Impact of Sun Drying on the Nutritive and Anti-oxidant Properties of Five Leafy Vegetables Consumed in Northern Côte d 'Ivoire

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ABSTRACT— ***Leafy vegetables are highly perishable in nature and their preservation is very important. Indeed, dehydration is a simple method of preservation of green leafy vegetables. The aim of this study was to evaluate the impact of sun drying on nutritional value and antioxidant properties of five leafy vegetables (Hibiscus sabdariffa, Amaranthus hybridus, Adansonia digitata, Vigna unguiculata and Ceiba pentandra) consumed in Northern Côte d'Ivoire. The selected leafy vegetables were subjected to sun drying for 1, 2 and 3 days (8 hours/day) and the physicochemical properties were determined using standard methods. The proximate analysis showed the following results after 3 days of sun-drying: moisture (4.62 ± 1.53-8.36 ± 2.77%), ash (8.69 ± 0.28-24.85 ± 0.19%), proteins (7.62 ± 0.02-11.51 ± 0.03%) and crude fiber (13.11 ± 3.11-32.19± 0.45%). The residual contents of minerals after 3 days of sun drying were: calcium (87.17±5.40- 459.12±9.46 mg/100g), magnesium (64.50±1.85- 338.79±4.84 mg/100g), phosphorus (108.26±0.99-297.68±6.16 mg/100g), potassium (253.37±2.35-833.83±2.08 mg/100g), iron (28.28±1.61-97.53±0.66 mg/100g) and zinc (12.87±2.09-20.55±0.04 mg/100 g). It was also observed that there was a decrease in vitamin C and carotenoids contents with calculated losses estimated to 89-37-97.5% and 69.82-89.03%, respectively after 3 days of sun drying. Contrary to the registered losses, polyphenols content increased with antioxidant activity ranged from 55 to 75%. The high nutrient levels of the dried leafy vegetables make them good sources of food for malnourish children and target population. Leafy vegetables consumed in Northern Côte d'Ivoire could be used in many traditional as well as commercial products for added value in order to overcome the health related problems.***

Keywords— Leafy vegetables, sun drying, nutritional value, antioxidant properties

1. INTRODUCTION

Vegetables are succulent edible plant parts that may be eating as supplementary food or side dishes in raw state or in cooked form, alone, with fish or meat stew or soups and various preparations [1]. They contain valuable amount of food ingredients which can be successfully utilized for general body biochemical processes making use of mineral elements, vitamins, proteins, carbohydrates, fibers and hormone precursors of the diet [2]. Green leafy vegetables such as *Amaranthus hybridus "*boronbrou", *Andasonia digitata* "baobab", *Ceiba pentandra* "fromager", *Hibiscus sabdariffa* "dah" and *Vigna unguiculata* "haricot" [3,4, 5] are essential constituents of the diet in most parts of Côte d'Ivoire. Among the twenty hundred and seven (207) leafy vegetables widely consumed in tropical Africa, about twenty (20) species of these belong to 6 botanical families which are widely consumed and cultivated by Ivorian populations [3, 4]. Furthermore, the consumption of these leafy vegetables is linked to the region and ethno-botanical studies have stated that most people in Northern Côte d'Ivoire

Vegetables are perishable products with high moisture content which range between 60.0- 90% [2]. Therefore, appropriate preservation and storage methods should be performed in order to extend to preserve them and improve shelf-life during storage for future consumption [6]. Drying is the process of removal of moisture due to simultaneous heat and mass transfer. It is the classical method of food preservation, which serves lighter weight for transportation and small space for storage [7]. Advantage of this method, if employed for vegetables, is that it can be easily converted into fresh-like form by rehydrating and can be used throughout the year. It facilitates the utilization of the dried leaves in other parts of the country or world where this vegetable is unavailable. Thus, the aim of this study was to evaluate the effect of sun drying on nutrient contents of five indigenous vegetables consumed in Northern Côte d'Ivoire.

2. MATERIAL AND METHODS

2.1 Samples collection

Leafy vegetables (*Amaranthus hybridus, Andasonia digitata, Ceiba pentandra, Hibiscus sabdariffa and Vigna unguiculata*) were collected fresh and at maturity from cultivated farmlands located at Dabou (latitude: 5°19′14″ North; longitude: 4°22′59″West) (Abidjan District). The samples were harvested at the early stage (between one and two weeks of the appearance of the leaves). These plants were previously authenticated by the National Floristic Center (University Felix Houphouët-Boigny, Abidjan-Côte d'Ivoire).

2.2 Samples processing

The fresh leafy vegetables were destalked, washed with deionized water and edible portions were separated from the stalk. The leaves were allowed to drain at ambient temperature and separated into two portions of 250 g each. The first portion was spread on black polythene sheet and dried under the sun (35-38°C) for 1, 2 and 3 days during 8 hours per day. The leaves were constantly turned each hour to avert fungal growth. The second 250 g portion of leaf vegetables was not subjected to any form of drying and used as the control (raw). After drying period, the leaves were crushed in porcelain mortar or ground with a laboratory crusher (Culatti, France) equipped with a 10 µm mesh sieve and stored at refrigerator (4°C) in air-tight containers for further analysis [8]. All further analyses were performed in triplicate in raw and dehydrated samples.

2.3 Nutritive properties

2.3.1 Proximate analysis

Ash, proteins and lipids content of the raw and dehydrated samples were determined using official methods [9]. For crude fibre determination, 2 g of dried powdered samples were successively digested with 50 mL sulphuric acid (0.25 M) and 50 mL sodium hydroxide solution (0.3 M). The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100 °C until a constant weight. The dried residue was then incinerated, and weighed for the determination of crude fibre content. Carbohydrate content and calorific value were calculated using the following formulas [10]:

Carbohydrates: 100 – (% moisture + % proteins + % lipids + % ash + % fibres).

Calorific value: (% proteins x 2.44) + (% carbohydrates x 3.57) + (% lipids x 8.37).

2.3.2 Mineral analysis

The dried powdered samples (5 g) were burned to ashes in a muffle furnace (Pyrolabo, France). The ashes obtained were dissolved in 10 mL of HCL/HNO_3 and transferred into 100 mL flasks and the volume was made up using deionized water. The mineral composition of each sample was determined using an Agilent 7500c inductively coupled argon plasma mass spectrometer (ICP-MS). Calibrations were performed using external standards prepared from a 1000 ppm single stock solution made up with 2 % (v/v) nitric acid.

2.3.3 Anti-nutritional factors determination

Oxalates content was performed using titration method [11]. One (1) g of dried powdered sample was weighed into 100 mL conical flask. A quantity of 75 mL of sulphuric acid (3 M) was added and stirred for 1 h with a magnetic stirrer. The mixture was filtered and 25 mL of the filtrate was titrated while hot against $KMnO_4$ solution (0.05 M) to the end point.

Phytates contents were determined using the Wade's reagent colorimetric method [12]. A quantity (1 g) of dried powdered sample was mixed with 20 mL of hydrochloric acid (0.65 N) and stirred for 12 h with a magnetic stirrer. The mixture was centrifuged at 12 000 rpm for 40 min. An aliquot (0.5 mL) of supernatant was added with 3 mL of Wade's reagent. The reaction mixture was incubated for 15 min and absorbance was measured at 490 nm using a spectrophotometer (PG Instruments, England). Phytates content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

2.3.4 Antioxidant properties

Vitamin C and Carotenoids determination

Vitamin C content was determined by titration [13]. About 10 g of samples were soaked for 10 min in 40 mL metaphosphoric acid-acetic acid (2%, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of distilled water. An amount of 10 mL of this mixture was titrated against 0.5 g/L of dichlorophenol-indophenol (DCPIP).

Carotenoids were extracted and quantified by using spectrophotometric method [14]. Two (2) g of samples were mixed three times with 50 mL of acetone until loss of pigmentation. The mixture obtained was filtered and total carotenoids were extracted with 100 mL of petroleum ether. Absorbance of extracted fraction was then read at 450 nm by using a spectrophotometer (PG Instruments, England). Total carotenoids content was subsequently estimated using a calibration curve of β-carotene (1 mg/mL) as standard. For carotenoids calibration curve determination, absorbances of tubes was read against a blank made of petroleum ether

Polyphenols determination

Polyphenols were extracted and determined using Folin–Ciocalteu's reagent [15]. A quantity (1 g) of dried powdered sample was soaked in 10 mL of methanol 70% (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin–Ciocalteu's reagent and neutralized by 1 mL of 20 % (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve performed with gallic acid (1 mg/mL) as standard.

Antioxidant activity

Antioxidant activity assay was carried out using the 2, 2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method [16]. About 1 mL of 0.3 mM DPPH solution in ethanol was added to 2.5 mL of sample solution (1 g of dried powdered sample mixed in 10 mL of methanol, filtered through Whatman No. 4 filter paper and was allowed to react for 30 min at room temperature. Absorbance values were measured with a spectrophotometer (PG Instruments, England) set at 415 nm. The average absorbance values were converted to percentage antioxidant activity using the following formula:

Antioxidant activity (%) = 100 – [(Abs of sample – Abs of blank) x 100/Abs positive control]

2.3.5 Statistical analysis

All the analyses were performed in triplicate and data were analyzed using EXCEL and STATISTICA 7.1 (StatSoft). Values were expressed as means ± standard deviation.

3. RESULTS AND DISCUSSION

3.1 Proximate composition

Table 1 shows the proximate composition of fresh and sun dried leafy vegetables. The results of physicochemical analysis showed that dehydrated leaf samples became a concentrated source of all the nutrients. Indeed, it was observed an increase in ash, fibres, proteins, lipids and carbohydrates contents after 3 days of sun-drying with significant differences ($p < 0.05$). Drying is known to reduce moisture in order to improve the shelf-life of foods by increasing dry matter [17]. The ash content after one day of sun drying ranged from 2.88 ± 0.01 to 16.18 ± 0.04 % These values were closed to 8.69 ± 0.28 and 24.85±0.19 after three days of sun drying. The higher ash contents of sun dried samples were similar to that reported by some authors [18]. Crude fibre content were higher (13.11-32.19%) for the dried samples after 3 days of exposure to the sun. This indicates that sun dried vegetables contain more fiber than fresh vegetables. This result highlighted that dried leafy vegetables could be of benefit in reducing incidence of constipation and other related diseases because these components are useful for maintaining bulk, motility and increasing intestinal tract [19,20]. Protein contents of the five vegetables increased during drying from 3.98% (*H. sabdariffa*) to 11.51% (*A. digitata*). These results are in agreement with previous studies which showed that dried leaves retained good amounts of protein [21]. Analyzing the studied samples, dried leaves of *A. digitata* and *V. unguiculata* could be considered as sources of proteins with regards to the values (11.51 and 10.85%) obtained after 3 days of sun drying. As concern fat contents (3 days) of the dried leafy vegetables, the values (2.97-6.65%) were higher than their fresh counter parts (0.41-0.84%) but dried leaves could not be considered as a rich source of fat. Carbohydrates content of the five leaves samples was in the range of 26.61- 55.85% after three days of sun drying. Vegetables in their fresh state have been noted to be poor sources of carbohydrate [20]. However, drying processing appears as a method for increasing of carbohydrate contents of vegetables. Indeed, drying processing decrease moisture content of food and therefore increasing the dry matter content [22]. Therefore, consumption of dried leafy vegetables could help to contribute to the energy requirements in human nutrition when supplemented with other foods [23]. Also,this potential could be explored after microbial and toxicological analyses of dried leafy vegetables samples.

Table 1. Proximate composition of sun dried leafy vegetables consumed in Northern Côte d'Ivoire.

	Moisture (%)	Ash (%)	Fibres (%)	Proteins (%)	Lipids (%)	Carbohydrates (%)	Caloric Energy (Kcal/10g)
				H. sabdariffa			
Raw	86.05±1.35a	1.44 ±0.01d	1.99±0.24d	2.02±0.01d	0.66±0.02d	7.86±0.25d	38.54±0.08d
1 days	55.41±3.42b	4.62±0.24c	6.39±0.99c	3.98±0.01c	1.92±0.64c	29.89±1.88c	127.10±1.37c
2 days	20.77±5.98c	8.26±0.34b	11.42±1.24b	7.88±0.01b	4.67±0.03b	48.63±1.53b	227.97±5.79b
3 days	4.62±1.53d	10.05±0.91a	14.17±0.09a	9.92±0.00a	5.84±0.03a	55.85±0.79a	271.35±3.06a

			A. hybridus				
Raw	72.98±0.16a	2.32± 0.36d	4.82± 0.08c	3.59±0.03d	0.58±0.00d	15.76±0.48d	82.61±2.09c
1 days	66.60±4.08b	2.88±0.01c	6.44±1.72b	4.07±0.00c	0.96±0.04c	21.75±1.75c	89.04±5.91c
2 days	20.90±0.63c	7.02±0.05b	15.36±0.05a	8.80±0.01b	2.38±0.01b	47.38±0.00b	206.06±0.06b
3 days	8.02±1.06d	8.69±0.28a	17.93±7.29a	9.46±0.03a	2.97±0.04a	53.68±7.64a	237.74±6.88a
			A. digitata				
Raw	77.63±0.15a	2.45± 0.09c	2.81± 0.10c	4.04±0.02d	0.49±0.00d	12.58±0.28c	59.73±0.89d
1 days	34.67±0.78b	7.20±0.06b	8.42±2.79b	4.75±0.00c	3.14±0.06c	43.47±2.78b	189.01±3.44c
2 days	8.11±3.15c	10.28±0.43a	11.98±0.39a	7.62±0.02b	4.92±0.01b	57.70±0.83a	264.24±5.96b
3 days	4.69±1.12d	10.74±0.19a	13.11±3.11a	11.51±0.03a	6.65±0.04a	53.83±3.27a	274.63±6.03a
			V. unguiculata				
Raw	80.04±0.56a	2.23±0.05d	3.59±0.18c	4.38±0.06d	0.84±0.04d	8.91 ± 0.34c	49.57± 2.06d
1 days	65.86±1.22b	3.82±0.24c	6.25±0.25b	5.70±0.00c	1.70±0.03c	20.42±0.05b	91.89±0.09c
2 days	20.68±8.94c	8.99±1.88b	14.75±2.02b	8.74±0.00b	4.47±0.04b	44.17±3.94a	212.04±3.70b
3 days	8.36±2.77d	10.56±0.13a	17.75±3.42a	10.85±0.01a	5.46±0.04a	47.92±3.34a	241.08±1.56a
			C. pentandra				
Raw	70.45±0.52a	7.58 ± 0.33c	9.30± 0.44d	4.49 ± 0.00c	0.41±0.06c	7.77±0.03c	42.14±2.29c
1 days	34.36±0.06b	16.18±0.04b	20.27±1.91c	5.60±0.03b	2.32±0.01b	20.36±1.87b	100.66±6.71b
2 days	7.79±0.77c	23.90±0.15a	30.37±1.60b	7.13±0.01a	3.74±0.00a	27.62±1.44b	154.97±5.22a
3 days	4.94±1.09d	24.85±0.19a	32.19±0.45a	7.63±0.01a	4.15±0.03a	26.61±0.21a	147.45±1.10a

Data are represented as means ± SD (n=3). Means in the column for each leafy vegetable with no common letter differ significantly (p<0.05).

3.2 Mineral composition

Mineral content is an essential component of the nutritive value of green leafy vegetable. Table 2 showed the mineral composition of fresh and sun dried leafy vegetables. The residual contents of minerals after three days on sun dried were: calcium (87.17±5.40- 459.12±9.46 mg/100g), magnesium (64.50±1.85- 338.79±4.84 mg/100g), phosphorus (108.26±0.99-297.68±6.16 mg/100g), potassium (253.37±2.35-833.83±2.08 mg/100g), iron (28.28±1.61-97.53±0.66 mg/100g) and zinc (12.87±2.09-20.55±0.04 mg/100 g). There was a significant increase ($p < 0.05$) in the mineral contents of leafy vegetables after sun drying. Mineral profile of foods is important because micronutrient deficiency also referred as hidden hunger is a major problem in developing countries. Considering the recommended dietary allowance (RDA) for minerals, consumption of sun dried leafy vegetables (3 days) could cover at least 50% RDA [24]. Therefore, they could contribute substantially for improving human diet and alleviate malnutrition linked to micronutrient deficiency. It is important noting that calcium and phosphorus are associated for growth and maintenance of bones, teeth and muscles while potassium may play a role in decreasing blood pressure [25,26]. Increasing potassium in the diet may protect against hypertension in people who are sensitive to high levels of sodium. As concern magnesium, this mineral is known to prevent cardiomyopathy, muscle degeneration, growth retardation, congenital malformations and bleeding disorders [27]. Iron is important in the diet of pregnant, infants and the elderly to reduce cases of deficiency associated with disease such as anemia while zinc is important for vitamin A and vitamin E metabolism [24, 25, 28].

Table 2. Mineral composition (mg/100g) of raw and sun dried leafy vegetables consumed in Northern Côte d'Ivoire

	Ca^{2+}	Mg^{2+}	$PO4^{3-}$	K^{+}	Fe^{2+}	Na^{+}	Zn^{2+}
				H. sabdariffa			
Raw	56.22±0.07b	41.37±0.06c	56.98±0.00d	114.10±0.16d	14.27±0.02d	3.28 ±0.00c	3.64±0.00d
1 day	79.65±2.09a	42.01±2.26c	81.88±1.76c	164.45±2.69c	15.70±0.59c	8.22±3.02b	9.70±0.00c
2 days	80.48±1.95a	55.52±5.53b	104.98±2.74b	198.52±1.87b	21.49±0.43b	10.69±3.48a	11.32±0.04b
3 days	87.17±5.40a	64.50±1.85a	123.78±2.83a	253.37±2.35a	28.28±1.61a	12.70±5.04a	18.78±0.02a
				A. hybridus			
Raw	252.45±0.15d	134.74±0.13d	99.80±0.00d	538.51±0.57d	21.08±0.01d	25.55±0.01d	8.59±0.01d
1 day	301.60±2.69c	166.35±1.35c	123.29±0.28c	564.66±0.59c	26.18±0.03c	32.24±0.17c	10.61±0.00c
2 days	338.59±4.26b	194.91±2.66b	143.79±1.91b	577.04±6.03b	43.32±0.98b	44.31±3.94b	16.28±0.03b
3 days	360.04±5.88a	229.21±5.48a	152.51±0.38a	833.83±2.08a	53.62±1.14a	68.04±4.59a	20.55±0.04a
				A. digitata			

Raw	111.01±0.49d	59.14±0.26d	170.38±0.00d	415.39±1.84d	23.77±0.10d	8.30± 0.03d	5.06± 0.02c
1 day	124.56±1.77c	72.99±6.47c	197.60±7.82c	513.20±3.52c	29.87±0.15c	11.93±2.27c	7.94±0.01b
2 days	177.52±6.16b	95.26±3.60b	230.35±4.07b	707.28±2.50b	38.92±2.20b	20.44±1.70b	9.23±0.07a
3 days	274.99±6.87a	155.71±6.84a	297.68±8.16a	772.44±5.10a	53.08±0.27a	26.75±1.74a	12.87±2.09a
				V. unguiculata			
Raw	87.73±0.11d	63.13±0.03d	61.68±0.00d	143.33± 0.18d	18.25±	6.65 ±0.00d	6.92±0.00d
1 day	102.00±1.56c	76.94±2.24c	86.10±2.92c	245.27±1.85c	0.02d	7.33±0.19c	8.02±0.02c
2 days	109.68±1.19b	82.21±5.35b	98.33±3.49b	270.61±2.1b0	21.37±0.21c	9.30±1.57b	10.22±0.32b
3 days	154.99±7.50a	116.32±9.51a	108.26±0.99a	261.20±1.90a	33.61±1.45b	12.61±2.67a	15.62±0.02a
					45.85±0.40a		
				C. pentandra			
Raw	294.62±0.16d	228.58±0.13d	168.69±0.62d	468.54±0.26d	64.96±0.03d	12.61±0.00c	10.54±0.00c
1 day	324.59±5.96c	285.21±4.04c	197.99±4.29c	493.36±6.28c	67.86±0.04c	15.38±1.24b	12.38±0.01b
2 days	360.25±4.97b	315.77±6.53b	227.67±3.88b	563.96±3.58b	74.54±0.29b	23.56±1.22a	13.24±0.01a
3 days	459.12±9.46a	338.79±4.84a	245.50±1.19a	709.72±7.58a	97.53±0.66a	27.22±2.50a	16.42±0.03a

Data are represented as means ± SD (n=3). Means in the column for each leafy vegetable with no common letter differ significantly ($p<0.05$).

To predict the bioavailability of calcium (Ca) and iron (Fe), anti-nutrients to nutrients ratios of were calculated (Table 3). It was observed a high increase of anti-nutritional factors (oxalates and phytates) in the sun dried samples compared to the fresh green leafy vegetables (Figure 1). After 3 days of sun drying, oxalates content was in the range 600-1100 mg/100g while that of phytates varied from 20 to 80 mg/100g. Excepted for *H. sabdariffa* dried leaves, the calculated [oxalates]/[Ca] and [phytates]/[Fe] ratios in all the species, were below the critical levels of 2.5 and 0.4 respectively known to impair calcium and iron bioavailability [29,30]. This implies that phytates and oxalates contents of *H. sabdariffa* dried leaves would have deleterious effects on human nutrition. However, these relatively higher contents of phytates and oxalates could be considerably reduced after processing such as soaking, boiling or frying [31].

Table 3. Anti-nutritional factors/mineral ratios of sun dried leafy vegetables consumed in Northern Côte d'Ivoire.

	Phytates/Ca	Phytates/Fe	Oxalates/Ca
		H. sabdariffa	
Raw	0.21	0.85	3.26
1 day	0.11	0.83	2.80
2 days	0.09	0.76	2.84
3 days	0.08	0.71	2.84
		A. hybridus	
Raw	0.01	0.41	0.07
1 day	0.02	0.37	0.07
2 days	0.02	0.31	0.06
3 days	0.01	0.27	0.06
		A. digitata	
Raw	0.04	0.19	1.57
1 day	0.03	0.15	1.44
2 days	0.02	0.11	1.46
3 days	0.02	0.11	1.41
		V.unguiculata	
Raw	0.04	0.19	1.66
1 day	0.03	0.17	1.55
2 days	0.02	0.12	1.53
3 days	0.02	0.11	1.45
		C. pentandra	
Raw	0.04	0.17	0.78
1 day	0.03	0.16	0.77
2 days	0.03	0.13	0.72
3 days	0.03	0.14	0.69

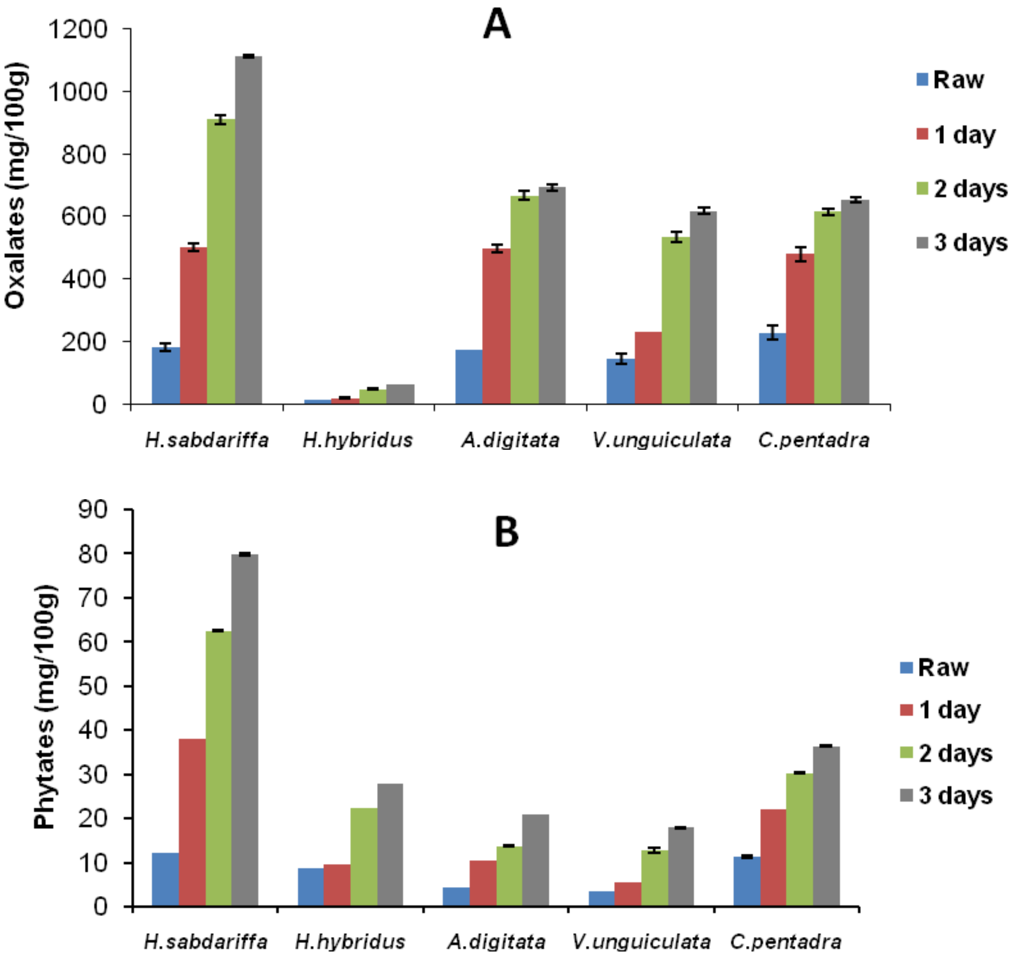

Figure 1. Oxalates (A) and phytates (B) contents of sun dried leafy vegetables consumed in Northern Côte d'Ivoire.

3.3 Antioxidant properties

Sun drying resulted in high decrease of carotenoids and vitamin C contents in the studied leafy vegetables (Figure 2). Carotenoids are precursors of vitamin A and play an important role in human health by acting as biological antioxidants while vitamin C is known as soluble antioxidant component [32]. Loss of carotenoids of the studied green leafy vegetables (*H. sabdariffa, A. hibiscus, A. digitata, V. unguiculata and C. pentandra*) ranged from 34.61 to 51.29% at one day of sun drying and 69.82 to 89.03% on the 3rd day. For vitamin C, the registered losses ranged from 39.57 to 89.3% at one day of sun-druing and 89.37 to 97.5% at three days of sun drying. During drying by exposure to the sun, factors such as heat, light and oxygen accelerate the rate of oxidation of carotenoids and vitamin C present in the vegetables [33, 34, 35]. With regards to the lowest retention levels of carotenoids and vitamin C, the dried leaves may be consumed through appropriate recipes in order to cover vitamin A and vitamin C requirements in human nutrition.

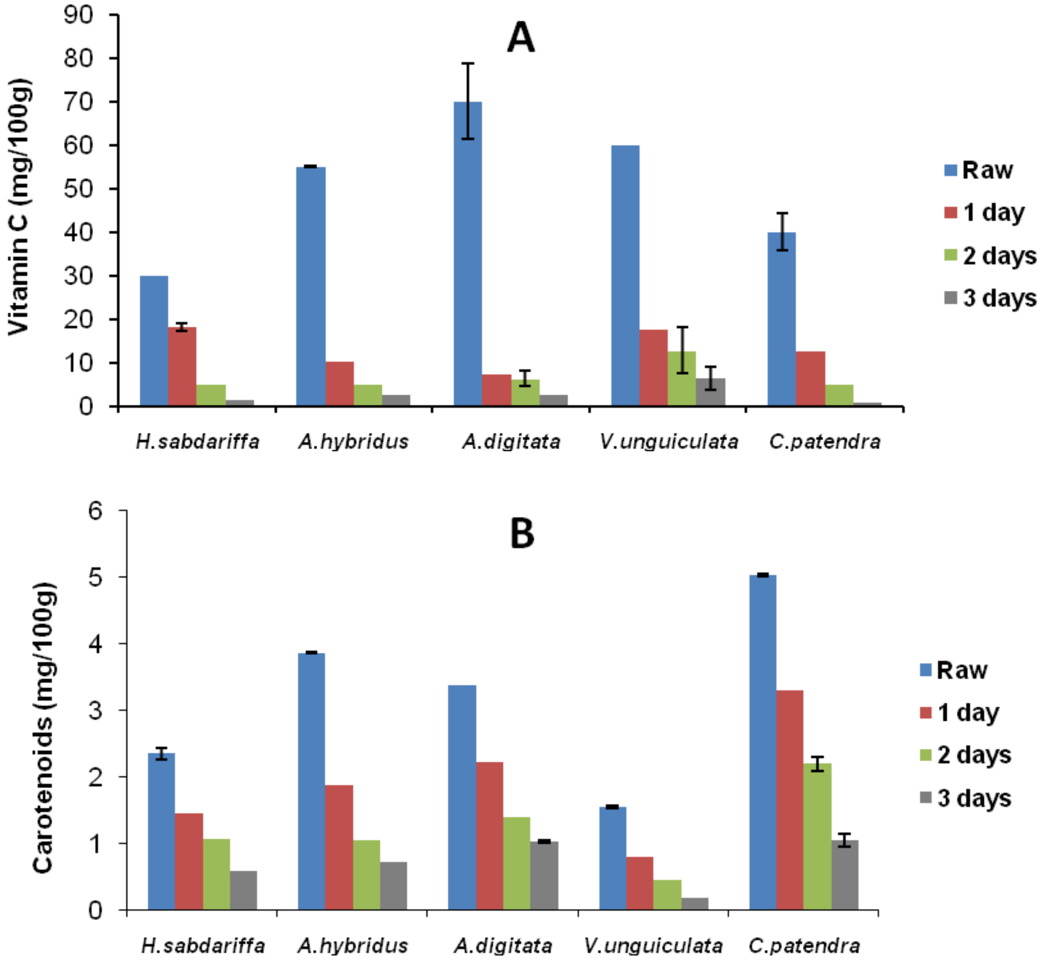

Figure 2: Vitamin C (A) and carotenoids (B) contents sun dried leafy vegetables consumed in Northern Côte d'Ivoire

The effect of sun drying on polyphenols content and antioxidant activity of the selected leafy vegetables is shown in (Figure 3). It was observed a high increase of polyphenols contents was coupled with antioxidant activity (55-75%) in the dried samples. The increase of phenolics content during sun dried may be due to breakdown of tough cell walls when vegetables and this fact could be advantageous for lower cellular oxidative stress which has been implicated in the manifestation of various neurodegenerative diseases, including Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis [36, 37].

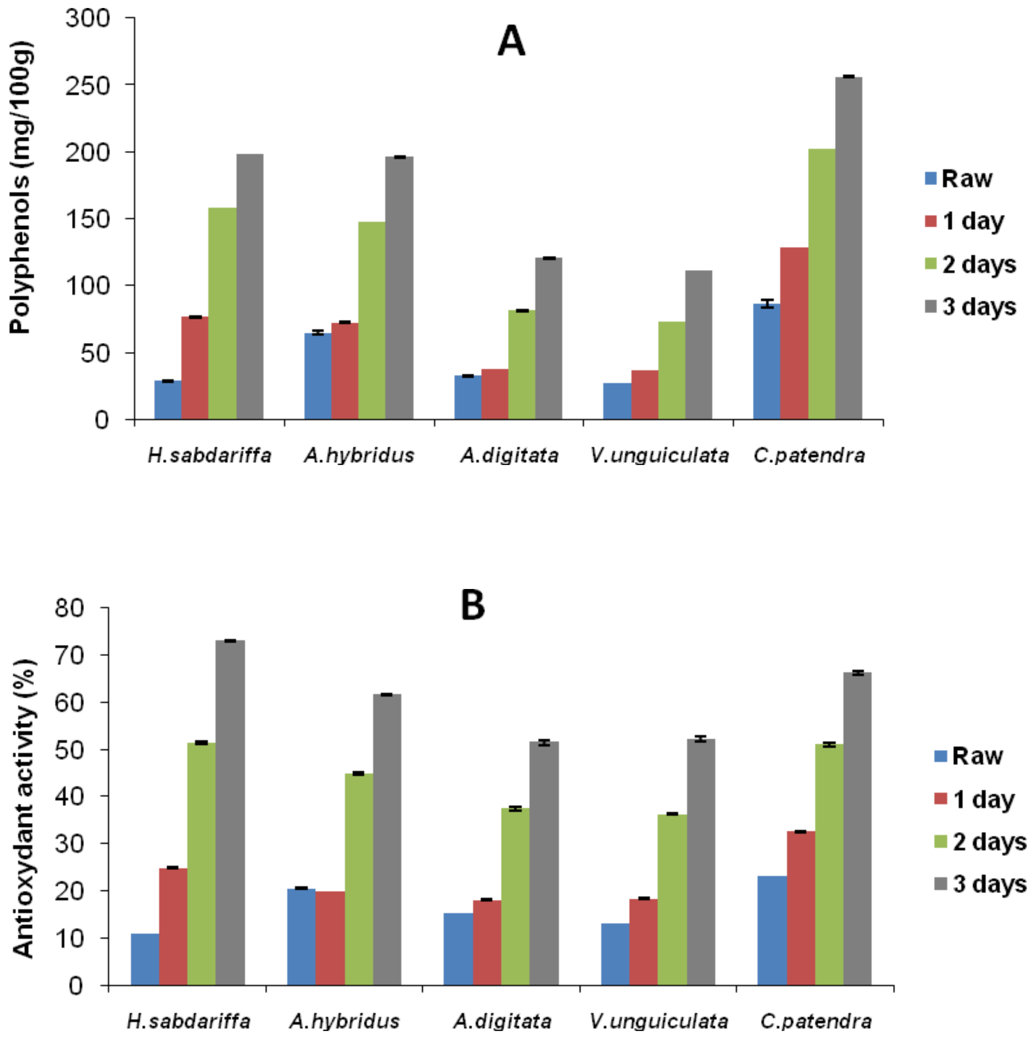

Figure 3: Polyphenols content (A) and antioxidant activity (B) of sun dried leafy vegetables consumed in Northern Côte d'Ivoire.

4. CONCLUSION

The nutrients contents of sun dried leafy vegetables (*H. sabdariffa, A. hibiscus, A. digitata, V. unguiculata and C. pentandra*) were higher than fresh leaves due to the concentration phenomenon. It was also observed a decrease of vitamin and carotenoids due to temperature effect during sun-drying. Dehydration is one of the best methods of preservation of green leafy vegetables which are highly seasonal and perishable foods. Being rich in essential micro – nutrients, the dried green leafy vegetables could be utilized for the purpose of enrichment deficient products. Leafy vegetables consumed in Northern Côte d'Ivoire may be used in many traditional as well as commercial products for added value in order to overcome the health related problems. In addition, it would be interesting to compare the effects of various drying methods on the nutritive potential of traditional leafy vegetables.

5. ACKNOWLEDGEMENT

Authors are grateful to Biotechnology Laboratory, Biosciences Department of University Felix Houphouet-Boigny, Abidjan (Côte d'Ivoire) for the technical support of this work.

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