The proximate and mineral compositions of two dried Nigerian leafy vegetables (*Corchorus olitorius* and *Amaranthus hybridus*)

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Vegetables play an important role in human nutrition, but high moisture contents seem to lead to susceptibility to extreme spoilage. Thus, two dried Nigerian leafy vegetables (*Corchorus olitorous* and *Amaranthus hybridus)* proximate and mineral compositions were investigated to ascertain their nutritional potentials after drying. Fresh vegetable samples were destalked, washed, blanched, drained and dried in the open sun and in the oven at 50, 60 and 70°C temperatures. The proximate and mineral compositions were determined using standard analytical methods. The proximate values of *Corchorus olitorius* leaves ranged between 8.16 – 12.37%, 13.53 – 15.10%, 2.15 – 2.44%, 8.68 – 9.20%, 13.21 – 13.68% and 50.08 – 53.91% while *Amaranthus hybridus* leaves ranged between 8.85 – 12.97%, 15.72 – 17.70%, 1.20 – 1.78%, 9.02 – 9.17%, 16.89 – 19.53% and 42.98 – 44.21% respectively for moisture content, protein content, crude fat, ash, crude fiber and carbohydrate values. The results showed an increase in the mineral concentrations after drying, indicating that the vegetables studied are all good sources of sodium, potassium, calcium, iron and magnesium. Thus, drying vegetables can help reduce food insecurity and improve nutritional contents.

Keywords: Nigerian leafy vegetables, proximate compositions, mineral compositions, drying

Vegetables are parts of plants that are consumed by humans or other animals as food. Vegetables are essential as food both from economic and nutritional standpoints. Their nutritive significance is their richness in minerals which is critical for maintaining human health (Bolaji et al. 2008). Ukom and Obi (2018) reported that vegetables are good sources of micronutrients, nonvolatile acids, organic acids, mineral salts, volatile sulphur compounds and tannin. They also contain antioxidant compounds like polyphenols, flavonoids and arrays of carotenoids, such as ß-carotene and ascorbic acid, which boost the body immunity. They contain bioactive compounds which protect the body from nutritional deficiency diseases and free radicals that cause oxidative damage to cells (Ukom and Obi 2018). Vegetables also contain valuable food ingredients which can be successfully utilized to build up and repair the body. They are beneficial in maintaining the body's alkaline reserve due to their high carbohydrate, vitamin and mineral contents (Onwordi et al. 2009). Yunus and Abdullahi (2021) reported that vegetables are widely used for culinary purposes and are rich in vitamins (especially vitamin C) and chemical elements essential for the maintenance of health and the prevention and treatment of various diseases.

Grubben et al. (2014) reported that *Corchorus olitorius* and *Amaranthus hybridus* are thought to benefit the human diet. *Corchorus olitorius* belongs to the family of tiliaceae plants. The plant is widely grown in the tropics for the viscosity of its leaves. The leaves (either fresh or dried) are cooked into a thick viscous soup or added to stew or soup and are rich sources of vitamins and minerals (Loumerem and Adriana, 2016). *Corchorus olitorius* is often recommended for pregnant women and nursing mothers because it is believed to be rich in iron (Oyedele et al.

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2006). *Amaranthus hybridus* is an herbaceous annual leafy vegetable that is one of the cheapest dark green leafy vegetables in tropical markets. It possesses excellent nutritional value because of its high carotene, calcium, vitamin C, folic acid and other micronutrients. *Amaranthus hybridus* leaves combined with condiments are used to prepare soup (Mepba et al. 2007). These two vegetables are widely consumed as food across Nigeria and some other West African countries. Thus, ascertaining the nutritional values of these vegetables can help to measure their potential to reduce food insecurity and improve nutrition.

Moisture in vegetables leads to susceptibility to extreme spoilage due to its role in solubilization and acting as a suitable medium for development of microbes. Therefore, there is a need to preserve vegetables by dehydration for better conservation. Also, vegetables are most prominent to seasonal fluctuations, growing well in the rainy season and usually scarce and costly during the dry season. Thus, due to the structural configuration of these types of products, the removal of moisture must be accomplished in a manner that will be the least detrimental to product quality. Hussein et al. (2018) indicated that drying considerably reduced humidity whatever the mode of treatment. This study, therefore, aims to investigate the proximate and mineral compositions of these two dried Nigerian leafy vegetables.

Materials and methods

Sample source and preparation

The fresh *Corchorus olitorous* and *Amaranthus hybridus* were obtained from the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. The two samples fresh and matured leaves (1.2 kg each) were destalked, thoroughly washed, blanched (at 60°C for 2 minutes) and drained.

Drying procedure

A portion of 200 g from each of the samples was spread in a tray and sun-dried until constant moisture was achieved. Three further portions of 200 g from each of the samples were dried in an electric oven (DHG-9101, Shanghai, China) set at temperatures of 50, 60 and 70°C, respectively. The samples were dried until no further significant changes in the weight of the leaves. The fresh leaves from each of the samples served as the control. The moisture content of the fresh leaves was immediately determined according to the AOAC (2016) method and found to be 30.39 ± 0.721 g water per 100 g sample for *Corchorus olitorius* and 32.75 ± 0.134 g water per 100 g sample for *Amaranthus hybridus*.

Determination of proximate and mineral compositions of the fresh and dried leafy vegetables

The moisture, protein, crude fats, ash and crude fibre compositions of each sample of *Corchorus olitorous* and *Amaranthus hybridus* were determined using the standard methods of AOAC (2016). The determination of the carbohydrate content was done by finding the difference between 100 and the sum of the percentages of moisture, protein, fat, fibre, and ash. The leafy vegetables were analyzed for their content elements (sodium, potassium, calcium, iron, and magnesium) by wet digestion using an Atomic Absorption Spectrophotometer (210VGS Buck Scientific Model, Inc.) as described by AOAC (2016). Appropriate quality assurance procedures and precautions were carried out to ensure the reliability of the data.

Determination of ascorbic acid contents of the fresh and dried leafy vegetables

Ascorbic acid was determined using the official titrimetry method as adopted by Hussein et al. (2016). An aliquot (10 g) of the sample was diluted to a fixed volume (100 ml) with 3% HPO3 and then titrated with 2,6-dichlorophenol indophenol. A standard ascorbic acid solution of 5 mL was added to 5 mL of 3% HPO_3 and titrated with dye solution to a pink colour which persisted for 15 seconds. Triplicate determinations were carried out, and the result averaged. Ascorbic acid (mg/100 g) of reconstituted juice was calculated using the following formula:

$$Ascorbic\ Acid\ \left(\frac{mg}{100}g\right) = \frac{T \times DF \times V_1}{V_2 \times V_3} \quad (1)$$

Where, T = titre; DF = dye factor; V_1 = volume made up (100 ml); V_2 = aliquot of extract taken for estimation (10 g) and V_3 = volume of sample taken for estimation (10 ml).

Statistical Analysis

All experiments were performed in triplicate, and the results were reported as means ± standard error). Analysis of variance and differences among the means were compared with Duncan New Multiple Range Test at the $P \leq 0.05$ level of significance. A randomized complete block design (RCBD) involving the two leafy vegetable varieties and the five treatment levels (sun-dried, oven-dried at 50, 60 and 70°C plus the control of fresh vegetables) was used. This was replicated three times to give a total of 10 x 3 = 30 samples.

Results and discussion

Proximate compositions of the fresh and dried leafy vegetables

The proximate compositions of the fresh and dried leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* are shown in Table 1. The percentage moisture contents ranged from 8.16 – 30.39% and 8.85 – 32.75% for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* respectively. These values are lower than 86.35% and 85.40% reported by Adeyeye et al. (2018) for *Corchorus olitorius* and *Amaranthus hybridus* respectively. These values are also lower than the range of 75.00 – 91.50% reported by Olaiya and Adebisi (2009) for some Nigerian green leafy vegetables (*Solanum aethiopicum, Telfaria occidentalis, Celosia argentea, Solanum nodiflorum, Basella alba, Amaranthus, caudatus, Amaranthus spainosus, Amaranthus hybridus, Cucurbita pepo* and *Talinum triangulare*) and 84.48% reported by Akubugwo et al. (2007) for *Amaranthus hybridus.* In contrast, they are within the range of 15.58 – 30.90% reported by Onwordi et al. (2009) for some leafy vegetables. The variation in the compositions of the same food type from different sources may be due to the climate of the location, soil type, varietal differences, growing conditions, application of natural or artificial manure, harvesting age and cultural practices employed during planting (Adeleke and Abiodun, 2010). The variation could also be attributed to the sampling period, which was from the onset of the dry season to the harmattan period (November 2017 to February 2018), a period characterized by intensive sunlight and dryness. Moisture content makes an essential contribution to the leaves' texture and helps maintain the cells' protoplasmic content.

The oven-dried samples gave significant ($P \leq 0.05$) reductions in moisture compared to the sun-drying method. The oven-dried *Corchorus olitorius* and *Amaranthus hybridus* leaves at 70°C had the lowest moisture contents of 8.16% and 8.85%, respectively. In comparison, sun-dried *Corchorus olitorius* and *Amaranthus hybridus* leaves had moisture contents of 12.37% and 12.97%, respectively. These values corroborated those reported earlier for some Nigerian green vegetables (Onwordi et al. 2009). They are also within the range of less than 15% reported by Ubwa et al. (2015) for dried *Ficus thonningii*, *Annona senegalensis* and *Hibiscus sabdariffa* and Hussein and Filli (2018) for dried tomatoes. The differences between these dried samples and the fresh samples of *Corchorus olitorius* (30.39%) and *Amaranthus hybridus* (32.75%) was considerable. The higher moisture contents observed in the fresh samples is an indication of increased susceptibility to microbial spoilage. It is expected that the sun-dried and oven-dried samples, which are characterized by lower moisture contents, will keep for longer periods than the fresh samples; hence the rate of deterioration, other micro-organic degradation and bio-molecular values should all be reduced.

The values of crude protein content of the fresh *Corchorus olitorius* and *Amaranthus hybridus* were 8.67% and 7.40%, respectively. These values are comparable to the range of 9.35 – 12.66% reported by Onwordi et al. (2009) for some leafy vegetables (*Amaranthus cruentus, Celusia argenta* and *Corchorus olitorius*). An increase in the crude protein content was observed after the drying process, with the oven-dried samples of *Corchorus olitorius* at 70^{o}C having the highest value (15.10%) and the open sun-dried samples having the lowest value (13.53%). Similarly, for *Amaranthus hybridus*, the oven-dried samples at 70^{o}C had the highest value (17.70%), while the open sun-dried samples had the lowest value (15.72%). These observations corroborated what was reported by Hussein and Filli (2018) that the protein content of a vegetable after drying could be greater than that of the fresh sample, which was attributed to microbes presence in the fresh sample. This result showed that these vegetables are good sources of protein, with dried leaves having an appreciable amount. The protein content of these vegetables will go a long way towards meeting the protein needs of people who supplement their food with vegetables. However, the lower values obtained for the sun-dried samples might be related to non-enzymatic browning reactions. A non-enzymatic reaction (Maillard) occurs between an amino acid and reducing sugar, usually requiring heat. The prolonged heating in sun-drying reduced the quality of dried products because of this non-enzymatic browning reaction (Hussein and Filli 2018).

The fresh *Corchorus olitorius* and *Amaranthus hybridus* crude fat contents were 1.07% and 0.70%, respectively. These values are comparable to the range of 1.05 – 1.20% reported by Adeyeye et al. (2018) for edible leafy vegetables in Nigeria. An increase in the crude fat contents was observed after the drying process. For *Corchorus olitorius* the oven-dried samples at 70^{o}C had the highest value (2.44%), while the open sun-dried samples had the lowest value (2.15%). Similarly, for *Amaranthus hybridus*, the oven-dried samples at 70^{o}C had the highest value (1.78%), while the open sun-dried samples had the lowest value (1.20%). For both vegetables the oven-dried samples at 50, 60, and 70^{o}C drying temperatures gave similar values of crude fat content, but they were higher than the sun-dried samples. The increase in crude fat contents was due to loss of moisture, thereby increasing the concentration of the vegetables nutrients. Hussein and Filli (2018) reported that a high drying rate in a short time prevents the melting of the fat, thereby increasing the value. However, very low fat contents of vegetables make them an excellent dietary habit and could be recommended to individuals suffering from overweight, obesity and other related diseases.

The crude fibre contents gave 3.73% for the fresh *Corchorus olitorius* and 2.81% for the fresh *Amaranthus hybridus*. These values are relatively higher than the 2.36 – 2.60% range reported by Adeyeye et al. (2018) for edible leafy vegetables in Nigeria. In contrast, they are lower than 6.36% for African spinach and 4.81% for bush mallow, as reported by Ukom and Obi (2018). For both *Corchorus olitorius* and *Amaranthus hybridus* increases in crude fibre content were observed after the drying process. These increases were larger for the oven-dried samples than for the sun-dried samples. For *Corchorus olitorius* the oven-dried samples had crude fibre values between 9.19 – 9.20% and the sun-dried samples had crude fat of 8.68%. For *Amaranthus hybridus* the oven-dried samples had crude fibre values between 9.16 – 9.17% and the sun-dried samples had crude fat of 9.02%. Adeyeye et al. (2018) reported that fibre aids and speeds up the excretion of waste and toxins from the body, preventing them from sitting in the intestine or bowel for too long, which could cause a build-up and lead to several diseases. Thus, the substantial amount of fibre in these vegetables shows that they could help keep the digestive system healthy and functioning correctly.

The ash contents were 5.65% for the fresh *Corchorus olitorius* and 7.05% for the fresh *Amaranthus hybridus*. These values are lower than the range of 21.00 – 21.40% (Ewedu), 22.40 – 30.80% (Tete) and 30.90 – 34.10% (Soko) reported by Onwordi et al. (2009). An increase in the ash contents was observed after the drying process. For *Corchorus olitorius* the oven-dried samples had ash contents between 13.56 – 13.68%, while the open sun-dried samples had ash content of 13.21%. For *Amaranthus hybridus*, the oven-dried samples had ash values between 19.43 – 19.53%, while the open sun-dried samples had an ash value of 16.89%. The high amount of ash contents after drying shows more combustible materials in dried vegetables than the fresh ones when subjected to dehydration (Hussein and Filli 2018).

The carbohydrate contents were 50.51% for the fresh *Corchorus olitorius* and 49.30% for the fresh *Amaranthus hybridus*. Whereas drying did not appear to make much difference to carbohydrate content of *Corchorus olitorius*, it did appear to cause somewhat lower carbohydrate content of *Amaranthus hybridus*. The values observed for carbohydrate content corroborated the 52.18% reported by Akubugwo et al. (2007). However, the observed values are very much higher than 3.46% for *Corchorus olitorius* and 5.54% for *Amaranthus hybridus* reported by Adeyeye et al. (2018). This result showed that the selected vegetables contain important quantities of carbohydrate. In contrast, Olaiya and Adebisi (2009) reported that vegetables are generally low in carbohydrates, fats and proteins and therefore contribute very little to the energy values. Micro-organisms readily ferment carbohydrate supply energy for nutrition and yield carbon dioxide, alcohol, organic acids and other compounds. The recommended dietary allowance (RDA) values for children, adults, pregnant and lactating mothers are 130, 130, 175, and 210 g, respectively (FND 2002). This implies that 38.85, 38.85, 28.86 and 24.05% for *Corchorus olitorius* and 37.92, 37.92, 28.17 and 23.48% for *Amaranthus hybridus* of these respective daily requirements can be met when 100 g dried leaves are consumed.

Table 1: Proximate compositions of fresh and dried *Corchorus olitorius* and *Amaranthus hybridus* (%)

	Moisture content	Crude protein	Crude fat	Crude fibre	Total ash	Carbohydrate
Corchorus olitorius						
Fresh	30.39^{a} ± 0.721	8.67^{d} ± 0.050	1.07^{d} ± 0.035	3.73^{c} ± 0.050	5.65^{d} ± 0.021	50.51^{b} ± 0.778
Sun-dried	12.37^{b} ± 0.156	13.53^{c} ± 0.643	2.15^{c} ± 0.028	8.68^{b} ± 0.013	13.21^{c} ± 0.035	50.08^{b} ± 0.940
Oven-dried at 50ºC	8.60^{c} ± 0.028	13.91^{c} ± 0.099	2.36^{b} ± 0.000	9.19^{a} ± 0.000	13.56^{b} ± 0.134	52.39^{a} ± 0.205
Oven-dried at 60ºC	8.38^{cd} ± 0.046	14.51^{b} ± 0.042	2.40^{ab} ± 0.018	9.20^{a} ± 0.007	13.62^{ab} ± 0.103	51.91^{a} ± 0.124
Oven-dried at 70ºC	8.16^{d} ± 0.064	15.10^{a} ± 0.014	2.44^{a} ± 0.035	9.20^{a} ± 0.014	13.68^{a} ± 0.071	51.43^{ab} ± 0.042
Amaranthus hybridus						
Fresh	32.75^{a} ± 0.134	7.40^{d} ± 0.057	0.70^{c} ± 0.028	2.81^{d} ± 0.021	7.05^{c} ± 0.071	49.30^{a} ± 0.099
Sun-dried	12.97^{b} ± 0.042	15.72^{c} ± 0.000	1.20^{b} ± 0.014	9.02^{c} ± 0.134	16.89^{b} ± 0.233	44.21^{b} ± 0.424
Oven-dried at 50ºC	9.32^{c} ± 0.134	16.97^{b} ± 0.070	1.73^{a} ± 0.000	9.16^{a} ± 0.000	19.43^{a} ± 0.014	43.40^{c} ± 0.219
Oven-dried at 60ºC	9.08^{d} ± 0.025	17.34^{ab} ± 0.085	1.76^{a} ± 0.021	9.16^{a} ± 0.004	19.48^{a} ± 0.045	43.19^{c} ± 0.046
Oven-dried at 70ºC	8.85^{e} ± 0.184	17.70^{a} ± 0.240	1.78^{a} ± 0.042	9.17^{a} ± 0.007	19.53^{a} ± 0.078	42.98^{c} ± 0.311

Values are means of triplicate ± SE, Values in the same column bearing different superscripts within each vegetable species are significantly different ($P \leq 0.05$)

Mineral compositions of the fresh and dried leafy vegetables

The mineral compositions of the fresh and dried leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* are shown in Table 2. The sodium contents ranged from 3.65 – 14.68 mg/100 g and 37.61– 100.92 mg/100 g for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus.* The values for *Corchorus olitorius* are lower than 22.98 mg/100 g as reported by Ukom and Obi (2018) for some selected vegetables in Nigeria. In contrast, the values for *Amaranthus hybridus* are higher than 22.98 mg/100g as reported by Ukom and Obi (2018). An increase in the mineral contents was observed after the drying of the two vegetables. The sodium contents for the oven-dried samples at the three drying temperatures were similar and were significantly higher ($P \leq 0.05$) that the sodium contents for the sun-dried samples. Ukom and Obi (2018) reported that sodium is one of the minerals whose absorption is considered a factor in hypertension aetiology. Thus, its lower availability in *Corchorus olitorius* can lower the incidence of hypertension.

The potassium contents of the fresh samples were 9.33 and 66.00 mg/100g for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* respectively. An increase in the potassium contents was observed after the drying process with the oven-dried samples showing significantly higher ($P \leq 0.05$) values than the sun-dried samples. For *Corchorus olitorius* the oven-dried samples had values ranging from 15.96 – 18.06 mg/100 g, while the open sun-dried samples had 10.70 mg/100 g. For *Amaranthus hybridus*, the oven-dried had values ranging from 101.26 – 116.82 mg/100g, while the open sun-dried samples had 85.70 mg/100g. Ukom and Obi (2018) reported that potassium is an intercellular salt that can combine with sodium to influence osmotic pressure and contributes to normal pH equilibrium in the body. The sodium to potassium ratio in the body is of great concern for preventing high blood pressure. A sodium to potassium ratio less than one is recommended (FND 2002). Hence, consuming these vegetables would probably reduce high blood pressure diseases because their sodium to potassium ratio is less than one.

The calcium contents of the fresh samples were 10.27 and 11.18 mg/100 g for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* respectively. These values are lower than the range of 45.61 – 430.69 mg/100g reported by Ukom and Obi (2018). The calcium contents for both vegetables increased after drying with oven-drying resulting in higher increases than sun-drying. Calcium helps in the growth and maintenance of the bones, structure of teeth and muscles.

The iron contents of the fresh samples were 7.66 and 80.39 mg/100 g for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* respectively. This value for *Amaranthus hybridus* is higher than 13.58 mg/100 g reported by Akubugwo et al. (2007). There was a significant increase in the iron contents of *Corchorus olitorius* leaves after drying with values ranging from 31.27– 39.69 mg/100 g. In contrast, iron values decreased significantly in *Amaranthus hybridus* after the drying process. Iron is an essential constituent of haemoglobin that helps in the central nervous system's normal functioning and the oxidation of carbohydrates, protein, and fats (Akubugwo et al. 2007).

The magnesium contents of the fresh samples were 6.10 and 19.06 mg/100 g for the leafy vegetables of *Corchorus olitorius* and *Amaranthus hybridus* respectively. These values are within the range of 11.05 – 198.14 mg/100g as reported by Ukom and Obi (2018). For both vegetables magnesium increased after oven-drying, but after sun-drying it increased for *Corchorus olitorius*, but not for *Amaranthus hybridus.* Magnesium functions as an adenosine triphosphate (ATP) activator, requiring enzymes such as hexokinase, phosphatase, alkaline, fructokinase and adenylcyclase. It also plays a vital role in the structure and function of the skeleton and muscle of the human body (Akubugwo et al. 2007).

Minerals are essential for vital body functions such as acid-base and water balance. Generally, iron represented the most abundant mineral in the leaves of *Corchorus olitorius* followed by calcium, magnesium, potassium and sodium. Potassium and sodium were the most abundant mineral elements in the leaves of *Amaranthus hybridus* followed by iron, calcium and magnesium. The mineral contents change may be due to the breakdown of complex compounds into more simple forms. This result is in accordance with the findings of Aletor and Adeogun (1995). They reported that mineral elements could be made available in considerable amount by destroying the anti-nutritional factors which inhibit the mineral elements present in the foods, during drying, soaking and cooking processes.

Table 2: Mineral compositions of fresh and dried *Corchorus olitorius* and *Amaranthus hybridus* (mg/100g)

	Sodium	Potassium	Calcium	Iron	Magnesium	Ascorbic acid
Corchorus olitorius						
Fresh	$3.65^{c} \pm 0.021$	$9.33^{d} \pm 0.771$	$10.27^{c} \pm 0.290$	$7.66^{b} \pm 0.127$	$6.10^{e} \pm 0.170$	$18.50^{a} \pm 0.368$
Sun-dried	$9.07^{b} \pm 0.021$	$10.70^{c} \pm 0.226$	$20.81^{b} \pm 0.078$	$31.27^{a} \pm 0.269$	$12.67^{d} \pm 0.276$	$16.36^{b} \pm 0.544$
Oven-dried at 50°C	$13.83^{a} \pm 0.085$	$15.96^{b} \pm 0.283$	$32.46^{a} \pm 0.375$	$37.67^{a} \pm 1.485$	$19.60^{c} \pm 0.318$	$18.32^{a} \pm 0.014$
Oven-dried at 60°C	$14.26^{a} \pm 0.028$	$17.01^{ab} \pm 0.071$	$32.39^{a} \pm 0.541$	$38.68^{a} \pm 0.735$	$20.89^{b} \pm 0.410$	$18.22^{a} \pm 0.035$
Oven-dried at 70°C	$14.68^{a} \pm 0.141$	$18.06^{a} \pm 0.141$	$32.32^{a} \pm 0.707$	$39.69^{a} \pm 0.014$	$22.18^{a} \pm 0.502$	$18.11^{a} \pm 0.057$
Amaranthus hybridus						
Fresh	$37.61^{e} \pm 1.860$	$66.00^{e} \pm 1.011$	$11.18^{e} \pm 0.629$	$80.39^{a} \pm 0.594$	$19.06^{c} \pm 0.191$	$28.27^{a} \pm 0.255$
Sun-dried	$82.58^{d} \pm 0.460$	$85.70^{d} \pm 0.071$	$27.34^{d} \pm 0.792$	$37.86^{c} \pm 0.014$	$16.55^{d} \pm 0.431$	$25.79^{c} \pm 0.071$
Oven-dried at 50°C	$96.24^{c} \pm 0.191$	$101.26^{c} \pm 0.085$	$31.95^{c} \pm 0.269$	$76.83^{b} \pm 4.284$	$27.92^{b} \pm 0.262$	$27.71^{ab} \pm 0.057$
Oven-dried at 60°C	$98.58^{b} \pm 0.757$	$109.04^{b} \pm 0.110$	$34.35^{b} \pm 0.057$	$75.62^{b} \pm 7.432$	$28.48^{ab} \pm 0.357$	$27.42^{b} \pm 0.046$
Oven-dried at 70°C	$100.92^{a} \pm 1.322$	$116.82^{a} \pm 0.134$	$36.75^{a} \pm 0.156$	$74.41^{b} \pm 0.580$	$29.05^{a} \pm 0.453$	$27.14^{b} \pm 0.035$

Values are means of triplicate ± SE, Values in the same column bearing different superscripts within each vegetable species are significantly different (P ≤ 0.05)

The ascorbic acid content of fresh and dried Corchorus olitorius and Amaranthus hybridus

Vitamins are chemical substances that are specified in their activities in the body. Ascorbic acid (vitamin C) is one of the most thermolabile components of food products; a fact also confirmed in vegetable drying. The ascorbic acid content of the two vegetables reduced significantly after sun-drying (P ≤ 0.05). After oven-drying at the three temperatures the ascorbic acid contents only declined marginally; for *Corchorus olitorius* oven-drying did not significantly (P > 0.05) reduce ascorbic acid, but for *Amaranthus hybridus* there was a small, but significant (P ≤ 0.05) reduction at higher oven-drying temperatures. The ascorbic acid of the fresh *Corchorus olitorius* was 18.50 mg/100 g; for the dried samples the values were 16.36 mg/100 g, 18.32 mg/100 g, 18.22 mg/100 g and 18.11 mg/100 g for sun-dried, oven-dried at 50, 60 and 70°C, respectively. In comparison, the ascorbic acid of the fresh *Amaranthus hybridus* was 28.27 mg/100 g, and the values for the dried samples were 25.79 mg/100 g, 27.71 mg/100 g, 27.42 mg/100 g and 27.14 mg/100 g for sun-dried, oven-dried at 50, 60 and 70°C, respectively (Table 2). These values are lower than the range of 39.84 - 98.73 mg/100 g as reported by Ukom and Obi (2018). The variation in ascorbic acid retention due to sun-drying could be due to leaching of the vitamin being water-soluble and oxidation due to a more extended drying period (Hussein et al. 2016).

Conclusion

The study conducted shows that the leafy vegetables investigated are nutritious with an appreciable amount of proteins, fat, fibre, carbohydrate, and mineral elements (sodium, potassium, calcium, iron and magnesium) and ascorbic acids. The lower moisture contents obtained after drying indicate fewer detrimental effects on the nutritional qualities and reduction in susceptibility to contamination and, therefore, prolong the vegetable's storage life. Also, drying at a moderate temperature range of 50 - 70^{o}C could retain the nutritional values of the leafy vegetables studied. Thus, dried *Corchorus olitorous* and *Amaranthus hybridus* leaves can contribute significantly to human nutrient requirements and should be used as sources of nutrients to supplement other significant sources.

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