RUHUNA JOURNAL OF SCIENCE
Vol 9: 32-43, June 2018
eISSN: 2536-8400
DOI: http://doi.org/10.4038/rjs.v9i1.36


# Ascorbic acid retention of freshly harvested seven Nigerian green leafy vegetables after soaking in water

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Received: 9th March 2018, Revised: 22nd June 2018, Accepted: 30th June 2018

**Abstract.** Vitamins are micronutrients needed in the body for important biologic functions. The current study examined the influence of steeping on vitamin C retention of seven Nigerian vegetable leaves after soaking for 8 h. One kilograme each was purchased and 6 lots of 100 g were sorted out, cleaned and treated as follow; whole leaf 1, whole leaf 2, sliced leaf 1, sliced leaf 2, sliced and salted leaf 1 and sliced and salted leaf 2. Each of the treatments 1 was soaked in 1 litre of distilled water while each of treatments 2 was soaked in 2 litres of distilled water. All treatments were kept for 8 h while monitoring the trend of reduction in vitamin C contents at 2 h intervals. Moisture (%) was determined following AOAC (2002) methods while dry matter content was estimated from moisture by calculating the difference. Ascorbic acid content (mg/100 g) was determined following the method of Ndawula *et al*. (2004). Result showed that; moisture, dry matter, and ascorbic acid contents of raw leaves ranged from 67.63–86.70%, 13.30–32.37%, and 103.00–1199.23 mg/100g respectively. During soaking, ascorbic acid retained by the seven green vegetables reduced as follows; 73.39–24.26% (*Amaranthus viridis*), 100.26–19.62% (*Gnetum africanum*), 129.05–27.72% (*Gongronema latifolium*), 66.84–7.55% (*Ocimum gratissmum*), 42.59–4.14% (*Piper guinense*), 77.38–10.26% (*Pterocapus mildbedii*) and 120.02–17.97% (*Telfaria occidentalis*). The study showed that ascorbic acid retention (%) of seven Nigerian green vegetable leaves decreased with increasing soaking duration.

**Keywords:** Nigeria, ascorbic acid, micronutrients, vegetable, soaking

## 1 Introduction

Vitamin C (Ascorbic acid, AA) is a significant vitamin in fruits and vegetables for human diets. It is a water dissoluble mineral demanded for a number of biologic activities and a strong reducing agent which easily oxidizes discretionally to dehydroascorbic acid (Bello and Fowoyo, 2014). When the cells of fruits and vegetables are cut opened, chopped or crushed, the vitamin C in them may become oxidized by enzyme called oxidases which are present within the cells (Fox and Cameron, 1980). This and other factors may suggest reasons why vitamin C is regarded as the most easily destroyed of all vitamins (Babalola *et al*., 2010).

Some animals can make vitamin C from glucose and galactose whereas certain groups of primates and the cavy could not do so (Bello and Fawoyo, 2014). Hence, their requirements for vitamin C must be satisfied through external sources especially through fruits and vegetables. To this end, Lee and Kader (2000) suggested a high recommendation of vitamin C intake of above 100 mg/day due to the fact that pressure of present day activities have placed high demands for this very important micronutrients.

Different preparation methods in which vegetable leaves undergo before and during cooking; including hot water dipping, squeezed washing, boiling and probably sun drying largely affect the availability of nutrients in them especially vitamin C. Whereas, vitamin C present in fruits are much more available because they are eaten in raw forms, those in vegetable leaves are not (Babalola *et al*., 2010). In addition, large portions of vitamin C is lost in the water during washing and processing of vegetables since it's a water dissoluble vitamin (Babalola *et al*., 2010).

One of the basic needs of man is the provision of sufficient and nutritionally adequate food (Yakubu *et al*., 2012). However, the tremendous post-harvest treatments they are subjected to often resulted in unequal food quality (Oboh, 2003). Several studies in this regard has established these facts. For instance, Favell (1998) stated that green vegetable leaves are prone to vitamin C damage. Domestic cooking also affects the resultant nutrients derived by the consumer particularly that of labile, water dissoluble C vitamin (Babalola *et al*., 2010). Aside that, various means through which fruits and green vegetables which consist vitamin C are apportioned reduced their retentivity. For example, the acts of contusion, peeling, slicing or cutting into pieces which introduce the materials into air also reduced vitamin C retentivity (Bello and Fawoyo, 2014). Ariahu and Egwujeh (2009) studied the results of hot water dipping and drying conditions on vitamin C retention of two green vegetable leaves. Akande *et al.* (2015) also examined the influence of steeping duration and amount of water on vitamin C concentrations of three green vegetable leaves from Nigeria.

It is a common knowledge and scientifically proven facts that soaking affects ascorbic acid concentration during processing, therefore the need for extensive study of most common leafy vegetables in Nigeria for the purpose of documentations and general knowledge. Hence, this study is an attempt to investigate the percentage vitamin C retention of freshly harvested seven Nigerian green leafy vegetables after soaking in water for eight hours.

## 2 Material and methods

### 2.1 Sample collection and treatments

Analytical grade chemicals and reagents were used throughout this work. Trichloroacetic acid (TCA) crystal was obtained from Loba Chemie India, L-Ascorbic acid and 2,6-Dichlorophenolindophenol (DCPIP) were obtained from Kem Light Laboratories PVT Ltd. India. Seven green leafy vegetables commonly consumed by the people of South-South and South-East zones of Nigeria; including *Amaranthus viridis* (African spinach, green, tete, inene), *Gnetum africanum* (ukazi), *Gongronema latifolium* (utazi), *Ocimum gratissimum* (scent leaf, efinrin-nla, nchanwu), *Piper guinense* (uziza), *Pterocarpus mildbreadii* (oha) and *Telfaria occidentalis* (fluted pumpkin leaf, ugu) were used for the present work. One kilogram (1 Kg) each of the above named freshly harvested green leafy vegetables was purchased from farmers and/or major holders in Mile 3 market, Diobu Area Port-Harcourt, Nigeria. Each sample was sorted, cleaned and 6 portions of 100 g each were separated out and treated as follows. For soaking, distilled water (dist. water) was used while for salting, NaCl (Royal Salt Ltd, Apapa, Lagos, Nigeria) was used.

Whole leaf 1 (WHL1): A portion of untreated leaves soaked in 1 L dist. water

Whole leaf 2 (WHL2): A portion of untreated leaves soaked in 2 L dist. water

Sliced leaf 1 (SLL1): A portion of sliced leaves soaked in 1 L dist. water

Sliced leaf 2 (SLL2): A portion of sliced leaves soaked in 2 L dist. water

Sliced and salted leaf 1 (SSL1): A portion of sliced leaves soaked in 2% salt solution (1 L)

Sliced and salted leaf 2 (SSL2): A portion of sliced leaves soaked in 2% salt solution (2 L)

The set up was kept on the laboratory bench under ambient conditions for 8 h while the ascorbic acid content was being determined every 2 h.

### 2.2 Determination of moisture and dry matter contents

Moisture (%) was carried out following AOAC (2002) methods. A known weight (5 g) of sample was dried first at 80°C for 4 h in hot-air oven and subsequently at 105°C for 2 h until constant weight was obtained. Percentage dry matter (DM) was determined from the moisture (%) of the leafy vegetables as, dry matter (%) = 100 - Miosture (%).

### 2.3 Determination of ascorbic acid content

Vitamin C content was estimated following the method of Ndawula *et al*. (2004). The method was slightly modified and used as follow; 2 g of leaf sample was homogenized in a mortar containing 10 mL of 5% TCA (extraction medium). The homogenized mixture was transferred into 100 mL standard flask and made up with more TCA solution to the mark and then filtered with Whatman filter paper number 1. Exactly 10 mL of the filtrate was titrated with standardized 2,6-dichlorophenolindophenol solution. Blank determination was carried out at the same time with 10 mL of trichloroacetic acid solution.

### 2.4 Determination of ascorbic acid retention (%)

The degree of reduction in AA was monitored every two hours of soaking and the amount of AA retained after each determination was used to estimate the percentage ascorbic acid retention using the relation

$$\textbf{\textit{Ascorbic acid retention}}\ (\%) = \frac{\textbf{\textit{Mean Final concentration}}}{\textbf{\textit{Mean Initial concentration}}}\ x\ 100\%$$

### 2.5 Analysis of results

Results of moisture, dry matter and vitamin C contents of raw leaves were expressed as mean ± SD. Ascorbic acid retention was expressed as percentage. Data were pooled and analyzed with one-way ANOVA by using SPSS for Windows version 20.0.0 (IBM SPSS Statistics, IBM Corporation Armonk NY, USA). Means were separated with New Duncan's Multiple Range F-Tests (DMRT) as described by Duncan (1955). Significance was tested at 95% confidence limit ($p<0.05$).

## 3 Result and Discussion

The results of moisture, dry matter and ascorbic acid contents of seven green vegetable leaves (Table 1) indicated that moisture contents (MC) of all the vegetables ranged from 67.63% (*Gnetum africanum*) to 86.70% (*Piper guinense*) and the dry matter (DM) contents of all the vegetables ranged from 13.30% (*P. guinense*) to 32.37% (*G. africanum*). The MC of *Piper guinense* was significantly high ($p<0.05$) when compared to other green vegetable leaves examined in this study while there was no significant difference ($p<0.05$) between the MC of *Amaranthus viridis*, *Gongronema latifolium* and

*Telfaria occidentalis*. The DM content of *G. africanum* was significantly ($p<0.05$) higher than the other vegetables while there was no significant difference ($p<0.05$) between the DM contents of *A. viridis*, *Gongronema latifolium* and *T. occidentalis*. The trends in the moisture and dry matter contents of the seven green leafy vegetables examined in this study is a direct reflection of their texture (hardness and/or softness). The same trend was reported (Akande *et al*., 2015) for freshly harvested three green vegetable leaves in Nigeria namely; *Heinsia crinata*, *Talinum triangulare* and *Vernonia amygdlina*. However, some reported values of moisture in the current work were lower in comparison with available data most especially the moisture contents of *T. occidentalis* (79.60%) for instance, Solanke and Awonorin (2002) reported the moisture content of *T. occidentalis* as 85.8%. Also Edeh *et al*. (2013) reported 87.21% and 83.95% for *T. occidentalis* and *Amaranthus caudatus* respectively. The reason for lower moisture content of *T. occidentalis* in the present study might probably be due to many factors ranging from environmental to varietal differences and post-harvest handlings.

**Table 1**: Moisture, dry matter and ascorbic acid contents of freshly harvested seven Nigerian vegetable leaves (mean ± SD, n=3 samples, # common name not available).

| Botanical name | Local /common name | Moisture (%) | Dry matter (%) | Ascorbic acid (mg/100 g ) |
|---|---|---|---|---|
| *Amaranthus viridis* | 'Tete' (african spinach) | $80.71^{c} \pm 1.08$ | $19.29^{c} \pm 1.08$ | $575.75^{b} \pm 1.34$ |
| *Gnetum africanum* | 'Ukazi'# | $67.63^{e} \pm 0.54$ | $32.37^{a} \pm 0.54$ | $322.14^{d} \pm 1.98$ |
| *Gongronema latifolium* | 'Utazi' (amaranth globe) | $80.55^{c} \pm 0.83$ | $19.45^{c} \pm 0.83$ | $227.40^{e} \pm 5.42$ |
| *Ocimum gratissimum* | 'Nchianwu, 'efinrin' (scent leaf) | $84.40^{b} \pm 0.64$ | $15.60^{d} \pm 0.64$ | $103.30^{g} \pm 5.99$ |
| *Piper guinense* | 'Uziza'(climbing black pepper) | $86.70^{a} \pm 0.59$ | $13.30^{e} \pm 0.59$ | $360.12^{c} \pm 8.01$ |
| *Pterocarpus mildbreadii* | 'Oha'# | $77.20^{d} \pm 0.20$ | $22.80^{b} \pm 0.20$ | $190.50^{f} \pm 1.08$ |
| *Telfaria occidentalis* | 'Ugu' (fluted pumpkin) | $79.60^{c} \pm 2.01$ | $20.40^{c} \pm 2.01$ | $1999.23^{a} \pm 0.24$ |

Means within the same column with unshared superscript letters are significantly different ($p<0.05$).

The ascorbic acid (AA) contents of seven Nigerian green leafy vegetables ranged from 103.30 mg/100 g dry weight (fresh *Ocimum gratissimum*) to 1999.23 mg/100 g dry weight (fresh *T. occidentalis*). The AA content of *T. occidentalis* was significantly ($p<0.05$) higher than the other vegetables examined in this study while the AA content of *O. gratissimum* was significantly ($p<0.05$) low compared to the other vegetables examined. The observed values of AA were higher than most available literature reports. For instance, Solanke and Awonorin (2002) reported the AA concentration of fresh *T. occidentalis* as 221.1 mg/100 g. The AA content of fresh *T. occidentalis* and *Amaranthus hybridus* were reported as 158.2 mg/100 g and 155.1 mg/100 g respectively (Ariahu and Egwujeh, 2009). Babalola *et al*. (2010) reported the AA content of *T. occidentalis* as 62.50 mg/100 g fresh weight and 24.00 mg/100 g fresh weight for *Amaranthus viridis*. Also in a report published by Edeh *et al*. (2013) the ascorbic acid contents of *T. occidentalis* and *Amaranthus caudatus* were 63.00 mg/100 g and 39.08 mg/100 g respectively. The reason for high values recorded for ascorbic acid contents in the present report might be attributed to the facts that; in our report, we calculated the ascorbic acid contents of seven green vegetable leaves on dry matter basis whereas other reports were estimated on fresh or wet weight basis. Other reasons may be attributed to environment and varietal differences as well.

Diminution in ascorbic acid contents (mg/100 g) was observed in all the seven freshly harvested Nigerian vegetable leaves after soaking for two, four, six and eight hours as presented in Table 2. Generally, whole leaf 1 (WHL1) and/or whole leaf 2 (WHL2) had significantly ($p<0.05$) high ascorbic acid content (mg/100 g) during all the sampling periods especially in *Telfaria occidentalis*, *Pterocarpus mildbredii*, *Piper guinense*, *Ocimum gratissimum*, *Gnetum africanum* and *Amaranthus viridis*.

The interaction between the ascorbic acid retention (%) of seven Nigerian green leafy vegetables and time (h) was generally a reverse order relation while the effects of pre-processing treatments (slicing, slicing with 2% salt solution) and volume of water varied from one leaf to the other (Figures 1–7). Soaking for 2 h resulted in increased AA concentrations in WHL1 (0.26%) of *Gnetum africanum* (Figure 2), WHL1 and WHL2 (29.05% each) of *Gongronema latifolium* (Figure 3) and WHL1 (20.02%) of *T. occidentalis* (Figure 7). Similar result was recorded when *Talinum triangulare* (whole leaves) was soaked in water for 2 h, the ascorbic acid content increased up to 161.93% (Akande *et al*., 2015).

A good number of treatments retained more than 50% of their original AA concentration after 8 h soaking time; these include, WHL2 and SSL2 (57.26% and 51.93% respectively) both in *Amaranthus viridis* (Figure 1), WHL1 (56.13%) in *Ocimum gratissimum* (Figure 4) and WHL1 (68.18%) in *Telfaria occidentalis* (Figure 7). Salt solution (2%) resulted into 14.36% increase in the AA retention (%) of sliced *Amaranthus viridis* compared to the same sample soaked in ordinary water. Similar results were obtained when *Amaranthus hybridus* was blanched in 0.2% sodium metabisulphite solution before drying; it resulted into 1.02 times more AA retention in solar dried sample than the sun dried sample within 8 h according to Ariahu and Egwujeh (2009).

**Table 2**: Ascorbic acid content (mg/100 g) of freshly harvested seven Nigerian vegetable leaves after soaking in water for 2, 4, 6, and 8 h (mean ± SD, n=3 samples, results expressed in dry matter basis).

| after 2 hours | WHL1 | WHL2 | SLL1 | SLL2 | SSL1 | SSL2 |
|---|---|---|---|---|---|---|
| *Amaranthus viridis* | 452.31$^{b}$± 7.09 | 392.65$^{a}$± 2.89 | 230.99$^{e}$± 1.73 | 321.65$^{c}$± 0.57 | 256.82$^{d}$± 6.64 | 347.98$^{b}$± 8.89 |
| *Gnetum africanum* | 285.41$^{a}$± 4.89 | 247.52$^{b}$± 2.50 | 153.99$^{e}$± 4.61 | 188.14$^{d}$± 2.60 | 195.55$^{c}$± 2.15 | 148.32$^{f}$± 5.50 |
| *Gongronema latifolium* | 193.80$^{a}$± 1.73 | 108.25$^{c}$± 1.98 | 174.43$^{b}$± 5.29 | 171.38$^{b}$± 0.00 | 107.59$^{c}$± 0.82 | 107.87$^{c}$± 2.79 |
| *Ocimum gratissimum* | 68.32$^{a}$± 8.44 | 69.05$^{a}$± 8.04 | 37.12$^{c}$± 3.23 | 33.79$^{c}$ ± 4.50 | 52.32$^{b}$± 1.96 | 49.73$^{b}$± 4.24 |
| *Piper guinense* | 147.99$^{a}$± 6.64 | 97.08$^{b}$± 3.10 | 55.09$^{e}$± 0.36 | 68.60$^{cd}$± 12.10 | 58.14$^{de}$± 5.11 | 45.05$^{f}$± 1.17 |
| *Pterocarpus mildbredii* | 134.28$^{b}$± 3.64 | 147.36$^{a}$± 6.15 | 118.74$^{c}$±3.28 | 120.85$^{c}$± 6.05 | 97.22$^{d}$± 5.81 | 95.87$^{d}$± 5.33 |
| *Telfaria occidentalis* | 2354.19$^{a}$ ± 49.65 | 1788.66$^{b}$± 28.67 | 1519.04$^{d}$± 11.39 | 1396.29$^{e}$± 43.79 | 1576.03$^{c}$± 15.18 | 1503.70$^{d}$± 21.14 |
| after 4 hours | | | | | | |
| *Amaranthus viridis* | 352.65$^{b}$ ±13.28 | 383.31$^{a}$ ±6.81 | 274.32$^{d}$ ±23.18 | 255.66$^{e}$ ±4.62 | 326.65$^{c}$ ±8.08 | 349.65$^{b}$ ±8.08 |
| *Gnetum africanum* | 322.98$^{a}$±2.30 | 88.94$^{f}$ ±1.72 | 159.15$^{e}$ ±2.37 | 163.23$^{d}$ ±1.87 | 183.14$^{bc}$ ±3.25 | 180.39$^{c}$ ±3.25 |
| *Gongronema latifolium* | 293.45$^{a}$±11.21 | 293.44$^{a}$±11.21 | 107.82$^{b}$±1.00 | 88.20$^{c}$±2.56 | 87.31$^{c}$±2.80 | 85.83$^{c}$±0.24 |
| *Ocimum gratissimum* | 51.59$^{b}$ ±2.82 | 69.79$^{a}$ ±7.18 | 13.73$^{c}$ ±3.23 | 20.40$^{c}$±2.82 | 45.66$^{b}$ ±7.74 | 50.06$^{b}$±3.92 |
| *Piper guinense* | 103.28$^{b}$ ±5.64 | 48.78$^{d}$±5.28 | 77.65$^{c}$±4.24 | 131.13$^{a}$ ±5.76 | 83.17$^{c}$±9.27 | 48.78$^{d}$±5.28 |
| Pterocarpusmildbredii | 104.75$^{b}$±3.08 | 136.49$^{a}$±6.34 | 80.58$^{d}$±4.03 | 89.46$^{c}$±1.00 | 56.81$^{e}$±6.15 | 87.69$^{cd}$±3.41 |
| Telfariaoccidentalis | 1907.02$^{a}$±28.67 | 1595.76$^{b}$±21.14 | 957.97$^{e}$±26.58 | 907.48$^{e}$±19.73 | 1205.59$^{c}$±20.09 | 1117.71$^{d}$±29.81 |
| after 6 hours | | | | | | |
| *Amaranthus viridis* | 251.65$^{d}$ ±2.31 | 327.98$^{a}$ ±5.20 | 269.66$^{bc}$ ±6.51 | 262.32$^{cd}$ ±12.66 | 261.32$^{cd}$ ±8.50 | 280.98$^{b}$ ±5.00 |
| *Gnetum africanum* | 164.90$^{b}$ ±2.75 | 157.99$^{c}$ ±c2.30 | 143.39$^{d}$±3.87 | 147.33$^{d}$ ±4.16 | 176.65$^{a}$ ±4.26 | 168.07$^{b}$ ±2.84 |
| *Gongronema latifolium* | 63.13$^{d}$ ±1.98 | 104.97$^{a}$ ±3.71 | 63.03$^{d}$ ±2.15 | 83.55$^{c}$ ±3.71 | 99.97$^{bc}$ ±12.37 | 71.41$^{d}$ ±12.37 |
| *Ocimum gratissimum* | 59.39$^{ab}$ ±2.82 | 43.79$^{b}$ ±4.20 | 44.92$^{b}$ ±3.23 | 46.79$^{b}$ ±7.80 | 47.52$^{b}$ ±6.73 | 50.12$^{b}$±7.74 |
| *Piper guinense* | 69.45$^{b}$±3.79 | 153.38$^{a}$±3.15 | 39.63$^{d}$ ±5.28 | 55.17$^{c}$±8.72 | 52.12$^{c}$ ±4.79 | 51.83$^{c}$ ±5.28 |
| *Pterocarpus mildbredii* | 116.53$^{a}$ ±1.13 | 122.51$^{a}$ ±0.00 | 85.26$^{b}$ ±4.77 | 89.46$^{b}$ ±1.00 | 69.24$^{c}$ ±0.00 | 116.31$^{a}$ ±8.57 |
| *Telfaria occidentalis* | 1828.11$^{a}$±43.12 | 1168.33$^{b}$±16.55 | 556.76$^{e}$±27.37 | 907.48$^{c}$±19.73 | 747.46$^{d}$ ±7.59 | 865.83$^{c}$ ±77.06 |
| after 8 hours | | | | | | |
| *Amaranthus viridis* | 139.66$^{d}$ ± 1.53 | 329.65$^{a}$± 13.28 | 141.32$^{d}$ ± 3.51 | 216.32$^{c}$ ± 12.10 | 222.32$^{c}$ ± 7.09 | 298.99$^{b}$ ± 0.00 |
| *Gnetum africanum* | 90.70$^{b}$± 0.00 | 85.44$^{c}$± 5.25 | 126.42$^{a}$± 0.00 | 63.21$^{d}$ ± 0.00 | 66.44$^{d}$ ± 3.85 | 92.27$^{b}$ ± 2.73 |
| *Gongronema latifolium* | 149.96$^{a}$ ± 21.42 | 164.24$^{a}$ ± 32.72 | 86.64$^{c}$± 1.64 | 109.02$^{b}$± 3.31 | 71.21$^{cd}$± 12.02 | 65.22$^{d}$± 1.64 |
| *Ocimum gratissimum* | 51.99$^{a}$± 9.01 | 13.73$^{c}$± 3.23 | 7.80$^{c}$± 0.00 | 10.40$^{c}$± 4.50 | 21.93$^{b}$± 5.74 | 10.40$^{c}$ ± 4.50 |
| *Piper guinense* | 62.12$^{a}$± 9.57 | 36.59$^{cd}$ ± 9.15 | 14.92$^{f}$ ± 2.92 | 24.96$^{ef}$ ± 10.07 | 42.69$^{bc}$ ± 10.56 | 34.11$^{de}$ ± 4.29 |
| *Pterocarpus mildbredii* | 26.63$^{b}$ ± 0.00 | 19.53$^{b}$ ± 3.07 | 40.62$^{a}$± 6.35 | 40.62$^{a}$± 6.35 | 38.41$^{a}$ ± 3.65 | 37.28$^{a}$ ± 0.00 |
| *Telfaria occidentalis* | 1343.69$^{a}$ ± 36.22 | 975.43$^{b}$ ± 32.44 | 401.13$^{f}$ ± 74.11 | 469.08$^{e}$ ± 42.28 | 734.34$^{c}$ ± 3.82 | 611.56$^{d}$ ± 47.42 |

Results are expressed as mean ± SD of triplicate readings (n=3). Mean values with different superscripts across the row for each interval are significantly different ($p<0.05$). WHL1=whole leaves in 1 L of water; WHL2= whole leaves in 2 L of water; SLL1=sliced leaves in 1 L of water; SLL2=sliced leaves in 2 L of water; SSL1=sliced leaves in 1 L of 2% salt solution; SSL2= sliced leaves in 2 L of 2% salt solution.

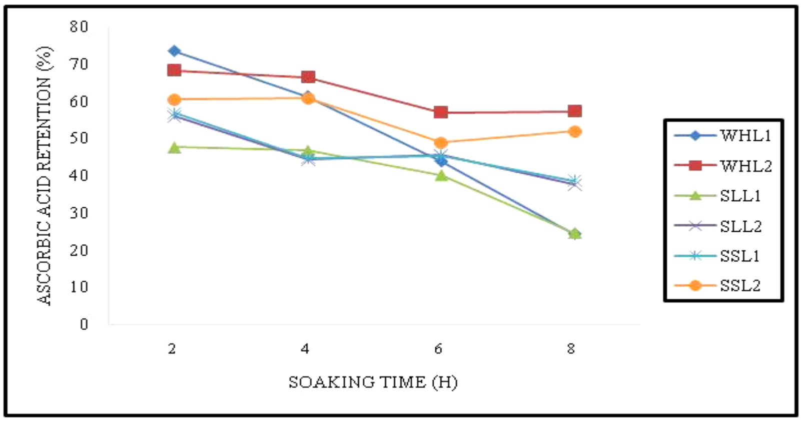


**Fig. 1. Changes in ascorbic acid retention (%) of *Amaranthus viridis* with soaking time, pre-processing treatments and volume of water.** Values showed percentage of ascorbic acid retained. WHL1=whole leaves in 1 L of water; WHL2= whole leaves in 2 L of water; SLL1=sliced leaves in 1 L of water; SLL2=sliced leaves in 2 L of water; SSL1=sliced leaves in 1 L of 2% salt solution; SSL2= sliced leaves in 2 L of 2% salt solution.

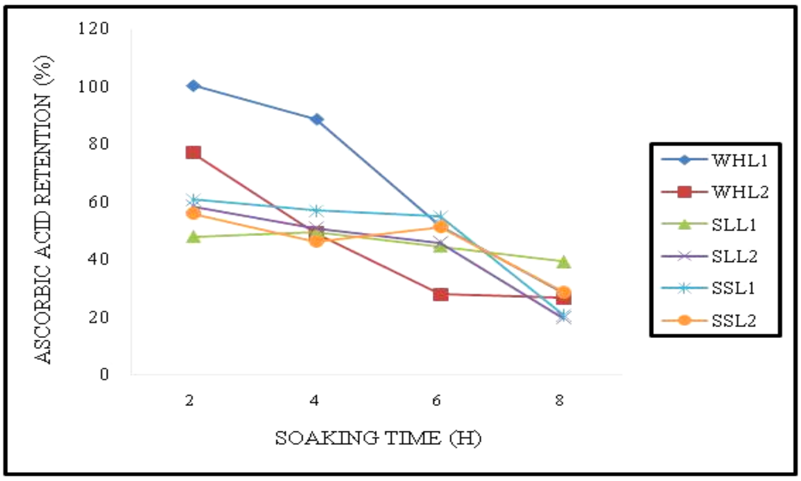


**Fig. 2. Variation of ascorbic acid retention (%) of *Gnetum africanum* with soaking time, pre-processing treatments and volume of water** (See Fig 1 for the description on the key).

Another category was leaves that did not retain up to 50% of initial AA concentration in any treatment (WHL1, WHL2, SLL1, SLL2, SSL1 and SSL2) after 8 h soaking time include *Gnetum africanum* (Figure 2), *Gongronema latifolium* (Figure 3) and *Pterocarpus mildbredii* (Figure 6). The case of *Piper guinense* was exceptional; more than 50% of the original AA concentration was lost in all the treatments even within 2 h soaking time

(Figure 5). The reason for lower AA retention time in *Piper guinense* may be due to its high residual moisture content. Since water serve as a medium that facilitates most chemical and biochemical reactions, its increase would be expected to aid chemically and biochemically mediated degradation losses of ascorbic acid as suggested by Ariahu and Egwujeh, (2009).

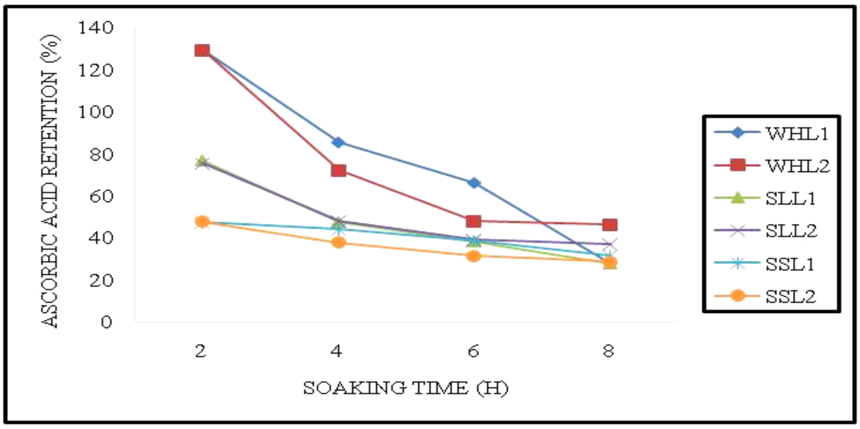


**Fig. 3. Variation of ascorbic acid retention (%) of *Gongronema latifolium* with soaking time, pre-processing treatments and volume of water** (See Fig 1 for the description on the key).

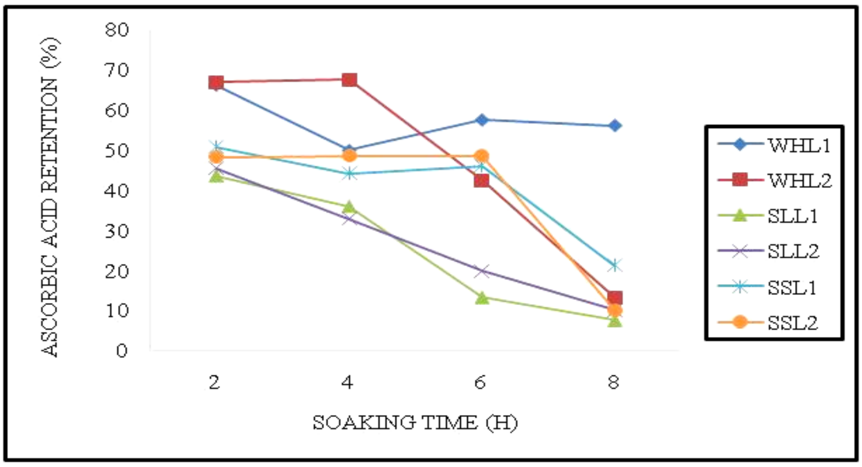


**Fig. 4**. **Variation of ascorbic acid retention (%) of *Ocimum gratissimum* with soaking time, pre-processing treatments and volume of water** (See Fig 1 for the description on the key).

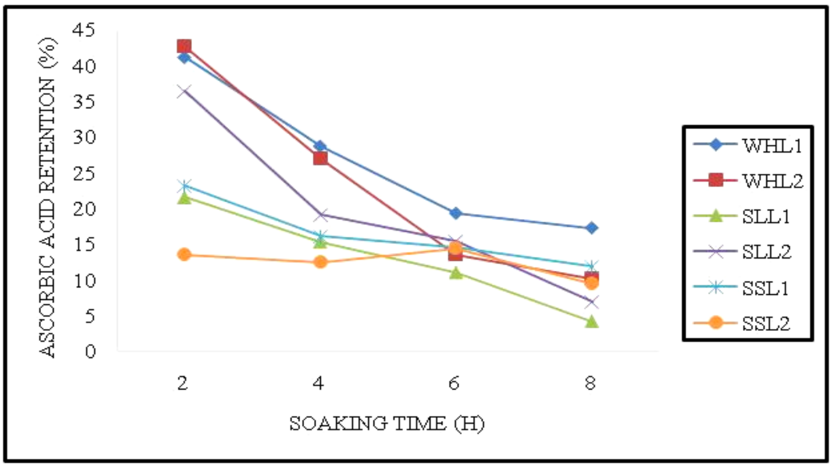


**Fig. 5. Variation of ascorbic acid retention (%) of *Piper guinense* with soaking time, pre-processing treatments and volume of water** (See Fig 1 for the description on the key).

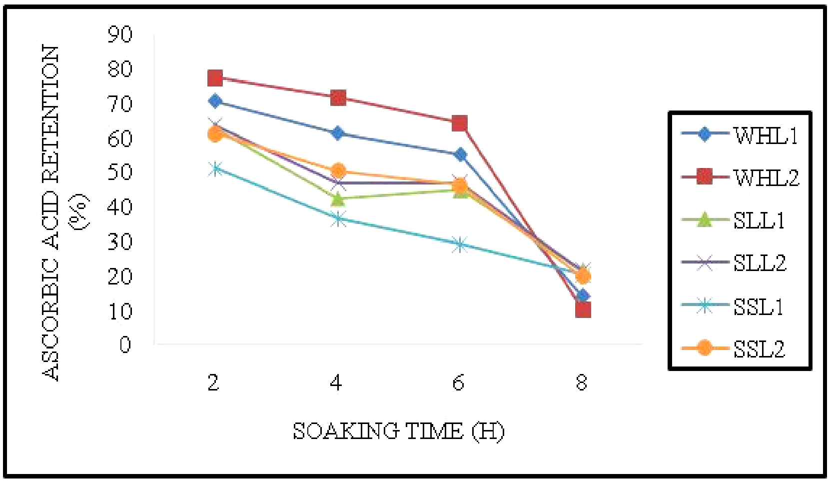


**Fig. 6. Variation of ascorbic acid retention (%) of *Pterocarpus mildbredii* with soaking time, pre-processing treatments and volume of water.** (See Fig 1 for the description on the key).

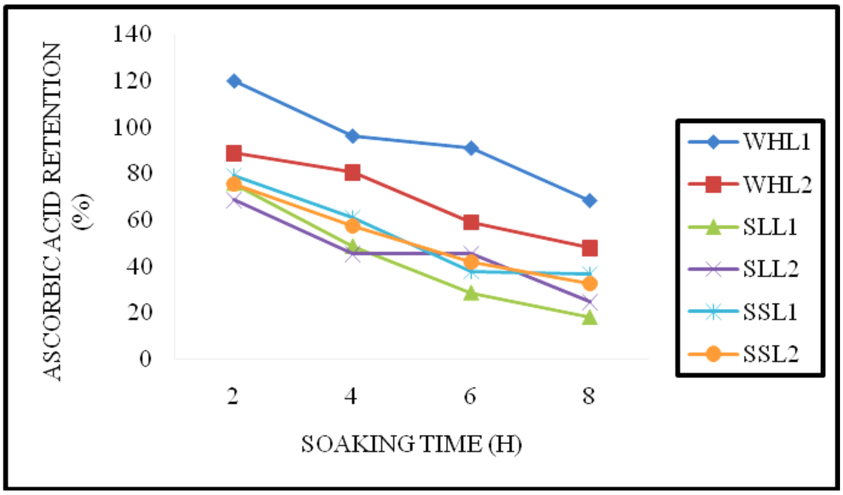


**Fig 7. Variation of ascorbic acid retention (%) of *Telfaria occidentalis* with soaking time, pre-processing treatments and volume of water** (See Fig 1 for the description on the key).

## 4 Conclusion

The study has shown that generally, the interaction between ascorbic acid retention (%) with respect to soaking time (h) is a reverse order relation. It is a common in-house practice in Nigeria to soak leafy vegetables in water probably after slicing in order to remove sand and other extraneous materials attached to them. This study has shown that it is better to wash or soak (if any need) a vegetable before slicing it. This measure would help reduction of oxidative degradation of ascorbic acid. Soaking for a maximum of 2 h and/or 4 h caused a significant increase in ascorbic acid content of *Gnetum africanum*, *Gongronema latifolium*, and *Telfaria occidentalis*. However, subsequent processing such as steaming or cooking may cause more damage or adverse effect on the other nutritional components. These areas are still open for more investigations. It is important to note that leafy vegetables are not being consumed majorly for the vitamin C they contained because an appreciable amount of it is lost during in-home processing and cooking. It is therefore advisable to take more fruits to complement the need for ascorbic acid.

**Acknowledgements** Authors wish to acknowledge the management of Nigerian Stored Products Research Institute, Port-Harcourt for the use of Laboratory facilities and equipment during the course of this research work. Two anonymous reviewers are acknowledged for comments on the initial manuscript.

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