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Comparative Studies on the Effect of Boiling and Sprouting on Antioxidant Potential of Onion (*Allium cepa*) and Garlic (*Allium sativum*)

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Abstract: The sprouted bulbs of *Allium* plants have been considered to be a waste in many kitchens and these discarded bulbs may contain improved antioxidant potentials as a result of sprouting. The study aimed to investigate how sprouting and boiling affect the antioxidant properties of garlic (*Allium sativum*) and onions (*Allium cepa*).

Garlic and onion bulbs were either sprouted for 0–10 days or boiled for 0–8 minutes. The aqueous, methanol, and chloroform of the bulb extracts were then prepared, screened phytochemically, and their ability to scavenge 2, 2-diphenyl-1–picril–hydrazil (DPPH) radicals was employed to evaluate their antioxidant potentials using conventional techniques.

The results show that boiling reduced the samples' total phenol, flavonoid, and ascorbic concentrations significantly ($p<0.05$) regardless of the kind of solvent utilized. The sprouted methanol extract of onions (7.84 mg/g RE) at day 8 and sprouted methanol extract of garlic (20.16 mg/g RE) at day 10 showed a considerably ($p<0.05$) higher total flavonoid content. All extracts expressed higher phenolic content at day 8 of sprouting onion and there was a significant increase till day 10 of sprouting garlic. The DPPH Scavenging activity of sprouted garlic and onions has the minimum activity on the 8th day. However, the comparative measure of ascorbic acid content in sprouted garlic and onions increases but differs slightly, Garlic has its maximum ascorbic content at the 10th day (8.820mg/g), while Onions has its maximum ascorbic content at 6th day (6.29mg/g). Generally, the antioxidant potentials of boiled extracts of onion and garlic decreased significantly.

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The study revealed that sprouting of onions and garlic could increase their antioxidant capacity while boiling reduces their antioxidant capacity in both samples.

Keywords: Garlic, Onion, sprouting, boiling, phytochemicals, antioxidant activity

1. Introduction

Onions *(Allium cepa, L.*) and garlic (*Allium sativum*) are the most commonly used species of Allium family. These plants are widely used as spice and herbs because of their antioxidants potentials (Teshika *et al*., 2018). The therapeutic benefits of onions as an antibacterial, antidiabetic, anti-atherogenic, and anticancer agent have been well researched (Saxena *et al*., 2013; Awuchi, 2019).

Allium sativum, or garlic, possesses antibacterial properties against a wide range of common bacterial, fungal, and viral strains. Garlic's therapeutic properties are attributed to its elevated sulfur component content. Garlic (*Allium sativum*) possesses antimicrobial activity against a wide range of common bacterial, fungal and viral strains. The therapeutic properties of garlic are attributed to its high concentration of sulfur compounds. Garlic has been extensively studied for its potential health benefits, primarily attributed to its rich chemical composition. The therapeutic potential of garlic in conditions like blood pressure, atherosclerosis, cancer, cardiovascular disease, diabetes, and hyperlipidemia has been supported by various studies (Gebreyohannes and Gebreyohannes, 2013; Imo and Zaaku, 2019). However, aside from being medicinal, onions and garlic are known to be renowned spice and ornamental plants (Prager and Gauglin, 2020). These vegetables are made into tonic, soup, eaten raw, or apply directly on the skin after being homogenized for several purposes (Ho *et al*., 2012; Hamza *et al*., 2013; Wiczkowski, 2018).

Processing techniques are well known to exert different impacts on total phenolic content and antioxidant activity of plant samples. The results range from minor to major decreases or increases in antioxidant activity (Ebhomienlen and Azeke, 2019). Food processing can enhance the potentials of antioxidants in food or encourage the synthesis of new antioxidant- containing compounds, resulting in an increase or decrease in total antioxidant activity (Pisochi and Negulescu, 2011).

Humans possess increasing cell oxidative damage with age, therefore increased intake of antioxidant subjects such as garlic and onions, fruits will likely support the defense of endogenous antioxidants and prevent degenerative diseases such as cancer, Parkinson, Alzheimer or atherosclerosis caused oxidative stress (Raghu *et al*., 2020)**.** Several studies revealed that when plant samples were heated, their total phenolic content and antioxidant activity decreased. The most often reported losses were those from vegetable (Bin *et al*., 2021). The decrease in antioxidant activity of samples that were heated was attributed to the thermal breakdown of phenolic compounds in addition to other methods used in food processing (Brewster and Rabinowitch, 2020; Ghafoor *et al*., 2018).

Onions and garlic, which are primarily used in most kitchens to prepare delicacies and infusions used by traditional medical expert to treat certain ailments, have little information available about the impact of various processing methods on their antioxidant status. Since onions and garlic are rarely eaten fresh without processing, this information would be more pertinent (Ebhomienlen and Azeke, 2020).

Herein, this study focused on the impacts of boiling and sprouting on the bioactive compounds in the *Allium* plants (garlic and onions) and the necessary implementation that can be applied or avoided to retain and increase the quality of bioactive compounds such as flavonoids, phenols etc.

2. Materials and Methods

2.1. Collection and Preparation of Sample

The Mature onions (*Allium cepa L.*) and garlic (*Allium sativum*) samples were collected fresh from a local market in the Edo State municipality of Esan North-East Local Government Area (Uromi). The plant samples were properly authenticated by a plant taxonomist. Onions and garlic were stripped of their dry skins and placed on steel tray that had damp tissue paper. They were allowed to sprout in the dark at 25 – 30°C for maximum of ten days. Separately, onion slices were boiled for two to eight minutes (2-3min), while a control group of onions was left unboiled and unsprouted. The processed and raw samples, totaling 25g, were then dried, ground, and mixed before being extracted with a range of solvents (water, methanol, and chloroform).

2.2 Method of Extraction

An analytical chemical balance was used to weigh 25 g of dried, pulverized sprouted onions (0, 2, 4, 6, 8, and 10 days), boiled onions (0, 2, 4, 6, and 8 mins), and sprouted dried garlic powder (0, 2, 4, 6, 8, and 10 days), boiled garlic (0, 2, 4, 6, and 8 mins) into different beakers. Each of them was homogenized separately using a laboratory mortar and pestle. After homogenization, 100ml of three different extraction solvents (methanol, chloroform and water) were utilized. The samples were centrifuged for thirty minutes at 4000 rpm. Whatman No. 1 filter paper was used to filter the supernatant, which was then concentrated and dissolved in dimethyl sulphoxide (DMSO) in a beaker.

2.3 Quantitative Phytochemical Screening

2.3.1 Determination of Total Flavonoids Content

The Meda *et al*. (2005) technique was used to calculate the total flavonoid. The reaction mixture is made up of the same volume of the onion and garlic extract solution and 2ml of 2% aluminum trichloride (AlCl3) in methanol. After 10 minutes of room temperature incubation, the mixtures were tested for absorbance at 415 nm using a spectrophotometer (JENWAY 6715, Bibby Scientific Ltd

UK). A negative control with no extract was employed as a blank. Using an equation derived from the standard rutin graph, the total flavonoid content was calculated as milligram of rutin equivalent.

$$\text{Flavonoids Content (\%w/w)} = \frac{RE \times D \times V \times 10^{-6}}{W} \times 100 \ldots\ldots\ldots \quad (1)$$

RE – Rutin equivalent (µg/ml), D – Dilution factor, V – Total volume of sample (ml), W –Weight of sample

2.3.2 Determination of Total Phenolic Content

The concentration of phenolic compounds in the sprouting and boiling extracts of onion (*Allium cepa L.*) and garlic (*Allium sativum*) was measured using the Folin-Ciocalteu reagent. The results were expressed as pyrocatechol equivalents (PEs) using a slightly modified version of Slinkard and Singleton (1997) methods. Forty six (46ml) milliliters of distilled aqueous were added to a separate volumetric flask containing about 1ml of the onion and garlic extracts. Then, 1ml of Folin-Ciocalteu reagent was added and thoroughly mixed in both flasks. Three (3) minutes later, 3 ml of 2% anhydrous sodium carbonate (Na2CO3) was added, and the mixture was allowed to rest for two hours while being periodically shaken. Using a blank that included all of the reaction components other than the extracts, the absorbance was measured at 760 nm in a spectrophotometer (JENWAY 6715, Bibby Scientific Ltd., UK). An equation derived from a typical pyrocatechol graph was used to compute the overall concentration of phenolic compounds in the extracts, expressed as micrograms of pyroctechol equivalent:

$$\text{Absorbance} = 0.0021 \times total\ phenols(\mu\text{gpyrocatechol}) - 0.0092 (R^2 = 0.9934) \ldots.. \quad (2)$$

2.3.3 Determination of Antioxidant Activity

The ability of sprouted, boiled onions and garlic extracts to scavenge free radicals was measured using DPPH. The procedure is comparable to the method Gadow *et al.*(1997) previously detailed with a minor adjustment. Specifically, 1ml of plant extract and 2ml of DPPH radical methanol solution at a concentration of 0.05 mg/ml were put in cuvettes. The mixture was well shaken and then left to stand at room temperature for half an hour. Using methanol as a blank, the absorbance was measured at 517 mm using an ultraviolet spectrophotometer (JENWAY 6715, Bibby Scientific Ltd UK).

The DPPH radical concentration was calculated suing the following equation

$$\%\ DPPH\ Inhibition = \frac{A_0 - A_1}{A_0} \times 100 \ldots\ldots\ldots \quad (3)$$

Where A_0= the absorbance of the control

A_1= the absorbance of DPPH solution containing sample extract

2.3.4 Determination of Ascorbic Acid (Vitamins C) Content of Onion and Garlic Extract

The titrimetric method proposed by Plummer was used to determine the content of vitamin C (Plummer, 1978). A 1ml of glacial acetic was added to a boiling tube containing 5ml of diluted extract. Subsequently, the mixture was titrated using a solution containing 0.1 mg/ml 2, 6-dichlorophenolindophenol. The standard used was a five milliliter solution of 0.022 mg/ml vitamin C solution. The vitamin C equivalent of the samples was determined by comparing the samples' titre values with this value.

2.4 Statistical Analysis

The data collected were presented as mean ± SEM (n=3). The Turkey Kramer Multiple Comparison Test and Analysis of Variance (ANOVA) were used to test for significant differences. Data analysis was done using the statistical software program Instat-GraphPad. A difference was considered statistically significant when $P<0.05$.

3. Results and Discussion

Table 1: Total Flavonoid Content (mg/g RE) of Differently Sprouted Garlic

Extracts	Days of Sprouting					
	Control (Day0)	Day 2	Day 4	Day 6	Day 8	Day 10
Aqueous	5.39 ± 0.02^{a}	6.69 ± 0.05^{b}	8.50 ± 0.00^{c}	9.09 ± 0.02^{d}	11.00 ± 0.02^{e}	11.96 ± 0.01^{f}
Methanol	5.88 ± 0.10^{a}	9.48 ± 0.03^{b}	13.41 ± 0.06^{c}	15.83 ± 0.029^{d}	18.29 ± 0.04^{e}	20.16 ± 0.08^{f}
Chloroform	4.22 ± 0.06^{a}	6.61 ± 0.02^{b}	7.26 ± 0.00^{c}	8.37 ± 0.06^{d}	9.76 ± 0.00^{e}	10.39 ± 0.06^{f}

Data are presented as Mean ± SD (n = 3 values); mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$). RE = rutin equivalent.

Table 2: Total Flavonoid Content (mg/g RE) of Differently Sprouted Onions

Extracts	Days of Sprouting					
	Control (Day0)	Day 2	Day 4	Day 6	Day 8	Day 10
Aqueous	4.06 ± 0.01^{a}	4.87 ± 0.03^{b}	5.19 ± 0.01^{c}	6.12 ± 0.00^{d}	6.71 ± 0.02^{e}	4.95 ± 0.02^{f}
Methanol	4.96 ± 0.02^{a}	5.64 ± 0.03^{b}	6.87 ± 0.01^{c}	7.79 ± 0.02^{d}	7.84 ± 0.02^{e}	5.15 ± 0.07^{f}
Chloroform	3.71 ± 0.02^{a}	3.44 ± 0.02^{b}	4.54 ± 0.01^{c}	5.73 ± 0.01^{d}	5.73 ± 0.01^{e}	3.12 ± 0.01^{f}

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$). RE = rutin equivalent.

The result from tables 1 and 2 shows a concomitant increase in sprouted garlic (0 to 10 days) and onions (0 to 8 days). With Onions extract, there was a significant decline at day 10 of sprouting.

Generally, the flavonoids content of sprouted garlic extract yielded a higher antioxidant properties (20.16mg/gRE) on the day 10 with the solvent methanol , when compared with onions extract which yielded a higher antioxidant property (7.89mg/gRE) on the day 8 with methanol.

Table 3: Total Flavonoid Content (mg/gRE) of Differently Boiled Garlic

Extracts	**Time of Boiling (minutes)**				
	0 Minute	**T_2**	**T_4**	**T_6**	**T_8**
Aqueous	5.39 ± 0.02^a	5.16 ± 0.00^b	4.64 ± 0.02^c	4.15 ± 0.01^d	3.56 ± 0.00^e
Methanol	5.88 ± 0.09^a	5.78 ± 0.03^b	4.72 ± 0.00^c	4.36 ± 0.02^d	3.96 ± 0.02^e
Chloroform	4.22 ± 0.06^a	4.017 ± 0.01^b	3.57 ± 0.02^c	3.20 ± 0.05^d	2.41 ± 0.01^e

Data are presented as Mean ± SD (n = 3 values) determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$); T_2 = 2 mins, T_4 = 4 mins; T_6 = 6 mins, and T_8 = 8 mins; RE = rutin equivalent.

Table 4: Total Flavonoid Content (mg/gRE) of Differently Boiled Onions

Extracts	**Time of Boiling (minutes**				
	0 Minute	**T_2**	**T_4**	**T_6**	**T_8**
Aqueous	4.06 ± 0.01^a	3.86 ± 0.02^b	2.66 ± 0.01^c	2.26 ± 0.01^d	2.21 ± 0.01^e
Methanol	4.96 ± 0.02^a	3.97 ± 0.00^b	3.17 ± 0.01^c	2.86 ± 0.01^d	2.18 ± 0.01^e
Chloroform	3.71 ± 0.02^a	3.27 ± 0.01^b	2.01 ± 0.01^c	1.52 ± 0.01^d	1.43 ± 0.01^e

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$); T_2 = 2 mins, T_4 = 4 mins; T_6 = 4 mins, and T_8 = 8 mins; RE = rutin equivalent.

The comparative result of the above tables 3 and 4 shows a concomitant decrease in boiled garlic (0 to 10 days) and onions. (0 to 10 days). With garlic and onions extract, there was a significant decline from day 0 to 10 of sprouting.

Generally, the Flavonoids content of boiled garlic extract yielded a higher antioxidant properties (5.88mg/gRE) at 0 min or at a state without boiling, with the methanol , when compared with onions extract which yielded a higher antioxidant property (4.96mg/gRE) at 0 minutes with the solvent methanol. This shows that the polarity of solvent used for extraction has an effect on the flavonoid content, thus, the higher the polarity of solvent the higher the concentration of flavonoid contents.

Table 5: Total Phenolic Content (mg/g PE) of Differently Sprouted Garlic

Extracts	**Days of Sprouting**

	Control (Day0)	Day 2	Day 4	Day 6	Day 8	Day 10
Aqueous	5.89 ± 0.03[a]	8.85 ±0.05[b]	11.73±0.07[c]	13.57±0.03[d]	15.11 ±0.05[e]	16.95±0.00[f]
Methanol	6.26 ± 0.00[a]	9.43±0.02[b]	14.06±0.050[c]	17.83±0.06[d]	21.360±0.00[e]	24.07±0.00[f]
Chloroform	4.587 ± 0.02[a]	5.970±0.00[b]	7.030±0.02[c]	9.733±0.06[d]	11.02±0.00[e]	12.29±0.04[f]

Data are presented as Mean ± SD (n = 3 values); mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference (P<0.05). PE = pyrocatechol equivalent

Table 6: Total Phenolic Content (mg/g PE) of Differently Sprouted Onions

Extracts	Days of Sprouting					
	Control (Day0)	Day 2	Day 4	Day 6	Day 8	Day 10
Aqueous	4.84 ± 0.08[a]	6.60[b] ± 0.06	10.42[c] ± 0.25	13.33[d] ± 0.07	14.03[e] ± 0.02	9.53[f] ± 0.02
Methanol	5.20[a] ± 0.05	6.84[b] ± 0.08	10.85[c] ± 0.06	14.02[d] ± 0.29	15.58[e] ± 0.03	10.42[c] ± 0.19
Chloroform	3.13[a] ± 0.02	4.84[b] ± 0.10	8.08[c] ± 0.05	11.51[d] ± 0.04	12.40[e] ± 0.06	8.83[f] ± 0.03

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference (P<0.05). PE = pyrocatechol equivalent.

The comparative results of tables 5and 6 above show a concomitant increase in sprouted garlic (0 to 10 days) and onions. (0 to 8 days). With Onions extract, there was a significant decline at day 10 of sprouting.

Generally, the phenolic content of sprouted garlic extract yielded highest antioxidant properties (24.07mg/gRE) on the day 10 with the solvent methanol , when compared with onions extract which yielded a higher antioxidant property (15.58mg/gRE) on the day 8 with the solvent methanol.

Table 7: Total Phenolic Content (mg/g PE) of Differently Boiled Garlic

Extracts	Time of Boiling (minutes				
	0 Minute	T_2	T_4	T_6	T_8
Aqueous	5.897 ± 0.029[a]	5.707 ± 0.050[b]	5.110 ± 0.000[c]	4.323 ± 0.012[d]	3.210 ± 0.000[e]
Methanol	6.257 ± 0.000[a]	6.000 ± 0.012[b]	5.533 ± 0.025[c]	4.940 ± 0.017[d]	4.203 ± 0.029[e]
Chloroform	4.587 ± 0.023[a]	4.237 ± 0.046[b]	4.160 ± 0.000[c]	3.357 ± 0.006[d]	2.063 ± 0.040[e]

Data are presented as mean ± SD (n = 3 values) determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference (P<0.05); T_2 =2mins, T_4 = 4 mins; T_6 = 6 mins, and T_8 = 8 mins. PE = pyrocatechol equivalent.

Table 8: Total Phenolic Content (mg/g PE) of Differently Boiled Onions

Extracts	Time of Boiling (minutes				
	0 Minute	T_2	T_4	T_6	T_8
Aqueous	4.84[a] ± 0.08	3.86[b] ± 0.02	3.46[c] ± 0.00	3.36[d] ± 0.03	2.79[e] ± 0.03

Methanol	$5.20^{a} \pm 0.05$	$4.56^{b} \pm 0.04$	$3.47^{c} \pm 0.02$	$3.22^{d} \pm 0.05$	$3.00^{e} \pm 0.03$
Chloroform	$3.13^{a} \pm 0.02$	$2.28^{b} \pm 0.01$	$2.19^{c} \pm 0.02$	$2.10^{d} \pm 0.00$	$2.00^{e} \pm 0.01$

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$); T_2 = 2 mins, T_4 = 4 mins; T_6 = 6 mins, and T_8 = 8 mins. PE = pyrocatechol equivalent.

The comparative result from tables 7 and 8 shows a concomitant decrease in boiled garlic (0 to 10 days) and onions. (0 to 10 days). With garlic and onions extract, there was a significant decline from day 0 to 10 of sprouting. The phenolic content of boiled garlic extract yielded a higher antioxidant properties (6.257mg/gPE) at 0 min or at a state without boiling, with the methanol , when compared with onions extract which yielded a higher antioxidant property (5.2mg/gPE) at 0 minutes with the solvent methanol.

Table 9: DPPH Radical Scavenging Activity (%) of Differently Sprouted Garlic

Extracts	**Days of sprouting**					
	Control Day0	**Day 2**	Day 4	Day8	Day8	Day10
Aqueous	42.07 ± 00^{a}	45.36 ± 0.02^{b}	49.16 ± 0.00^{c}	56.84 ± 0.03^{d}	68.30 ± 0.04^{e}	71.23 ± 0.03^{f}
Methanol	46.20 ± 0.02^{a}	58.71 ± 0.02^{b}	63.20 ± 0.09^{c}	72.43 ± 0.05^{d}	83.56 ± 0.02^{e}	96.30 ± 0.00^{f}
Chloroform	37.63 ± 0.00^{a}	39.26 ± 0.05^{b}	44.35 ± 0.02^{c}	46.53 ± 0.02^{d}	59.16 ± 0.00^{e}	64.36 ± 0.00^{f}

Data are presented as mean ± SD (n = 3 values) determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$).

Table 10: DPPH Radical Scavenging Activity (%) of Differently Sprouted Onions

Extracts	**Days of Sprouting**					
	Control (Day 0)	**Day 2**	**Day 4**	**Day 6**	**Day 8**	**Day 10**
Aqueous	26.19 ± 2.38^{a}	37.05 ± 6.17^{b}	56.61 ± 3.55^{c}	66.19 ± 2.38^{d}	89.05 ± 4.76^{e}	67.95 ± 2.38^{f}
Methanol	27.16 ± 2.41^{a}	39.52 ± 8.60^{b}	60.18 ± 8.26^{c}	68.57 ± 4.12^{d}	94.52 ± 2.38^{e}	69.43 ± 4.12^{f}
Chloroform	24.38 ± 2.38^{a}	33.98 ± 3.43^{b}	45.77 ± 10.94^{c}	57.64 ± 4.73^{d}	65.96 ± 2.37^{e}	56.67 ± 2.38^{f}

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$).

The comparative result from table 9 and 10 show a concomitant increase in sprouted garlic (0 to 10 days) and onions. (0 to 8 days). With Onions extract, there was a significant decline at day 8 of sprouting. Generally, the DPPH free radical scavenging activity of sprouted garlic extract yielded highest antioxidant properties (96.3mg/g) on the day 10 with the solvent methanol, when compared with onions extract which yielded a higher antioxidant property (94.52mg/gRE) on the day 8 with the solvent methanol.

Table 11: DPPH Radical Scavenging Activity (%) of Differently Boiled Garlic

Extracts	Time of Boiling (minutes)				
	0 Minute	T_2	T_4	T_6	T_8
Aqueous	42.09 ± 0.02[a]	36.68±0.00[b]	30.28±0.05[c]	27.53±0.03[d]	24.89±0.02[e]
Methanol	46.20 ± 0.02[a]	41.74±0.06[b]	39.83 ±0.02[c]	33.37 ± 0.05[d]	30.04 ± 0.03[e]
Chloroform	37.63 ± 0.00[a]	33.00±0.04[b]	28.43 ±0.02[c]	24.21 ± 0.00[d]	21.93 ± 0.03[e]

Data are presented as mean ± SD (n = 3 values) determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$).; T_2 = 2 mins, T_4 = 4 mins; T_6 = 6 mins, and T_8 = 8 mins.

Table 12: DPPH Radical Scavenging Activity (%) of Differently Boiled Onions

Extracts	Time of Boiling (minutes				
	0 Minute	T_2	T_4	T_6	T_8
Aqueous	26.19[a]±2.38	21.90[b] ± 2.39	17.76[c] ± 2.38	13.48[d] ± 2.38	7.24[e] ± 2.38
Methanol	27.16[a]±2.41	22.91[b] ± 2.38	19.48[c] ± 2.38	14.38[d] ± 2.38	9.24[e] ± 2.38
Chloroform	24.38[a]±2.38	19.62[b] ± 2.38	15.33[c] ± 2.38	11.95[d] ± 2.38	6.09[e] ± 2.38

Data are presented as mean ± standard error mean (SEM) of triplicate determinations; mean values exhibiting distinct alphabetical superscripts within a row indicate a statistically significant difference ($P<0.05$); T_2 = 2 mins, T_4 = 4 mins; T_6 = 6 mins, and T_8 = 8 mins.

The comparative result of the tables 11 and 12 above revealed a concomitant decrease in boiled garlic and onions (0 - 8 mins). With garlic and onions extract, there was a significant decline from day 0 to 10 of sprouting. The DPPH activity of boiled methanolic garlic extract yielded a higher antioxidant properties (46.2mg/gPE) at 0 min or at a state without boiling when compared with methanolic onions extract which yielded a higher antioxidant property (27.16mg/gPE) at 0 minutes.

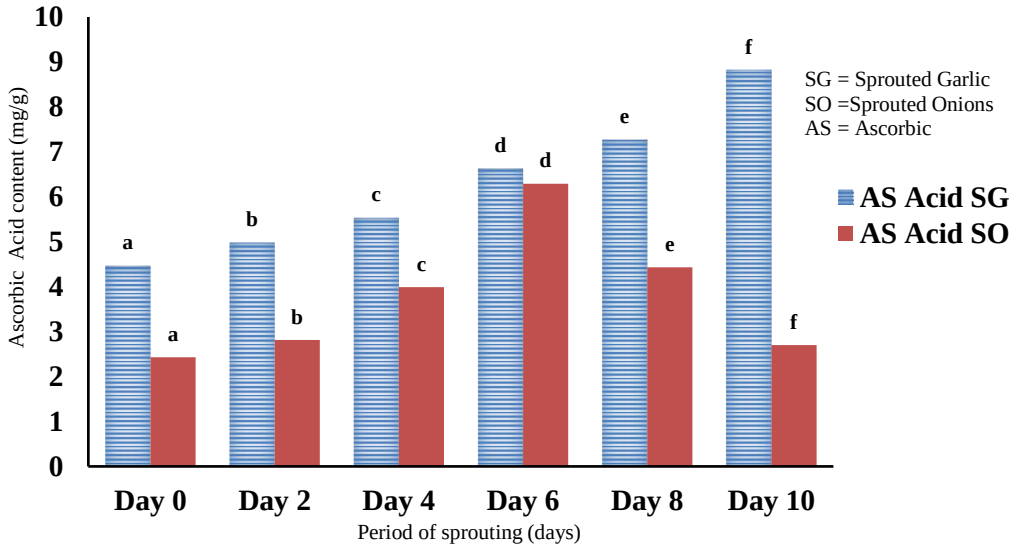

Figure 1: Ascorbic acid content of differently sprouted garlic and onions; bars with different alphabets depict a statistically significant difference($P<0.05$).

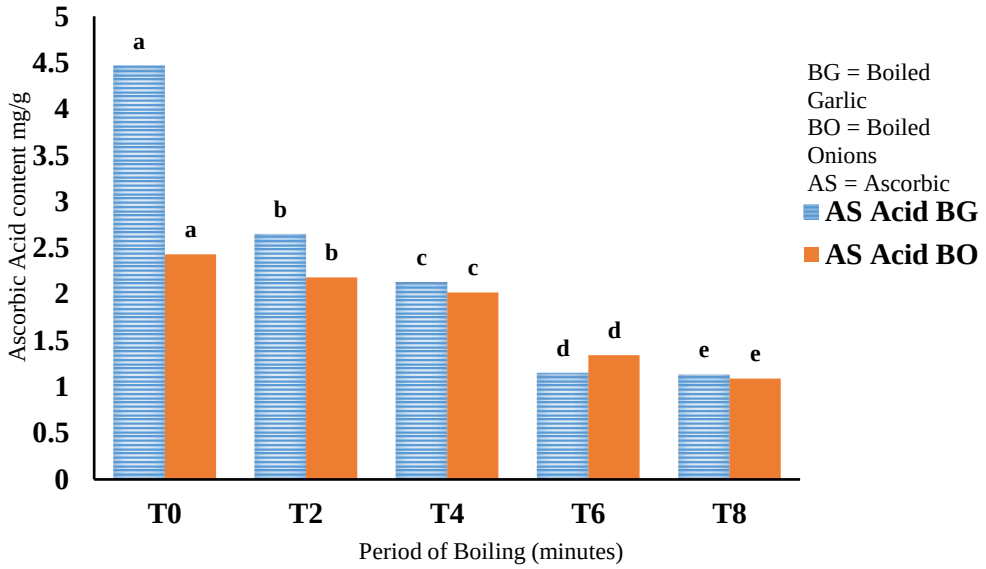

Figure 2: Ascorbic Acid Content of Differently Boiled Garlic and Onions; bars with different alphabets depict a statistically significant difference ($P<0.05$); T_2 = 2 mins, T_4 = 4 mins, T_6 = 6 mins, T_8 = 8 mins.

The comparative results of the above chart (figure 1) show a concomitant increase in sprouted garlic (0 to 10 days) and onions. (0 to 6 days). With Onions extract, the ascorbic acid content decline on day 6 of sprouting. Generally, the ascorbic activity of sprouted garlic extract yielded highest antioxidant property on day 10 (8.820mg/g) while the highest antioxidant property for ascorbic acid content was recorded in onions on day 6 (6.29mg/g).

The result from figure 2 above shows a concomitant decrease in boiled garlic and onions (0 to 8minutes). Generally, the ascorbic content of boiled garlic extract yielded higher antioxidant properties (4.667mg/g) at 0 min or at a state without boiling, with the methanol, when compared with onions extract which yielded a higher antioxidant property (2.43mg/g) at 0 minutes with the solvent methanol. The results revealed that sprouting is a good method of processing both in garlic and onion, as the day of sprouting increases the antioxidant activity increases. However, sprouting in onion above 8 days can cause a decrease in antioxidant activity. In order to retain the flavonoids and phenolic compounds present in these vegetables boiling should be avoided and if necessary boiling time should be minimal.

3.1 Discussion

The medicinal property of garlic (*Allium sativum*) is an attribute possessed due to its antioxidants potential. Antioxidant potential is responsible for its immune enhancing functions, anti-microbial functions and anti-cancer activities (Batiha *et al*., 2020).

Several processes, including sprouting and boiling, have been found to either improve or diminish the antioxidant qualities of medicinal plants. It has been demonstrated that sprouting, a

simple technological method for germination of seeds, increases the nutritional value of seeds (Ebhomienlen and Azeke, 2019). One crucial food processing method is boiling, which improves the digestibility of certain elements like proteins and carbohydrates (Ikanone and Oyekan, 2014).

The result from this work further confirms that sprouting increases the antioxidant potential of garlic while boiling reduces it. Onions (*Allium cepa*), another vegetable that has been used for therapeutic purposes for a long time also demonstrated the same anti-inflammatory and antibacterial properties (Shitole and Wadaskar, 2014). Onions lose some of their phytochemical components during boiling, including a flavonoid called quercetin glycosides (Ebhomienlen and Azeke, 2020).

Phenols as well as flavonoid compounds acts as free radicals terminator (Shitole and Wadaskar, 2014). **T**hese compounds are also the primary source of free radicals that break lipid oxidation (Ayala *et al*., 2014). Tables 1,2,5 and 6 shows that sprouting increases the phenolic content and flavonoids content of garlic. This claim was supported by Shan *et al*. (2005), Wu *et al*. (2006), Wong *et al*. (2006) and Sharma (2014). These researchers subjected the samples to sprouting for 0, 7 and 15 days and revealed that the total phenolic content of the sprouted onions increased till day 7 and then continued to drop as the sprouting period extended to 15 days. Boiling on the other hand reduces the phenolic and flavonoids content of garlic samples extracts.

Methanolic extracts of garlic showed the highest flavonoid and phenolic content compared to aqueous and chloroform extracts with increase in sprouting days (0-10days) while chloroform extract showed the lowest phenolic content with increase in boiling time (0-8mins) compared to methanolic, and aqueous extract respectively. During sprouting of onions and garlic in this study, phenolic and flavonoids content peaked at day 8 and optimal at day 4. In a study based on this finding, he examined how sprouting affected the physicochemical, antioxidant, and flavonoid profiles of various onion cultivars and found that sprouted onions had a significantly higher total flavonoid concentration than raw onions ($P<0.05$). Another study denotes that, in boiling, the total phenolic content of some vegetables including garlic were significantly reduced due to lixiviation phenomenon in boiling (Alexandre *et al*., 2020). According to tables 3 and 4 of this study, boiling for 8 minutes reduced the total flavonoid content by 45%, 56% and 61% for the aqueous extract, methanol extract and the chloroform extract respectively.

On the other hand, several researchers (Crozier *et al*., 1997; Ewald *et al*., 1999; Juaniz *et al*., 2016) noticed that phenolic concentrations tended to rise with all heat treatments. They did, however, ascribe the release of these chemicals to the heat breakdown of subcellular compartments and cell walls during cooking procedures. They ascribed the release of these chemicals to the heat breakdown of subcellular compartments and cell walls during cooking procedures. Therefore sprouting may be used as harnessing the flavonoid content in Onions.

Sprouted garlic and onion show increase in DPPH radical scavenging activity as the day of germination increases. In this project the garlic and Onion sprouting span for 0-10 days and at day 8

the highest DPPH radical scavenging activity was identified. Also, the onion extract that was grown for ten days showed the highest antioxidant activity.

The 2, 2-diphenyl-1-picril-hydrazil (DPPH) radical is a stable free radical with a maximum absorption at 517 nm that is frequently utilized to assess the capacity of natural compound to scavenge free radicals. When free radicals of natural compounds are evaluated, the electron becomes paired off in the presence and absorption is greatly reduced, resulting to decolourization, this decolourization is proportion to the number of electrons taken up (Smith and Adanlawo, 2014). This is consistent with a study (Cowie *et al*., 2008) that reported that as the concentration of the extracts and days of sprouting increases so also the free radical-scavenging activity of onion and ginger increased significantly. However, garlic and onions sample extracts DPPH scavenging activity reduces with increase in boiling time.

A similar result is noticed in boiled garlic and onions since DPPH radical scavenging activity records a significant decrease as the boiling time increases. In the present study, the reductions ranged from 35.1% (methanol extract), 40.9% (aqueous extract) to 41.7% (chloroform extract) for sample extracts of boiled Garlic, while reduction ranged from 65% methanol extract ,72% aqueous extract and 75% chloroform extract for samples extracts of boiled onions, after 8 minutes of boiling.

According to Denre [35], ascorbic acid is one of the strongest antioxidants that scavenge dangerous free radicals and other reactive oxygen species. Moreover, it regenerates tocopherol and other sub-antioxidants.The results from this study (Fig. 1) are consistent with a research by Denre (2014) which recorded that the ascorbic content of onions has a significant ($P<0.05$) increase as sprouting days increased.

The comparative measure of vitamin C (ascorbic acid) content in garlic and onions sprouted for different days as well as the un-sprouted (Day 0) is shown in Figure 1. Due to the fact that sprouting resulted in 54.5% increase in ascorbic acid, garlic sprouted for ten days recorded a significant ($p <0.05$) higher ascorbic acid content (8.820mg/g). While, the control sample of garlic extracts had the lowest ascorbic acid content (4.467mg/g). However, onion sprouted for six days recorded a significant ($P<0.05$) higher ascorbic acid content (6.29mg/g), followed by a decrease seen after 6 days.

Observations from the bar chart (Figure 2) denotes that as boiling increases, the ascorbic acid content of the boiled garlic sample reduce continuously, until eighth minutes (1.13mg/g) of boiling, which results in a sudden loss of 80% loss in ascorbic acid. This similar pattern is seen in the boiled onion extracts; the only significant difference is that vitamin C (ascorbic acid) content reduces with increasing boiling time all through from 0-8 minutes.

4. Conclusion

The above study revealed that sprouting of onions and garlic can improve the antioxidant potential of garlic and onions. It is recommended that garlic and onions be sprouted for 4-10 days and 4-6 days

respectively before processing for consumption. Further studies can be conducted to determine whether the increased antioxidant potential of sprouted bulbs can help overcome losses due to cooking processes.

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