ASSESSMENT OF THE NUTRITIONAL VALUE OF SPONTANEOUS LEAFY VEGETABLES OF INTEREST FROM THE MARAHOUE (COTE D'IVOIRE) REGION AND THEIR TRADITIONAL HOME MADE SAUCES

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ABSTRACT

Local plant resources with high nutritional potential including wild leafy vegetables are an essential link in strategies to promote food security for low-income populations. However, little attention is paid to them, even in localities where their consumption is limited to the lean season. Thus, the evaluation of the nutritional contribution of five major spontaneous leafy vegetables (Acalypha ciliata (AC) ; Celosia trygina (CT) ; Cleome gynandra (CG) ; Solanum nigrum (SN) ; Sesammum radiatum (SR)) from the Marahouet region (Côte d'Ivoire) and their sauces was carried out. Biochemical properties were investigated. The five spontaneous leafy vegetables very rich in water contained carotenoids (251 (CG)-48.71 (SR)), total polyphenols (5138.31 (CT)-1483.51 (SR), flavonoids (44.21 (CT)-7.86 (AC) and tannins (874.85 (CT)-23.52 (356.00 (AC), mg/100g DM, respectively in high concentrations. Protein, ash, lipid and fiber contents were similar to those of cultivated leafy vegetables. Only, the traditional method allowed a retention rate of 9.10 to 30.11 % of micronutrients with antioxidant potential. The residual contents are sufficient to cover the needs of children and women. Spontaneous leafy vegetables are therefore good sources of molecules with antioxidant value to be valued in the context of the prevalence of diseases related to oxidative stress.

Keywords : Nutritive value ; traditionnals sauces ; spontaneous leafy vegetables ; assessment ; Marahoué

RESUME

EVALUATION DE LA VALEUR NUTRITIONNELLE DE LEGUMES-FEUILLES SPONTANES D'INTERET DE LA REGION DE LA MARAHOUE (COTE D'IVOIRE) ET DE LEURS SAUCES TRADITIONNELLES

*Les légumes-feuilles sauvages constituent un maillon essentiel dans les stratégies de promotion de la sécurité alimentaire des populations à faible revenu. Cependant peu d'intérêt leur est accordé, même dans les localités où, leur consommation se limite aux périodes de soudure. Ainsi, l'évaluation de l'apport nutritionnel de cinq légumes-feuilles spontanées (*Acalypha ciliata (AC) ; Celosia trygina (CT) ; Cleome gynandra (CG) ; Solanum nigrum (SN) ; Sesammum radiatum (SR)*) majeurs de la région de Marahouet (Côte d'Ivoire) et de leurs sauces a été effectuée. Des propriétés biochimiques ont été recherchées. Les cinq légumes-feuilles spontanés très riches en eau contiennent des caroténoïdes (251 (*CG*)-48,71 (*SR*)), polyphenols totaux (5138,31 (*CT*)- 1483,51 (*SR*), flavonoïdes (44,21 (*CT*)-7,86 (*AC*) et tanins (874,85 (*CT*)-23,52 (356,00 (*AC*), mg/100g MS, respectivement en concentrations élevées. Les teneurs en protéines, cendres, lipides et fibres sont similaires à celles des légumes feuilles cultivés. Seulement, la méthode traditionnelle a permis un taux de rétention de 9,10 à 30,11 % des micronutriments à potentiel antioxydant. Les teneurs résiduelles suffisent à couvrir les besoins des enfants et des femmes. Les légumes-feuilles spontanés sont donc de bonnes sources de molécules à valeur antioxydante à valorisés dans le contexte de prévalence de maladies liées au stress oxydatif.*

Mots clés : *Propriétés biochimiques, potentiel antioxydant ; sauces traditionnelles ; légumes-feuilles spontanées ; Marahoué*

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INTRODUCTION

Leafy vegetables have a significant role in diets where they contribute to the food security of people around the world, particularly in developing countries (Bailey, 2003). They are defined as plants (grass, liana, shrub, tree) whose leaves are used to accompany basic starchy foods in Africa (Chweya and Eyzaguirre, 1999 ; CTA, 2004 ; Batawila *et al.,* 2005). Leafy vegetables are made up of so-called modern species such as cabbage (*Brassica oleracea* Linn) and lettuce (*Lactuca sativa* Linn), but also traditional species (Adjatin, 2006) which are widely distributed in Africa.

These traditional leafy vegetables can be prepared as sauce, alone or in combination, with ingredients such as tomato, onion, chilli, peanut paste, palm oil (red or bleached) to enhance the flavour (Kahane *et al.,* 2005). Dietally and medicinally, these leaves are effective against certain pathologies such as anaemia, diabetes, constipation, malaria and high blood pressure (Grubben, 1975 ; Dansi *et al.,* 2008). In agronomy, leafy vegetables increase the productivity of other crops by improving soil fertility (FAO, 2002 a). In nutritional terms, they contain micronutrients (vitamins, minerals) that contribute to the body's well-being (FAO, 1988 ; Rubaihayo, 1996). From a socio-economic point of view, the relatively low cost and ease of production of leafy vegetables contribute to a significant improvement in household income in urban areas (Diouf *et al.,* 2007).

Like many African countries, Côte d'Ivoire is endowed with a great diversity of traditional leafy vegetables (Okigbo, 1977 ; Almekinders and de Boef, 2000 ; Acho *et al.,* 2014 ; Zoro et al., 2015). Among these taditional leafy vegetables are, on the one hand, market garden plants and plants sold on markets, which are widely studied (Acho et al., 2014 ; Zoro *et al.,* 2015 ; Oulai *et al.,* 2016) and, on the other hand, traditional spontaneous leafy vegetables consisting of plants or shrubs that grow in the wild. These spontaneous edible leafy vegetables have many economic, dietary, social and therapeutic advantages. They play an important role in the survival of rural populations during periods of food shortages (Bédiakon *et al.,* 2018). However, despite their potential, these edible plants are threatened with extinction. Thus, in recent years several ethnobotanical studies have been carried out in several localities and regions of Côte d'Ivoire to identify these resources and the know-how of the user populations (N'Dri *et al.,* 2008 ; Kouamé *et al.,* 2015 ; Bédiakon *et al.,* 2018). In the same way, an ethnobotanical study of spontaneous edible plants made in the department of Zuénoula (Marahoué region) was initiated (data not show). A total of 70 species of wild edible plants in 36 families were identified. Among them, 5 species of leafy vegetables are highly appreciated and consumed daily by the populations of this locality : *Solanum nigrum* (nanny), *Celosia trigyna* (pala yrôlô or yrôlô), *Cleome gynandra* (sanwôh), *Acalypha ciliata* (sôla sônin) and *Sesamum radiatum* (nihi). These plants are consumed for their leaves, which are boiled and then crushed into a paste and used in sauce, to which palm or peanut oil is added. It should be noted that the nutritional potential of these leafy vegetables and their sauces is almost unknown. Thus, due to their importance in local markets and their use in households, it is necessary to valorise them in order to contribute to the food security of the populations of the Marahoué region (Department of Zuénoula).

MATERIAL AND METHODS

PRE-TREATMENT OF LEAFY VEGETABLES

Leafy vegetables (*Acalypha ciliata*; *Celosia trygina*; *Cleome gynandra*; *Solanum nigrum* and *Sesammum radiatum*) (Figure 1) collected from different fields in zuénoula region were packaged in sterile bags and transported in coolers with carboglaces to the Biotechnology Laboratory of the Félix Houphouët Boigny University.

They underwent a preliminary treatment which consisted in detaching the leaves from the stems, sorting them and washing them abundantly with tap water. The selected leaves were then drained at laboratory temperature (20 °C) on absorbent paper and then divided into several batches for the analyses requiring dry matter and fresh matter and for preparing sauces.

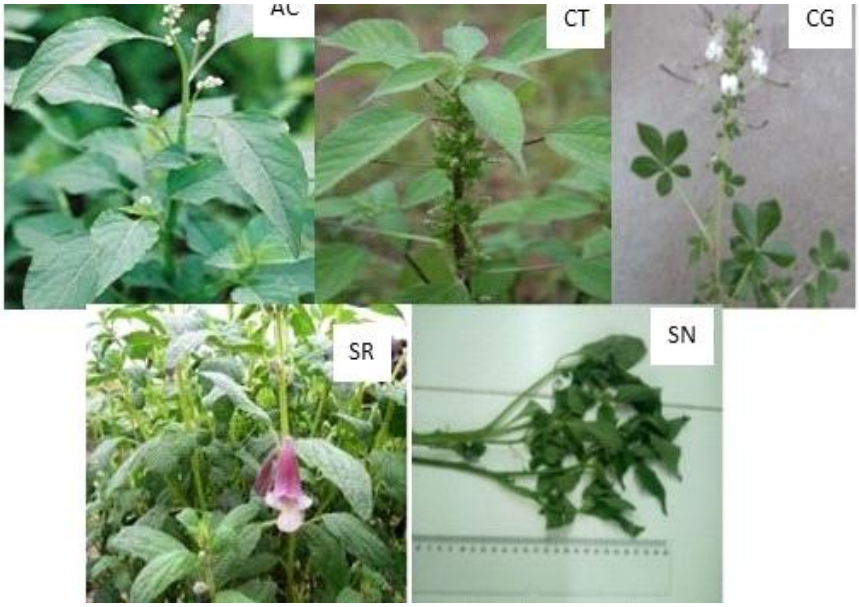

Figure 1 : Photography of the different leafy vegetables studied.

Photographie des différents légumes-feuilles étudiés.

AC : Acalypha ciliata ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* and SR : *Sesammum radiatum*

PREPARATION OF SAUCES

The leafy vegetable-based sauces were prepared according to the traditional method used in households in the Department of Zuénoula (Marahoué region). Five hundred (500) g of fresh leafy vegetables were immersed in 1.5 L of tap water previously brought to the boil (100 °C). The leafy vegetables were cooked for 1 h and 45 min. After cooling at room temperature, the cooked leaves were crushed in a porcelain mortar until a homogeneous paste is obtained, then 25 % of red palm oil was added to the paste (i.e. 25 ml of red oil per 100 g of leafy vegetable paste) (Figure 2). The leafy vegetable sauces thus formed were divided into 100 g batches in aluminium food jars and stored in the freezer (-18 °C) for further analysis.

Figure 2 : leafy vegetable-based sauce.

sauce à base de légumes-feuilles.

PROXIMATE ANALYSIS

The nutritional content of sauces and their leaves, was evaluated by the analysis of their proximate composition like moisture content, ash content in the dry method, crude fat content by Soxhlet extraction method, crude protein (N×6.25) content by Kjeldahl method in triplicate according to the Standard Association of Official Analytical Chemists procedures (AOAC (1997).

Total fiber content was determined according to the method described by Wolf (1968). Total carbohydrate content of foods was calculated by difference according to the method recommended by the FAO (2002b) and The energy value of the samples of leafy vegetables or sauces is calculated on the basis of the energy coefficients defined by the FAO (2002b) according to the following formula :

5Ø}Ü5ØlÜ (kcal/100 g) = 2.44×C (%) + 8.37×L (%) + 4.57×P (%)

VE, C, L and P refer to the energy value, carbohydrate, fat and protein contents respectively.

FUNCTIONAL PROPERTIES

Determination of carotenoids content

The carotenoids contained in leafy vegetables and sauces were extracted with hexane after saponification as described by Howe and Tanumihardjo (2006). The carotenoids containt was quantified by measuring the OD with a spectrophotometer (PG Instruments, England) at 450 nm. The carotenoid content was expressed as µg of mass by the following formula :

$$\text{Carotenoids (µg/g)} = (\text{OD (450nm)} \times \text{VT} \times 10^4) / (A^{1\%}_{1cm} \times \text{me})$$

and

me : mass of the sample (g);

VT: total volume of supernatant;

$A^{1\%}_{1cm}$ = extinction coefficient of â-carotene equivalent to 2592

Determination of total phenols content (TPC)

Phenolic compounds were quantified by Singleton *et al.,* (1999) method after extraction with methanol. A standard range established from a gallic acid stock solution (1mg/mL), under the same conditions as the test determined the amount of polyphenol in the sample. TPC was expressed as gallic acid equivalents (mg GAE/g dry weight).

Determination of flavonoids content

Flavonoids were quantified by Meda *et al.,* (2005) method after extraction with methanol. The absorbance was measured with a spectrophoto-meter at 415 nm against a blank. A calibration range was performed from a 0.1 mg/mL quercetin stock solution.

Determination of tanins content

Tanins content was determined by the method of Bainbridge *et al.,* 1996. Standard curve was prepared using tannic acid (R^2= 0.971). The tannin content was expressed as mg tannic acid equivalents/ 100 g DM.

MICRONUTRIENT RETENTION RATE

The retention rate of nutrients (polyphenols, flavonoids, carotenoids) in leafy vegetable-based sauces is given according to Rodriguez-Amaya (2001) by the following relationship :

% R = micronutrients content in the sauce / micronutrients content in the leafs × 100

Statistical analysis

All measurements were recorded in triplicate and results were expressed as mean ± standard deviation (S.D.). Moreover, the data was subjected to one-way analysis of variance using Microsoft Excel (ver. 2016, Microsoft Corp. USA) and difference between the means was evaluated by Ducan test at significance level of $p<0.05$ using the 2006 version of the Statistica 7.1 software.

RESULTS AND DISCUSSION

PROXIMATE COMPOSITION OF THE STUDIED LEAFY VEGETABLES AND THEIR SAUCES

The five spontaneous leafy vegetables (Table 1) and their sauce (Table 2) prepared according to the traditional method were studied in regard to proximal parameters to assess their nutritional potential. The results on proximal composition of the five spontaneous leafy vegetable and their sauce revealed significant differences (p ÂÙ 0.05) amongst them with regard to the studied parameters.

The results showed that the five spontaneous leafy vegetables recorded relatively high moisture contents between 68.33±0.20 (*Celosia trygina*), 68.38±0.18 % DM (*Solanum nigrum*) and 70.43±0.14 % DM (*Sesammum radiatum*). It should be noted that these moisture values are within the ranges generally reported for the leafy vegetables cultivated and usually consumed (Chitsulo, 2013 ; Acho *et al.,* 2014). The same observation was also observed for sauces prepared from the five spontaneous leafy vegetables studied. In fact, these sauces (Table 2) recorded moisture contents between 75.32±0.23 % DM (*Cleome gynandra*) and 82.43±0,25 % DM (*Acalypha ciliata*), in the same range of those (72.50 - 84.30 %) reported by Houkpatin (2011) for the traditional Amaranth leaf sauces consumed in Benin. These values are still high and show that these different dishes must be eaten as soon as they are prepared to avoid any rapid deterioration.

Ash content is an index of mineral content in a plant material. The results show that the five spontaneous leafy vegetables recorded ash contents between 2.31±0.03 (*Sesammum radiatum*) and 5.12±0.13% DM (*Celosia trygina*) well below those (8.09×Ù14.20% DM) reported by Tchiegang and Kitikil, (2004) for leafy vegetables comonly consumed. However, these ash values on indigenous leafy vegetables are higher than those of some commonly consumed leafy vegetables such as lettuce (*Lactuca sativa*) (0.4 % DM) and spinach (*Spinacia oleracea*) (0.7 % DM) (Salazar *et al.,* 2006). Ash contents in sauces between 00.95±0,01 (*Acalypha ciliata*) and 01.43±0.05 % DM (*Celosia trygina*) are also low and below the range 5.40 - 9.90 % DM reported by Hounkpatin (2011) in traditional leafy vegetable sauces. Therefore, these ash values indicate that both leafy vegetables and studied sauces may be significant sources of minerals.

The fiber contents are shown on table 1 (leafy vegetable) and table 2 (sauces). Among the five spontaneous leafy vegetables studied, *Sesammum radiatum* (09.20±0.27 % DM) recorded the hightest value of fiber contrary to *Solanum nigrum* (06.69±0.21 % DM) with the lowest value. Although the fiber content of leafy vegetables and their sauces is low, they may play an important role in digestion. Raw fibre aids digestion through its ability to retain moisture, facilitating cell hydration and intestinal transit. For example, the consumption of sauces based on leafy vegetables would help digestion as crude fibre acts on the digestive tract, prevents the absorption of excess cholesterol and helps to fight against cardiovascular disease (Mensah *et al.,* 2008).

For proteins content, the values obtained in leafy vegetables (Table 1) were ranged within 4.78±0.00 to 10.75±0.24 % DM for *Sesammum radiatum* and *Cleome gynandra* and sauces (Table 2) between 3.23±0.01 (*Acalypha ciliata*) and 8.56±0.10 % DM (*Cleome gynandra*). These values are both below the limit (12 %) for a food to be considered a source of protein (FAO, 1996). In view of these low protein content, the combination of more than two leafy vegetables in a sauce would help to improve the protein status of the sauce. Moreover, the association of these traditional sauces with protein-rich foods (soy, fish, meat, etc.) would help cover the protein needs of the populations of the Marohoué region.

Furthermore, the results indicate that, on the whole, the five leafy vegetables (Table 1) are less rich in lipids since the values were ranged from 0.48±0.15 (*Celosia trygina*) to 0.81±00.03 % DM (*Acalypha ciliata*). This finding was in agreement with the results of Ejoh *et al.,* (1996) and Onyeike *et al.,* (2003) who worked

respectively on the leaves of Vernonia calvoana var. bitter, V. amygdalina, V. colorata and pumpkin and oha. They should therefore be eaten together with oil-rich products such as oilseeds (peanut, juice or palm oil). The lipid content of spontaneous leafy vegetable-based sauces confirms this theory. The addition of red palm oil to the different sauces prepared has allowed the lipid contents to increase by more than 23 %. These lipid values of leafy vegetable-based sauces are in line with the WHO (2004) recommended intake between 15 and 30 % of daily energy intake. The enrichment of sauces with oils is an advantage both in terms of their calorific value and in improving the vitamin status (fat-soluble vitamin such as vitamin A) of these sauces. Indeed, lipids are the components of the diet that have the highest energy value (8.37 kcal/g) in plants (FAO, 2002 a).

The results of carbohydrate content on the five spontaneous leafy vegetable and their sauces are depected on table 1 and table 2, respectively. Similarly to lipids, the five spontaneous leafy vegetables and their studied sauces are not good sources of carbohydrates. Their consumption should therefore be accompanied by carbohydrate-rich foods such as cereals, roots and tubers, which contain up to 70 % carbohydrates (Cheftel and Cheftel, 1984).

Table 1: Proximate composition of the leaves of the five spontaneous leafy-vegetables studied.

Composition proche des feuilles des cinq légumes-feuilles spontanés étudiés.

Composition (%)	AC	CT	CG	SN	SR
Moisture	69.58±00.15^{b}	68.33±0.20^{c}	69.48±0.19^{b}	68.38±0.18^{c}	70.43±0.14^{a}
Crude protein	06.34±00.22^{d}	07.80±0.22^{c}	10.75±0.24^{a}	08.86±0.02^{b}	04.78±0.01^{e}
Crude fat	00.81±00.03^{a}	00.48±0.15^{e}	00.66±0.66^{c}	00.58±0.06^{d}	00.78±0.17^{b}
Ash	03.42±00.12^{c}	05.12±0.13^{a}	03.84±0.05^{b}	03.75±0.02^{b}	02.31±0.03^{d}
Crude fiber	07.82±00.12^{b}	07.87±0.33^{b}	07.02±0.45^{c}	06.69±0.21^{d}	09.20±0.27^{a}
Carbohydrate	12.04±00.02^{b}	10.40±0.08^{d}	08.25±0.09^{e}	11.74±0.11^{c}	13.27±0.12^{a}
Energy Value (Kcal/100 g)	65.08±01.52^{c}	65.04±0.24^{c}	74.78±0.56^{a}	73.99±0.86^{b}	60.75±0.94^{d}

Note : Data are represented as means ± SEM (n=3). Mean with different letters in the same line are statistically different ($p < 0.05$) according to Duncan's test

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

Table 2 : Proximate composition of sauce-made leafy vegetables with mixed red oil /100gDM.

Composition approximative de légumes à feuilles en sauce avec mélange d'huile rouge / 100gDM.

Composition (%)	AC	CT	CG	SN	SR
Moisture	82.43±0,25^{a}	76.74±0.31^{d}	75.32±0.23^{e}	77.89±0.05^{c}	80.16±0.04^{b}
Crude protein	03.23±0,09^{e}	06.31±0.02^{b}	08.56±0.01^{a}	05.58±0.01^{c}	04.69±0.03^{d}
Crude fat	23.40±0,01^{a}	23.60±0.01^{a}	23.03±0.01^{b}	23.49±0.02^{a}	23.45±0.02^{a}
Ash	00.95±0,01^{c}	01.43±0.05^{a}	01.10±0.08^{b}	01.05±0.01^{c}	01.00±0.02^{c}
Crude fiber	03.34±0,38^{e}	04.26±0.52^{a}	03.80±0.37^{c}	04.09±0.25^{b}	03.50±0.33^{d}
Carbohydrate	12.92±0,51^{a}	11.04±0.71^{d}	11.01±0.41^{d}	11.13±0.35^{c}	11.30±0.44^{b}
Energy value (Kcal)	242.14±0,49^{d}	253.31±0.15^{b}	258.75±1.23^{a}	249.27±0.32^{c}	245.28±0.21^{c}

Note : Data are represented as means ± SEM (n=3). Mean with different letters in the same line are statistically different ($p < 0.05$) according to Duncan's test.

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

FUNCTIONAL PROPERTY OF STUDIED LEAFY VEGETABLE AND THEIR SAUCES

Functional property is related to the presence of bioactive compounds in plant material and to their antioxidant capacity capable of limiting or preventing oxidative stress induced by free radicals. In this study, we focus our attention on the main bioactive compound such as Polyphenol, flavonoid, tannin and carotenoid compounds.

Analysis of the results on total polyphenol compound (TPC) at the 5 % limit in samples of leafy vegetables and their sauces (Figure 3) showed a significant difference according to Duncan test.

In view of figure 3, TPC values of the five spontaneous leafy vegetables were in the range of 1483.51±2.55 to 5138.31±2.19 mg/100 g DM. *Celosia trygina* recorded the highest TPC value while the lowest value was from *Sesammum radiatum*. The polyphenol values were much higher than those reported by Acho *et al.,* (2014) and Zoro *et al.,* (2015) for some leafy vegetables consumed in Côte d'Ivoire. Many factors affect polyphenol biosynthesis, such as plant breeding, geographical region, climate and postharvest handling (Deng *et al.,* 2013). The high content of TPC found in these leafy vegetable highlighted the importance of promoting their incorporation into diet of consumers. However, the cooking of the spontaneous leafy vegetables studied in water for sauces preparation could cause significant losses (Table 3) of polyphenols with residual contents between 237.83±0.82 for *Cleome gynandra* and 656.45±0.23% for *Celosia trygina* (Figure 3). These losses could be explained by the great ease by which the soluble polyphenols can be extracted during cooking, following the embrittlement of the cell walls by heat. Loss through cell bursting facilitates the release of polyphenolic compounds into the cooking water (Malika and Fouzia, 2011).

As regard TFC (total flavonoids content), the values of the different studied leafy vegetables and their sauces were presented on figure 4. These values were in range of 07.86±0.23 to 44.21±0.85 mg/100 g DM. *Acalypha ciliata* showed the lowest value conversly to *Celosia trygina* with the highest value. In addition, these results also showed that flavonoids values were relatively higher than those reported in the literature for leafy vegetables of Ivorian origin (Oulaï *et al.,* 2016). These vegetables could therefore represent excellent sources of bioactive compounds with high impact on the nutrition and health of consumers. However, similarly to TPC, cooking with water greatly affects the TFC in leafy vegetable based-sauces (Figure 4) with values between 1.29±0.01 and 8.09±0.05 g/100 g MS for leafy vegetables *Acalypha ciliata* and *Celosia trygina*, respectively. This is normal because flavonoids, natural pigments present in most plant tissues, are among the main classes of polyphenols. However, although the TF content in sauces has dropped from 5.39 (*Sesammum radiatum*) to 13.48 % (*Cleome gynandra*) compared to the initial levels in spontaneous leafy vegetables, the TF contents of these leafy vegetable based-sauces were not negligibles. Therefore, the traditional studied sauces could contribute to the fight against free radicals responsible for various disorders and disorganisations in the body, including cancers, cell degeneration diseases and cellular ageing (Vauzour *et al.,* 2010). An awareness campaign should be conducted among the rural populations of the Marahoué region on the need to reduce the heat treatment time of these leafy vegetables.

As far as carotenoids are concerned, huge losses are observed in sauces (Figure 5 ; table 3). This could be explained by the oxidation and isomerisation of â-carotene (Speek *et al.,* 1986). However, the retention percentages were below 25% for all the studied leafy vegetables. These retention percentages are due to the addition of red palm oil after cooking sauces, thus avoiding heating of the oil, which would lead to a drastic loss (70 - 80 %) of carotenoids following the oxidation and isomerisation of â-caroten (Hounkpatin, 2011). So, the consumption of 100 g of leafy vegetables sauces can provide between 1525±2.33 and 5800±3.15 ìg carotenoids respectively for *Sesammum radiatum* and *Solanum nigrum* sauces (Figure 5). Considering the daily recommended intake (RDA) for vitamin A recommended by the FAO/WHO (2002) (400 ìg/day for children aged 1 to 3 years and 750 ìg/ day for pregnant women), the consumption of 100 g of sauces based on the two leafy vegetables studied could cover more than 100 % of the RDA of children and pregnant women in the Marahoué region.

Tanins, relatively high molecular compounds constitute the third important group of phenolics, (Hagerman, 2012). Figure 6 depicted the total tanins content (TTC) within the five sponta-neous leafy vegetable and their sauces-based.

These values were in range from 365.00± (*Acalypha ciliata*) to 874.85± mg/100 g DM (*Celosia trygina*) within the studied leafy vegetables. Like the other phenolic compounds, heat treatments caused low tanin retention in all the studied leafy vegetable based-sauces.

Tanins losses increased (Table 3) in the consecutive order such as *Solanum nigrum* (1.18 %) Ã *Celosia trygina* (1.22 %) Ã *Sesammum radiatum* (1.63 %) Ã *Acalypha ciliata* (2.18 %) Ã *Cleome gynandra* (3.09 %). These values were quite higher than those (0, 01 to 0, 14 mg/mL) previously described by Essack and *et al.,* (2017) in *Solanum nigrum Amaranthus hybridus, Oxygonum sinuatum, Chenopodium album, Emex australis.* Tanins are identified as plant polyphenols that have diverse effects on biological systems since they have amongst others biological antioxidants function.

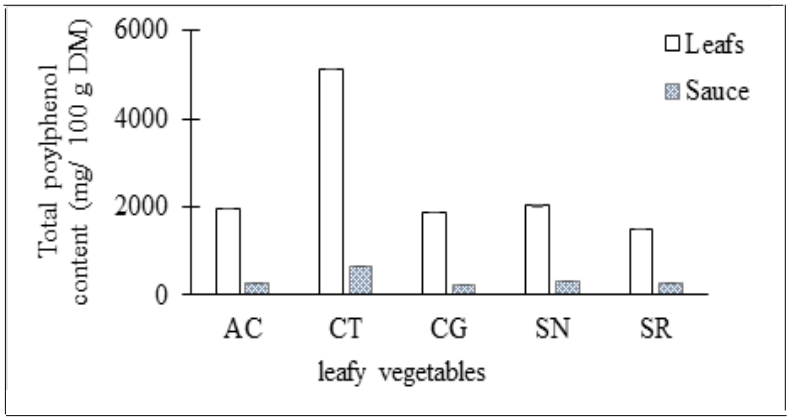

Figure 3 : Total polyphenols content of the different leafy vegetables studied and their sauces.

Teneur en polyphénols totaux des différents légumes-feuilles étudiés et de leurs sauces.

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

Table 3 : Micronutrient retention rate of the five leafy vegetables in sauces based on these leafy vegetables.

Taux de rétention des micronutriments des cinq légumes-feuilles dans les sauces à base de ces légumes-feuilles.

	Retention rate of micronutrients in the sauce (%)				
Nutrients/Sauces	AC	CT	CG	SN	SR
Total polyphénols	20.00	20.50	19.69	15.09	18.00
Total flavonoïds	11.15	12.66	11.41	09.32	10.35
Total tanins	17.20	15.30	10.50	09.10	18.20
Total Carotenoïds	27.22	30.11	27.58	28.22	28.50

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

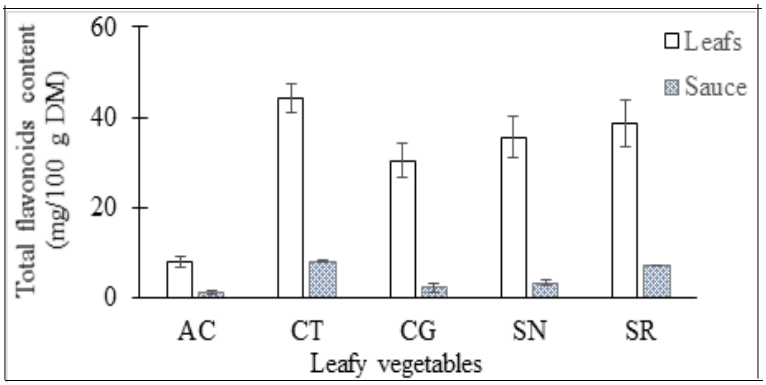

Figure 4 : Total flavonoids content of the different leafy vegetables studied and their sauces.

Teneur en flavonoïdes totaux des différents légumes-feuilles étudiés et de leurs sauces.

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

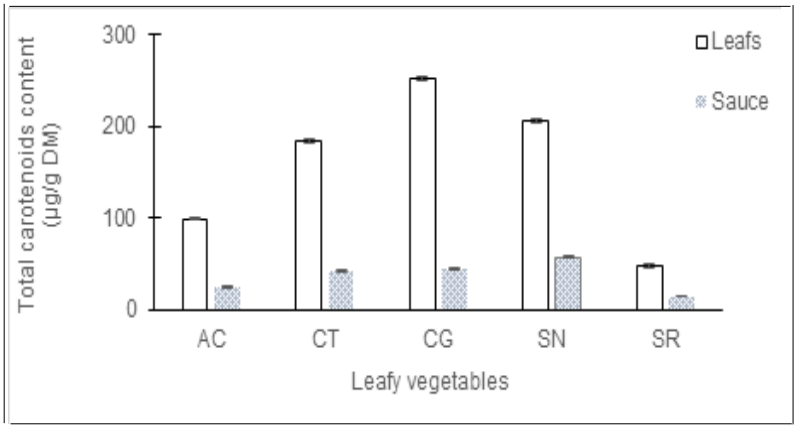

Figure 5 : Total carotenoids content of the different leafy vegetables studied and their sauces.

Teneur en caroténoïdes totaux des différents légumes-feuilles étudiés et de leurs sauces.

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

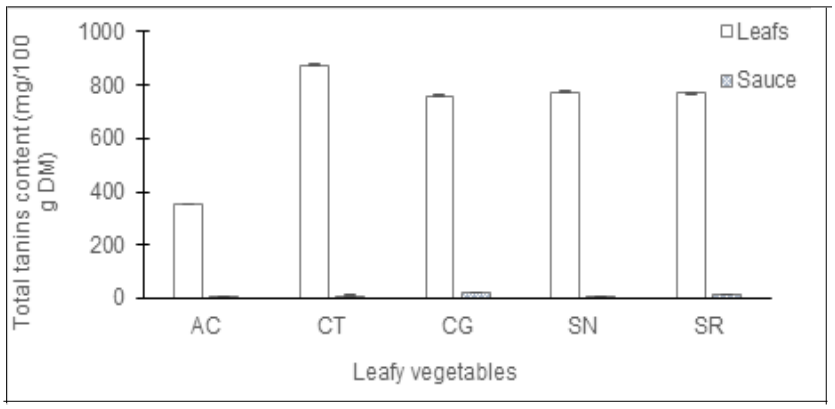

Figure 6 : Total tanins content of the different leafy vegetables studied and their sauces.

Teneur en tanins totaux des différents légumes-feuilles étudiés et de leurs sauces.

AC : *Acalypha ciliata* ; CT : *Celosia trygina* ; CG : *Cleome gynandra* ; SN : *Solanum nigrum* ; SR : *Sesammum radiatum*

CONCLUSION

The five spontaneous leafy vegetables were found to have interesting biochemical and nutritional characteristics for household diets with significant ash, protein and fibers content. However, the temperature and the traditional way of preparing sauces at household level had a negative impact on the nutritional value of these leafy vegetables. Nonetheless, addition of red oil at the end of cooking in these sauces has contributed to a significant improvement in fat content and calorific value. This addition has also made it possible to keep the phenolic compounds (total polyphenols, flavonoids and tannins) and carotenoids at an acceptable level despite the high losses caused by the heat treatment. In order to efficiently ensure permanent coverage of the specific needs of the target populations, nutrient losses should be reduced as much as possible by advising the consuming populations to adopt simple techniques such as bleaching and reduction of cooking time.

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