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EVALUATION OF NUTRITIVE AND ANTIOXIDANT PROPERTIES OF BLANCHED LEAFY VEGETABLES CONSUMED IN WESTERN COTE D'IVOIRE

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Abstract: *African leafy vegetables are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibres and other beneficial nutrients. Five leafy vegetable species (Abelmoschus esculentus, Celosia argentea, Ipomea batatas, Manihot esculenta and Myrianthus arboreus) that are used as soup condiments in Western Côte d'Ivoire were subjected to steam blanching in order to evaluate the effect of this processing method on their nutritive value and antioxidant properties. The result of the study revealed that longer time of blanching (higher than 15 min) caused negative impact by reducing nutritive value but positive impact by reducing anti-nutrients such as oxalates and phytates. The registered losses at 15 min were as follow: ash (3.78 – 55.81 %), proteins (0.1 - 10.79 %), vitamin C (1.04 – 79.70 %), carotenoids (47.91 - 66.28%) oxalates (5.51 – 33.33 %) and phytates (43.83– 78.16 %).The average reduction of polyphenols content at 15 min of blanching was 13.84 – 38.23 %. Contrary to these reductions, a significant increase (0.4 – 29.94 %) of fibres content was observed in the studied blanched leafy vegetables. Furthermore after 15 min of blanching time the residual contents of minerals were: calcium (228.62 – 402.39 mg/100g), magnesium (92.19 – 270.82 mg/100g), potassium (1255.24 – 2215.65 mg/100g), iron (17.24 – 43.48 mg/100g) and zinc (10.91 – 32.30 mg/100g). All these results suggest that the recommended time of domestic blanching must be less than 15 min for the studied leafy vegetables in order to contribute efficiently to the nutritional requirement and to the food security of Ivorian population.*

Keywords: *antioxidant properties* - *blanching processing* - *leafy vegetables* - *nutritive value*

1. Introduction

African Leafy Vegetables (ALVs) are indigenous or traditional vegetables whose leaves, young shoots and flowers are consumed [1,2]. Agronomic characteristics of ALVs include: short growth period with harvesting within 3-4 weeks; the ability to produce seed under tropical conditions; they respond well to organic fertilizers and can tolerate both biotic and abiotic stress [3]. Socio-economic surveys conducted in various parts of Africa indicate that ALVs are important commodities in household food and nutrition security [4].There is empirical evidence that ALVs have several advantages and values that include high micronutrient content, medicinal properties and contribute to food and nutrition security in Sub-saharan Africa [5]. Indeed, ALVs contain high levels of vitamin A, vitamin C, iron, calcium and protein and are a valuable source of nutrients in rural areas where they contribute substantially to protein, mineral and vitamin intake [6, 7, 8, 9]. They are compatible to use with starchy staples and represent affordable nutrition to the poor sector of the population. Fresh leaves of most ALVs like vegetable amaranths (*Amaranthus*), slenderleaf (*Crotalaria brevidens*), spiderplant (*Chlorophytum comosum*), vegetable cowpeas (*Vigna*), pumpkin leaves (cucurbits) and jute mallow (*Corchorus*) contain more than 100% of the recommended daily allowances for vitamins and minerals and 40% proteins for growing children and lactating mothers [10]. The high moisture content of fresh leafy vegetables renders them perishable and seasonal availability limits their utilization all round the year. Hence, there is a need to preserve this nature's store house of nutrients through proper processing techniques for safe storage with efficient nutrient retention [11]. One common processing using before consumption of leafy vegetables is blanching which could be briefly described as the process of heating vegetables to a temperature high enough to destroy enzymes present in the tissue. It stops the enzyme action, sets the colour, and shortens the drying and dehydration time [12]. It is usually carried out in hot water or in steam; this technique is used by indigenous people to reduce or eliminate the bitterness of the vegetables and acid components that are common in leaves [13]. Blanching affords also a series of secondary benefits, due to its washing action, such as elimination of off-flavors that may have been formed during the time between harvesting and processing, and removal of any residual pesticides [14]. Blanching, however, has some adverse effects, such as pigment modifications, tissues softening and nutrient losses [15,16]. In Côte d'Ivoire, more than twenty (20) species of leafy vegetables belong to 6 botanical families, are consumed by populations through confectionary soups using boiling or blanched processing [17]. Furthermore, the consumption of these leafy vegetables is linked to the region and ethno-botanical studies have stated that most people in Western Côte d'Ivoire consume indigenous green leafy vegetables such as *Abelmoschus esculentus* "gombo", *Celosia argentea* "soko", *Ipomea batatas* "patate", *Manihot esculenta* "manioc" and *Myrianthus arboreus* "tikliti" [18,19,20]. Earlier reports have highlighted the nutritive potential of these fresh leafy vegetables [7] but there is a lack of scientific data with regards to the effect of blanching processing on their physicochemical and nutritive characteristics. Therefore, the purpose of this study is to conduct investigation on the effect of blanching on the nutritive value of these selected leafy vegetables in order to provide necessary information for their wider utilization and contribution to food security of Ivorian populations.

2. Material and methods

2.1. Samples collection

Leafy vegetables (*Abelmoschus esculentus*, *Celosia argentea*, *Ipomea batatas*, *Manihot esculenta* and *Myrianthus arboreus*) 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 rinsed with deionized water and the edible portions were separated from the inedible portion. The edible portions were chopped into small pieces (500 g) and allowed to drain at ambient temperature. Each sample was divided into two lots. The first lot (raw, 250 g) was dried in an oven (Memmert, Germany) [21], ground with a laboratory crusher (Culatti, France) equipped with a 10 μm mesh sieve. Each sample was stored in a clean dry air-tight sample bottle in a refrigerator (4°C) until further analyses. The second lot (250 g) was steam blanched for 15, 25 and 45 min in a pressure cooker. The blanched samples were cooled, drained at ambient temperature and subjected to the same treatment using for raw samples.

2.3. Chemicals

All solvents (n-hexane, petroleum ether, acetone, ethanol and methanol) were purchased from Merck. Standards used (gallic acid, β-carotene) and reagents (metaphosphoric acid, Folin-Ciocalteu, DPPH) were purchased from Sigma-Aldrich. All chemicals used in the study were of analytical grade.

2.4. Nutritive properties

2.4.1. Proximate analysis

Ash, proteins and lipids were determined using official methods [22]. For crude fibres, 2 g of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100°C until constant weight. The dried residue was then incinerated, and weighed for the determination of crude fibres content. Carbohydrates and calorific value were calculated using the following formulas [23]: *Carbohydrates: 100 – (% moisture + % proteins + % lipids + % ash + % fibres).*

Calorific value: (% proteins x 2.44) + (% carbohydrates x 3.57) + (% lipids x 8.37). The results of ash, fibres, proteins, lipids and carbohydrates contents were expressed on dry matter basis.

2.4.2. 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, 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% nitric acid.

2.4.3. Anti-nutritional factors

Oxalates content was performed using a titration method [24]. 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 [25]. 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

2.5. Antioxidant properties

2.5.1 Vitamin C and carotenoids determination

Vitamin C contained in analysed samples was determined by titration [26]. 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 by using a spectrophotometric method [27]. 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.

2.5.2. Polyphenols determination

Polyphenols were extracted and determined using Folin–Ciocalteu's reagent [28]. 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.

Antioxidant activity Antioxidant activity assay was carried out using the 2,2-diphenyl-1-pycrilhydrazyl (DPPH) spectrophotometric method [29]. 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 and 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]

2.6 Statistical analysis

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

3. Results and discussion

The proximate composition of the blanched leafy vegetables examined in this study is presented in Table 1. The ash content after 15 min of blanching ranged from 7.36 ± 0.01 % (*M. esculenta*) to 11.99 ± 0.02 % (*C. argentea*). Besides the decrease rate at 15 min (3.78 – 55.81 %) the studied leafy vegetables may be considered as good sources of minerals when compared to values obtained for cereals and tubers [30]. Blanching of all selected leafy vegetables resulted in a significant increase (0.4 – 29.94 %) in their crude fibres content at 15 min. Indeed, the increased temperature during blanching leads to breakage of weak bonds between polysaccharides and the cleavage of glycosidic linkages, which may result in solubilization of the dietary fibre [31]. With regard to their fibres content at 15 min (15.84 – 29.78 %), adequate intake of blanched leafy vegetables could lower the risk of constipation, diabetes, colon and breast cancer [32]. As concern proteins content, blanching processing used in this study caused 0.1 to 10.79 % reduction after 15 min. This reduced protein contents of blanched leafy vegetables could be attributed to the severity of thermal process during blanching which leads to protein degradation [33].

With regards to their protein contents (21.52 ± 0.02; 15.08 ± 0.02 and 15.12 ± 0.02%) at 15 min, blanched leaves of *M. esculenta, I. batatas* and *M. arboreus* could be considered as non negligible sources in view to the minimal value (12%) recommended for protein foods [34]. The relatively low values of lipids contents at 15 min of blanching (2.11 – 7.58 %) in the studied cooked leafy vegetables corroborate the findings of many authors which showed that leafy vegetables are poor sources of fat [35]. The estimated calorific values agree with general observation that vegetables have low energy values due to their low crude fat and relatively high level of moisture [36].

Table 1

Proximate composition of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

	Ash (%)	**Fibres (%)**	**Proteins (%)**	**Lipids (%)**	**Carbohydrates (%)**	**Calorific value (kcal /100g)**
A. esculentus						
Raw	11.90 ± 0.10	15.66 ± 0.05	9.19 ± 0.15	3.38 ± 1.59	59.87± 1.90	264.44± 2.51
15 min	11.45 ± 0.02	18.93 ± 0.25	9.18 ± 0.00	7.04 ± 0.08	48.19 ± 0.42	263.64 ± 2.63
25 min	11.16 ± 0.02	18.35 ± 0.02	9.15 ± 0.02	7.59 ± 0.16	48.66 ± 0.95	271.78 ± 5.31
45 min	11.06 ± 0.02	18.37 ± 0.06	9.15 ± 0.02	6.92 ± 0.03	47.99 ± 0.92	265.25 ± 5.77
M.esculenta						
Raw	9.03 ± 2.12	26.23 ± 0.31	23.39 ± 0.71	4.09 ± 0.02	37.27 ± 3.16	224.35 ± 15.67
15 min	7.36 ± 0.01	26.34 ± 0.02	21.52 ± 0.02	7.58 ± 0.13	38.20 ± 0.31	252.31 ± 3.04
25 min	7.09 ± 0.09	26.87 ± 1.09	21.21 ± 0.00	8.15 ± 0.25	40.90 ± 0.73	256.17 ± 5.34
45 min	7.00 ± 0.05	26.88 ± 0.10	21.02 ± 0.00	7.84 ± 0.16	41.66 ± 0.23	254.91 ± 2.20
I. batatas						
Raw	23.56 ± 2.13	21.5 ± 0.82	15.52 ± 0.40	2.63 ± 0.06	36.79 ± 3.41	232.91 ± 15.78
15 min	10.41 ± 0.11	24.62 ± 0.54	15.08 ± 0.02	3.02 ± 0.03	42.87 ± 0.73	224.85 ± 3.21
25 min	10.24 ± 0.08	23.25 ± 0.44	15.00 ± 0.02	3.87 ± 0.12	45.15 ± 0.54	236.01 ± 3.31
45 min	9.84 ± 0.05	23.55 ± 1.36	15.00 ± 0.02	3.63 ± 0.14	42.98 ± 1.30	232.59 ± 7.93
C. argentea						
Raw	22.10 ± 0.75	30.83 ± 1.61	9.77 ± 0.10	1.79 ± 0.20	35.52 ± 0.6	165.62 ± 6.40
15 min	11.99 ± 0.02	29.78 ± 0.02	9.21 ± 0.00	4.71 ± 0.01	44.32 ± 1.49	244.47 ± 7.42
25 min	11.72 ± 0.12	22.80 ± 1.44	9.13 ± 0.00	4.59 ± 0.08	41.84 ± 2.70	234.93 ± 13.82
45 min	11.64 ± 0.10	22.09 ± 0.08	9.10 ± 0.02	4.75 ± 0.08	41.72 ± 1.51	237.00 ± 9.51
M. arboreus						
Raw	11.73 ± 0,76	12.19 ± 0,73	16.95 ± 0.05	1.47 ± 0.02	56.70 ± 1.74	259.5 ± 5.26
15 min	9.14 ± 0.58	15.84 ± 1.10	15.12 ± 0.02	2.11 ± 0.18	49.80 ± 0.94	227.42 ± 4.90
25 min	8.92 ± 0.03	14.67 ± 0.83	15.08 ± 0.00	3.52 ± 0.07	48.59 ± 0.88	237.28 ± 4.50
45 min	8.56 ± 0.05	13.25 ± 0.65	15.00 ± 0.00	2.42 ± 0.13	52.31 ± 0.60	239.86 ± 3.48

Values are mean of triplicate determination ± standard deviation

Mineral composition of blanched leafy vegetables used in this study is shown in table 2. The residual contents of minerals after 15 min of blanching were: calcium (228.62 – 402.39 mg/100g), magnesium (92.19 – 270.82 mg/100g), potassium (1255.24 – 2215.65 mg/100g), iron (17.24 – 43.48 mg/100g) and zinc (10.91 – 32.30

mg/100g). These observed reductions may be due to the losses of ashes as observed previously. Considering the recommended dietary allowance (RDA) for minerals [37]: calcium (1000 mg/day); magnesium (400 mg/day), iron (8 mg/day) and zinc (6 mg/day), consumption of 15 min blanched leafy vegetables could cover at least 50% RDA. Therefore, they could contribute substantially for improving human diet. Calcium and phosphorus are associated for growth and maintenance of bones, teeth and muscles [38]. As concern magnesium, this mineral is known to prevent cardiomyopathy, muscle degeneration, growth retardation, congenital malformations and bleeding disorders [39]. Iron plays important role in prevention of anemia while zinc is important for vitamin A and vitamin E metabolism [37, 40].

Table 2.

Mineral composition of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

	Ca	Mg	P	K	Fe	Na	Zn
A. esculentus							
Raw	468.45±0.55	364.11±0.43	671.5 ± 0.79	1844.25 ± 8.22	130.95±0.15	35.76 ± 0.04	41.45 ±0.04
15 min	386.39±1.72	154.44±0.68	222.80±0.99	1695.10±14.98	41.32 ± 0.31	19.94 ± 0.08	32.30 ±0.28
25 min	374.41±2.81	151.23±1.33	176.53±1.32	1636.85 ± 1.94	34.11 ± 0.30	18.12 ± 0.16	25.34 ±0.11
45 min	376.46±3.32	149.49±1.12	166.21±1.46	1531.42±11.50	31.34 ± 0.13	16.75 ± 0.12	21.50 ±0.16
M.esculenta							
Raw	296.66±0.46	229.45±0.35	759.81±1.18	2306.09 ± 3.61	48.69 ± 0.07	18.30 ± 0.02	45.48 ±0.31
15 min	248.61±0.47	92.19 ± 0.63	229.21±0.44	1405.93 ± 2.70	43.48 ± 0.30	9.53 ± 0.01	21.01 ±0.03
25 min	239.28±1.65	80.57 ± 0.15	201.81±1.40	1320.68 ± 9.16	42.52 ±0. 08	8.75 ± 0.06	27.46 ±0.24
45 min	194.75±1.77	56.61 ±0. 51	188.86±1.71	935.00 ± 8.50	29.26 ± 0.26	8.52 ± 0.07	36.76 ±0.07
I. batatas							
Raw	898.83±0.53	501.75±0.30	494.76±0.29	1377.81 ± 0.22	53.54 ± 0.03	404.30±3.62	30.10 ±0.01
15 min	228.62±1.39	165.18±1.00	281.06±1.70	1362.73±12.20	19.74 ± 0.17	236.58±0.34	10.91 ±0.01
25 min	246.59 ± 2.2	161.55±1.44	266.89±2.39	1282.98± 2.13	18.67 ± 0.11	199.66±1.21	10.26 ±0.06
45 min	230.03±0.33	154.66±0.22	220.02±0.31	1280.07 ± 7.78	17.57 ± 0.02	139.69±0.08	10.20 ±0.09
C. argentea							
Raw	788.02±0.50	981.31±0.62	650.37±0.41	4987.15 ± 3.19	285.31±0.18	42.26 ± 0.02	62.01 ±0.03
15 min	402.39±0.95	270.82±3.20	172.85±0.40	1255.24 ± 2.96	17.24 ± 0.20	34.64±0.041	26.58 ±0.06
25 min	407.75±4.90	249.91±0.59	151.07±1.81	1190.69±14.33	16.44 ± 0.03	32.58 ± 0.07	23.92 ±0.27
45 min	340.60±3.92	199.33±2.29	148.18±1.70	840.41 ± 9.68	13.76 ± 0.15	26.29 ±0.30	23.31 ±0.28
M. arboreus							
Raw	436.64±0.52	354.23±0.42	283.19±0.34	2350.58 ± 2.83	79.54 ± 0.09	20.83 ± 0.02	75.20 ±0.09
15 min	293.81±3.53	213.89±2.46	269.64±7.78	2215.65±25.54	21.09 ± 0.24	18.34 ±0.04	22.43 ±0.25
25 min	277.74±3.20	205.23±2.47	232.31±0.91	1809.88±21.78	18.51 ± 0.04	15.85 ± 0.18	21.98 ±0.26
45 min	248.01±0.58	177.60±0.41	193.98±0.96	1688.05 ± 3.98	18.42 ± 0.22	15.19 ± 0.18	18.72 ±0.04

Values are mean of triplicate determination ± standard deviation

To predict the bioavailability of calcium and iron, anti-nutrients to nutrients ratios of blanched leafy vegetables were calculated (Table 3). The calculated [phytates]/[Ca] and [phytates]/[Fe] ratios in all the blanched species were below the critical levels of 2.5 and 0.4 which are known to impair calcium and iron bioavailability [41,42]. The effect of blanching on anti-nutritional factors (oxalates and phytates) contents is depicted in figure 1. Levels losses at 15 min were 5.51 – 33.33 % and 43.83– 78.16 % for oxalates and phytates, respectively. The reductions in oxalates and phytates contents during blanching could be advantageous for improving the health status of consumers. Indeed, oxalates and phytates are anti-nutrients which chelate divalent cations such as calcium, magnesium, zinc and iron, thereby reducing their bioavailability [43]. Therefore, blanching of leafy vegetables appears as a detoxification procedure by removing these anti-nutritional factors [44]

Table 3
Anti-nutritional factors/mineral ratios of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

	Phytate/ Ca	Phytate/ Fe	Oxalate/ Ca
A. esculentus			
Raw	0.07	0.28	1.66
15 min	0.02	0.27	1.50
25 min	0.02	0.23	1.46
45 min	0.01	0.22	1.34
M.esculenta			
Raw	0.12	0.75	2.69
15 min	0.05	0.32	2.43
25 min	0.04	0.27	2.43
45 min	0.05	0.37	2.82
I. batatas			
Raw	0.01	0.31	0.08
15 min	0.03	0.34	0.22
25 min	0.02	0.32	0.11
45 min	0.01	0.17	0.11
C. argentea			
Raw	0.03	0.08	1.01
15 min	0.01	0.30	1.45
25 min	0.005	0.12	1.34
45 min	0.001	0.02	1.46
M. arboreus			
Raw	0.05	0.31	1.19
15 min	0.04	0.66	1.67
25 min	0.04	0.68	1.16
45 min	0.04	0.63	1.24

Blanching also resulted in a decrease of carotenoids and vitamin C contents in the studied leafy vegetables (Figure 2). For carotenoids, losses at 15 min were estimated to 47.91 to 66.28%. The decrease in the concentration of the total carotenoids could be attributed to the oxidation and isomerization of β-carotene [45]. Carotenoids are considered as sources of provitamin A in plants and their amount determine their bioavailability in human diet [27]. Therefore, increased intake of blanched leafy with fat added, contributed significantly to improving the vitamin A status in children [46]. For vitamin C content, a significant reduction (1.04 – 79.70 %) was highlighted at 15 min during blanching processing (Figure 2). This decrease in vitamin C content agrees with earlier findings on some tropical vegetables that reported 47.5 - 82.4% loss in vitamin C content during blanching [16]. It is important noting that ascorbic acid is heat labile and water-soluble antioxidant that promotes absorption of soluble iron by chelating or by maintaining the iron in the reduced form [47]. With regard to the decrease of vitamin C, consumption of blanched leafy vegetables may be supplemented with other sources of vitamin C such as tropical fruits to cover the daily need for humans (40 mg/day) as recommended by food agriculture organization [37].

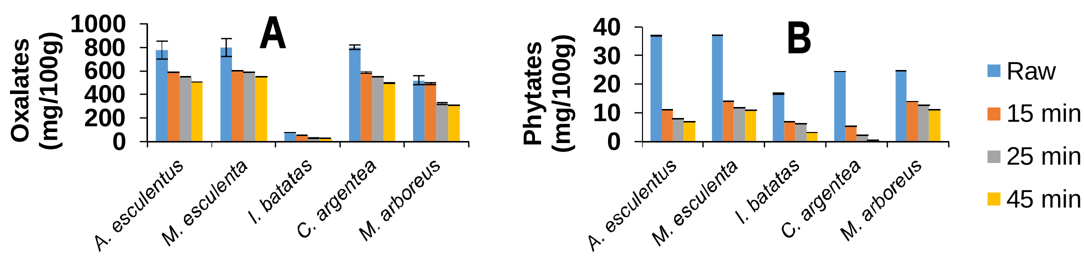

Figure 1: Oxalates (A) and phytates (B) contents of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

The effect of blanching on polyphenols content and antioxidant activity of the selected leafy vegetables is depicted in figure 3. The losses of polyphenols contents at 15 min of cooking were 13.84 – 38.23 %. The decrease of the polyphenolic compounds content and overall antioxidant activity could be due to the heat lability of specific flavonoids [48]. Indeed, flavonoids such as myricetin, quercetin, kaempferol, isorhamnetin and luteolin have been previously reported in leafy vegetables [49]. The negative impact of blanching on polyphenols content may affect the medicinal potentialities of leafy vegetables as previously mentioned [5]. Therefore, other processing methods such as soaking, solar drying and refrigeration of leafy vegetables should be used to limit or avoid losses of polyphenols as observed during blanching.

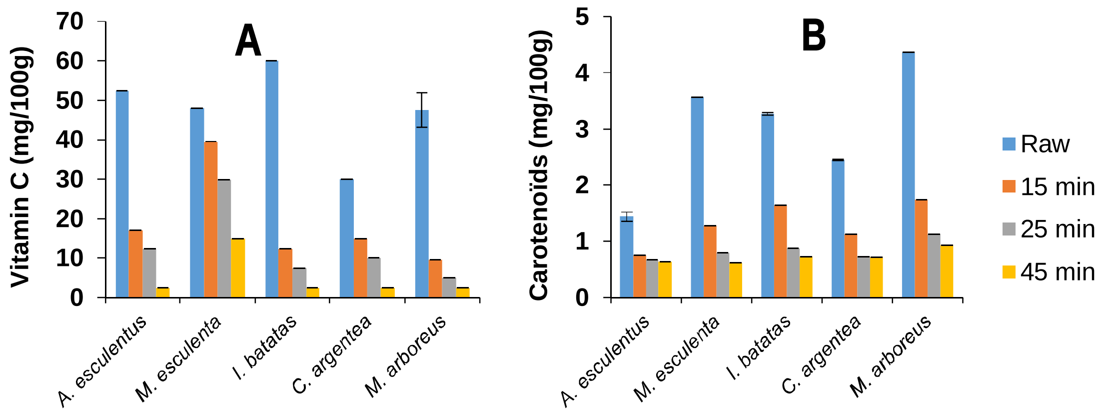

Figure 2: Vitamin C (A) and carotenoids (B) contents of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

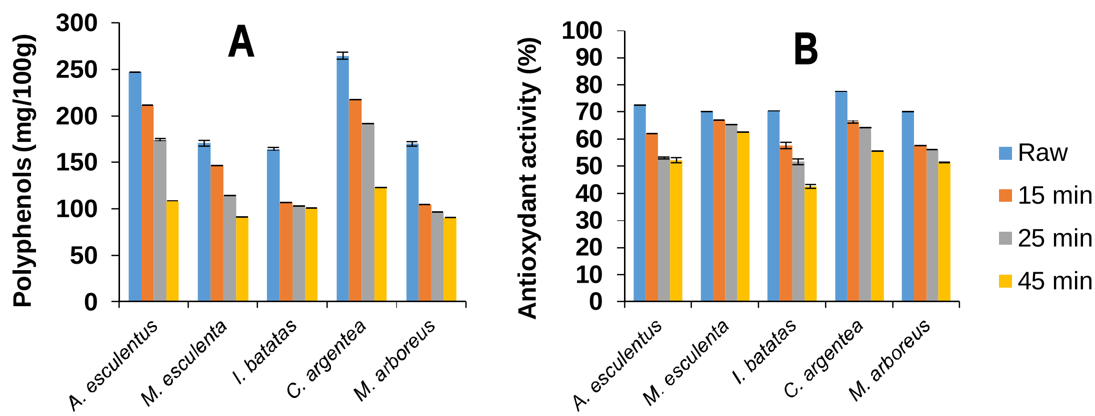

Figure 3: Polyphenols contents (A) and antioxidant activity (B) of raw and blanched leafy vegetables consumed in Western Côte d'Ivoire

4. Conclusions

African leafy vegetables (ALVs) contain significant levels of nutrients that are essential for human health. The result of this study revealed that blanching at 15, 25 and 45 minutes decreased considerably the nutritional value of these leafy vegetables. Nevertheless, the losses in anti-nutrients (oxalates, phytates) might have asserted a beneficial effect on bioavailability of minerals like calcium, iron and zinc. Thus, the study suggests that the recommended time of domestic blanching must be less than 15 min for the studied leafy vegetables in order to contribute efficiently to the nutritional requirement and to the food security of Ivorian population.

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