (Lêniféré et al., 2022). Among these, there are Hibiscus Sabdariffa whose leaves and chalices are used for the preparation of sauce and red chalices in the manufacture of drinks (Diop et al., 2023). *Hibiscus Sabdariffa* L. is one of the species for multiple uses. This culture effectively contributes to food security and the fight against poverty to operators. It is a very popular vegetable in household food in central Africa, where it is consumed in cooked dishes sauces or as a fresh drink (Bissap) (Maurice et al., 2016). *Hibiscus sabdariffa* L. belongs to the Malvaceae family in the same way as cotton or gombo (Mady et al., 2017). The calyxes of the fruit are used in the preparation of thirsty and invigorating drinks without alcohol (juice, tea, syrup, etc.) (Clarisse, 2013). The red to white red -colored calyxes are edible (Cissé et al., 2009 a). The sorrel is one of those many legumes much appreciated and cultivated without interruption in the country (Chad). It is a plant of great importance for Chadians, because entering the food of all social categories: poor and rich (Atosa, 2008). *Hibiscus sabdariffa* L. is cultivated in Chad in the sudano-sahelian area, in the Borkou and the enemy oases, several green or red varieties are cultivated for the leaves consumed in vegetables or the flowers from which drinks are drawn (Jean and Cyrille, 2019). Knowledge of the chemical composition of food is fundamental, in the dietary treatment of diseases or for any quantitative study on human nutrition (Heather and Sougathe, 2007). Given the importance of the consumption of sorrel's chalices in Chad, and in Bongor in particular, we would like to determine the nutritional composition of these foods in order to provide the nutritional aspect of this vegetable and encourage populations to more consumption.

MATERIAL AND METHODS

Study Area

The city of Bongor is located in the southwest of Chad between 10 ° and 11 ° north latitude and 15 ° and 16 ° west longitude. It is located equidistant from Moundou, the economic capital and N'Djamena, the political capital is 235km on both sides.

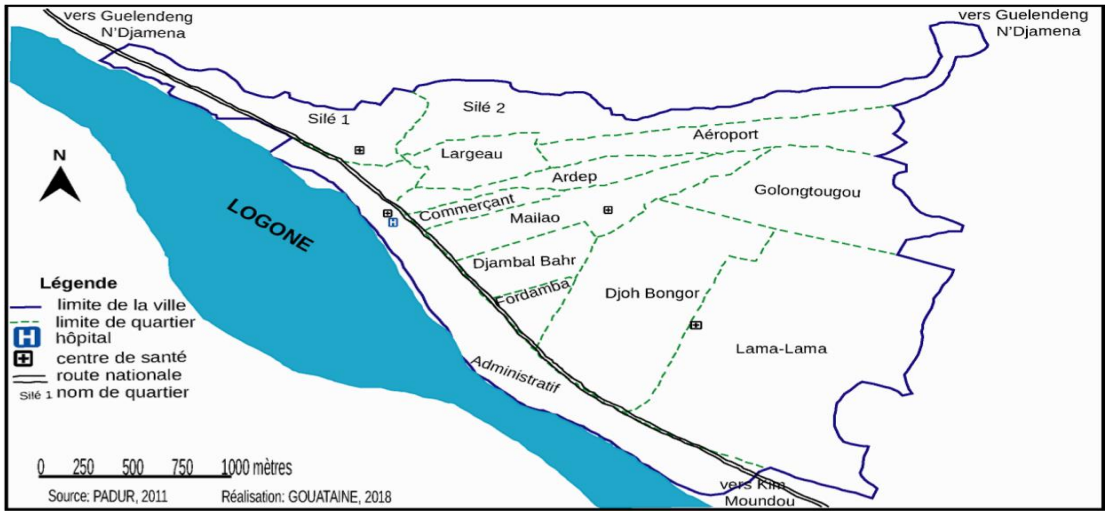

Figure 1: Source study area
Gouataine and Ymba (2019)

Five districts were chosen, including a southern district (Lamalama), a northern district (Silé), a district of the East (Golongtougou), a western district (Djambal Bahr) and a center in the center (merchant) in order to obtain the best information on the consumption of sorrels.

Material

Biological Material:

Biological equipment consists of fresh and dry chalices of green sorrel and fresh and dry chalices of red sorrel. The chalices of *Hibiscus sabdariffa* L. used during this work, come from the plants that we cultivated In Bongor precisely in the Golongtougou district east of the ENSB on June 20, 2024. The dry chalices were harvested in November 2024, dried in the sun on the sets for 7 to 8 days.

Figure 2: Fresh chalices *Hibiscus Sabdariffa* L.
Source: Azlona Massamngué (2024)

Figure 3: Dry chalices of *Hibiscus Sabdariffa* L.
Source: Azlona Massamngué (2024)

Laboratory Material:

The experiments required as equipment, a tray, the crucibles, a pliers, a pliers, Spatulas, 50ml and 100ml test pieces, pumice stones, 500ml, 250ml, 200ml, 1000ml beaker, 500ml round background balloons, capsules, matras, a micropipette, a tip, a pissette, a mortar, a pill.

Reactive:
The reagents used for this study are: N-Hexane, copper sulfate, potassium sulfate, an anti-dot agent, sulfuric acid, bromocreosol green, methyl red, sodium hydroxide, distilled water and ethanol.

Apparatus:
The devices used are: an electrical retsch zm 200 electric shredder, an analytical balance, specifies at 0.0001 g nearest, a desiccator, a dry-line drying oven VWR DL 53, a nabertherm oven (30-3000 ° C), a digestion device (Speed Digerter K-439 Buchi and Scrubber K-415), a distiller (Bucgi Unit K-350), a titration device (VWR VS-C4 titration), a Soxhlet and a Heidolph rotary evaporator.

Methods
Data Collection:
The survey concerned 150 people due to 30 people per neighborhood. The investigation took place from 02 to 20 November 2024 to the survey sheet. The choice of households was made at random. The respondent is subject to the questions following the chronology of the investigation sheet and the answers are noted by me or the interviewee.

Statistical Analysis:
The data collected were processed and analyzed using Excel 2013 software.

Physico-chemical Analyzes:
The dry and fresh chalices were packed in plastic bags and then transported to the CECOQDA (Center for the control and quality of food) in N'Djamena for the analyzes. Fresh chalices were collected on December 22, 2024 and transported to N'Djamena on the same day, including dry chalices. The analyzes took place on December 23, 2024.

Determination of the Water Content:
The water content of dry chalices and *Hibiscus sabdariffa* L. fees was determined by the method (NF EN ISO 2171, 2023) in three (3) stages:

Preparation of the Sample:
- powdered powdered for dry chalices using electric shredder and fresh chalices using mortar;
- Speech in the oven at 105 ° C for an hour of empty crucibles and their cooling in the desiccators.

Figure 4: Dry and chalices reduced to powders
Source: Azlona Massamngué (2024)

Operating Mode:

- we weighed empty crucibles and weighing5g dry chalices/*Hibiscus sabdariffa* L. Reduced.

Figure 5: testing
Source: Azlona Massamngué (2024)

- mat on the whole oven (crucibles and chalice samples) for two (2) hours at 105 ° C
- Cooling of crucibles containing dry materials in the desiccators.

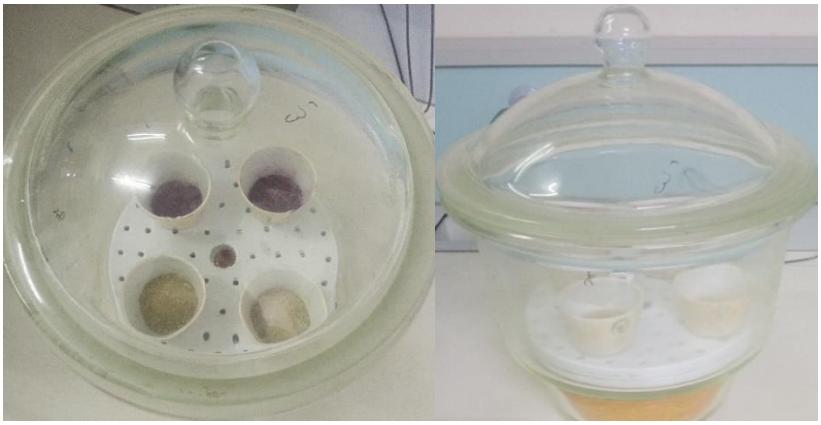

Figure 6: cooling of crucibles containing dry materials in the desiccator

- Peserins containing dry materials after cooling

Expression of Results

$$TE=\frac{(CV+PE)-CMS}{PE}*100$$

With, TE = water content; CV = empty crucible; CMS = Creuset dry matter and PE = testing.

Determination of the Ash Content

The ashes content of the fresh and dry chalices of the chalices of *Hibiscus sabdariffa* L. was determined by the method (NF En ISO 2171, 2023), as follows: The crucibles used were dried in the oven at 105 ° C for an hour, then cooled in the desiccator. Then, 5g of the fresh and dry chalices already crushed, were weighed in these crucibles and the whole was put in the oven at 105 ° C for two (2) hours. After being cooled in the desiccator, these crucibles containing the dry materials were weighed and are put in the oven at 550 ° C for eight (8) hours. These crucibles withdrew and let cool in the desiccator, are weighed. Expression of results

$$TC=\frac{CMI-CV}{CMS-CV}*100$$

With, TC = ash content; CMI = crucible cremated matter; CV = Empty crucible and CMS = D Creset dry matter.

Determination of the Protein Content

The NF EN ISO 20483 (2013) method was used for determining the protein content. We first determined the nitrogen content and then deduces the protein level.

Sample Preparation

- Dry -powder powder reduction using electric shredder and fresh chalices using mortar;
- Drying in the oven at 105 ° C for an hour of empty crucibles and their cooling in the desicc.

Three (3) main stages constituted this method:

- **Step 1: Digestion or Mineralization of the Sample:** 3g of calyx samples have been introduced into the Matra tubes. 0.6g of copper sulfate were added in 10g of potassium sulfate, 4 to 5 pumice stones, 20ml of sulfuric acid, a few drops of anti -manging agent and the whole was mineralized for 165 minutes at 480 ° C.
- **Step 2: Distillations of the Mineralized Solution:** 50ml of distilled water have been added to the Matra tubes. After cooling, 70ml of Naoh at 32% concentration were added. 50ml of boric acid were poured into each Erlenmeyer and 10 drops of bromocreosol green, 4 drops of methyl green were distilled. Then everything was distilled for 6 minutes.

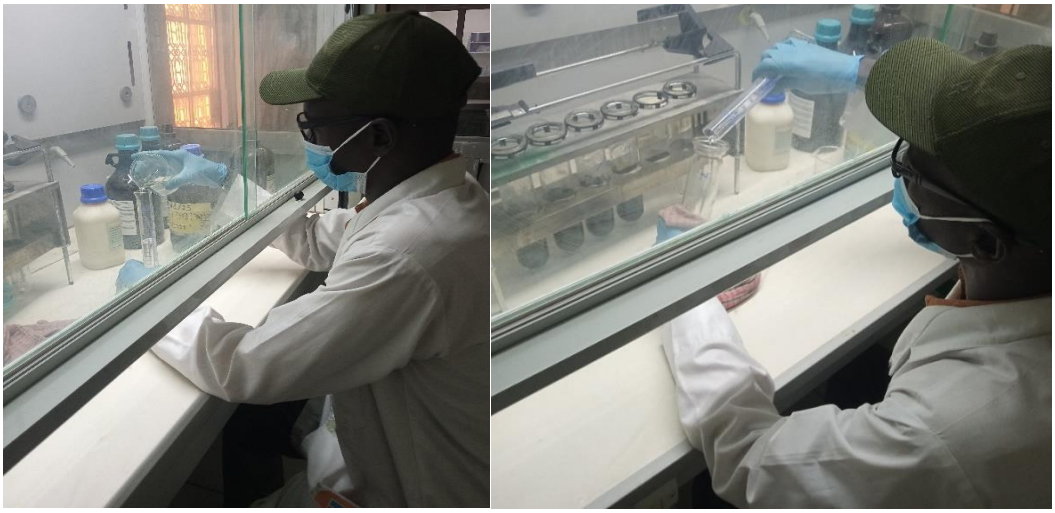

Figure 7: Measurement and addition of 70 ml of NAOH in the matra
Source tube: Azlona Massamngué (2024)

- **Step: 3 Distillat Titrages:** The titration is carried out using the sulfuric acid solution thanks to the titration device.

Figure 8: Distillat titrages
Source: Azlona Massamngué (2024)

Expression of Results
Calculation of the Nitrogen:

$$WN=\frac{1{,}4007*T*(V1-V0)}{PE}$$

WN = Nitrogen level; T = Concentration of the titrating solution; VO = Volume of white; V1 = Sample volume and PE = Testing

Calculation of the Protein Levels:

$$WP=WN*6\ ,25$$

With WP = protein and WN rate = nitrogen rate determination of the lipid content

Determination of the Lipid:
The ISO 11085 (2015) method was used for the determination of the lipid content.

Sample Preparation:
-Reduction powder of dry chalices using electric shredder; Drying in the oven at 105 ° C for an hour of empty crucibles and their cooling in the desiccators. After preparing the sample, the following steps were respected.

Extraction of Fat:
g of sample of the chalices were introduced into a capsule, 60ml of N-Hexane and a few pumice balls in the extraction tube were added. The capsule with content was introduced into the extraction tube and then mounted on the Soxhlet which was put in heating for 8 hours at a temperature of 105 ° C.

Figure 9: Start of assembly of the Soxhlet device
Source: Azlona Massamngué (2024)

- **Step 2: Separation of the Fat Material of N-Hexane:** The empty and fat balloon were weighed and then put in Rotavor, all boiled in the presence of the N-Hexane which was separated from the fat after boiling.
- **Step 3: Weighed Dried Balloon:** Drying with an oven at 105 ° C for 30 minutes from the ball containing the fat then cooling in the desiccutor which will be weighed.

Expression of Result

$$TMG= \frac{BS-BV}{PE}*100$$

With TMG = fat content; BS = dried balloon; Bv = empty balloon and pe = test take

Determination of Total Sugars:
The determination of the carbohydrate content was carried out according to the following formula (Soro et al., 2013).

%Glucid= 100- (%Humidity+%Protein+%Lipid+%Ash)

Determination of Energy Value:
The theoretical energy value of *Hibiscus sabdariffa* L. was calculated using the coefficients of (Merril and Watt, 1955), adopted by FAO (1970).

Or P, G, and L, the respective percentages of proteins, carbohydrates and lipids. The energy value of the chalices has been determined as follows:

Energy Value (kcal /100g) = (P*4+G*4+L*9) KJ

Statistical Analysis:
The data was entered in Excel 2013 then transferred to SPSS 20. (Statistical Package for Social Sciences) for statistical analyzes. The results presented in the form of figures were carried out in Excel.

RESULTS

Survey Results
Characteristics Sociodemographic:
Socio -demographic characteristics concern five variables: age, gender, matrimonial status, level of study and profession of 150 people surveyed.

Age Slices:
Among the 150 people surveyed, there are 48 whose age varies from 15-30, or 32.00%; 77 from 31-45 years old, or 51.33% and finally 25 people of 46-plus, or 16.67%. So most respondents are between 31 to 45 years old. The following diagram confirms these results.

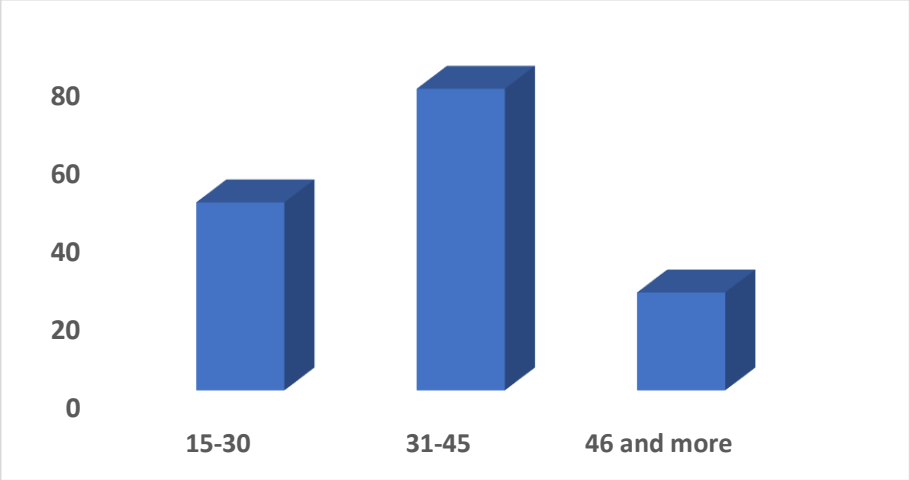

Figure 10: Ages slices

Gender:

About gender, we have counted, 86 men (57%) and 64 women (43%). The diagram below attests these results.

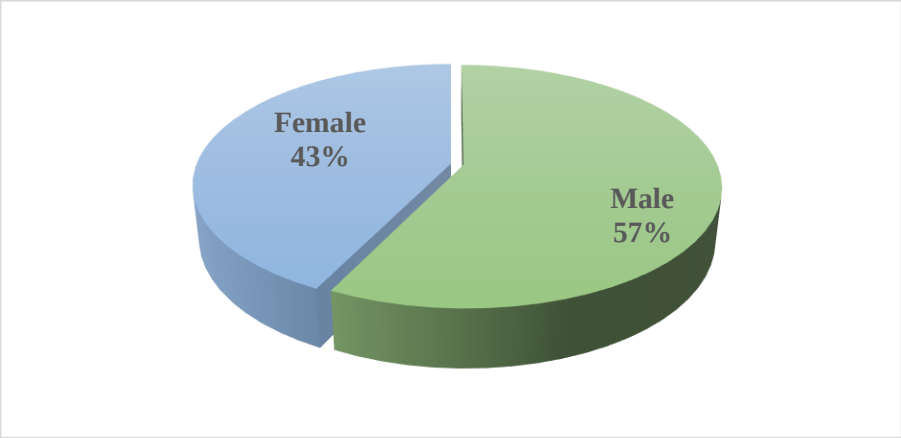

Figure 11: Distribution of respondents according to the genre

Matrimonial Status:

Investigations are mainly groom (e) s (82 or 54.66%) and singles (64 or 42.66%). Widows only 4.68% and zero divorced. These results are confirmed by the following diagram:

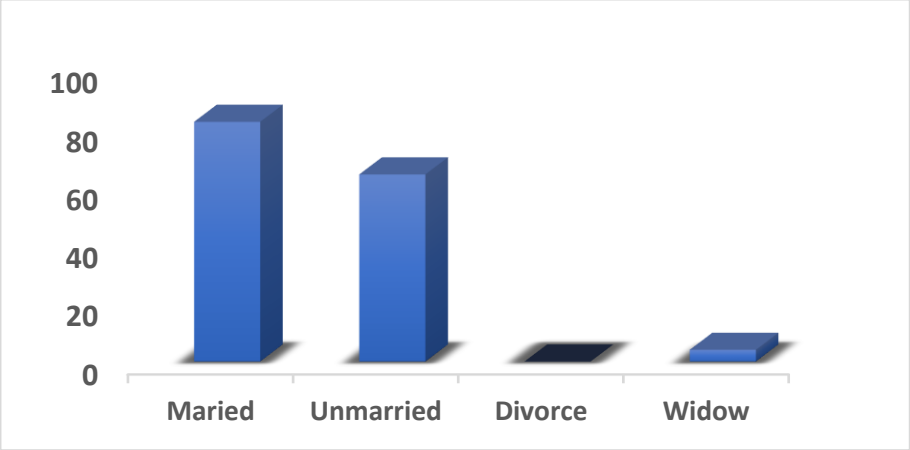

Figure 11: Matrimonial status

Study Level:

Table 1: study level

Designation		Number	%
Level of study	Primary	22	14,66%
	Secondary	55	36,66%
	Higher	45	30,00%
	Coranic	28	18,68%
	Total	150	100%

The majority of respondents have the secondary level (36.66%), followed by the higher level (30%).

Profession:

Tableau 2: Profession

Designation	Profession	Number	%
Profession	Housewife	24	16,00%
	Shooping	19	12,66%
	peasant	58	38,68%
	Pupil /student	39	26,00%
	Official	10	6,66%
	Total	150	100%

These people belong to five (5) professions, including housewife (16%), trader (12.66%), peasant (38.68%), student/student (26%) and civil servant (6.66%). So the peasant (n) are in the majority.

Information on Green Sorrel Chalices:

Culture de l'oseille verte

Table 3: Green sorrel culture

Désignation	Response	Number	%
	yes	69	46%

Green sorrel culture	No Total	81 150	54% 100%

69/150 (46%) of the people surveyed cultivate the green sorrel and 81/150 people (54%) do not cultivate it.

Consumption of Green Sorrel Chalices:
The chalices of green sorrel are consumed 100% by the target population surveyed.

Use of Green Chalices:

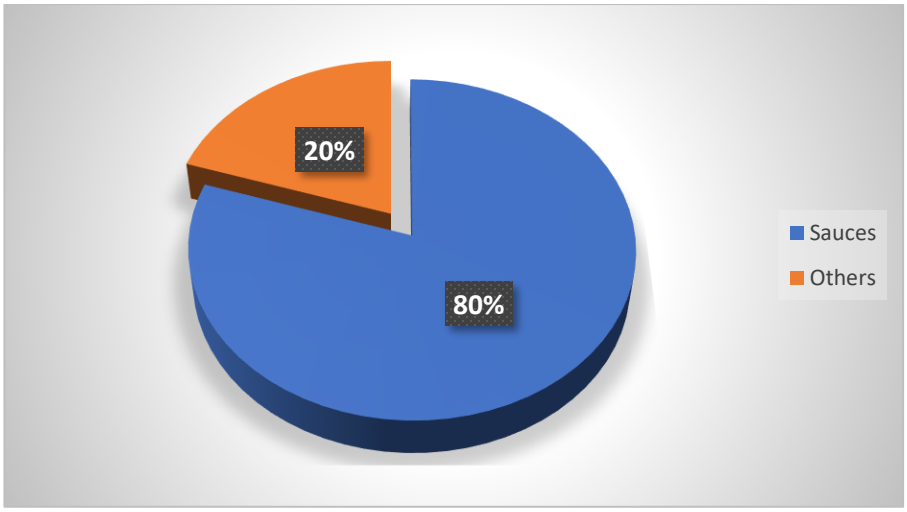

Figure 12: Use of green chalices

These chalices are generally used in the form of sauce (80%).

Frequency of Consumption of Green Chalices:

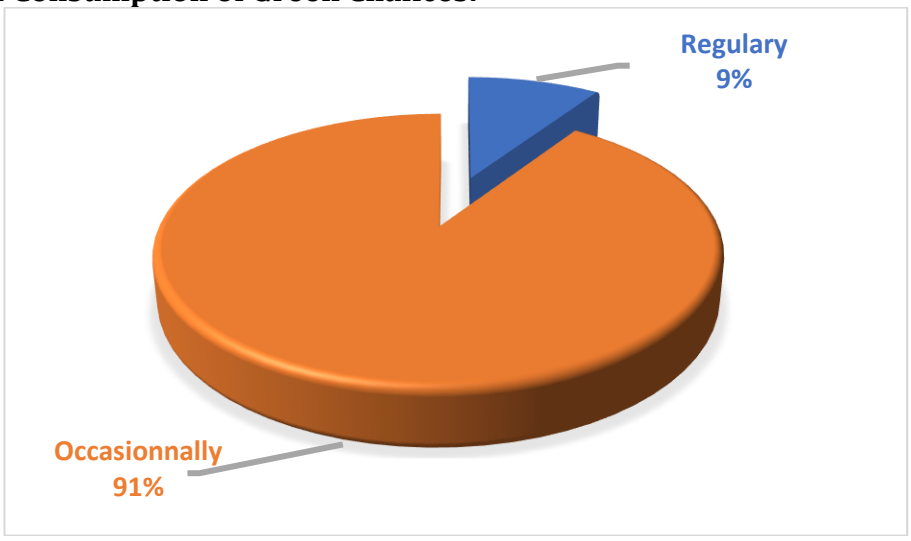

Figure 13: Frequency of consumption of green chalices

The frequency of consumption is occasional (136/150, 91%).

Higher Consumption Frequency Period:

Table 4: higher consumption period of green chalices

Designation	Period	Number	%
Period at higher consumption frequency	Rain season	36	24%
	Dry season	144	76%
	Total	150	100%

The period at higher consumption frequency is the dry season (76%).

Form of Consumption:

Table 5: Form of consumption of green chalices

Designation	Form	Number	%
Consumption form	Crue	10	6,66%
	Cuite	140	93,34%
	Total	150	100%

The form of consumption is generally cooked (93.34%)

Health Problems Linked to Green Chalices:

Table 6: Health problems linked to green chalices

Designation	Response	Number	%
Health problems linked to the consumption of these green chalices	Non	114	76%
	Oui	36	24%
	Total	150	100%

Many do not have health problems linked to the consumption of these chalices, only 24%.

Information on Red Sorrel Chalices:

- Knowledge of the red sorrel: All people surveyed know 100%red sorrel.
- Culture of the red sorrel: 50 people/150 (33.33%) only cultivated it and 100/150 (66.67%) do not cultivate it.
- Consumption of red sorrel chalices: 44/150 (96%) consume the chalices of red sorrel and 6/150 (4%) only do not consume these chalices
- Form of consumption of the red shower chalices: These vegetables are generally consumed in dry form (116/150 or 77.33%).

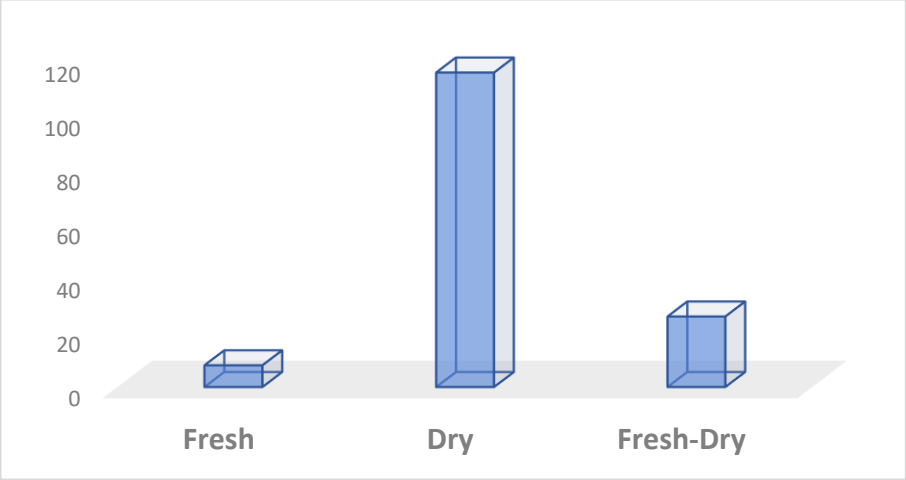

Figure 14: Form of consumption of the red shower chalices

- Use of red chalices: These red chye chalices are mainly used for the preparation of juice and tea (juice: 88/150; juice and tea: 44/150).

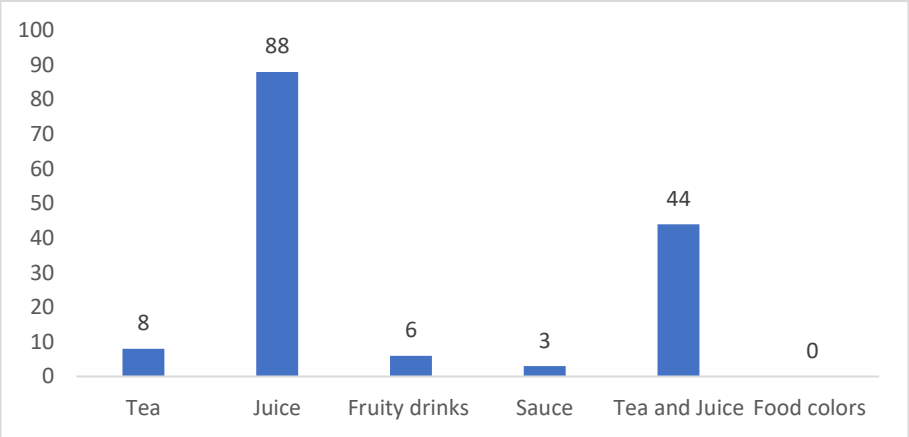

Figure 15: Use of the Red Chalices

- Food problems linked to the consumption of red chalices

Table 7: Food problems linked to the consumption of red chalices

Designation	Response	Number	%
Food problems linked to the consumption of red sorrel chalices	Non	124	82,66%
	Oui	26	17,34%
	Total	150	100%

The majority of respondents do not have food problems linked to the consumption of red -red chalices (82.66%).

Results of Physicochemical Analyzes

The results obtained from physicochemical analyzes are recorded in the following table.

Table 8: Results of physicochemical analyzes of fresh and dry chalices of *Hibiscus sabdariffa* l.

Calices / **Paramètres**	**Fresh red**	**Dry red**	**Fresh Green**	**Dry Green**
Water content (%)	86,32±0,02	5,49±0,13	88,27±0,09	7,61±0,04
Ash rate (%)	43,6±0,04	14,13±0,76	7,01±0,1	14,49±0,01
Fat (%)		0,51±0,01		0,9±0,02
Protein rate (%)	0,78±0,02	6,13±0,02	1,45±0,01	5,47±0,04
Total carbohydrate levels (%)		73,01±0,15		71,11±0,42
Valeur énergétique (KJ)		321,33±0,18		314,98±0,54

DISCUSSION

Survey Results

ll people surveyed know the species well, only 46% cultivate the green sorrel and 33.33% cultivate the red sorrel, unlike the studies carried out by Jocelyne et al. (2021) in Burkina Faso (*Hibiscus sabdariffa* L. is produced in the dry season and in the rainy season by 88% of the people surveyed), and Jean et al. (2022) in Benin (61.31% cultivated sorrel and 28.87% cultivate and buy).

Physicochemical Analysis Results

The water content of red fresh and green fresh charges (86.34%) is similar to the average value of the costs fees found by (CISSE et al., 2009b; after 2010 Khady project) (86.34g/100g). The value we have obtained is a little high compared to the value found by (Babacar and Gboho, 2013) (86.2g/100g), and (Rotary, 2022) (86.0%). The water content of the red (5.59%) and green (7.65%) dry (5.59%) is lower than the contents found by (Medjekane and Sahili, 2020; Lamrani and Mammeri, 2022) (red chalice 11%; white chalice 9.30%), (9.2g/100g) (SUSTIVES, 2022; Bâ, 2023). Red fresh and fresh Hibliscus sabdariffa L. de Bongor hibes caly ties respectively contain 43.64% and 7.03% of ashes respectively. These quantities are high compared to the results of the work (Ahabar, 2012; Hocine and Ibriche, 2021) (6.63g/100g), (André, 2016) (0.9-1.3g/100g). As for the red and green dry and green chalices respectively contain (14.67% and 14.48%) of ashes, these values are largely high with the values obtained by (Tchiegang and Kitikil, 2004, Cisse et al., 2009) (6.9g/100g). These results seem to indicate that the chalices of *Hibiscus sabdariffa* L. de Bongor contain a high percentage in mineral matters. All these differences would certainly be due to varietal difference or the nature of the soil.

The fat content of the red (0.50%) and green (0.89%) dry (0.50%) and the value found in the value found by (Medjekane and Sahili, 2020; Lamrani and Mammeri, 2022), (0.16% red chalice and 0.12% white chalice). In addition, other researchers have found values higher than our results such as (Tchiegang and Kitikil, 2004, SUSTIVES, 2022; Bâ, 2023) (2.61g/100g) and (Denis et al., 2008) (the concentration of lip lipids is between 1 and 2%). Protein levels in red fresh (0.77%) and green fees (1.44%) are in disagreement with those reported by (Traore, 2003) (1.145g/100g), (Babacar, 2013) (1.6g/100g) and (Khady, 2018), (6.59g/100g on average). All these differences would certainly be due to varietal difference or the nature of the soil.

As for the green and red dry and red chalices, they contain 5.44% and 6.12% of proteins respectively. These results are lower than those obtained by (Medjekane and Sahili, 2020; Lamrani and Mammeri, 2022) (red chalice 7.88% and white chalice 7.53%). On the other hand, our results are much higher than those obtained by (Denis et al., 2008) (the protein content of the chalices varies between 1.5% and 3.5%), (SUSTIVES, 2022) (1.14g/100g), (Guendouze and Mansri, 2023) (1.9g/100g). All these differences would certainly be due to varietal difference or the nature of the soil.

Total carbohydrates rates obtained (73.12% dry red chalices and 71.4% Green dry chalices) are higher than those reported by (Medjekane and Sahili 2020, Lamrani and Mammeri, 2022) (total carbohydrates of the red chalices: 57.16% and dry white chalices: 61.55%). The energy value obtained from our chalices is largely raised to that obtained by (GBOHO, 2013), (44kcal = 183.92KJ) and that obtained by (Rotary, 2022), 185 KJ. Our local chalices are very rich in energy compared to other chalices. This variability of the composition is linked to several factors such as: rainfall, the nature of the soil, the temperature, the variety of *Hibiscus sabdariffa* L., the cultivation conditions and also the analysis technique etc (Babacar, 2013).

CONCLUSION

At the end of this study, it appears that the chalices of *Hibiscus sabdariffa* L. are widely consumed by the target population (100% for green chalices and 96% for red chalices). Dried green chalices and dried red chalices are consumed by the local population. The consumption of these vegetables is very widespread in the dry season. The dried green chalices are mainly used in the form of sauce (80%), occasionally (91%). As for dry red chalices, they are consumed in the form of juice (57.33%) and tea-just (29.33%). Most of the target population get their supplies from these chalices by buying it at the Bongor market, because (33.33% cultivate red sorrel and 46% green sorrel). Physicochemical analyzes have reported that the chalices of *Hibiscus Sabdariffa* L. de Bongor (Chad) contain water in % (red costs and green costs: 86.34, red dry: 5.59 and green dry: 7.65); Ash in % (red costs: 43.64, red dry: 14.67, green costs: 7.03 and green dry: 14.48); fats in % (red dry: 0.50 and dry green: 0.89); Proteins in % (red costs: 0.77, red dry: 6.12, green costs: 1.44 and green dry: 5.44); Total carbohydrate levels in % (red dry: 73.12 and green dry: 71.4) and energy value in KJ (red dry: 321.46 and green dry: 315.37). These are good sources of mineral materials, proteins, carbohydrates and energy. In perspective, to provide in -depth nutritional knowledge on the nutritional composition of these local vegetables, other research would deserve to be carried out.

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