

Responses of Antioxidant Activity of Onion (*Allium Cepa*) and Garlic (*Allium Sativum*) To Different Dehydration Methods

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Abstract- *Allium cepa* (onion) and *Allium sativum* (garlic) are widely used for their nutritional and medicinal properties, but their high perishability leads to post-harvest losses and seasonal scarcity. This study investigated preservation techniques to extend shelf life while retaining nutritional quality. Fresh onion and garlic bulbs were purchased from Wadata market, Makurdi, Nigeria and taxonomically authenticated. It was then taken to the laboratory for preparation and analyses. Forty bulbs each were sliced and divided into four parts: one fresh (meshed and stored), and three processed via sun drying, freeze drying, and microwave irradiation. Samples underwent phytochemical screening and quantification, antioxidant assays and allicin quantification. All samples contained tannins, flavonoids, glycosides, phenols, alkaloids, saponins, phytate, and steroids. Oxalate was undetected in freeze-dried samples, minimizing potential health risks like kidney stones. High flavonoid (3.75 ± 0.01 - 4.89 ± 0.01 mg/100 g) and phenol (4.89 ± 0.01 - 96.97 ± 1.27 mg/100 g) contents suggested strong antioxidant capacity. Freeze-dried samples showed the highest antioxidant activity, particularly in the DPPH assay (40.67 ± 0.11 % at 1000 $\mu\text{g/mL}$), and similar trends were seen in other assays. Freeze-dried onion and garlic also had the highest allicin content (93.63 ± 0.01 $\mu\text{g}/100$ g in onion, 95.60 ± 0.06 $\mu\text{g}/100$ g in garlic), contributing to enhanced bioactivity. While all methods retained key compounds, freeze drying proved most effective in preserving antioxidants and eliminating oxalate. Therefore, freeze-dried onion and garlic offer superior nutritional and medicinal benefits.

Keyword: Onion; Garlic; Phytochemical; Antioxidant; Allicin

I. INTRODUCTION

It has long been recognized that garlic and onion, two plants of the *Allium* genus--which also includes petiveria, leeks, chives, scallions, and shallots--possess great medicinal value. Garlic (*Allium*

sativum) and onion (*Allium cepa*) were among the earliest of cultivated foods and spices, easily identified by primitive food-seekers by their distinctive smell, now known to be associated with organosulfur compounds (Lynett et al., 2011).

In recent times, the biological activities of extracts of these plants have been ascribed to the antioxidant properties of the thiosulphinat secondary metabolites allicin and S-benzyl phenylmethanethiosulphinat (BPT) (Lynett et al., 2011). Allicin (diallylthiosulphinat) is a defense molecule from garlic and even onion with a broad range of biological activities. Allicin is produced upon tissue damage from the non-proteinogenic amino acid alliin (S-allylcysteine sulphoxide) in a reaction that is catalyzed by the enzyme alliinase. Being a thiosulphinat, allicin is a reactive sulphur species (RSS) and undergoes a redox-reaction with thiol groups in glutathione and proteins that is thought to be essential for its biological activity. Allicin is physiologically active to microbial, plant and mammalian cells. In a dose-dependent manner allicin can inhibit the proliferation of both bacteria and fungi or kill cells outright, including antibiotic strains like methicillin-resistant *Staphylococcus aureus* (MRSA).

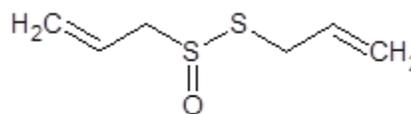


Figure 1: Structure of Allicin

Allium was discovered in 1944 by Cavallito and co-workers, Cavallito and Bbailey (1994), who first noted its potent anti-microbial activity. Allicin is produced

by an enzymatic reaction when fresh garlic and onion are either crushed or injured. The enzyme alliinase combines with alliin and produces allicin.

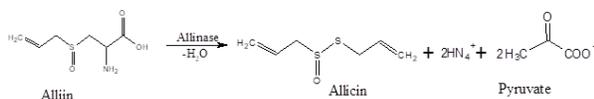


Figure 2: Production of Allicin from Alliin by the action of the enzyme alliinase

Allicin has been reported to possess numerous biological and biochemical activities. They include beside antibacterial effects, reduction of serum cholesterol and triglycerides (Augusti and Mathew, 1994), inhibition of plate at aggregation.

II. MATERIALS AND METHODS

Collection of samples

Fresh *A. cepa* (onion) and *A. sativum* (garlic) bulbs were bought from Wadata Market, Makurdi, Benue State, Nigeria, and were taxonomically authenticated. The samples were then taken to the laboratory for preparation and analysis.

Preparation of Sample

The fresh onion and garlic bulbs were examined and separated by hand picking to remove any bad ones; those without any physical defect (40 bulbs each) were selected for the analyses. The outer skin and ends of the onions and garlic bulbs were removed and washed with running tap water to remove adhering debris and then with deionized water and allowed to dry. The samples (10 bulbs each) were thereafter sliced into chips using stainless steel knife and meshed using a mortar and pestle. The meshed samples were collected in airtight containers and preserved in refrigerator at 4 °C respective analyses (Abiola et al., 2017).

Drying of the samples

The remaining part of the onion and garlic bulbs (30 pieces each) were sliced, separated into three parts each and used for different drying operations. The first part of the sliced samples was sundried, the second part freeze-dried and the third part dried using microwave (4 h) according to method described by Freeman and Whenham, 2006; Pu and Hui, 2016; Guine, 2018 and Uribe et al., 2018. The dried sample were then pulverized using mortar and pestle and

sieved into fine particles. The particles were stored in an airtight container prior to analyses.

Qualitative Phytochemical Analyses

The n-hexane crude extract was checked for the presence of phytochemicals according to Official Methods of Analysis (AOAC), 2023.

Quantitative Phytochemical Analysis

The n-hexane crude extract was evaluated for the composition of phytochemicals according to Official Methods of Analysis (AOAC), 2023.

Determination of Antioxidant Activity

DPPH Radical Scavenging

The antioxidant analysis was done according to method described by Ademoye et al, (2008). 0.1mM working solution of (DPPH) in methanol was prepared. 1 mg/mL of the sample was prepared in approximately solvents. The concentration of the sample was varied to 100-500 µg/mL by serial dilution. The reaction mixture contained 100 µL of the sample and 500 µL of DPPH reagent. The mixture was allowed to incubate at room temperature for 30 minutes in the dark. The absorbance of the reaction mixture was taken against blank, methanol. The control involved methanol and DPPH reagent. Ascorbic acid was used as standard to compare the percentage (%) inhibition.

$$\% \text{ Inhibition} = \frac{\text{Absorbance ctrl} - \text{Absorbance Sample}}{\text{Absorbance ctrl}} \times 100$$

(1)

Test for Ferric Reducing Antioxidant Power (FRAP)

Two (2) mL of the sample was measured into the test tube as well as 2.5 mL of 0.2 M sulphate buffer, 2.5 mL of K₂[Fe(CN)₆] was added into the test tube, then each sample in the test tube was placed on a vortex mixer for 5 min. after which it was put in the cupboard for 20 min. then a solution of 2.5 mL of trichloroacetic acid (CCl₃-COOH) was added to the sample and placed in a centrifuge for 10 min. after, 2 mL of distilled water and 0.5 mL of FeCl₃ was added to the sample and the result was obtained (Marcu et al., 2025; Putra & Suarjana, 2025)

Test for Cupric ion Reducing Antioxidant Capacity (CUPRAC) Assay

0.25 mL of CuCl₂ (0.01 M), 0.25 mL of neocuproine ethanol solution (7.5x10⁻³M) and 0.25 mL of CH₃COONH₄ (1.0 M) buffer solution were mixed in a test tube, and then 0.5 mL of the extract was added. The total volume was then made to 2 mL with distilled water and mixed. The tubes were closed and left at room temperature. Absorbance at 450 nm was measured against blank reagents (water) after 30 min and readings were obtained (Apak et al., 2004).

Scavenging Activity of Hydrogen Peroxide on the sample

Hydrogen peroxides scavenging activity was assayed according to the method described by (Sultana et al., 2009). A solution of hydrogen peroxide (40 mM) was prepared in phosphate buffer (pH 7.4). 0.5 mL extracts were added to a hydrogen peroxide solution (0.6 mL, 40 mM). The absorbance of hydrogen peroxide at 230 nm was determined after 10 minutes against a blank solution containing phosphate buffer without hydrogen peroxide. The percentage of hydrogen peroxide scavenging activity by the extracts and a standard was calculated.

$$\frac{H_2O_2 \text{ Scavenging activity (\%)}}{(\text{absorbance of control}) - (\text{absorbance of sample})} \times 100 \text{ (2)}$$

Determination of Allicin

A spectrophotometric assay developed by Wanyika et al. (2011) was used to quantify allicin in the experiments. In preparing garlic extract, 1 g of garlic powder was dissolved in 10 mL of deionized water. It was allowed to stand for 30 minutes at room

temperature then equal volume of cold methanol was added to the hydrated sample (e.g., 1:1 ratio with water). The mixture was centrifuged at 10,000 rpm for 10 minutes. The supernatant was collected and the extract passed through a 0.22 µm syringe filter into a clean HPLC vial

For fresh sample, 5 g of the sample was weighed, crushed and homogenized in 20 mL of cold methanol. It was allowed to stand for 10–15 min for enzymatic conversion of alliin to allicin. It was then filtered to remove solids. The final extract was filtered through a 0.22 µm syringe filter and transferred to HPLC vial. Serial dilutions of pure allicin standard were prepared (e.g., 5, 10, 20, 50 µg/mL) and Injected into HPLC and the peak area vs. concentration were recorded. This was used to quantify the allicin in the sample (Wanyika et al., 2011)

RESULTS AND DISCUSSION

Results

The results of phytochemical screening, phytochemical quantification, DPPH antioxidant properties, other antioxidant assay (Cupric ion Reducing Antioxidant Capacity (CUPRAC), Ferric Reducing Antioxidant Power (FRAP) and Scavenging Activity of Hydrogen Peroxide (H₂O₂)) and quantification of allicin for onion and garlic respectively are presented in Table 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively.

Table 1: Phytochemical screening of onion before and after the different drying methods

Sample	Tannins	Flavonoids	Glycoside	Phenol	Alkaloid	Oxalate	Saponins	Phytate	Steroid
FO	+	+	+	+	+	+	+	+	+
SDO	+	+	+	+	+	+	+	+	+
FDO	+	+	+	+	+	-	+	+	+
MWO	+	+	+	+	+	+	+	+	+

Tanins: FeCl₃ test; Flavonoids: Lead Acetate test;
 Glycosides: Keller-Kallani's test; Phenols: Ferric
 Chloride test; Alkaloids: Hagar's test; Oxalate test:
 CaCl₂ test; Saponins: Froth test; Phytate: FeCl₃ test;
 Steroids: Libbermann Burchard,s Test

KEY: FO: Fresh Onion; SDO: Sun Dried Onion;
 FDO: Freeze Dried Onion; MWO:
 Microwave Irradiated Onion;
 + = Present; - = Absent

Table 2: Phytochemical screening of garlic before and after the different drying methods

Sample	Tannins	Flavonoids	Glycoside	Phenol	Alkaloid	Oxalate	Saponins	Phytate	Steroid
FG	+	+	+	+	+	+	+	+	+
SDG	+	+	+	+	+	+	+	+	+
FDG	+	+	+	+	+	-	+	+	+
MWG	+	+	+	+	+	+	+	+	+

Tanins: FeCl₃ test; Flavonoids: Lead Acetate test;
 Glycosides: Keller-Kallani's test; Phenols: Ferric
 Chloride test; Alkaloids: Hagar's test; Oxalate test:
 CaCl₂ test; Saponins: Froth test; Phytate: FeCl₃ test;
 Steroids: Libbermann Burchard,s Test

KEY: FO: Fresh Onion; SDO: Sun Dried Onion;
 FDO: Freeze Dried Onion; MWO:
 Microwave Irradiated Onion;
 + = Present; - = Absent

Table 3: Phytochemical composition of onion before and after the different drying methods

Samp le	Tanins (%)	Flavanoi ds (%)	Glycosid e (%)	Phenol (mg/100 g)	Alkaloid (%)	Oxalate (mg/100 g)	Saponin s (%)	Phytate (%)	Steroid (mg/100 g)
FO	1.70 ^b ±0.00	4.19 ^b ±0.01	1.58 ^b ±0.03	15.03 ^b ±1.27	3.02 ^a ±0.01	0.45 ^c ±0.01	0.30 ^a ±0.01	0.62 ^b ±0.01	7.53 ^a ±0.03
SDO	2.08 ^c ±0.00	4.89 ^d ±0.01	5.61 ^d ±0.04	24.75 ^c ±0.00	3.09 ^c ±0.01	0.56 ^d ±0.01	0.81 ^c ±0.01	0.40 ^a ±0.01	8.78 ^c ±0.07
FDO	2.25 ^d ±0.00	4.79 ^c ±0.03	3.22 ^c ±0.01	19.75 ^a ±0.00	2.89 ^b ±0.01	0.00 ^a ±0.00	1.07 ^d ±0.01	0.81 ^c ±0.01	11.52 ^d ±0.04
MW O	0.22 ^a ±0.00	3.80 ^a ±0.04	1.14 ^a ±0.06	24.75 ^c ±0.00	3.09 ^c ±0.02	0.32 ^b ±0.01	0.64 ^b ±0.00	0.82 ^c ±0.01	8.41 ^b ±0.03

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different (p> 0.05).

KEY: FO: Fresh Onion; SDO: Sun Dried Onion;
 FDO: Freeze Dried Onion; MWO:
 Microwave Irradiated Onion;

Table 4: Phytochemical composition of garlic before and after the different drying methods

Samp le	Tanins (%)	Flavanoi ds (%)	Glycosid e (%)	Phenol (mg/100 g)	Alkaloid (%)	Oxalate (mg/100 g)	Saponin s (%)	Phytate (%)	Steroid (mg/100 g)
RG	1.99 ^d ±0.00	4.12 ^b ±0.03	1.58 ^d ±0.03	48.08 ^a ±3.00	2.64 ^b ±0.01	0.21 ^c ±0.01	0.19 ^a ±0.01	0.13 ^a ±0.01	5.78 ^c ±0.03
SDG	1.44 ^b ±0.00	4.89 ^c ±0.01	1.40 ^b ±0.05	42.25 ^a ±7.26	2.42 ^a ±0.01	0.12 ^b ±0.01	1.34 ^d ±0.01	0.81 ^c ±0.01	6.70 ^d ±0.06
FDG	1.59 ^c ±0.00	3.75 ^a ±0.01	1.04 ^a ±0.02	96.97 ^b ±1.27	2.89 ^c ±0.01	0.00 ^a ±0.00	0.34 ^b ±0.01	0.12 ^a ±0.01	4.19 ^b ±0.06
MWG	0.45 ^a ±0.00	4.17 ^b ±0.04	1.41 ^c ±0.03	38.36 ^a ±6.03	3.05 ^d ±0.02	0.22 ^d ±0.01	0.83 ^c ±0.02	0.41 ^b ±0.01	2.75 ^a ±0.14

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different (p> 0.05).

KEY: RG: Fresh Garlic; SDG: Sun Dried Garlic; FDG: Freeze Dried Garlic; MWG: Microwave Irradiated Garlic

Table 5 Percentage inhibition (%) by DPPH (DPPH: 2, 2-diphenyl-1-picrylhydrazyl) Radical Scavenging Activity (RSA) of onion before and after the different drying methods at different extract concentrations (µg/mL)

Sam ple	200	400	600	800	1000
FO	24.4 ^d ±0.06	30.81 ^d ±0.12	33.60 ^b ±0.00	32.30 ^b ±0.11	39.87 ^b ±0.05
SDO	21.55 ^a ±0.06	27.76 ^b ±0.06	34.70 ^c ±0.11	38.79 ^c ±0.05	40.55 ^c ±0.05
FDO	23.73 ^b ±0.12	30.53 ^c ±0.06	39.30 ^d ±0.06	40.97 ^d ±0.055	40.67 ^c ±0.11
MWO	24.02 ^c ±0.06	15.75 ^a ±0.12	19.48 ^a ±0.06	20.99 ^a ±0.06	24.81 ^a ±0.05

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different (p> 0.05).

KEY: FO: Fresh Onion; SDO: Sun Dried Onion; FDO: Freeze Dried Onion; MWO: Microwave Irradiated Onion

Table 6: Percentage inhibition (%) by DPPH (DPPH: 2, 2-diphenyl-1-picrylhydrazyl) Radical Scavenging Activity (RSA) of garlic before and after the different

drying methods at different extract concentrations (µg/mL)

Sam ple	200	400	600	800	1000
FG	39.89 ^c ±0.12	52.83 ^d ±0.06	37.38 ^c ±0.11	37.12 ^b ±0.11	40.55 ^c ±0.16
SDG	41.38 ^d ±0.12	40.54 ^c ±0.06	29.94 ^b ±0.06	35.10 ^a ±0.11	37.36 ^a ±0.05
FDG	26.82 ^a ±0.06	29.14 ^a ±0.06	28.92 ^a ±0.06	40.31 ^c ±0.11	41.85 ^d ±0.05
MWG	38.90 ^b ±0.12	37.48 ^b ±0.12	40.09 ^c ±0.06	41.71 ^d ±0.00	40.29 ^b ±0.11

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different (p> 0.05).

KEY: FG: Fresh Garlic; SDG: Sun Dried Garlic; FDG: Freeze Dried Garlic; MWG: Microwave Irradiated Garlic

Table 7: CUPRAC, FRAP and H2O2 Antioxidant activity of onion before and after the different drying methods

Sampl e	CUPRAC (mmol/g)	FRAP (µmol/mL)	H ₂ O ₂ (%)
RO	44.23 ^a ±0.37	40.86 ^a ±3.97	99.49 ^d ±0.61
SDO	45.97 ^b ±0.04	44.12 ^b ±1.55	97.98 ^c ±0.25
FDO	56.86 ^c ±0.34	39.99 ^a ±0.04	98.57 ^b ±0.23
MWO	45.70 ^b ±0.15	37.59 ^a ±4.08	92.13 ^a ±0.98

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different ($p > 0.05$).

KEY: RO: Fresh Onion;SDO: Sun Dried Onion;
 FDO: Freeze Dried Onion;MWO:
 Microwave Irradiated Onion;
 CUPRAC: Cupric Ion Reducing Antioxidant Capacity; FRAP: Ferric reducing Antioxidant Power; H2O2: Hydrogen Peroxide

Table 8: CUPRAC, FRAP and H2O2 Antioxidant activity of garlic before and after the different drying methods

Sample	CUPRAC (mmol/g)	FRAP (mmol/mL)	H ₂ O ₂ (%)
FG	13.51 ^b ±0.1	40.04 ^{bc} ±0.1	99.86 ^d ±0.8
	2	0	9
SDG	18.23 ^c ±0.2	35.95 ^b ±6.41	98.04 ^c ±0.6
	1		7
FDG	20.90 ^a ±0.2	20.92 ^a ±0.37	98.72 ^b ±0.0
	2		4
MWG	28.18 ^d ±0.1	43.06 ^{bc} ±6.1	94.64 ^a ±0.0
	8	6	3

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different ($p > 0.05$).

KEY: FG: Fresh Garlic;SDG: Sun Dried Garlic;
 FDG: Freeze Dried Garlic;MWG:
 Microwave Irradiated Garlic
 CUPRAC: Cupric Ion Reducing Antioxidant Capacity; FRAP: Ferric reducing Antioxidant Power; H2O2: Hydrogen Peroxide

Table 9: Concentration of Allicin of onion before and after the different drying methods

Sample	Allicin (µg/100 g)
FO	93.84 ^b ±0.01
SDO	88.27 ^a ±0.05
FDO	93.63 ^b ±0.01
MWO	87.67 ^a ±0.01

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different ($p > 0.05$).

KEY: FO: Fresh Onion;SDO: Sun Dried Onion;
 FDO: Freeze Dried Onion;MWO:
 Microwave Irradiated Onion

Table 10: Concentration of Allicin of garlic before and after the different drying methods

Sample	Allicin (µg/100 g)
FG	95.13 ^b ±0.01
SDG	92.25 ^a ±0.01
FDG	95.60 ^b ±0.057
MWG	92.66 ^a ±0.01

Results are mean±SD of triplicate analysis. Values within the same column with the same superscript are not significantly different ($p > 0.05$).

KEY: FG: Fresh Garlic; SDG: Sun Dried Garlic;
 FDG: Freeze Dried Garlic;MWG:
 Microwave Irradiated Garlic

Discussion of Results

Phytochemical screening of Onion and Garlic Before and After the Different Drying Methods

The result in Table 1 and 2 revealed that onions and garlic contain a range of bioactive compounds, including tannins, flavonoids, glycosides, phenols, alkaloids, oxalates, saponins, phytates, and steroids. Tannins, phenols, saponins and flavonoids are present in all forms and are known for their antioxidant, anti-inflammatory, antidiabetic and antimicrobial effects. Flavonoids in garlic and onions help reduce oxidative stress and are linked to lowering the risk of chronic diseases like cancer and cardiovascular conditions (Pawase et al., 2024; Thacker & Ram, 2024).

Alkaloids, including sulphur-containing types like alliin (a precursor to allicin), are evident in all samples. This is in line with Divya, et al., (2017) where a study on phytochemicals, functional groups and mineral composition of *Allium cepa* (onion) and *Allium sativum* (Garlic) Cloves was carried out. Allicin is recognized for its strong antimicrobial and anticancer effects. Oxalates were present in fresh samples but absent in freeze-dried forms, reducing potential kidney stone risks.

Steroids, mainly phytosterols, were found in all samples and are associated with cardiovascular protection. Despite some loss of compounds during processing, both garlic and onion retain significant nutritional and medicinal value across preparation methods.

Table 3 and 4 showed that onions and garlic contain various bioactive compounds: tannins, flavonoids, glycosides, phenols, alkaloids, oxalates, saponins, phytates, and steroids. The result aligns with Divya, et al., (2017) on their study of phytochemicals, functional groups and mineral composition of *Allium cepa* (onion) and *Allium sativum* (Garlic) Cloves. Tannins exhibited antioxidant, antimicrobial, and anti-inflammatory properties, while flavonoids (3.75 ± 0.01 - 4.89 ± 0.01 mg/100 g) helped reduce oxidative stress and inflammation (Chihomvu et al., 2024; Monika et al., 2020).

Glycosides and phenols (4.89 ± 0.01 - 96.97 ± 1.27 mg/100 g), offers antioxidant and anticancer benefits. Alkaloids, including sulphur-based types like alliin and allicin was highest in freeze-dried garlic (95.60 ± 0.06 µg/100 g) and onion (93.63 ± 0.01 µg/100 g), supporting antimicrobial and anticancer activity (Thacker & Ram, 2024).

Oxalates (0.00 ± 0.00 mg/100 g) were absent in freeze-dried samples, lowering kidney stone risk (Pawase et al., 2024). Saponins and phytates offer cholesterol-lowering, antidiabetic, antioxidant, and anticancer effects (Pawase et al., 2024). Steroids (phytosterols) support cardiovascular health. Despite processing losses, garlic and onion retain substantial bioactive content. This is similar with related works like (Al Saiqali et al., 2025).

Table 5 and 6 presented the DPPH radical scavenging activity (RSA) of fresh and processed onion and garlic respectively. Fresh garlic showed higher DPPH inhibition (40.55 ± 0.17 %) than fresh onion (39.87 ± 0.06 %) at 1000 µg/mL, likely due to higher sulphur compounds like allicin. Sun-dried onion had lower RSA (40.55 ± 0.05 %) compared to fresh, likely due to heat-induced degradation. Freeze-dried onion exhibited the highest RSA (40.67 ± 0.11 %) at 1000 µg/mL, supporting studies that freeze-drying better preserves antioxidants. Microwave-irradiated onion showed significantly lower RSA, particularly at 400 µg/mL (15.75 ± 0.11 %), suggesting thermal degradation of sensitive compounds.

For garlic, sun-drying reduced RSA at lower concentrations (41.38 ± 0.12 % at 200 µg/mL), but maintained moderate activity at 1000 µg/mL

(37.36 ± 0.05 %). Freeze-dried garlic had the highest RSA (41.85 ± 0.05 %), while microwave-irradiated garlic maintained consistent RSA (e.g., 41.71 ± 0.00 % at 800 µg/mL), aligning with studies noting its ability to retain some antioxidant properties (De Lima & Almeida, 2017). Overall, freeze-drying preserved antioxidant activity best, while microwave and sun-drying had mixed effects.

The Table 7 and 8 showed the antioxidant activities of onion and garlic, measured using three different methods: CUPRAC (Cupric Ion Reducing Antioxidant Capacity), FRAP (Ferric Reducing Antioxidant Power), and H₂O₂ (Hydrogen Peroxide Scavenging Activity), before and after various drying methods (sun-drying, freeze-drying, and microwave-irradiation).

The CUPRAC assay measures antioxidant capacity by evaluating a substance's ability to reduce Cu²⁺ to Cu⁺. Fresh onion had the highest CUPRAC value (44.23 ± 0.37) compared to fresh garlic (13.51 ± 0.12), suggesting stronger antioxidant activity due to onion's high flavonoid content, particularly quercetin (Ebhomienlen et al., 2024).

Sun-dried onion showed slightly higher CUPRAC activity (45.97 ± 0.04), attributed to compound concentration as moisture is lost. Freeze-dried onion had the highest value (56.86 ± 0.34), reflecting the method's effectiveness in preserving bioactive compounds. Microwave-irradiated onion (45.70 ± 0.15) also showed good antioxidant capacity but slightly less than freeze-dried, due to potential compound degradation at high temperatures (Ebhomienlen et al., 2024)

FRAP assesses antioxidant activity based on Fe³⁺ reduction to Fe²⁺. Fresh onion (40.86 ± 3.97) and garlic (40.04 ± 0.10) had similar values, aligning with the presence of sulphur compounds like alliin. Sun-dried onion increased to 44.12 ± 1.55 , indicating enhanced activity post-drying (Oluomachi, et al., 2025).

Freeze-dried onion showed a high FRAP value (39.99 ± 0.04), while microwave-irradiated onion (37.59 ± 4.08) was slightly lower, reflecting heat sensitivity (Hamza et al., 2025).

On H₂O₂, scavenging activity, both fresh onion (99.49 ± 0.6100 %) and garlic (99.86 ± 0.89 %) showed high scavenging activity, with garlic slightly higher due to sulphur content (Liu et al., 2017).

Freeze-dried onion (98.57 ± 0.23 %) and garlic (98.72 ± 0.03 %) also showed strong hydrogen peroxide activity, likely due to concentration and preservation of active compounds. Microwave-irradiated onion (92.13 ± 0.98 %) and garlic (94.64 ± 0.03 %) had lower scavenging values, possibly due to heat-induced compound degradation (Bozin et al., 2008). According to Ebhomienlen et al., (2024), the antioxidant potentials of boiled extracts of onion and garlic decreased significantly. This is in agreement with the research findings.

Allicin is a sulphur compound formed from alliin upon crushing garlic or onion. In Table 9 and 10, fresh onion (93.84 ± 0.01 µg/100 g) and garlic (95.13 ± 0.01 µg/100 g) showed high allicin content, with garlic slightly higher, consistent with literature (Rao et al., 2015).

Sun-dried onion (88.27 ± 0.05 µg/100 g) and garlic (92.25 ± 0.01 µg/100 g) exhibited reduced levels, likely due to volatilization and sunlight exposure (Srinivasan, 2017).

Freeze-dried onion (93.63 ± 0.01 µg/100 g) and garlic (95.60 ± 0.06 µg/100 g) retained allicin content nearly identical to fresh samples. This preservation is attributed to the absence of high heat during freeze-drying.

Microwave-irradiated onion (87.67 ± 0.01 µg/100 g) and garlic (92.66 ± 0.01 µg/100 g) showed a notable reduction in allicin, consistent with studies indicating that heat disrupts the alliinase enzyme and degrades allicin. Similarly, Frontiers, (2023) opined that, drying (thermal and non-thermal) adversely affects allicin content.

CONCLUSION

The proximate composition of onion and garlic showed typical trends, with freeze-drying concentrating nutrients such as carbohydrates and ash more effectively than sun or microwave drying.

There is presence of many bioactive compounds which remained consistent across fresh and processed forms. Both garlic and onion retained strong antioxidant and anti-inflammatory agents, supporting their known health benefits.

DPPH results showed freeze-dried garlic had the highest antioxidant activity (e.g., 40.667 ± 0.11 % at 1000 µg/mL), while fresh garlic outperformed fresh onion. CUPRAC, FRAP and H₂O₂ assays supported these findings.

Allicin was best retained in freeze-dried garlic (95.60 ± 0.06 µg/100 g) and onion (93.63 ± 0.01 µg/100 g). Freeze-drying proved most effective overall in preserving nutrients, antioxidants, and sulphur compounds essential for health.

Generally, all the study methods of dehydrations do not cause much degradation of phytochemicals and antioxidant activities. However, freeze-dried samples stand tall in terms of both phytochemical retention and antioxidant activity owing to the fact that the method completely eliminates oxalate responsible for kidney stone, retention of Phenols which is responsible for antioxidant activities, exhibits high antioxidant activity especially using CUPRAC assay and retention of allicin; an organo-sulphur compound responsible for antioxidant activity especially in garlic.

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