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EFFECT OF SUN DRYING ON NUTRITIVE AND ANTIOXIDANT PROPERTIES OF FIVE LEAFY VEGETABLES CONSUMED IN SOUTHERN CÔTE D'IVOIRE

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Abstract: *This study aimed to evaluate the effect of sun drying on nutrient and antioxidant properties of five leafy vegetables (Basella alba, Colocasia esculenta, Solanum melongena, Talinum triangulare and Corchorius olitorus) commonly used in Southern Côte d'Ivoire. The result of this study revealed that sun drying increased some nutrient contents by concentration phenomenon after 1, 2 and 3 days at 30-32 °C. Ash, fibres, proteins, lipids and carbohydrates contents varied after 3 days of sun drying as follow: 10.12 ± 0.00 to 25.78 ± 0.00 %, 16.50 ± 0.00 to 29.81 ± 0.01 %, 16.67 ± 0.01 to 23.68 ± 0.00 %, 6.28 ± 0.00 to 14.24 ± 0.00 % and 10.21 ± 0.00 to 37.68 ± 0.00 %. The mineral contents increased with respective values after 3 days of sun drying: calcium (82.86-481.65 mg/100 g), magnesium (81.98-298.46 mg/100 g), phosphorus (63.41-297.69 mg/100 g), potassium (419.81-993.41 mg/100 g), iron (20.05-90.37 mg/100 g), sodium (19.43-150.51 mg/100 g) and zinc (15.76-64.39 mg/100 g). However, anti-nutritional factors such as oxalates varied from 123.01 to 815.97 mg/ 100 g for the same period of drying. Losses of vitamin C and carotenoids were estimated to 85.12-96.42% and 98-100% respectively. Contrary to these losses, the antioxidant activity increased and ranged from 75.92 to 82.30% after 3 days of sun drying. All these results suggest that sun drying technique could contribute efficiently to the nutritional requirements and to the food security of Ivorian population.*

Keywords:*Sun drying, Nutritive value, Antioxidant properties, Leafy vegetables.*

1. Introduction

Hunger and malnutrition threaten millions of people in sub-Saharan andthe increase in consumption of African leafy vegetables (ALVs) can have a positive effect on nutrition, health and economic well-being of both rural and urban populations [1]. Traditional African Leafy vegetables are eaten by many African families because they are rich in micro nutrients needed by humans for good health, growth and development [2]. These plants occupy an important place among the food crops as they provide adequate amounts of many vitamins and minerals for humans[3]. The ethno-botanical reports offers information on medicinal properties of ALVs like anti-diabetic, anti-histaminic, anti-carcinogenic, hypolipidemic and antibacterial activity [4,5]. However ways of leafy vegetables preparation and preservation may affect significantly the concentration and availability of minerals, vitamins and other essential compounds. Indeed, losses of nutrients from vegetables during drying and cooking have been noted in previous studies[6, 7].Drying is the process of removal of moisture due to simultaneous heat and mass transfer actions. It is the classical method for food preservation which serves lighter weight for transportation and small space for storage[8].Apart from moisture losses, the changes in organoleptic quality of dried vegetables are: optical properties (colour, appearance), sensory properties (odour, taste, flavour), and structural properties (density, porosity, specific volume, textural properties). Dried vegetables are generally tasty, nutritious, lightweight, easy-to prepare, and easy-to-store and use[9]. In rural areas of Southern Côte d'Ivoire (Ivory Coast) were population are not provided by refrigerator, sun drying is the method used for the preservation of leafy vegetables before their consumption through recipes made of sauces and starchy staples foods[10]. Ethno-botanical studies have stated that most people in Southern Côte d'Ivoire consume indigenous green leafy vegetables such as *Basella alba* "epinard", *Colocasia esculenta* "taro", *Corchorus olitorius* "kplala", *Solanum melongena* "aubergine" and *Talinum triangulare* "mamichou" [11, 12, 13]. Earlier reports have highlighted the nutritive potential of these fresh leafy vegetables [14] but there is a lack of scientific data with regards to the effect of sun drying methods on their physicochemical and nutritive characteristics. The aim of this study was to determine the effect of sun drying method on chemical composition of five leafy vegetables consumed in Southern Côte d'Ivoire.

2. Matherials and methods

2.1Materials

2.1.1 Samples collection

Leafy vegetables(*Basella alba*, *Colocasia esculenta*, *Corchorus olitorius*, *Solanum melongena* and *Talinum triangulare*) 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).

2.1.2 Samples processing

The fresh leafy vegetables were destalked, washed with deionized water and edible portions were separated from the inedible portion. The edible portions 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 [15]. The leaves were constantly turned to avert fungal growth. The second 250 g portion of leafy vegetables was not subjected to any form of drying and used as the control (raw). After drying period, the dried leaves were ground with a laboratory crusher (Culatti,France) equipped with a 10 µm mesh sieve and stored in air-tight containers for further analysis.

2.2 Methods

2.2.1 Nutritive properties

2.2.1.1 Proximate analysis

Proximate analysis was performed using official methods [16]. The moisture content was determined by the difference of weight before and after drying the sample (10 g) in an oven (Memmert, Germany) at 105°C until constant weight. Ash fraction was determined by the incineration of dried sample (5 g) in a muffle furnace (Pyrolabo, France) at 550°C for 12 h. The percentage residue weight was expressed as ash content. For crude fibres, 2 g of sample were weighed into separate 500 mL round bottom flasks and 100 mL of 0.25 M sulphuric acid solution was added. The mixture obtained was boiled under reflux for 30 min. Thereafter, 100 mL of 0.3 M sodium hydroxide solution was added and the mixture were boiled again under reflux for 30 min and filtered through Whatman paper. The insoluble residue was then incinerated, and weighed for the determination of crude fibres content. Proteins were determined through the Kjeldhal method and the lipid content was determined by Soxhlet extraction using hexane as solvent. Carbohydrates and calorific value were calculated using the following formulas [17]:

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

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

2.2.1.2 Mineral analysis

Minerals contents were determined by the ICP-MS (inductively coupled argon plasma mass spectrometer) method [18].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 argon plasma mass spectrometer. Calibrations were performed using external standards prepared from a 1000 ppm single stock solution made up with 2% nitric acid.

2.2.1.3 Anti-nutritional factors determination

Oxalates content was performed by using a titration method [19]. 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 [20]. 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. The mixture was centrifuged at 12000 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 by using a spectrophotometer (PG Instruments, England). Phytates content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

2.2.2 Antioxidant properties

2.2.2.1 Vitamin C and carotenoids determination

Vitamin C contained in analyzed samples was determined by titration [21]. About 10 g of ground fresh leaves 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 bi-distilled water. Ten (10) mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L.

Carotenoids were extracted and quantified following a spectrophotometric method [22]. Two (2) g of ground fresh leaves 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.

2.2.2.2 Polyphenols determination

Polyphenols were extracted and determined using Folin–Ciocalteu's reagent [23]. 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 by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of gallic acid (1 mg/mL) as standard.

2.2.2.3 Antioxidant activity

Antioxidant activity assay was carried out using the 2, 2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method [24]. 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]

2.2.3 Statistical analysis

All the analyses were performed in triplicate and data were expressed as mean ± standard deviation (SD). Data were analyzed using EXCELL and STATISTICA 7.1 (StatSoft). Differences between means were evaluated by Duncan's test. Statistical significant difference was stated at $p < 0.05$.

3. Results and discussion

Nutritive and anti-nutritive properties:The results of moisture, ash, fibre, protein, lipid, carbohydratecontents are presented in Table 1.

Table 1:
Proximate composition of sun dried leafy vegetables consumed in Southern Côte d'Ivoire

	Moisture (%)	Ash (%)	Fibres (%)	Proteins (%)	Lipids (%)	Carbohyd. (%)	Energy (kcal /100g)
C. esculenta							
Raw	82.35 ± 2.83a	2.65 ± 0.00d	4.23 ± 0.01d	1.72 ± 0.00d	1.47 ± 0.00d	7.56 ± 0.70d	44.53 ± 0.04d
1 day	58.43 ± 1.12b	6.58 ± 0.00c	10.46 ± 0.02c	5.72 ± 0.02c	3.69 ± 0.00c	15.09 ± 0.08c	98.81 ± 0.03c
2 days	19.42 ± 0.70c	13.05 ± 0.00b	23.07 ± 0.01b	13.73 ± 0.02b	7.51 ± 0.00b	23.18 ± 0.05a	179.18 ± 0.04b
3 days	9.79 ± 1.23d	16.13 ± 0.00a	29.81 ± 0.01a	16.67 ± 0.01a	9.26 ± 0.00a	18.28 ± 0.07b	183.60 ± 0.08a
B. alba							
Raw	89.82 ± 1.24a	2.01 ± 0.00d	1.67 ± 0.00d	1.00 ± 0.00d	0.69 ± 0.00d	4.78 ± 0.10d	25.36 ± 0.02d

1 day	76.08 ± 2.72b	5.09 ± 0.02c	4.46 ± 0.00c	3.26 ± 0.06c	2.03 ± 0.00c	9.05 ± 0.70c	57.36 ± 0.13c
2 days	31.52 ± 1.37c	15.58 ± 0.01b	16.07 ± 0.00b	12.84 ± 0.03b	8.43 ± 0.00b	15.52 ± 0.50a	157.44 ± 0.06b
3 days	12.07 ± 0.29d	22.36 ± 0.00a	23.83 ± 0.00a	17.24 ± 0.00a	14.24 ± 0.00a	10.21 ± 0.10b	197.79 ± 0.00a
S. melongena							
Raw	74.38 ± 0.72a	5.20 ± 0.01d	3.50 ± 0.00d	3.16 ± 0.00d	0.69 ± 0.00d	13.04 ± 0.02d	71.11 ± 0.09c
1 day	17.71 ± 0.65b	17.69 ± 0.00c	12.07 ± 0.00c	14.06 ± 0.01c	2.44 ± 0.00c	36.59 ± 0.05a	185.45 ± 0.02b
2 days	13.01 ± 1.93c	20.29 ± 0.01b	13.59 ± 0.02b	17.27 ± 0.04b	6.38 ± 0.00b	29.42 ± 0.08b	200.64 ± 0.03a
3 days	8.43 ± 0.90d	24.56 ± 0.00a	17.01 ± 0.00a	19.90 ± 0.01a	9.17 ± 0.00a	20.88 ± 0.50c	199.98 ± 0.03a
T. triangulare							
Raw	90.20 ± 0.21a	2.17 ± 0.00d	1.37 ± 0.00d	1.68 ± 0.00d	0.48 ± 0.00d	5.17 ± 0.01c	26.58 ± 0.01d
1 day	65.77 ± 0.57b	8.47 ± 0.00c	4.98 ± 0.00c	6.01 ± 0.00c	1.75 ± 0.00c	12.98 ± 0.05b	75.79 ± 0.00c
2 days	28.43 ± 1.27c	19.28 ± 0.00b	11.00 ± 0.00b	13.21 ± 0.00b	5.51 ± 0.00b	22.53 ± 0.70a	158.9 ± 0.02b
3 days	9.96 ± 0.30d	25.78 ± 0.00a	16.50 ± 0.00a	18.17 ± 0.00a	7.33 ± 0.00a	22.22 ± 0.02a	185.12 ± 0.00a
C. olitorius							
Raw	84.28 ± 0.34a	1.34 ± 0.00d	1.80 ± 0.00d	3.32 ± 0.00d	0.51 ± 0.00d	8.73 ± 0.01c	43.60 ± 0.00d
1 day	30.40 ± 4.03b	6.22 ± 0.00c	8.84 ± 0.00c	15.70 ± 0.00c	2.30 ± 0.00c	36.50 ± 0.50b	187.94 ± 0.00c
2 days	14.93 ± 4.82c	8.26 ± 0.00b	13.16 ± 0.00b	20.15 ± 0.00b	4.57 ± 0.00b	38.89 ± 0.50a	226.33 ± 0.00b
3 days	5.55 ± 0.30d	10.12 ± 0.00a	16.64 ± 0.00a	23.68 ± 0.00a	6.28 ± 0.00a	37.68 ± 0.01a	244.95 ± 0.00a

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

The moisture contents ranged between 5.55-12.07 % after 3 days. Moisture generally refers to the presence of water, often in trace amounts [25]. High moisture content in vegetables is indicative of freshness as well as easy perishability [26]. Higher moisture content of vegetables also suggests that the vegetable could not be stored for long time without microbial spoilage [27,28]. During drying, warm temperatures cause the moisture to move quickly from the food to the air [29].The low moisture content of the dried vegetables makes them suitable for longer storage period [25]. Ash is defined as the inorganic residue remaining after the water and organic matter [30,31]. In this study, ash content was found to be in the range of 1.34-5.20 % (fresh leaves) and 10.12-25.78 % (dried leaves) after 3 days. These results suggest that the dehydration could retain more minerals which may be benefit for consumers.

Indeed, it has been reported that leaves should contain 3 % ash are considered as beneficial human foods [32].The values of fibre contents ranged from 4.46 ± 0.00 % to 12.07 ± 0.00 after 1 day and from 16.50 ± 0.00 % to 29.81 ± 0.01 % after 3 days of sun-drying. The higher fibre contents may be advantageous since their consumption could enhance digestion and prevent constipation. High crude fibre in the vegetable according could also help in blood cholesterol attenuation, as well as blood glucose attenuation when consumed [33,34,35]. The protein contents in the five dehydrated samples were in the ranged of 3.26-5.72 %, 12.84-20.15 % and 16.67-23.68 % after 1, 2 and 3 days respectively. The sun drying method increased protein content of the studied vegetables compared to their controls. The increase in protein was due to loss of moisture during drying processing. Many workers had reported similar phenomenon [36]. It is known that loss of moisture increases nutrient content and extends keeping quality of the food [37]. Protein helps in building and maintaining all tissues in the body, forms an important part of enzymes, fluids and hormones of the body [38]. Plant proteins may be less digestible because of intrinsic differences in the nature and the presence of other factors such as fibre, which may reduce protein digestibility.Nevertheless, dietary studies show the adequacy of plant foods, as sole sources of protein [39]. The lipids contents after 3 days of drying were in the range 6.28-14.24 %. The lipid content of dried leaf samples were also higher than their fresh counter parts but leafy vegetables could not be considered as rich source of fat [40, 41]. The relatively low lipid content of the dried vegetables makes them suitable for people who suffer from heart related diseases [25]. Vegetables in their fresh state have been noted to be poor sources of carbohydrate [40,42,43]. However, after drying, carbohydrate content increased and varied from 10.21 to 37.68 % after 3 days of sun drying. Carbohydrates are the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake [44,45]. The low caloric values obtained in this study could be explained to low proteins, lipids and total carbohydrate contents. The result of anti-nutritional factors (oxalates and phytates) contents of the sun dried leafy vegetables were presented in Fig.1.

The values ranged within 123.01-815.97 mg/ 100 g and 0.65-3.60 mg/100 g after 3 days of sun drying for oxalates and phytates, respectively. Contrary to the phytate contents, oxalates content increased with sun drying time compared to their controls. Oxalates and phytates are considered as anti-nutritionnal factors because of their ability to chelate minerals such as calcium, iron, magnesium and zinc [46,47].

***Mineral composition*:** Sun drying method had concentration effect on mineral composition of leafy vegetables consumed in Southern Côte d'Ivoire (Table 2). Levels minerals contents were as follow: calcium (82.86-481.65 mg/100 g), magnesium (81.98-298.46 mg/100 g), phosphorus (63.41-297.69 mg/100 g), potassium (419.81-993.41 mg/100 g), iron (20.05-90.37 mg/100 g), sodium (19.43-150.51 mg/100 g) and zinc (15.76-64.39 mg/100 g) after 3 days. With regards to the recommended dietary allowances (RDA) as mg/day/person for minerals, the level of iron and zinc in the samples could cover RDA and contribute substantially for improving human diet [48,49,50].

Iron is known to be an essential part of red blood cells (haemoglobin) and enzymes (cytochromes) and consumption of these leafy vegetablescould reduce considerably the risk of anaemia [51]. To predict the effect of phytates and oxalates on nutrients, anti-nutritional factors/minerals ratios were calculated (Table 3).

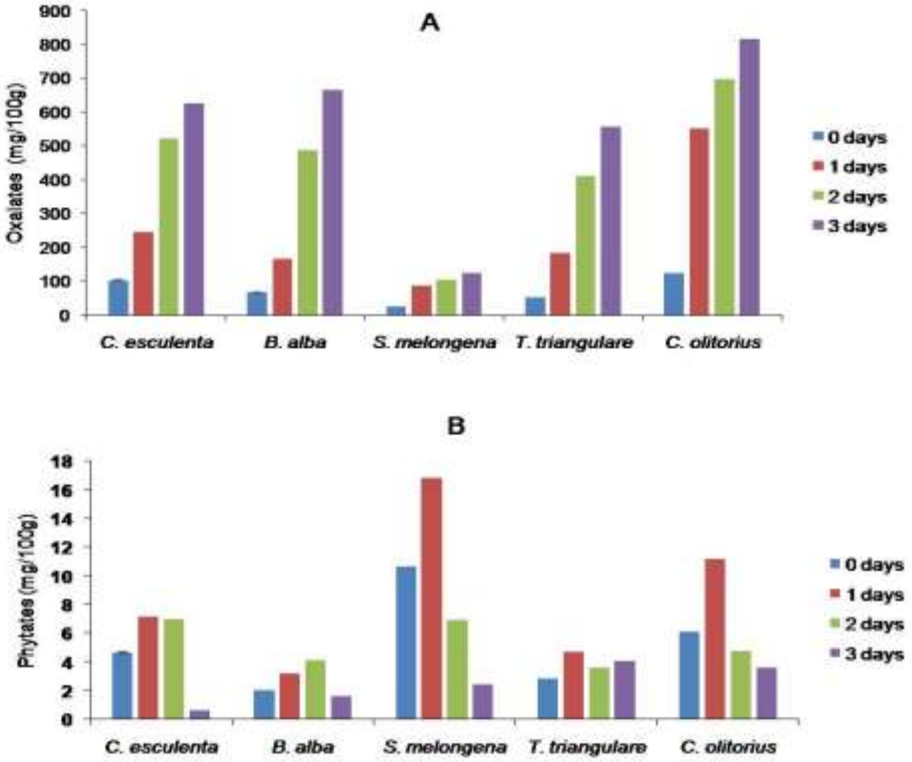

Fig.1. Effect of sun drying on oxalate (A) and phytate (B) contents of leafy vegetables consumed in Southern Côte d'Ivoire

The calculated phytates/ calcium, phytates/iron and oxalates/calcium ratios of the studied leafy vegetables were below the critical level of 0.5, 0.4 and 2.5, respectively [44]. This implies that phytates and oxalates contents of the dried leaves would have deleterious effects on human nutrition.

Table 2.

Mineral composition of sun dried leafy vegetables consumed in Southern Côte d'Ivoire

	Ca	Mg	P	K	Fe	Na	Zn
				C. esculenta			
Raw	103.64 ± 0.01c	61.29 ± 0.00d	139.08 ± 0.02d	402.70 ± 0.06d	25.30 ± 0.00d	6.96 ± 0.00d	6.58 ± 0.00d
1 day	247.21 ± 0.02b	150.70 ± 0.02c	238.91 ± 0.02c	562.68± 0.03c	63.43 ± 0.01c	10.84 ± 0.02c	10.43 ± 0.01c
2 days	302.53 ± 0.02a	156.58 ± 0.01b	274.64 ± 0.01b	577.03 ± 0.02b	67.71 ± 0.01b	18.16 ± 0.01b	10.92 ± 0.00b
3 days	302.13 ± 0.05a	171.21 ± 0.04a	297.69 ± 0.04a	628.14 ± 0.04a	73.98 ± 0.00a	19.43 ± 0.02a	15.76 ± 0.01a
				B. alba			
Raw	76.38 ± 0.00d	76.74 ± 0.00d	39.71 ± 0.00d	275.31 ± 0.02d	7.88 ± 0.00d	56.50 ± 0.07d	6.84 ± 0.00d

1 day	102.47 ± 0.07c	81.83 ± 0.09c	95.74 ± 0.05c	349.64 ± 0.06c	10.26 ± 0.00c	84.95 ± 0.08c	17.46 ± 0.03c
2 days	135.49 ± 0.03b	105.44 ± 0.05b	104.77 ± 0.02b	387.98 ± 0.04b	19.64 ± 0.00b	101.08 ± 0.05b	19.07 ± 0.02b
3 days	175.16 ± 0.00a	107.95 ± 0.00a	136.63 ± 0.40a	419.81 ± 0.00a	20.05 ± 0.00a	135.90 ± 0.01a	27.59 ± 0.00a
S. melongena							
Raw	204.07 ± 0.00d	123.46 ± 0.00d	95.93 ± 0.00d	578.01 ± 0.01d	35.73 ± 0.00d	82.78 ± 0.02d	16.58 ± 0.00d
1 day	380.48 ± 0.01c	208.71 ± 0.00c	132.28 ± 0.01c	883.38 ± 0.01c	60.63 ± 0.01c	92.47 ± 0.01c	31.65 ± 0.00c
2 days	423.80 ± 0.07b	269.47 ± 0.02b	168.66 ± 0.04b	893.15 ± 0.04b	66.66 ± 0.00b	103.57 ± 0.05b	45.71 ± 0.00b
3 days	481.65 ± 0.02a	298.46 ± 0.01a	171.56 ± 0.02a	993.41 ± 0.02a	90.37 ± 0.01a	150.51 ± 0.01a	64.39 ± 0.00a
T. triangulare							
Raw	58.93 ± 0.00d	74.08 ± 0.00d	23.47 ± 0.00d	495.21 ± 0.00d	10.02 ± 0.00d	25.50 ± 0.00d	3.53 ± 0.00d
1 day	69.81 ± 0.02c	80.76 ± 0.00c	33.41 ± 0.00c	637.37 ± 0.02c	37.10 ± 0.00c	32.75 ± 0.01c	16.74 ± 0.00c
2 days	70.27 ± 0.03b	84.90 ± 0.03b	48.38 ± 0.00b	656.79 ± 0.04b	42.94 ± 0.01b	38.13 ± 0.02b	23.27 ± 0.01b
3 days	82.86 ± 0.00a	92.22 ± 0.00a	63.41 ± 0.00a	672.83 ± 0.01a	46.93 ± 0.00a	47.39 ± 0.00a	29.51 ± 0.00a
C. olitorius							
Raw	58.00 ± 0.00d	36.86 ± 0.00d	49.80 ± 0.00d	412.26 ± 0.05d	15.34 ± 0.00d	4.36 ± 0.00d	3.88 ± 0.00d
1 day	78.96 ± 0.00c	54.45 ± 0.00c	58.38 ± 0.00c	447.80 ± 0.00c	26.03 ± 0.00c	19.07 ± 0.00c	5.59 ± 0.00c
2 days	83.37 ± 0.02b	63.69 ± 0.00b	63.02 ± 1.35b	473.83 ± 0.03b	33.44 ± 0.00b	25.86 ± 0.01b	15.77 ± 0.00b
3 days	86.83 ± 0.01a	81.98 ± 0.00a	72.20 ± 0.00a	549.90 ± 0.01a	42.61 ± 0.00a	37.82 ± 0.00a	30.24 ± 0.00a

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

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

	Phytates/Ca	Phytates/Fe	Oxalates/Ca
C. esculenta			
Raw	0.04	0.18	0.99
1 day	0.03	0.11	0.99
2 days	0.01	0.05	1.04
3 days	0.01	0.01	1.04
B. alba			
Raw	0.03	0.26	0.87
1 day	0.02	0.16	0.91
2 days	0.01	0.06	0.91
3 days	0.01	0.02	0.94

S. melongena			
Raw	0.05	0.30	0.12
1 day	0.02	0.13	0.13
2 days	0.01	0.04	0.14
3 days	0.01	0.01	0.16
T. triangulare			
Raw	0.05	0.29	0.86
1 day	0.02	0.13	0.87
2 days	0.01	0.04	0.91
3 days	0.01	0.03	0.94
C. olitorius			
Raw	0.11	0.40	2.11
1 day	0.04	0.15	1.79
2 days	0.01	0.05	1.75
3 days	0.01	0.03	1.76

***Antioxidant properties*:**

Antioxidantcomponentsare substances that may protect cells from the damage caused by molecules known as free radicals. Most common antioxidants in vegetables and spices are vitamin C, E, phenolic compounds and carotenoids [52]. Vitamin C and carotenoids contents of the studied leafy vegetables are shown in Fig. 2.

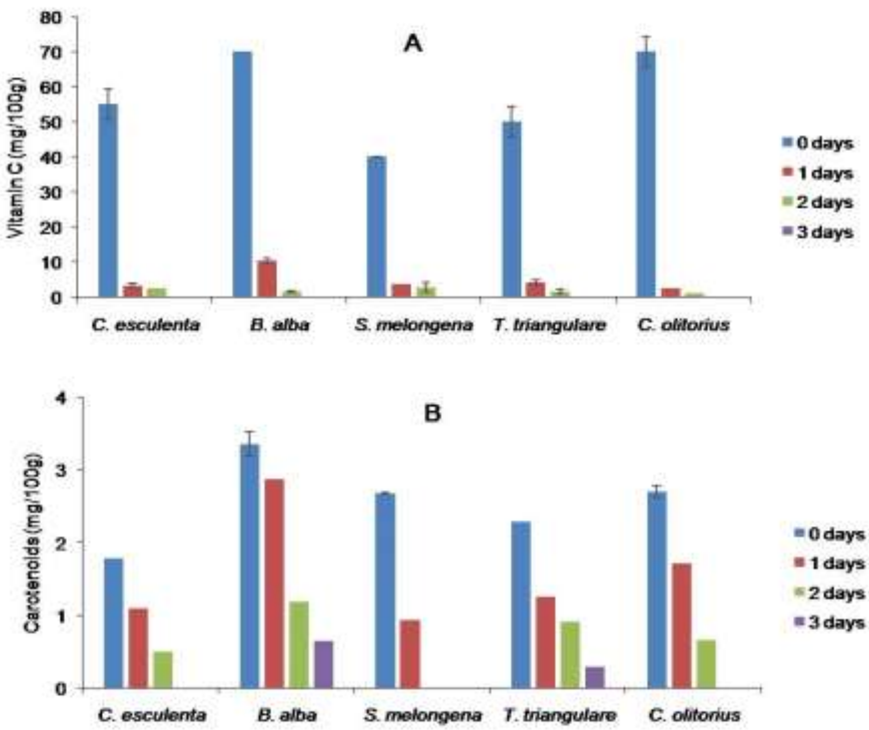

Fig.2. Effect of sun drying on vitamin C (A) and carotenoids (B) contents of leafy vegetables consumed in Southern Côte d'Ivoire

Vitamin C losses were estimated to 85.12-96.42 %, after 1 day of sun drying. This decrease could be explained by the fact that vitamin C is subjected to oxidation by exposure to sunlight [41]. Carotenoids are important precursors of retinol (vitamin A) and they have also been studied for their potential protection against numerous cancers [52,53]. After sun drying processing, carotenoids contentsdecreased in all the analyzed samples. Carotenoid losses were estimated to 97.48-98 % and 99.07-100 % after 1 day and 3 days of sun drying respectively.

The drying techniqueused in this work involved subjecting the vegetables to heat, light and oxygen and all of these factors will accelerate the rate of oxidation of carotenoids[54]. Phenolic coupounds and antioxidant activity of the studied leafy vegetables are shown in Fig.3.

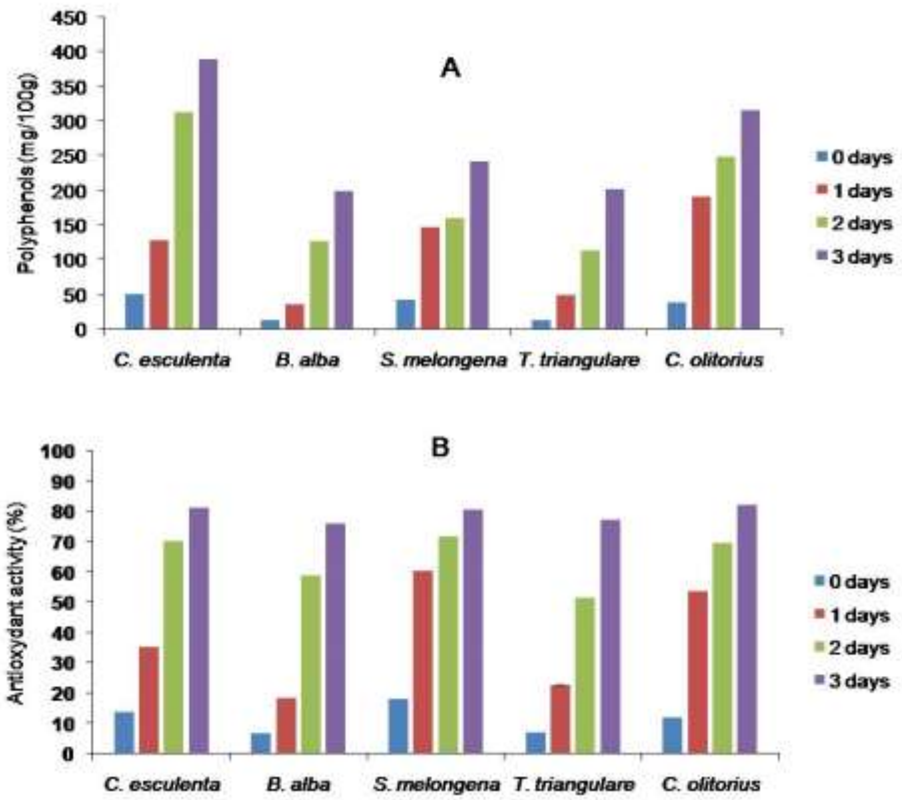

Fig.3. Effect of sun drying on polyphenols C (A) and antioxidant activity (B) contents of leafy vegetables consumed in Southern Côte d'Ivoire

Phenolic agents are major class of antioxidants that are found in plant foodswith relatively high concentration[55, 56]. The phenolic contents of the samples increased during sun drying. The values were in the range of 35.44-191.01 mg/100 g and 198.53-388.69 mg/100 g at 1 day and 3 days, respectively. Phenolic compounds are secondary metabolites synthesized by plants, both during normal development and in response to stress conditions (infection, wounding, UV radiation and others) [57]. They also have antioxidant properties that enable them to quench free radicals in the body [58]. Phenolic compounds have potentially beneficial effect on human health by reducing the occurrence of coronary heart disease, age-related-eye diseases and atherogenic processes [59, 60]. Moreover, this increase in phenolic contents caused the increase of antioxidant activity because there is a direct correlation between the concentration of antioxidant compounds and the antioxidant activity [61]. Antioxidant activity ranged from 77.36 ± 0.00 % to 82.30 ± 0.00 % after 3 days of sun drying. This increase could to be advantageous from the consumers because antioxidants prevent many diseases [62].

4. Conclusion

The results of the present study showed that *Basella alba, Colocasia esculenta, Solanum melongena, Talinum triangulare* and *Corchorius olitorus* consumed as leafy vegetbles in Southern Côte d'Ivoire are good sources of nutrients. It was also observed that sun-drying was the method used to process leafy vegetables for long term preservation by decreasing moisture. Moreover, this technique resulted in concentration of nutrients content of the vegetables (protein, ash, fat, crude fiber and carbohydrates). However, factors such as heat, light and oxygen caused the decreaseof vitamin C and carotenoids. A comparaison with the major methods as solar drying, shadow drying and oven drying must be studied to determine the best preservation method of leavy vegetables.

5. References

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