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Effect of Dehydration Methods on The Nutritional Composition of Onion and Garlic

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ABSTRACT
Allium cepa (onion) and Allium sativum (garlic) are important spices with notable nutritional and medicinal properties. However, their high perishability causes post-harvest losses and seasonal scarcity. This study explored preservation techniques to extend shelf life while retaining nutritional quality. Fresh bulbs were procured from Wadata market, Makurdi, Nigeria and taxonomically authenticated. It was then taken to the laboratory for preparation and analysis. Forty bulbs each of onion and garlic were sliced and divided into four parts. One part was meshed and stored in airtight containers as fresh samples; others were processed via sun drying, freeze drying, and microwave irradiation. Samples were subjected to proximate, mineral, vitamin, and amino acid analyses. Fresh onion and garlic had high moisture contents (85.47±0.55 % and 66.82±0.10 %), while dried samples ranged from 7.73±0.01 % to 18.80±0.25 %, supporting microbiological stability. As moisture decreased, ash, fat, protein, fibre, and carbohydrate levels increased. Mineral content remained stable, though potassium in onion rose from 16.99±0.01 mg/100 g (fresh) to 163.37±0.00 mg/100 g (freeze-dried). Vitamins A, B_1, and B_2 were consistently low. Vitamin C declined, especially in microwave-dried garlic (1.25±0.01 to 0.04±0.00 mg/100 g). Amino acid levels increased with drying; microwave-treated garlic had high lysine (5.83±0.01 mg/100 g). Freeze drying proved most effective, best preserving nutrients and bioactivity in onion and garlic.

Keywords:
Onion; garlic;
Nutritional composition;
Proximate analysis;
Mineral analysis;
Vitamin analysis,
Amino acids analysis

INTRODUCTION

Natural food spices are essential in both food and medicines due to their nutritive and antioxidant properties (Abiola et al., 2017). They enhance the sensory appeal of foods by contributing unique flavours and tastes. Many also serve as natural preservatives, particularly in industrial food processing (Ambuja et al., 2015). Common spices include onion, garlic, pepper, ginger, thyme, and curry.

Among these, *Allium* species-part of the Alliaceae family-stand out as some of the oldest and most widely cultivated spices worldwide (USDA, 2014; Bhagya et al., 2017). Although *Allium* varieties differ in taste, they share similarities in their biochemical and phytochemical profiles (Lawal & Matazu, 2015). They are known for their antibacterial, antifungal, and antioxidant properties, largely due to their rich content of sulphur compounds and phenolic substances.

These natural compounds can combat infections and support healing in the human body (Eleazu et al., 2012; Bhattacharjee et al., 2013; Yashin et al., 2017; Dahhat et al., 2018).

Allium cepa (onion) and *Allium sativum* (garlic) are the most prominent *Allium* species consumed globally (Abiola et al., 2017). In Nigeria, they are widely cultivated as food crops. Onion is used fresh, ripe, pickled, powdered, or cooked in stews and soups. Its leaves are also edible. Garlic is primarily used as a flavour enhancer. Due to increasing rates of cancer and cardiovascular diseases, garlic is considered an affordable natural alternative to conventional medicine when consumed regularly.

Both *A. cepa* and *A. sativum* offer high moisture content, carbohydrates, essential nutrients, and naturally occurring antioxidants (Abayomi et al., 2018).

Their most biologically active compounds are quercetin (onion) and allicin (garlic) (Bi et al., 2017).

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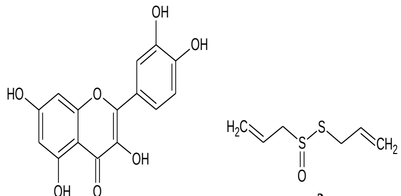

1 2

Figure 1: Structures of Quercetin (1) and Allicin (2) respectively

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 were selected for the analyses (40 bulbs each). 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 ºC for the 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; Uribe et al., 2018; Iortile, et al., 2026. 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.

Proximate analysis

Proximate analysis was carried out according to AOAC methods (2023), Iortile et al., 2023 and Iorkpiligh et al., 2026.

Mineral Determination

The major elements, comprising zinc, manganese, phosphorus, sodium, potassium, and magnesium were determined according to the method (Shahidi et al., 1999). The ground sample was sieved with a 2 mm rubber sieve and 2 g of the sample was weighed and subjected to dry ashing in a well-cleaned porcelain crucible in a muffle furnace at 550 °C. The resultant ash was dissolved in 5 mL of HNO_3/HCl/H_2O (1:2:3) and heated gently on a hot plate until brown fumes disappeared. To the remaining material in the crucible, 5 mL of deionized water was added and heated until a colourless solution was obtained. The mineral solution in the crucible was transferred into a 100 mL volumetric flask by filtration through a whatman No 42 filter paper and the volume made up to the mark with deionized water. This solution was used for elemental analysis by atomic absorption spectrophotometer.

Phosphorus content of the digest was determined colorimetrically. To 0.5 mL of the diluted digest, 4 mL of deionized water, 3 mL of 0.75 M H_2SO_4, 0.4 mL of 10 $(NH_4)_6MO_7O_{24}.4H_2O$ and 0.4 mL of 2 % (w/v) ascorbic acid were added and mixed. The solution was allowed to stand for 20 min and absorbance was recorded at 660 nm. The content of phosphorus in the extract was determined.

$$Concentration\ (mg\ /\ kg) = \frac{Actual\ conc\ (ppm) \times Vol\ (mL)\ of\ digested\ sample}{Mass\ of\ sample\ (g)}$$

Vitamin analysis

The method of Okwu and Josiah, 2006 was used to determine Vitamin A, Vitamin B_1, Vitamin B_2, Vitamin B_3, Vitamin C, Vitamin D, Vitamin E and Vitamin K

Determination of amino acid profile

The sample was extracted using Soxhlet extractor. The extract was then hydrolysed by adding 6 mL of 6 N HCl and 0.1 % phenol to 10 mg of the sample. This was flushed with nitrogen and incubated for 24 hours at 110 °C. The sample was dried by evaporating the acid under vacuum.

Subsequently, the hydrolysed sample was neutralized with sodium hydroxide solution to pH 7.0. The neutralized sample was filtered through Whatman No. 4 filter paper into a 100 mL volumetric flask, and the volume of filtrate was adjusted to 100 mL with deionized water.

Following this, 1 mL of the sample extract was pipetted into test tubes, to which 2 mL of isopropanol was added. The content of the test tube was thoroughly mixed and incubated for 30 minutes at 40 °C. After the incubation period, 20 µL was injected into the HPLC system along with the standard solution. The amino acid derivatives were separated using an isocratic mobile phase of methanol and water, and their detection was carried out using an ultraviolet detector at a wavelength of 254 nm. The peak area of both the sample and the standard solution was calculated using a standard curve generated by plotting the peak area against the concentration of the standard solutions. Finally, the concentration of amino acid was determined using the standard curve and expressed in milligrams per gram of the sample.

RESULTS AND DISCUSSION

The results of proximate analysis, mineral analysis, vitamin analysis, essential amino acid analysis, non-essential amino acid profile for onion and garlic respectively are presented in Tables 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 respectively.

Table 1: Proximate composition of onion before and after the different drying methods

Sample	Moisture	Ash	Fat	Protein	Fiber	CHO
FO	85.47^{d}±0.55	0.53^{b}±0.01	0.03^{a}±0.00	1.15^{b}±0.015	0.13^{a}±0.006	12.83^{a}±0.69
SDO	15.58^{c}±0.17	0.42^{a}±0.02	0.03^{a}±0.00	0.62^{a}±0.006	0.67^{b}±0.02	82.68^{b}±0.18
FDO	9.57^{a}±0.03	1.66^{d}±0.02	0.04^{a}±0.00	0.51^{a}±0.010	0.99^{b}±0.005	87.24^{d}±0.01
MWO	14.57^{b}±0.04	1.32^{c}±0.03	0.07^{b}±0.00	0.58^{a}±0.006	0.22^{a}±0.01	83.23^{c}±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 2: Proximate composition of garlic before and after the different drying methods

Sample	Moisture	Ash	Fat	Protein	Fiber	CHO
FG	66.82^{d}±0.10	1.76^{d}±0.03	0.06^{a}±0.0000	0.80^{a}±0.01	0.42^{a}±0.01	30.13^{a}±0.07
SDG	18.80^{c}±0.25	1.26^{b}±0.06	0.32^{a}±0.0115	0.91^{a}±0.01	0.08^{a}±0.00	78.63^{b}±0.25
FDG	7.73^{a}±0.01	1.86^{c}±0.03	0.37^{c}±0.0100	0.79^{a}±0.01	0.26^{a}±0.01	88.99^{d}±0.037
MWG	9.23^{b}±0.09	0.91^{a}±0.01	0.54^{d}±0.0173	1.38^{b}±5.8	4.41^{b}±7.44	83.44^{c}±0.19

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 3: Mineral composition of onion (mg/100 g) before and after the different drying methods

Sample	K	Mg	Mn	Na	Zn	P
FO	16.99^{a}±0.01	27.81^{a}±0.01	2.97^{b}±0.01	382.74^{c}±0.01	1.44^{a}±0.00	1.74^{d}±0.00
SDO	136.38^{d}±0.01	81.94^{d}±0.01	2.66^{a}±0.02	410.91^{d}±0.02	1.58^{c}±0.00	1.31^{b}±0.00
FDO	102.91^{c}±0.01	69.65^{b}±0.01	3.32^{c}±0.01	328.99^{a}±0.02	1.63^{d}±0.00	1.25^{a}±0.00
MWO	84.09^{b}±0.01	79.78^{c}±0.01	3.52^{d}±0.01	360.08^{b}±0.02	1.54^{b}±0.00	1.55^{c}±0.00

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: Mineral composition of garlic (mg/100 g) before and after the different drying methods

Sample	K	Mg	Mn	Na	Zn	P
FG	80.18^{a}±0.00	39.34^{a}±0.00	2.68^{a}±0.00	350.25^{b}±0.01	1.59^{c}±0.00	1.33^{b}±0.00
SDG	150.91^{c}±0.01	68.87^{c}±0.00	2.78^{c}±0.00	398.26^{f}±0.02	1.50^{a}±0.00	1.66^{d}±0.00
FDG	163.37^{d}±0.01	65.09^{b}±0.01	2.39^{d}±0.00	413.40^{h}±0.02	1.51^{b}±0.00	1.45^{c}±0.00
MWG	105.85^{b}±0.01	70.31^{d}±0.02	3.15^{b}±0.00	385.43^{e}±0.01	1.61^{d}±0.00	1.07^{a}±0.00

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 5: Vitamin composition of onion before and after the different drying methods (mg/100 g)

Sample	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin B_3	Vitamin B_6	Vitamin C	Vitamin D	Vitamin E	Vitamin K
FO	0.25^{d}±0.00	0.038^{a}±0.00	0.101^{c}±0.01	0.98^{a}±0.01	0.079^{a}±0.00	1.25^{d}±0.03	13.16^{d}±0.04	3.90^{b}±0.0	0.76^{a}±0.00
SDO	0.14^{c}±0.01	0.10^{b}±0.01	0.053^{b}±0.01	1.01^{b}±0.03	0.18^{b}±0.00	0.49^{c}±0.02	4.87^{b}±0.03	6.09^{d}±0.14	1.42^{c}±0.01
FDO	0.068^{a}±0.01	0.17^{c}±0.01	0.017^{a}±0.01	1.11^{b}±0.03	0.17^{b}±0.00	0.44^{b}±0.01	4.39^{a}±0.01	2.55^{a}±0.01	1.62^{d}±0.011
MWO	0.10^{b}±0.01	0.26^{d}±0.01	0.24^{d}±0.01	0.95^{a}±0.01	0.09^{a}±0.00	0.04^{a}±0.00	6.76^{c}±0.29	5.52^{c}±0.00	0.84^{b}±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 6: Vitamin composition of garlic before and after the different drying methods (mg/100 g)

Sample	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin B_3	Vitamin B_6	Vitamin C	Vitamin D	Vitamin E	Vitamin K
FG	0.22^{c}±0.00	0.038^{a}±0.00	0.188^{c}±0.00	1.04^{c}±0.03	0.061^{b}±0.0	0.75^{d}±0.02	18.60^{c}±0.05	3.38^{c}±0.00	0.76^{a}±0.00
SDG	0.12^{a}±0.00	0.072^{ab}±0.06	0.147^{b}±0.00	0.92^{a}±0.02	0.086^{c}±0.00	0.29^{c}±0.01	0.74^{a}±0.07	3.04^{b}±0.01	1.12^{d}±0.03
FDG	0.18^{b}±0.01	0.054^{a}±0.00	0.0096^{a}±0.00	0.93^{a}±0.02	0.044^{a}±0.00	0.14^{a}±0.00	17.06^{d}±0.12	2.91^{a}±0.04	0.97^{b}±0.01
MWG	0.11^{a}±0.00	0.10^{b}±0.00	0.176^{c}±0.01	0.95^{ab}±0.00	0.069^{c}±0.00	0.25^{b}±0.01	2.72^{b}±0.51	5.19^{d}±0.10	1.03^{c}±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: FG: Fresh Garlic; SDG: Sun Dried Garlic; FDG: Freeze Dried Garlic; MWG: Microwave Irradiated Garlic

Table 7: Essential amino acid composition of onion before and after the different drying methods (mg/100 g)

Sample	Lysine	Methionine	Threonine	Isoleusine	Leusine	Phenylalanine	Valine	Histidine	Tryptophan
FO	1.54^{a}±0.01	0.86^{a}±0.01	1.75^{a}±0.01	2.01^{a}±0.01	6.25^{a}±0.01	2.75^{a}±0.00	3.87^{a}±0.01	1.54^{a}±0.02	2.72^{a}±0.01
SDO	4.00^{c}±0.00	1.93^{c}±0.00	2.87^{c}±0.01	4.00^{b}±0.00	8.26^{c}±0.01	8.26^{c}±0.01	3.96^{b}±0.01	4.45^{d}±0.00	4.32^{c}±0.01
FDO	3.77^{b}±0.01	1.67^{b}±0.01	1.95^{b}±0.00	4.00^{b}±0.00	7.78^{b}±0.01	7.78^{d}±0.01	3.95^{b}±0.00	3.61^{b}±0.07	4.23^{b}±0.01
MWO	4.83^{d}±0.01	2.76^{d}±0.01	5.13^{d}±0.01	4.13^{b}±0.01	9.32^{d}±0.01	5.60^{b}±0.00	5.52^{c}±0.01	4.04^{c}±0.01	5.63^{d}±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 8: Essential amino acid composition of garlic before and after the different drying methods (mg/100 g)

Sample	Lysine	Methionine	Threonine	Isoleusine	Leusine	Phenylalanine	Valine	Histidine	Tryptophan
FG	2.62^{a}±0.01	1.13^{a}±0.01	2.25^{a}±0.00	2.85^{a}±0.01	7.34^{a}±0.01	7.34^{d}±0.01	3.84^{a}±0.01	3.78^{a}±0.01	4.01^{a}±0.01
SDG	4.17^{c}±0.01	2.62^{c}±0.01	4.66^{c}±0.01	4.04^{c}±0.01	8.93^{c}±0.00	5.37^{b}±0.01	4.96^{c}±0.01	3.86^{b}±0.01	5.26^{c}±0.01
FDG	4.06^{b}±0.01	2.34^{b}±0.01	3.84^{b}±0.01	4.01^{b}±0.01	8.78^{b}±0.02	4.84^{a}±0.06	4.71^{b}±0.01	5.62^{c}±0.01	3.70^{b}±0.00
MWG	5.83^{d}±0.01	3.65^{d}±0.01	5.84^{d}±0.01	4.78^{d}±0.01	12.41^{d}±0.00	5.81^{c}±0.01	7.82^{d}±0.01	4.54^{d}±0.01	5.89^{d}±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

Proximate Composition of Onion and Garlic Before and After the Different Drying Methods

Table 1 and 2 present the proximate composition (moisture, ash, fat, protein, fiber, and carbohydrate content) of onion and garlic before and after being subjected to different drying methods (sun-drying, freeze-drying, and microwave irradiation).

Fresh onion and garlic showed 85.47±0.55 % and 66.82±0.10 %, respectively. This is in line with 60–90 % reported by Iortile et al., (2023). Dried samples ranged from 7.73±0.01 % to 18.80±0.25 %, within acceptable microbial stability limits (12–15 %) (Kaunda & Mwangwela, 2025). Freeze-dried garlic and onion had the lowest values: 7.73±0.01 % and 9.57±0.03 %. All drying methods significantly reduced moisture, with freeze-drying being the most effective.

Drying increased fat content, protein and fibre due to water loss. Also drying can cause cell wall breakdown and release of intracellular proteins, fat and enzymes and metabolites.

increase is due to moisture loss with higher values in freeze-dried garlic (0.37±0.01 %) and microwave-irradiated garlic (0.54±0.02 %) (Shim, et al., 2021; Andersa, et al., 2024).

Mineral composition of Onion and Garlic Before and After the Different Drying Methods

Table 3 and 4 respectively presents the mineral composition (K, Mg, Mn, Na, Zn, P) of onion and garlic samples processed by different methods: fresh, sun-dried, freeze-dried, and microwave-irradiated.

Freeze-dried garlic had the highest potassium (136.39±0.00 mg/100 g), followed by freeze-dried onion (102.91±0.00 mg/100 g). Fresh samples showed much lower levels: onion (16.99±0.01 mg/100 g) and garlic (80.18±0.00 mg/100 g). Higher potassium in dried samples results from water loss during drying. Sun-dried onion (81.94±0.00 mg/100 g) and microwave-irradiated onion (79.78±0.00 mg/100 g) had the highest magnesium levels. Fresh garlic showed the lowest (39.34±0.00 mg/100 g), while freeze-dried garlic contained 65.09±0.00 mg/100 g. Drying appears to concentrate magnesium.

Microwave-irradiated onion had the highest Mn content (3.52±0.00 mg/100 g), followed by freeze-dried onion (3.32±0.00 mg/100 g). Freeze-dried garlic had the lowest (2.39±0.00 mg/100 g). These findings align with existing reports that onions generally have higher Mn than garlic. Sodium was highest in freeze-dried garlic (413.40±0.02 mg/100 g) and sun-dried onion (410.91±0.01 mg/100 g). Freeze-dried onion had the lowest Na (328.99±0.03 mg/100 g). The drying process concentrated sodium due to water removal (Abdullahi et al., 2025). Zinc levels ranged from fresh garlic (1.44±0.00 mg/100 g) to freeze-dried onion (1.61±0.00 mg/100 g). Zinc concentration increased slightly in dried samples, which may reflect the concentrating effects of drying. (Yildirim & Kocabas, 2003).

Fresh onion had the highest phosphorus (1.74±0.00 mg/100 g), while freeze-dried garlic and onion had moderate levels (0.15 mg/100 g and 0.13 mg/100 g, respectively). These values fall within reported ranges for allium species. Wongsa et al., (2016), found that oven-drying produced better acceptable quality characteristics and better conservation of bio-active compounds compared to vacuum or freeze drying.

Overall, mineral concentrations increased post-drying, largely due to moisture loss. Freeze-drying consistently showed higher retention of minerals.

Vitamin Content of Onion and Garlic Before and After the Different Drying Methods (mg/100 g)

Table 5 and 6 respectively presents the vitamin content (mg/100 g) of fresh and processed onions and garlic, including different drying methods such as sun-drying, freeze-drying, and microwave irradiation.

Fresh onion and garlic contain 0.25±0.00 mg/100 g and 0.22±0.00 mg/100 g of vitamin A, respectively. Onions and garlic are minor vitamin A sources compared to vegetables like carrots. Vitamin A is sensitive to heat and light, leading to degradation during processing. Freeze-dried onion had a substantial reduction to 0.068±0.01 mg/100 g, and microwave-irradiated onion showed 0.10±0.01 mg/100 g, reflecting vitamin A's sensitivity. Onion and garlic both contain moderate thiamine levels (0.038±0.00 mg/100 g). Interestingly, freeze-drying and microwave irradiation increased thiamine content, likely due to water loss concentrating nutrients. Microwave-irradiated garlic showed a notable rise, possibly because rapid processing better preserves heat-sensitive vitamins. Garlic has higher riboflavin (0.19±0.01 mg/100 g) than onion (0.10±0.01 mg/100 g). Drying reduces riboflavin, but microwave irradiation preserves it relatively well, consistent with other studies that show quick cooking is less destructive. Garlic naturally contains more vitamin B_6 (1.04±0.03 mg/100 g), but drying notably increased B_6 in onions (sun-dried: 0.18±0.00 mg/100 g; freeze-dried: 0.17±0.00 mg/100 g; microwave: 0.091±0.00 mg/100 g) compared to fresh onion (0.0788±0.0066 mg/100 g). Drying concentrated B_6 in onions, but freeze-drying caused slight losses in garlic (Yang & Yao, 2019).

Garlic contains more vitamin C (0.14±0.00 mg/100 g) than onion (0.04±0.00 mg/100 g). Freeze-drying best preserved vitamin C compared to other methods. However, dehydration reduced vitamin C by at least 72 %, likely due to photo-oxidative and thermal degradation. Additives like SO_2 or $CaCl_2$ can help protect vitamin C during processing (Armand et al., 2018).

Fresh garlic and onion had high vitamin D levels (13.16±0.03 mg/100 g and 18.60±0.05 mg/100 g). Drying significantly reduced vitamin D content, though sun-dried and freeze-dried garlic retained more vitamin D than other treatments.

Onion and garlic contained 3.90±0.01 and 3.38±0.00 mg/100 g of vitamin E, respectively. Sun-dried onion showed an increase to 6.09±0.14 mg/100 g, consistent with drying concentrating fat-soluble vitamins by water loss.

Vitamin K levels were low in onion (0.76±0.00 mg/100 g) and garlic (0.76±0.0 mg/100 g) but increased with drying, which concentrates fat-soluble vitamins. Afolabi & Tame (2020), in their study which focused broadly on "nutritional values," it found that drying methods and packaging influenced nutrient maintenance-but detailed vitamin (C, A, E) losses were not deeply quantified which agreed with this finding.

Essential Amino Acids of Onion and Garlic Before and After Drying

Table 7 & 8 respectively showed essential amino acid content in fresh and processed onion and garlic. Drying generally increased amino acid concentrations due to moisture loss. Lysine, methionine, and phenylalanine levels align with literature values, where fresh onions contain about 0.8–1.5 % amino acids by weight (Ríos & Recio, 2005).

Rao et al. (1995) reported lysine and methionine in garlic ranging from 2–3 mg/100 g. Garlic's higher sulfur amino acid content explains elevated methionine after drying.

Sun-drying significantly concentrated amino acids, e.g., sun-dried onions had lysine (4.00±0.00 mg/100 g), methionine (1.93±0.00 mg/100 g), and phenylalanine (8.26±0.01 mg/100 g) (Rattigan & McDougall, 2005; Sagar, et al, 2020; Pirunon et al, 2020). Freeze-drying preserved nutrients well but with less concentration effect than sun-drying. Freeze-dried onion and garlic showed increased lysine, threonine, and phenylalanine (Singiri, et al, 2022; Singh & Kumar, 2017). Similarly, Mirkomilov et al., (2025) Studied garlic slices under different drying methods: convective (50-70 °C), vacuum (40-60 °C, 50 kPa), freeze-drying (–40 °C, 0.1 kPa), microwave (600 W under vacuum), and combined freeze + microwave and found that freeze-drying preserved ~98-100 % of amino acids; vacuum drying ~60-70 %; microwave ~75 %; convective ~60 %. This indicates that drying method significantly influences amino acid retention in onion and garlic. Microwave irradiation can degrade some amino acids due to heat but may also increase certain amino acids like phenylalanine and methionine (Basak, 2020). Microwave-irradiated garlic showed very high lysine (5.8250±0.0071 mg/100 g), possibly from protein breakdown enhancing amino acid concentration (Yildirim & Kocabas, 2003).

CONCLUSION

The proximate composition of onion and garlic before and after drying follows expected trends. Freeze-drying led to the greatest nutrient concentration, especially in carbohydrates and ash, while microwave-irradiated drying caused less dramatic changes. These findings align with literature emphasizing the importance of drying methods on nutritional profiles. Both fresh and processed garlic and onion contain a broad array of bioactive compounds. While processing alters some levels, these vegetables remain rich in antioxidants and anti-inflammatory agents, supporting their known medicinal properties (Srinivasan, 2017). Mineral composition results also align with existing studies. Drying techniques like sun-drying, freeze-drying, and microwave-irradiation not only preserve but can concentrate nutrients differently than traditional methods.

Vitamin retention varied by drying method. Microwave-irradiation preserved or enhanced vitamins B_1, B_6, and C, while sun-drying concentrated vitamins K, B_1, and E. Freeze-drying showed similar trends but caused more significant losses in vitamins A and B_2. This agrees with research showing that dehydration methods influence vitamin retention, with microwave methods often better preserving heat-sensitive nutrients such as vitamin C. Amino acid concentrations, especially lysine and methionine, increased after sun-drying, freeze-drying, and microwave treatment. These methods can enhance amino acid content, consistent with literature suggesting protein breakdown leads to higher free amino acids. Freeze-dried garlic stood out for high cysteine content (e.g., 1–5 mg/100 g fresh), a sulfur-containing amino acid. Overall, freeze-drying best retains nutrients, antioxidants, and bioactive compounds (including vitamin C and allicin), showing superior moisture removal and antioxidant preservation compared to other drying methods.

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