**Effect of Local Storage on Nutritional and Antioxidant Profiles of Onion and Garlic from Northwest Nigeria**

**Abstract**

Fruits and vegetables are important food components; they are a vital source of essential and nonessential micronutrients that are essential for wellbeing. Onion and garlic are among the most widely consumed vegetable. Their broad nutritional and pharmacological benefits arise from the diverse micronutrients and phytochemicals present in the plants. The present study investigated the effect of local preservation/storage method on the proximate composition, antioxidant vitamins and activity, pungency, mineral composition and amino acid profile of two onion varieties (red and white) and garlic collected from Northwest Nigeria. It was observed that moisture and lipid content decreased upon storage, while other proximate parameters increased. Vitamin A increased from 37.750 ± 0.050 mg/dl to 49.470 ± 0.442 mg/dl upon storage of garlic. In white onion, it decreased from 8.600 ± 0.183 mg/dl to 2.123 ± 0.125 mg/dl. Vitamin C, vitamin E, and pyruvate (a measure of pungency) generally decreased with storage. While antioxidant activities decreased following storage, % DPPH activity for garlic increased (77.813 ± 0.156 % to 90.673 ± 3.294 %). Except for Ca, Mg and Na, mineral element composition tends to decrease with storage. A varied influence of storage on amino acid levels was observed; Glu, Asp and Arg of onion samples increased but Glu levels decreased. In garlic, Lys, Phe, Ser and Asp levels were elevated while Iso, Val, Tyr, His, and Cys dropped. Thus, preservation/storage differently affected the levels of parameters analysed.

**Keywords:** Amino acid, Antioxidant, Garlic, Minerals, Onion, Proximate, Pungency.

1. **INTRODUCTION**

Oxidation stress and free radicals have detrimental consequences to human health, particularly due to their ability to trigger numerous pathological diseases ranging from cardiovascular disease (CVD) to cancer (Pizzino *et al.,* 2017). Biological system possesses an antioxidant defence mechanism for preventing ROS-induced cellular damage (Deponte *et al.,* 2012). Antioxidants are natural or synthetic compounds capable of counteracting oxidative stress caused by free radicals; unstable molecules that the system produces due to reaction to environmental and other pressures. Thus, antioxidants mitigate the effects of oxidative stress on individuals’ health (Pizzino *et al.,* 2017). These antioxidants can be sourced either endogenously or exogenously. Both are highly critical in prevention, management, and treatment of several human pathologies. Therefore, consumption of food containing antioxidants may diminish the oxidative damage caused by free radicals on the human biological system (Lin and Yen, 1999). High intake of exogenous antioxidant particularly from plants would prevent the damage resulting from oxidative stress via preventing the initiation and propagation of oxidative chain reaction, acting as free radical scavengers, quenchers of singlet oxygen and reducing agents (Baiano and Del Nobile, 2015).

*Allium cepa* L. (family: Liliaceae) and *Allium sativum* L. (family: [Amaryllidaceae](https://www.google.com/search?sxsrf=AJOqlzXq1a5J75tiS775Ov4Hi_Vli5V6jg:1678614446500&q=tafarnuwa+amaryllidaceae&stick=H4sIAAAAAAAAAONgVuLUz9U3MCozLjd5xGjCLfDyxz1hKe1Ja05eY1Tl4grOyC93zSvJLKkUEudig7J4pbi5ELp4FrFKlCSmJRbllZYnKiTmJhZV5uRkpiQmpyamAgCC_ERgXwAAAA&sa=X&ved=2ahUKEwi7q7GOjtb9AhXFSPEDHfD8DZoQzIcDKAB6BAgVEAE)) are commonly known as onion and garlic respectively (Sidhu *et al.,* 2019). These two (2) *Allium* species are amongst the oldest cultivated plants (Lanzotti, 2006), they are presently cultivated throughout the world (Bisen and Emerald, 2016). Onion (*A. cepa*) is categorized by its colour (yellow, red, or white), and taste (sweet or non-sweet) (Albishi *et al.,* 2013). Onion and garlic are considered to be multi-use vegetables; consumed fresh as salad, as well as in a number of processed forms (as spices in dried powdered form or as an essential oil) (Takahashi and Shibamoto, 2008; Bouba *et al.,* 2014). Several studies have shown that both onion and garlic possessed several agents with numerous pharmacological characteristics (Benmalek *et al.,* 2013). These pharmacological properties include antioxidant, antimicrobial, anti-inflammatory, antidiabetic, antispasmodic, antimutagenic, antiplatelet, anti-asthmatic agent, anticancer, antithrombotic, and antitumor effects (Galmarini *et al.,* 2001; Rahman, 2001; Shri and Bora, 2008; Nasri *et al.,* 2012; Albishi *et al.,* 2013; Elberry *et al.,* 2014; El-Saber *et al.,* 2020). These plants are also used for treatment snakebites, stomach diseases, throat infection, fever, cholera, dysentery, common cold, arthritis, and hepatitis (Corzo-Martinez *et al.,* 2007; Akash *et al.,* 2014). Abduljalil *et al.* (2022) have extensively reviewed the medicinal benefits of these plants. It is reported that the frequent consumption of onion and garlic improves internal antioxidant capacity. Moreso, it decreases oxidative stress effects via enhancing the endogenous antioxidant synthesis or by decreasing the production of oxygen free radical species (ROS) (Asdaq and Inamdar, 2011).

Several studies have evaluated the nutritional composition and antioxidant capacity of onion and garlic in different perspectives (Yahaya *et al.,* 2010; Cheng *et al.,* 2013; Osuji *et al.,* 2013; Asanga *et al.,* 2015; Jurgiel-Malecka *et al.,* 2015; Lenkova *et al.,* 2016; Salawu *et al.,* 2021; Ani *et al.,* 2022; Tahir *et al.,* 2022).Although*,* genotype, growing location, and environmental elements have been shown to influence the antioxidants status of onions and garlic both qualitatively and quantitatively (Mogren *et al.,* 2007; Kaur *et al.,* 2009), none of these studies evaluated the impact of storage on such parameters despite their wide consumption. Ukoha *et al.* (2016) have evaluated the antioxidant capacity of onions (red and white) and garlic, but the antioxidant parameters evaluated are limited. Therefore, this study was aimed at evaluating and comparing the antioxidant properties of 2 different varieties (red and white) of fresh and locally preserved onions and garlic cultivated in Northwest Nigeria. It is considered necessary to identify the variety with high antioxidant capacity, for healthier or functional antioxidant nutraceutical which provides medicinal benefits beyond nutritional requirement.

1. **MATERIALS AND METHODS**
   1. **Study Location**

Sokoto and Kebbi States are one of the leading onion and garlic producing states in Northwest ern region of Nigeria. Here, several farmers cultivate onion and garlic in the Fadama under irrigation during the dry season or in the uplands during rainy seasons (Umar, 2014). About 80% of the inhabitants of these state are engaged in different forms of farming. Among vegetable farmers, about 75% of them are involved in onion and garlic farming as a major cash crop (Umar, 2014).

* 1. **Sample Collection**

Plant samples were collected (in June, 2024) from same farmers, using the same farming applications in order to avoid any possible environment influence. The samples were randomly selected, so as to give each sample an equal and independent opportunity of being selected and to avoid biasness. The sample of both onions and garlic were authenticated by the Herbarium unit of the Department of Biological Sciences, Usmanu Danfodiyo University Sokoto, Nigeria (Botanical numbers????).

During sample collection, only well germinated and mature onion (red and white) and garlic, not subjected to any agrochemical for 2 weeks were selected for the study. Some of the freshly cultivated samples devoid of any physical damage/disease were randomly picked and locally preserved for 6 months.

* 1. **Onion and Garlic Preservation Method**

The freshly cultivated onions were preserved using an age-long methods of onion preservation practiced by the onion farmers in northern Nigeria. In this method, the onion bulbs are raised above the ground using wooden racks and covered with dry Gamba grass(*Imperata cylindrica*) as described by Shehu *et al.* (2023). The *Imperata cylindrical* (Gamba grass) influences the temperature and humidity (Imoukhuede and Ale, [2015](https://iadns.onlinelibrary.wiley.com/doi/10.1002/fpf2.12009#fpf212009-bib-0052)) and enhance proper ventilation; hence onion can be stored for up to 6 months (WVC, 2018). Here in, the preserved onions are periodically monitored to promptly remove rotten and decomposed onions. This preservation system minimizes the spouting and growth of bacteria via stacking the onion above the ground to allow sufficient aeration of the onions (Muhammad *et. al.,* 2012).

Fresh garlic bulbs were preserved using local preservation method. The local preservation method entails the storage of the garlic in a cool dry place with proper ventilation. This is a good method particularly for commercial storage where garlic bulbs are kept in good condition for up to 9 months as described by Harris (2016).

The samples were grouped into six (6) different groups as follows:

1. Freshly cultivated red onions.
2. Locally preserved red of onions (preserved for 6 months).
3. Freshly cultivated white onions.
4. Locally preserved white of onions (preserved for 6 months).
5. Freshly cultivated varieties of garlic.
6. Locally preserved varieties of garlic (preserved for 6 months).
   1. **Preparation of Sample**

Prior to biochemical analysis, the onions (red and white) and garlic were subjected to thorough cleaning so as to remove dirt and sand particles. The samples were washed with distilled water, peeled and sliced using a stainless-steel kitchen knife.

* 1. **Proximate** **Analysis**

Proximate analysis comprising of percentage moisture, ash, crude lipid, crude protein and carbohydrate was evaluated according to the recommended methods of the Association of Official Analytical Chemists (AOAC) (AOAC, 2000).

Moisture content of the samples was obtained by weighing empty crucible and labelled as W0; thereafter 2 g of each sample was introduced into the empty crucible, weighed and also labelled as W1. The crucible containing sample was transferred into the hot air-drying oven and allowed to dry for 2 hours at 105oC. It was transferred into the desiccators and allowed to cool, then weighed and labelled as W2, with minimum exposure to air.

Ash content of the sample was measured after a dry platinum dish was weighted as W0, then 2 g of the sample was weighted and introduced into the crucible and weighed as W1. The crucible containing the sample was ashed by inserting it into the muffle furnace where it was heated at 550oC. The crucible was allowed to cool in the desiccators, and then weighed as W2.

For lipid content of the samples, then 2 g of each sample was weighed, then inserted into a labelled permeable thimble and covered with a piece of cotton wool. Pet ether of 200 ml measured and added into the dried 250 ml extraction flask and weighed W1. Thereafter, the thimbles were positioned into the extractor and the extraction was made for about 5 to 6 hours. The pet ether was collected on the top of the container (tube) for re-use. The extraction flask was removed from the extraction flask, when the petroleum ether is almost free. The sample was then dried in an oven for an hour at 150-110oC, allowed to cool in a desiccator and then weighed as W2. After this, the amount of lipid extracted is achieved by the variations between the weight of the flask prior and after the extraction.

Protein content determination involves three (3) steps, namely: digestion, distillation, and titration. For digestion, 0.2 g of each sample was weight and put in a test tube, a 0.2 g of catalyst (10:1 of sodium sulphate and copper sulphate) and 4 ml of concentrated H2SO4 were added. The mixture was digested until a clear solution was obtained and then diluted with water to obtain a total volume of 10 ml. For distillation step, 10 ml of the digested sample was inserted into a Kjeldahl flask and 30 ml of 40% NaOH was added. The Kjeldahl flask containing the mixture was connected to a micro Kjeldahl distillation machine for 10 to 20 minutes. The ammonia released was collected into a flask containing 10 ml of 2% boric acid which resulted to a colour change from purple to green. Lastly, the distilled solution was titrated using a standard 0.1 M hydrochloric acid (HCl) until a pink colour appeared, which indicates the end point. The titre value (TV) was recorded for calculation according to Kjeldahl method (1883).

Percentage of nitrogen (% N) is calculated as follows:

% Nitrogen (N) = TV × 0.1 x 0.014 x 10 x 100 and % Crude protein = % N × 6.25

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Where: TV is Titre value, 0.1 is the normality of acid, N is the nitrogen factor (0.014), DF is the dilution factor whereas 6.25 is the conversion factor

For fibre content, 2 g of each sample was weighed (W2) and 20 ml of 15% sulfuric acid added and placed in water bath and boiled for 30 minutes. The solution was allowed to cool and filtered. The filtrate was discarded and residue was treated with 20 ml of 10% sodium hydroxide (NaOH). It was shaken and returned to water bath for additional 30 minutes. It was cooled and filtered again. The residue was transferred to a clean crucible of known weight (W1), then placed in a muffle furnace for 5 hours at 550-600oC. The crucible was removed and allowed to cool in a desiccator and weighed (W3).

The percentage crude fibre content of each sample was calculated using the formula:

Fiber (%) = W3-W1 × 100

W2

Where: W1 is the weight of empty crucible, W2 is the weight of sample, and W3 is weight of crucible with sample after ashing.

The carbohydrate content of each sample was estimated by subtracting the combined percentages of ash, fibre, protein and lipid from 100%.

Carbohydrate (%), = 100 – [protein (%) + Moisture (%) + Ash (%) + Fibre (%) +Fat (%)].

* 1. **Quantitative Determination of Phytochemicals**

Total flavonoid contents were determined using the method of Boham and Kocipai-Abyazan (1974). First, 10 g of sample was extracted thrice with 100 ml each of 80% aqueous methanol at room temperature. The solution was filtered and filtrate was transferred into a crucible, evaporated to dryness and weighted to constant weight. The difference in the weight of flavonoid was expressed as percentage of the weight of sample analysed.

For determination of alkaloid, gravimetric method of Harbone, (1998) was adopted. Initially, 5 g of the sample was weighed into a 250 ml beaker and 200 ml of 10% acetic acid in ethanol was added to the sample and was allowed to stand for 4 h. After cooling, the extract was filtered and concentrated NH4OH was added drop wise to the extract until the preparation is completed. It was allowed to settled, filtered and washed with 1% NH4OH solution. The precipitate in the filter paper was dried at 60ºC for 30 min and was reweighed.

Saponins were determined according to gravimetric method of AOAC (1990) using Soxhlet extractor and two different organic solvents for the extraction purpose. Initially, 2 g of the sample was weighed into a thimble and inserted into Soxhlet extractor. The extraction was conducted using acetone in a 250 ml bottom flask for 3 hours, and then additional weighed 250 ml flask with methanol was fitted to the same extractor, where the extraction continues for another 3 h. After the second extraction, methanol was recovered through distillation, while the flask was oven-dried in order to remove the remaining solvent in the flask. Finally, the flask was cooled in a desiccator and then weighed.

Determination of tannin content was carried out spectrophotometrically using Folin-Denis’s method as described by Pearson (1976). A fine powdered sample that passes through a sieve of 1 mm diameter was used. Extraction of tannins was carried out by weighing 400 mg of the powdered sample into conical flask, followed by addition of 40 ml diethyl ether containing 1% acetic acid (v/v), it was then mixed in order to remove any colorant material. After, 5 minutes the supernatant was gently cast-off and 70% aqueous acetone was added and wrapped with cotton wool plug and stirred for 2 h using electric shaker for proper extraction. Thereafter, it was filtered using Whatman filter paper and kept at 4ºC for further analysis.

Glycoside determination was carried out using alkaline picrate method of Onwuka (2005). About 5 g of sample was dissolved in 50 ml of distilled water and allowed to stay overnight and then filtered. For this, different standard concentrations of potassium cyanide (KCN) solution containing 0.1 to 1.0 mg/ml cyanide were formed. Subsequently, 1 ml of the sample filtrate and standard KCN solution was pipetted in test tubes; followed by addition of 4 ml of alkaline picrate solution. It was incubated for 15 minutes in water bath and after colour change; absorbance was read at 490 nm against a blank which contains simply 1 ml of distilled water and 4 ml of alkaline picrate solution. The cyanide content was extrapolated from the cyanide standard curve.

* 1. **Antioxidant** **Vitamins**

Method of Bassey *et al*. (1946) was used for determination of vitamin A in the samples, while vitamins C and E was estimated according to the method of Baker and Frank’s (1968). Vitamin A content of the sample was determined by dissolving 0.5 g of sample in 10 ml of distilled water, allowed to stand for 1 hour, filtered using Whatman filter paper, shaken thoroughly and centrifuged for 10 minutes at 2000 rpm. Thereafter, 1 ml of supernatant and the segment containing petroleum ether solution were separately read spectrophotometrically at 450 nm. For vitamin C, 0.5 g of samples were dissolved in 10 ml of distilled water, incubated at room temperature for 30 minutes, filtered and centrifuged for 10 minutes at 2000 rpm. The absorbance was measured at 700 nm. Likewise, for vitamin E determination, 0.5g of each sample was dissolved in 10 ml of distilled water, and incubated at room temperature for 30 minutes. The solution was then filtered and thereafter, 0.5 ml was transferred into clean test tube. Subsequently, 0.5 ml of ethanol was added and vortexed for 1 minute. Then, xylen of 3ml was introduced and shaken for another 1 minute and centrifuged at 2000 rpm for 10 minutes, and then incubated for 3 minutes. The absorbance was spectrophotometrically measured at 539 nm.

* 1. **Antioxidant Activity**

The thiobarbituric acid (TBA) assay is usually used to estimate the thiobarbituric acid-reactive substances (TBARS) of lipid oxidation in several plant and food constituents. The TBA assay was done according to the method of Du and Bramlage (1992). Thiobarbituric acid react with malondialdehyde (MDA) which is a product of lipid oxidation to produce a red fluorescent 1:2 MDA/TBA compound with extreme absorbance at 532nm. Measurement of MDA content in samples is an indication of the antioxidant capacity of the onion and garlic. Therefore, the MDA levels in the samples were calculated using the formular:

MDA conc. (mM/g) =

Absorbance of test x Assay volume (1.5ml) x 103

Molar extinction coefficient (1.56x105) x Weight of substance (g) x sample volume (0.5)

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity of the samples was assessed by initially preparing the stock solution as 40 mg was dissolved in 100 ml of methanol which was stored at -20°C. Absorbance of 1.0 ± 0.01 units was obtained by mixed 350mL of the stock solution with 350 mL methanol by using spectrophotometer (Epoch, Biotek, USA) at 517 nm wavelength. Subsequently, about 100 μL onions and garlic extracts with 1 ml methanolic DPPH solution was prepared were kept 2 hours for scavenging reaction in the dark (Alyaqoubi *et al*., 2014). The percentage of DPPH scavenging activity was calculated using the formular:

DPPH scavenging activity (%) = [(A blank–A sample)/A blank] × 100.

Where, A stands for absorbance.

The ferric reducing antioxidant power (FRAP) reagent was prepared using 300 mM acetate buffer, pH 3.6 (3.1 g sodium acetate trihydrate, and 16 mL glacial acid made up to 1:1 with distilled water), 10 mM TPTZ [2,4,6-tris (2-pyridyl)-s-triazine], in 40 mM HCl; and 20mM FeCl3•6H2O in the ratio of 10:1:1 to obtain the working reagent. Consequently, 100 µL of onion and garlic extract was added to 1 mL of FRAP reagent. The absorbance was spectrophotometrically monitored after 30 min at 595 nm. The calibration curve of Trolox was set up to estimate the activity capacity of each sample. The result was expressed as mg of Trolox equivalents per 100 g of fresh samples (mg TE/100 g of FW) (Alyaqoubi *et al*., 2014).

Total phenolic content (TPC) was estimated by adopting the method of Alyaqoubi *et al*. (2014). To 100 μL of extracted onion and garlic samples, 0.4 mL distilled water and 0.5 mL diluted Folin-Ciocalteu reagent was added. The samples containing the reagent were incubated at room temperature for 5 minutes and consequently 1 mL of 7.5% sodium carbonate (w/v) was added. The absorbance was monitored spectrophotometrically at 765 nm after 2 hours. To evaluate the activity capacity of the samples, a calibration curve of gallic acid was set up. The result obtained was expressed as mg of gallic acid equivalents per 100 g of fresh sample (mg GA/100g of FW).

Total pungency test (pyruvic acid determination) of the samples (onions and garlic) were measured as flavour strength of the samples and is expressed in terms of total pyruvic acid content of the sample according to the method of Teare Ketter and Randle (1998). Pyruvate is produced in a mole for mole relationship with the flavour precursors, thus it is considered as only indicator of pungency and is expressed in μmol pyruvic acid content /ml of juice. Firstly, fresh samples of onions (red or white) or garlic was taken and squeezed with a Randle/Bussard press where the slurry was obtained in a 600 mL beaker, covered and allowed to settle for 10 min. After it was settled, 0.5 ml of slurry was pipetted into a large test tube, and then 1.5 ml of 5% TCA (50 g of trichloroacetic acid was dissolved in 1000 ml of distilled water) was added, covered with Parafilm and also vortexed. The preparation was allowed to settle for at least 1 hour, Parafilm was removed and 18 ml of deionized water was added, sealed with Parafilm and vortexed. Subsequently, 1 ml of the solution was pipetted and transferred into small test tubes where 1 ml of 0.0125% 2, 4-DNPH [0.125 g of 2, 4-dinitrophenylhydrazine was dissolved in 1000 ml of 2 N HCl solution (2 N HCl was formed by diluting 228 ml of 37.8% HCl to 1000 ml of distilled water)] and 1 ml of deionized water was added, covered with Parafilm and vortexed. The test tube was inserted into water bath at 37oC for 10 min. and then 5 ml of 0.6 N NaOH (24 g of NaOH was dissolved in 1000 ml of distilled water) was added to test tube. The absorbance was measured at 420nm using spectrophotometer (Spec. AE-350, Jefferson Ltd, USA).

* 1. **Determination of Antioxidant Mineral Elements**

The method of Bhatti *et al*.(2006) was used for wet digestion. The entire wet digestion process was carried out in a fume cupboard for safety. Initially, 0.5 mL of each sample was taken into a 50 mL conical flask, and then 5 mL of nitric acid (HNO3) was added which led to the formation of yellow fume mixture. The yellow fume disappeared after gentle heating for 2 minutes. Consequently, the mixture was allowed to cool for 30 minutes, thereafter 2.5 mL of perchloric acid (HClO4`) was added and heated until it became colourless. Lastly, 20 ml of distilled water was added to the heated samples and filtered into plastic bottles. The samples obtained were used for analysis of mineral elements using Plasma Atomic Emission Spectroscopy (MP-AES) (Model: G8007A, Agilent Technologies, Australia).

* 1. **Determination of Amino Acids Profile**

Both the onions (red and white) and garlic samples were dried at 70oC to constant weight. The samples were defatted, hydrolysed, evaporated using a rotary evaporator and then loaded into the Applied Biosystems PTH Amino acid analyser. A chloroform/methanol mixture of ratio 2:1 was used for defatting of samples. For extraction process, 4 g of the sample was introduced into an extraction thimble and extracted for 15 hours using Soxhlet extraction apparatus according to the method of Association of Official Analytical Chemists (AOAC, 2006). Amino acid analyser (120A PTH, Applied Biosystems Inc, USA) was used for determination of amino acids in the samples as described by AOAC’s method of 2006. The machine (amino acid analyser) was used due to its ability to spontaneously analyse phenylthiohydantoin (PTH) amino acids derived from the Edman degradation of proteins and peptides.

* 1. **Statistical analysis**

The data were expressed as mean ± standard deviation (SD) and were analyses using GraphPad Prism Software, version 6.01 (San Diego, USA). Also, the statistical significance was obtained using one-way ANOVA (analysis of variance analysis) followed by Turkey’s multiple comparison post hoc test, and then p <0.05 was considered statistically significant.

**3. RESULT**

* 1. **Proximate Analysis**

Proximate composition of onion and garlic samples of the present study are presented in Table 1. Moisture content was highest in fresh red onion (88.758 ± 0.018 %), followed by preserved red onion (86.689 ± 0.005 %), while preserved garlic had the lowest moisture content (64.761 ± 0.007 %). Conversely, preserved (1.661 ± 0.002 %) and fresh (1.485 ± 0.003 %) garlic respectively had higher percentage ash composition among the analysed samples. The lowest ash content (0.234 ± 0.003 %) was seen in fresh white onion. Fresh and preserved red onion exhibited higher protein content (0.772 ± 0.025 and 0.910 ± 0.032 %), but had the lowest carbohydrate contents (7.311 ± 1.428 and 10.503 ± 0.757 % respectively) as compared to other samples. Fresh and preserved garlic samples had the highest composition of lipid (2.165 ± 0.002 and 2.067 ± 0.087 %), carbohydrate (27.363 ± 0.064 and 31.148 ± 0.081 % respectively) and fiber (2.062 ± 0.074 and 1.983 ± 0.003 % respectively). The preserved red onion presented the lowest lipid (1.154 ± 0.043 %) and fiber composition (1.341 ± 0.008 %).

**Table 1:** Proximate composition of onion and garlic samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **FRO** | **PRO** | **FWO** | **PWO** | **FG** | **PG** |
| Moisture (%) | 88.758 ± 0.018a | 86.689 ± 0.005b | 80.634 ± 0.003c | 78.762 ± 0.005d | 68.667 ± 0.033e | 64.761 ± 0.007f |
| Ash (%) | 0.265 ± 0.002a | 0.293 ± 0.004b | 0.234 ± 0.003c | 0.275 ± 0.002d | 1.485 ± 0.003e | 1.661 ± 0.002f |
| Protein (%) | 0.772 ± 0.025a | 0.910 ± 0.032a,b | 0.661 ± 0.090a,c | 0.743 ± 0.022a,c | 0.315 ± 0.044d | 0.310 ± 0.070d |
| Lipid (%) | 1.312 ± 0.080a | 1.154 ± 0.043b | 1.467 ± 0.006c | 1.339 ± 0.004a,c | 2.165 ± 0.002d | 2.067 ± 0.087d |
| Carbohydrate (%) | 7.311 ± 1.428a | 10.503 ± 0.757a | 14.335 ± 2.974b | 18.882 ± 0.024c | 27.363 ± 0.064d | 31.148 ± 0.081d |
| Fiber (%) | 1.636 ± 0.004a | 1.341 ± 0.008b | 1.737 ± 0.005c | 1.695 ± 0.002a,c | 2.062 ± 0.074d | 1.983 ± 0.003d |

Values are expressed as the mean ± S.D. of triplicate measurements. Values with different superscripts along the rows are significantly different (*p* < 0.05), while values with the same superscript in a row are not significant (*p* > 0.05) (One-way ANOVA with Tukey's Multiple Comparison Test). Samples: FRO = Fresh Red Onion; PRO = Preserved Red Onion; FWO = Fresh White Onion; PWO = Preserved White Onion; FG = Fresh Garlic; PG = Preserved Garlic.

* 1. **Phytochemical Analysis**

The phytochemical composition of onion and garlic samples analysed in the present study are presented in Table 2. In comparison to other samples, preserved and fresh red onion samples had higher flavonoid (0.420 ± 0.004 and 0.390 ± 0.047 g/100g respectively) composition. Tannin levels were higher in both fresh white and red onion (0.147 ± 0.004 and 0.139 ± 0.003 mg/100g respectively) as compared to the preserved onions (0.125 ± 0.008 and 0.135 ± 0.006 mg/100g respectively). Saponin levels were highest in fresh red onion (0.162 ± 0.005 g/100g), followed by preserved red onion (0.139 ± 0.004 g/100g), while preserved garlic had the lowest level of saponin (0.087 ± 0.006 g/100g). Alkaloids (1.053 ± 0.002 and 0.852 ± 0.016 g/100g respectively) and glycosides (1.127 ± 0.009 and 1.192 ± 0.005 g/100g respectively) were comparatively high in fresh and preserved garlic samples than in the onion samples. Nevertheless, fresh red onion possessed moderate level of alkaloids (0.822 ± 0.002 g/100g). The lowest level of alkaloids is seen in preserved red onion (0.545 ± 0.038 g/100g), while fresh white onion had lowest level of glycosides (0.537 ± 0.013 g/100g).

**Table 2:** Phytochemical composition of onion and garlic samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **FRO** | **PRO** | **FWO** | **PWO** | **FG** | **PG** |
| Flavonoids (g/100g) | 0.390 ± 0.047a | 0.420 ± 0.004a | 0.176 ± 0.002b | 0.150 ± 0.008b | ND | ND |
| Tannins (mg/100g) | 0.139 ± 0.003a | 0.125 ± 0.008b | 0.147 ± 0.004a | 0.135 ± 0.006a,b | ND | ND |
| Saponin (g/100g) | 0.162 ± 0.005a | 0.139 ± 0.004b | 0.104 ± 0.005c | 0.125 ± 0.003d | 0.115 ± 0.004c,d | 0.087 ± 0.006e |
| Alkaloids (g/100g) | 0.822 ± 0.002a | 0.545 ± 0.038a,b | 0.804 ± 0.002a | 0.710 ± 0.445a | 1.053 ± 0.002a,c | 0.852 ± 0.016a |
| Glycoside (g/100g) | 0.894 ± 0.008a | 0.606 ± 0.002b | 0.537 ± 0.013c | 0.898 ± 0.004a | 1.127 ± 0.009c | 1.192 ± 0.005d |

Values are expressed as the mean ± S.D. of triplicate measurements. Values with different superscripts along the rows are significantly different (*p* < 0.05), while values with the same superscript in a row are not significant (*p* > 0.05) (One-way ANOVA with Tukey's Multiple Comparison Test). ND = Not detected. Samples: FRO = Fresh Red Onion; PRO = Preserved Red Onion; FWO = Fresh White Onion; PWO = Preserved White Onion; FG = Fresh Garlic; PG = Preserved Garlic.

* 1. **Antioxidant Vitamins and Antioxidant Activity**

In Table 3, antioxidant vitamins, antioxidant capacity and pungency test of onion and garlic samples are presented. Vitamin A content was found to be highest in preserved and fresh garlic (49.470 ± 0.442 and 37.750 ± 0.050 mg/dl respectively). Preserved white onion comparatively (*p* < 0.05) had the least vitamin A composition (2.123 ± 0.125 mg/dl). Fresh red onion and fresh white onion had statistically similar (*p* > 0.05) high levels of vitamin C (142.660 ± 0.365 and 142.133 ± 1.504 mg/dl respectively) as compared to other samples. Statistically, the highest level of vitamin E was observed in fresh garlic (156.800 ± 1.152 mg/dl), followed by preserved garlic (148.767 ± 3.570 mg/dl) and then fresh red onion (127.167 ± 2.139 mg/dl). Preserved red onion had the least vitamin E content (60.233 ± 1.474 mg/dl) among the studied samples. Among the tested samples, Fresh white onion had the highest TBA value, followed by preserved red onion and preserved garlic (448.433 ± 0.929, 430.300 ± 1.015 and 422.167 ± 0.971 mM/g). The lowest TBA value was seen in fresh red onion (345.467 ± 0.651 mM/g). The preserved red onion exhibited higher DPPH radical scavenging activity (97.500 ± 0.436 %), which is statistically similar to that of fresh red onion (97.020 ± 0.292 %) and fresh white onion (92.233 ± 0.601 %). FRAP activity was comparatively higher (*p* < 0.05) in fresh and preserved red onion (17.697 ± 0.339 and 13.200 ± 1.046 mgTE/100g of FW respectively) when compared to other samples. Preserved red onion, fresh white onion and fresh garlic had comparatively similar ((*p* > 0.05)) TPC values (2.433 ± 0.292, 2.223 ± 0.055 and 2.592 ± 0.004 mgGA/100g of FW respectively). Compared to the aforementioned, fresh red onion, preserved white onion and preserved garlic had comparatively lower (*p* < 0.05) TPC values (1.673 ± 0.012, 1.727 ± 0.015 and 1.740 ± 0.010 mgGA/100g of FW respectively).

**Table 3:** Antioxidant vitamins, antioxidant capacity and pungency test of onion and garlic samples

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameters** | **FRO** | **PRO** | **FWO** | **PWO** | **FG** | **PG** |
| Vitamin A (mg/dl) | 11.200 ± 0.066a | 11.557 ± 1.079a | 8.600 ± 0.183b | 2.123 ± 0.125c | 37.750 ± 0.050d | 49.470 ± 0.442e |
| Vitamin C (mg/dl) | 142.660 ± 0.365a | 116.867 ± 0.153b | 142.133 ± 1.504a | 115.700 ± 0.361b,c | 134.917 ± 1.546d | 113.400 ± 0.458c |
| Vitamin E (mg/dl) | 127.167 ± 2.139a | 60.233 ± 1.474b | 117.800 ± 2.193c | 72.267 ± 2.139d | 156.800 ± 1.152e | 148.767 ± 3.570f |
| TBA (mM/g) | 345.467 ± 0.651a | 430.300 ± 1.015b | 448.433 ± 0.929c | 413.233 ± 1.060d | 396.533 ± 1.222e | 422.167 ± 0.971f |
| DPPH (%) | 97.020 ± 0.292a | 97.500 ± 0.436a | 92.233 ± 0.601a,b,d | 90.120 ± 2.782b,c,d | 77.813 ± 0.156c | 90.673 ± 3.294d |
| FRAP (mgTE/100g of FW) | 17.697 ± 0.339a | 13.200 ± 1.046b | 6.297 ± 0.112c | 7.763 ± 0.091d,e | 7.958 ± 0.126d | 6.623 ± 0.105c,e |
| TPC (mgGA/100g of FW) | 1.673 ± 0.012a | 2.433 ± 0.292b | 2.223 ± 0.055b,c | 1.727 ± 0.015a | 2.592 ± 0.004b,d | 1.740 ± 0.010a |
| Pyruvate (µmoles/mL) | 27.214 ± 0.220a | 18.655 ± 0.111b | 14.685 ± 0.088c | 10.602 ± 0.082d | 26.719 ± 0.133e | 8.595 ± 0.220f |

Values are expressed as the mean ± S.D. of triplicate measurements. Values with different superscripts along the rows are significantly different (*p* < 0.05), while values with the same superscript in a row are not significant (*p* > 0.05) (One-way ANOVA with Tukey's Multiple Comparison Test). Samples: FRO = Fresh Red Onion; PRO = Preserved Red Onion; FWO = Fresh White Onion; PWO = Preserved White Onion; FG = Fresh Garlic; PG = Preserved Garlic. TBA = Thiobarbituric acid; DPPH = 2,2-diphenyl-1-picrylhydrazyl radical scavenging activity; FRAP = Ferric reducing antioxidant power; TPC = Total phenolic content.

* 1. **Mineral elements**

The concentration of mineral elements in both fresh and processed samples of onion and garlic are given in Table 4. The highest concentration of Selenium (Se) was observed in fresh garlic and fresh white onion (9.227 ± 0.015 and 8.760 ± 0.236 ppm respectively). Preserved red onion had the least selenium content (4.170 ± 0.046 ppm) when statistically compared to other samples analysed (*p* < 0.05). Fe content was higher in fresh garlic (24.213 ± 0.025 ppm) and fresh red onion (24.213 ± 0.025 ppm), while preserved white onion had the least Fe content (1.937 ± 0.080 ppm). Fresh white onion had the highest Zn, Ca and K contents (8.143 ± 0.061, 68.177 ± 0.045 and 88.757 ± 0.050 ppm respectively) in comparison to the other samples. Moderately high Zn and K contents were observed in fresh red onion (6.841 ± 0.102 and 73.267 ± 0.045 ppm respectively). Similarly, fresh garlic possessed moderately high Ca and K contents (62.983 ± 0.228 and 71.840 ± 0.010 ppm respectively). Among the studies samples, preserved garlic exhibited the least content of Zn (3.870 ± 0.080 ppm) and K (36.243 ± 0.035 ppm), while preserved white onion had the least Ca content (35.957 ± 0.087 ppm). Statistically (*p* < 0.05), preserved red onion had the highest Mg content (15.667 ± 0.015 ppm), followed by preserved white onion (11.047 ± 0.021 ppm), while fresh red onion had the least Mg composition (4.657 ± 0.025 ppm). The fresh white and fresh red onion had comparatively higher Mn content (1.513 ± 0.100 and 1.347 ± 0.021 ppm) than other samples. The least Mn composition (0.887 ± 0.074 ppm) was exhibited by preserved garlic. Na content was higher in fresh red onion sample (12.313 ± 0.031 ppm) compared to others (*p* < 0.05). Preserved white onion also had moderately high levels of Na (10.023 ± 0.035 ppm), while the least Na content of 5.020 ± 0.130 ppm was seen in fresh garlic sample.

**Table 4:** Concentration of mineral elements in onion and garlic samples.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Minerals (ppm)** | **FRO** | **PRO** | **FWO** | **PWO** | **FG** | **PG** |
| Selenium (Se) | 7.347 ± 0.070a | 4.170 ± 0.046b | 8.760 ± 0.236c | 5.290 ± 0.046d | 9.227 ± 0.015e | 5.060 ± 0.046d |
| Iron (Fe) | 22.757 ± 0.081a | 4.283 ± 0.035b | 4.440 ± 0.036c | 1.937 ± 0.080d | 24.213 ± 0.025e | 14.957 ± 0.031f |
| Zinc (Zn) | 6.841 ± 0.102a | 5.357 ± 0.015b | 8.1n43 ± 0.061c | 3.880 ± 0.150d | 4.220 ± 0.020e | 3.870 ± 0.080d |
| Calcium (Ca) | 52.133 ± 0.068a | 55.530 ± 0.046b | 68.177 ± 0.045c | 35.957 ± 0.087d | 62.983 ± 0.228e | 55.933 ± 0.057f |
| Potassium (K) | 73.267 ± 0.045a | 58.807 ± 0.023b | 88.757 ± 0.050c | 60.550 ± 0.053d | 71.840 ± 0.010e | 36.243 ± 0.035f |
| Magnesium (Mg) | 4.657 ± 0.025a | 15.667 ± 0.015b | 8.630 ± 0.050c | 11.047 ± 0.021d | 6.563 ± 0.012e | 9.207 ± 0.045f |
| Manganese (Mn) | 1.347 ± 0.021a | 0.990 ± 0.087b | 1.513 ± 0.100a | 0.990 ± 0.040b,c,d | 1.070 ± 0.010b,c | 0.887 ± 0.074b,d |
| Sodium (Na) | 12.313 ± 0.031a | 8.247 ± 0.038b | 6.937 ± 0.031c | 10.023 ± 0.035d | 5.020 ± 0.130e | 8.623 ± 0.057f |

Values are expressed as the mean ± S.D. of triplicate measurements. Values with different superscripts along the rows are significantly different (*p* < 0.05), while values with the same superscript in a row are not significant (*p* > 0.05) (One-way ANOVA with Tukey's Multiple Comparison Test). Samples: FRO = Fresh Red Onion; PRO = Preserved Red Onion; FWO = Fresh White Onion; PWO = Preserved White Onion; FG = Fresh Garlic; PG = Preserved Garlic.

* 1. **Amino acids profile**

Figure 1 depicts the levels of various amino acids found in onion and garlic samples. According to the result, glutamic acid was most abundant amino acid in all analysed samples. It highest and lowest level was found to be 300.49 g/100g (in fresh garlic), and 223.88 g/100g (in preserved garlic). Similarly, aspartic acid was found to be moderately high in all the samples (ranging between 90.46-123.84 g/100g). The levels of lysine, proline, tryptophan, tyrosine, histidine, serine and methionine were considerably high in garlic sample than in red and white onion samples. Arginine, leucine and glycine levels of fresh and preserved onion samples were higher than that of garlic samples. The cystine level of fresh garlic was considerably higher than that of other samples. Other amino acid detected in the samples analysed are isoleucine, phenylalanine, valine, alanine and threonine.



**Figure 1:** Amino Acid concentration (g/100g sample) of onion and garlic samples

Key: FRO = Fresh Red Onion; PRO = Preserved Red Onion; FWO = Fresh White Onion; PWO = Preserved White Onion; FG = Fresh Garlic; PG = Preserved Garlic.

1. **DISCUSSION**

Micronutrients, such as polyphenol, vitamins and minerals elements and their plant sources have been proven to exhibit vast health benefits. While vitamins and minerals are essential for the activities of a wide range of enzymes, as well as metabolic activities, polyphenols amongst other phytochemicals exhibit a wide range of biochemical activities. Most notably, polyphenols (e.g. flavonoids) exhibit antioxidant effect; they scavenge free radicals from a biological system, douse chain reactions, prevent oxidative stress/damage and improve overall human health (Pandey and Rizvi, 2009; Ashadevir and Gotmare, 2015; Iqbal *et al*., 2023). Fruits and vegetables are a rich source of beneficial phytochemicals (Liu, 2013). They provide a wide range of nutritionally non-essential substances having immense nutraceutical, pharmacological and therapeutic benefits (Smith and Eyzaguirre, 2007; Lewu and Mavengahama, 2010; Septembre-Malaterre *et al*., 2018; Kumar *et al*., 2023).

Amongst vegetables, garlic and onion are very popular (Abiola *et al*., 2017). They are can be consumed either fresh (in salad) dried (as spices) or as flavours (as extracted essential oil) (Wiczkowski, 2011; Lawande, 2012; Tesfaye, 2021). These attributes own them the name multi-use vegetable and thus, their fame. Several studies have shown that both garlic and onion possessed several agents with numerous pharmacological characteristics (Ali *et al*., 2000; Kianian *et al*., 2021). Sabo and Haliru (2021) reported that raw garlic has proximate composition as follows: moisture content 63.4 ± 1.05%, ash 4.26 ± 0.20%, crude protein 14.0 ± 1.75%, crude fat 3.8 ± 0.37%, carbohydrate 32.3 ± 1.06% and crude fibre 9.0 ± 0.50%. Similarly, Sajid *et al*. (2014) reported a high moisture content of 64.58± 2.06% in garlic sample. Ash content was 2.46±0.09%, while crude protein, crude fat and crude fibre were 7.87±0.32%, 0.52±0.01%, 2.3±0.08% respectively. Similarly, fresh onions possessed high moisture (82.99 - 82.77 %), and carbohydrate composition (14.15 - 14.77 %) (Bhattacharjee *et al*., 2013). A moisture content of between 77.31±0.63 - 73.74±0.80% for fresh onion was reported by Dinkecha and Muniye (2017). The findings of the present study (for both fresh and preserved samples) align with the aforementioned reports, where high moisture content was observed in the samples. On the contrary, low moisture content of 4.55% and 5.52% respectively were reported by Yusuf *et al*. (2018), and Ali and Ibrahim (2019) for processed garlic. Higher carbohydrate (73.22%) and crude protein (15.33%), but lesser crude fat (0.72%), crude fibre (2.10%) and ash (4.08%) were reported for same sample by Yusuf *et al*. (2018). Similar trend was reported for the sample analyzed by Ali and Ibrahim (2019); crude protein (16.23%), crude fats (2.44%), crude fibre (3.96%), and ash content (5.85%). The high carbohydrate and low moisture contents of processed garlic and onion is due to dehydration and drying of such samples.

Varying levels of alkaloids, flavonoids, glycoside, saponin and tannins in garlic and onion have been reported by several researchers (Otunola *et al*., 2010; Lawal *et al*., 2018; Yusuf *et al*., 2018; Ali and Ibrahim, 2019). In the present study, all these phytochemicals were found in garlic and onion samples, except flavonoid and tannins which were not detected in garlic samples. Nevertheless, El Kadi *et al*. (2024) reported that while total tannin was not detected in yellow onion only, flavonoids/anthocyanins were not detected in all onion samples (red, yellow and purple). The variations the composition of phytochemicals may have arisen as a result of difference in variety and site of cultivation.

Vitamins have been reported to be an essential component of garlic and onion. Yahaya *et al*. (2010) reported that the vitamin A and C levels in onion bulbs respectively are 88.50±3.97 and 108.65±12.79 mg/100g dry weight. A vitamin C level ranging from 2.21-4.41g/100g was reported for different Ethiopian onion cultivars (Dinkecha and Muniye, 2017). Vitamin A, C and E were found in all studied samples of the present study. While 6 months of storage was observed to cause a significant decrease of vitamin E in both onion samples, slight variation occurred in garlic samples. Vitamin C concentration was seen not to have pronounced effect on vitamin C level. The storage regime resulted in an increase in vitamin A level in stored garlic. Conversely, a decreased vitamin A level was observed in preserved white onion, while a non-significant increase was observed in preserved red onion sample. Kiura *et al*. (2021) have demonstrated that two weeks of curing could increase vitamin C levels of onion bulb.

Chatepa *et al*. (2022) demonstrated that red onion had excellent total phenolic content and moderate reducing power. Dinkecha and Muniye (2017) reported that temperature/heat can alter the pungency of onion sample. El Kadi *et al*. (2024) observed that the ethanolic extract of red yellow and purple onion exhibited both DPPH and FRAP activities. In the present study, thiobarbituric acid (TBA) - a reflection of lipid peroxidation and quality of lipids in samples, was found to have increased in both preserved red onion and garlic samples. On the contrary, TBA decreased upon preservation of white onion. Preservation did not affect the DPPH radical scavenging activity of onion samples. However, preserved garlic exhibited stronger DPPH radical scavenging activity than the fresh sample. This is positively correlated with an increased level of vitamin A in in the preserved garlic sample. In garlic sample, preservation resulted in the decrease of FRAP and TPC. While fresh red onion had lower FRAP value that its preserved counterpart, preserved white onion had higher FRAP value than the fresh sample. The reverse of the aforementioned was observed for TPC. Pungent value was generally observed to decrease in preserved samples of the present study. Thus, storage resulted to decreased pyruvic acid level but may have enhanced flavour quality of these vegetables due to dehydration. Dinkecha and Muniye (2017) expressed pungency to be a value of pyruvic acid content and antibiotic sulphur compound present in onion. They found that pungency of Ethiopian onions ranges from high to medium, depending on the variety. Mallor *et al*. (2011) observed *Fuentes de Ebro* (a Spanish sweet onion variety) to have low pungency. Nevertheless, red onion used in the present study had an excellent pungency, while moderate pungency was seen in the white onion. In garlic, pyruvic acid ranged from 20.9 to 24.9 μmol/ml (Tripathi *et al*., 2021). The finding is closely related to the outcome of the present study in which fresh garlic had a pyruvic acid concentration of 26.719 ± 0.133 µmol/ml.

Reports have indicated that onion and garlic are excellent repository and nutritional sources of mineral elements. The composition of these elements varies with the portion of onion utilized. While K, Ca, Mn, Fe and Cu are found the onion bulb, Zn, Sr, Ti and Cr in addition to the aforementioned are found in the top-bottom. Except for Cr, all these elements are present in the outer scale of the onion (Bello *et al*., 2013). Likewise, P, Na and S have been reported to be present in onion samples (Bhattacharjee *et al*., 2013; Kiura *et al*., 2021; Tripathi *et al*., 2021). Similarly, garlic has been reported to contain Ca, K, Mg, Zn, P, Fe and Cu (Ali and Ibrahim, 2019). In addition to these elements, the presence of Mn, Na, S, and Cr have been reported in garlic samples (Otunola *et al*., 2010; Sajid *et al*., 2014; Devi and Brar, 2018; Sabo and Haliru, 2021). Ni, Pb and Cd are also reported to be found in garlic (Yahaya *et al*., 2010). In addition to some of the beneficial mineral elements earlier reported to be found in onion and garlic, the present study detected the presence of Selenium (Se) in all the samples studies. It is important to note that Se is an essential microelement (toxic at high doses) with wide array of biological function. It is described to play a vital role as antioxidant agent. It also possesses anti-inflammatory as well as antiviral properties (Wrobel *et al*., 2016; Genchi *et al*., 2023).

Essential and nonessential amino acid are listed to be among the nutritional agents present in onion and garlic. All the standard amino acid were detected in both onion and garlic samples of the present study. Similar to the present outcomes, Asp, Glu, Asn, Ser, Gln, His, Gly, Thr, Arg, Ala, Tyr, Met, Val, Trp, Phe, Ile, Leu and Lys are found in onion and garlic (Hansen, 2001; Lee and Harnly, 2005; Kwon *et al*., 2014; Okonkwo and Achilike, 2022); the most abundant amino acids are shown to be arginine and glutamine (Hansen, 2001). In line with the aforesaid, Glu was the most abundant amino acid in onion samples of the present study, followed by Arg and then Asp. In garlic, Glu was also the most abundant. Pro, Lys, Arg, Ser and Asp respectively were next in richness. Kwon *et al*. (2014) established that Arg and Asn accounted for more than 78% of total amino acids in both bulb and callus of Korean and foreign garlic samples. Glu, Lys, Asp, Val, Gly, and His accordingly followed suit. In general, Hansen (2001) demonstrated that long term storage affects the concentration of amino acids in onion sample; levels of Gln, Asn and Phe significantly increased, while Arg, Leu, Asp and Ly significantly decreased. In the present study, Glu, Asp and Arg of onion samples were reasonably increased upon storage. For garlic, the 6 months storage regime employed is seen to significantly decreased Glu levels. While Lys, Phe, Ser and Asp levels were raised, Iso, Val, Tyr, His, and Cys declined after storage of the garlic.

1. **CONCLUSION**

Onion and garlic are amongst the most widely used vegetable, either fresh as salad or dry as spices. Storage of fresh vegetable can have daunting effect on their nutritional quality. In the present study, it was demonstrated that 6 months of storage influenced proximate composition of both onion and garlic; while moisture and lipids tend to decrease, other parameters increased. Depending on variety, phytochemicals such as alkaloids, flavonoids and glycosides were also affected by storage. Storage did not affect the level of Vit A in red onion; it was decreased significantly in white onion and increased in stored garlic. Vitamin C and E significantly diminished following the storage of both vegetables. Antioxidant activities were also affected by storage. Pyruvate level was seen to mostly decrease after storage. Except for Ca, Mg and Na, mineral element composition tends to decrease with storage. A mixed influence of storage on amino acid levels was noted; Glu, Asp and Arg of onion samples increased but Glu levels decreased. In garlic, Lys, Phe, Ser and Asp levels were elevated while Iso, Val, Tyr, His, and Cys dropped.

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