

The influences of storage period and morphotypes on the proximate and selected vitamins of pumpkin (*Cucurbita pepo* L.) fruits

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Abstract

Pumpkin, a member of the Cucurbitaceae plant family is an underutilized crop in Nigeria. This plant requires minimal agronomic input to produce optimal yield and it is drought tolerant. However, due to preservation, the fruit does not remain biochemically the same. What happens to squash stored for months after harvesting at room temperature needs to be examined from nutritional point of view. Therefore, this study was performed to evaluate the effects of storage at ambient temperature and relative humidity on selected vitamins (A, C, and E), and the proximate (crude protein, crude fiber, crude ash, and carbohydrate) in the green and orange morphotypes of pumpkin fruit. Pumpkins harvested in 2015 were stored for 4 months (January to April) and nutritional parameters evaluated monthly using standard assays. The results showed that the vitamin A content did not change significantly ($P < 0.05$) over the storage period and morphotypes while the vitamin C and vitamin E contents decreased by 15% and 18%, respectively, when comparing the 1st and 4th months of storage. Crude protein and fat content decreased significantly over the storage period. However, crude fiber and ash increased in storage time. Except for crude fiber, the two morphotypes behaved similarly over the storage period. Remarkably, vitamin A concentrations in squash did not change after harvest, and some of the nutrients studied were not significantly affected during the first 4 months of storage. This information is especially important for people in rural areas limited in modern ways of storing fruit vegetable after harvest.

Keywords: gourd fruit; protein; pumpkin fruits; squash; room temperature; shelf life; vitamins

Introduction

Pumpkin (*Cucurbita pepo* Linn.), a complementary food mainly for low-income people in Nigeria, was found to contain high amounts of vitamins A, C, E, lycopene, and dietary fiber (Snowdon, 1991). Although cultivated on a sufficient scale in Nigeria, it is considered an underutilized crop with no commercial importance. However, there are no statistics related to the production, post-harvest handling and consumption of gourd fruit in Nigeria. Squash remains underutilized due to lack of recognition of its potential, market demand, and often small and irregular storage methods (Malik, 2010). Human demand for fruits and vegetables is increasing and can only be met by commercial imports of underutilized fruits and vegetables or by employing techniques to prevent post-harvest spoilage (Sornu, 2013). According to Padulosi (2003), there is an urgent need not only to recognize underutilized commodities, but also to use and explore these commodities to meet

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the needs of current and future generations. Squash is widely cultivated and consumed by rural people in Nigeria, where the ripe fruits serve as food security due to their long shelf life during the dry season (Oloyede, 2013). Unfortunately, a little-known potential trade item, pumpkin served as a staple food for vulnerable people in Nigeria during a tomato shortage when they are stored. Pumpkin fruit, in both immature and ripe stages, is widely used as a vegetable in Nigeria. The immature pumpkin fruit, called 'Kundu' in the Southwest, is steamed and eaten in combination with young pumpkin shoots called 'Gubolo'. Ripe fruits are eaten raw or dried and added to soups (Oloyede, 2012; Messiaen, 2014). The use of pumpkin pulp as a poultice to treat burns, inflammation, and tumors and as a cooling poultice to treat headaches and neuralgia has been documented. Pumpkin peel has antifungal effects and treats fungal infections in adults and infants (Park, 2010). Recent research on pumpkin has shown that it is a true source of antioxidants needed to boost the human body's immunity against deadly diseases such as cancer and coronary heart disease (Messiaen, 2014). (Ezin, 2021) reported that squash plays a significant role in protecting against Avitaminosis A, which affects about 250 million less than 5 years old children across the globe.

Controlled storage conditions are essential for the shelf life of fruits and vegetables. A very important aspect of post-harvest activities is maintaining the quality of the product so that it reaches the consumer in the best possible condition (George, 2009). Keeping fresh gourd fruit requires strict control of room temperature and humidity to minimize chemical and physicochemical changes. The high cost of developing and maintaining cold storage and controlled atmosphere warehouses are a pressing concern in several developing countries (Basediva, 2013). The nutritional content and flavor of fruits and vegetables are affected by ripeness, quality at harvest, and subsequent storage. Shelf life and nutrient retention are maximized if produce can be stored under appropriate conditions immediately after harvesting (Mackay, 1984). Yawalkar (1985) reported that under normal household conditions, well-ripened squash fruits can be stored for 2-4 months, thus meeting off-season vegetable demand.

In addition, its high carotenoid content and attractive orange flesh, which indicates a long post-harvest shelf life, may lead to its adoption as a minimally processed product in the fresh food market. This important horticultural crop is not grown commercially, but locals grow it on small farms and home gardens, store the ripe fruit in a kitchen corner or warehouse a large quantity in a small room and use in soup preparations. Due to its long shelf life, gourd fruit can be stored at room temperature for months. After harvesting, the product remains viable and continues its normal physiological activity. However, their chemical composition is expected to change. Therefore, this study provides answers to the following questions: how can traditional storage system affect the nutritional content of pumpkin fruit? How long can farmers preserve this fruit without affecting its chemical properties? What effect can ambient temperature and relative humidity (RH) have on stored pumpkin fruit? Harvested pumpkin fruits are traditionally preserved, but little or no information is available about possible changes in chemical composition. Although several studies have been conducted on the nutritional value and physicochemical properties of pumpkin, but little or no information on how temperature and relative humidity affects the orange and green morphotypes of pumpkin during storage during dry season. However, a review of the literature revealed little information about the effects of storage on chemical changes in *C. pepo* cultivars harvested in Nigeria. Therefore, the present study was conducted to elucidate the chemical properties during storage that provide better scope for improving utilization by aiding the selection of fruits with appropriate storage periods.

Materials and Methods

Field experiment

Field tests were conducted during the late growing season (August to November) in 2014 at the Osun State University (UNIOSUN) Teaching and Research Farm, Faculty of Agriculture, Ejigbo Campus, Nigeria. The experiment began with two pumpkin seeds planted 2 m × 2 m apart on May 17, then culled to 1 seedling

per stand after 2 weeks, yielding a population of 42 plants per plot and 2,500 plants per hectare, with a plot size of 10 m × 12 m, according to standard pumpkin cropping practices (Oloyede, 2012; 2014). Fully ripe fruits of the pumpkin cultivars were harvested until three to four months after sowing (depending on the variety). Seventy healthy fruits were selected and washed for post-harvest studies. This study employs a simple method of utilizing storage space to store gourd fruits. This is the most popular and cost-effective method of storing fruits and vegetables in rural Nigeria.

Raw material and sample preparation

The pumpkin fruit samples used were obtained from UNIOSUN College of Agriculture Teaching and Research Farm in Ejigbo Campus. The harvested matured fruits were harvested when they became hardened, skin is dull and dried. They are then stored in a shady, dry, and cool room protected from pests in one of the recently completed buildings on campus. Initial storage temperature was 26 °C and relative humidity of 75%. The plan was to select 36 squash fruits from orange and green cultivars, size them into 3 sizes of large (>3 kg), medium (2-2.9 kg), and small (1-1.9 kg) with uniform shape and color from orange and green varieties and make 6 replicates. Selected fruit surfaces were cleaned with soft tissue, stored at room temperature (25-31 °C, 75-90% relative humidity) for up to 180 days however, fruits were weighed every two weeks and fruit samples (two from each replicate) were taken every 4 weeks to determine nutritional value. Samples were prepared by washing the fruit and slicing it in half with a serrated knife. The interior was then scraped to remove seeds and filamentous material covering the interior surface. Pumpkin fruits were cut into pieces, peeled, and dried in an oven for nutrient content analysis.

Storage room management

The guidelines followed for storage were consistent with Cornell Cooperative Extension guidelines for fruits and vegetables. These guidelines are followed to maximize pumpkin fruit quality and minimize spoilage during storage. Pumpkins is harvested at maximum maturity to ensure that the fruits have no visible signs of disease. In addition, the harvested fruits are free from insect damage. Damaged fruit is at increased risk of mold and bacterial growth during storage. Fruits are handled carefully to avoid cutting or bruising, as this can lead to the spread of disease. The storage room was protected from direct sunlight to keep the pumpkin fruit from getting too hot. Pumpkin fruit is stored in a cool, dry, well-ventilated storage area. Humidity was monitored with a hygrometer while thermometer was used to monitor the temperature in this storage room. Data were recorded and calculated using a hygrometer chart to determine relative humidity. In the storage room, the fruits are placed on wooden pallets. Squash was placed on wooden piles to reduce disease transmission instead of placing on bare ground. Storage rooms are properly cleaned, pest protected and well ventilated. Also, the storage room was regularly checked to remove rotten fruit and the fruit selected for analysis.

Laboratory analysis

Proximate analysis

Samples were dried at 70 °C for 24 hours, ground and refrigerated prior to analysis. Crude protein, carbohydrate, ash, crude fiber, and ether extract (fat) were determined using routine chemical analysis methods (AOAC, 1995a; 1995b).

Analysis of vitamin A (beta-carotene)

The equipment used is a water bath, a spectrophotometer, a separatory funnel, and a beaker. The reagents are the alcohol KOH: (4 g in 50 ml alcohol, make up to 100 ml with alcohol), 2 g chloroform, and sodium tetraoxosulfate (Na₂SO₄). A two g sample was weighed into a beaker. 10 ml of distilled water was added and gently shaken to form a paste. 25 mL of alcoholic KOH solution was added and heated in a water bath for 1 hour with frequent shaking. The mixture is then rapidly cooled. 30 ml of water are then added. The mixture is then transferred to a separatory funnel. Three times 250 ml of chloroform were used for the extraction. 2 g

of anhydrous Na_2SO_4 was added to the extract, then the mixture was filtered into a 100 mL volumetric flask and water was added to the mark. Absorbance was read at 328 nm. 0.003 g (100 ppm) of β -carotene dissolved in 100 ml of chloroform was weighed as a standard. For the working standard, pipette 5 mL, 10 mL, 15 mL, 20 mL, and 25 mL of the 100-ppm stock solution into a 50 mL flask make the mark with chloroform. This includes 10, 20, 30, 40 and 50 ppm. The International Unit (IU) of vitamin A is the biological equivalent of 0.3 μg retinol or 0.6 μg beta-carotene.

$$\text{Vitamin A} \left(\mu \frac{\text{g}}{100\text{g}} \right) = \frac{\text{absorbance of sample}}{\text{weight of sample}} \times \text{DF}$$

Analysis of vitamin C (ascorbic acid)

The equipment used is a spectrophotometer and an Erlenmeyer flask. The reagents used were ascorbic acid (AA) and trichloroacetic acid (TCA): 27% (2 g in 98 ml distilled water). A 15 g portion of each ground pumpkin sample was weighed. 50 ml of 2% TCA solution was added, shaken on a mechanical shaker for 5 minutes, then centrifuged at 550 μpm for 5 minutes and then filtered. 1 ml of the filtrate was placed in a 50 ml flask, water was added to the mark and read at 270 nm. For broth (1000 ppm), weigh 0.1 g of ascorbic acid (AA) into a 100 mL flask. For intermediate solutions (50 ppm), pipette 5 mL of 1000 ppm into a 100 mL flask. For working standards from 50 ppm, dilute 0, 1, 2, 3, 4, 5 in 10 mL flasks to make 5 ppm, 10, 15, 20, 25 ppm with TCA was read at 270 nm.

Analysis of Vitamin E (alpha-tocopherol)

The reagent/kit consists of sodium dihydrogen phosphate (NaHPO_4) (0.84 g), ammonium molybdate 1.24 g, and H_2SO_4 8.15 ml which were dissolved in 250 mL of methanol. 1 g of solid sample was weighed, 10 mL of methanol in ethanol was added, and 0.4 mL of extract was pipetted into a 50 mL flask. 7.6 ml of reagent (color developer) was added, 0.4 ml of methanol/ethanol was also added, then incubated at 900 °C for 1 hour and read at 695 nm. For the standard curve, 0.1 g of vitamin E (tocopherol) was prepared in 100% pure methanol over ethanol (1000 ppm), working standards were also prepared from 20 ppm to 100 ppm and 0.4 ml standards were pipetted starting from 4 above.

Statistical analysis

The experiment was performed using completely randomized design (CRD) with 6 replications. Data were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980) using CoStat's statistical package (CoHort Software 2007). Results showing significant differences were subjected to mean separation using the LSD test at $P < 0.05$. The least significant difference (LSD) was used to compare the physical properties nutrient content, and seed germination rate of pumpkin fruits and seeds.

Results and Discussion

Change in storage conditions

The measured average temperature and relative humidity were 28.3 °C and 80.7% respectively (Table 1). The recommended storage temperature and relative humidity for squash was 12.2 °C and 70-75% for 84-160 days, respectively (Ozuna, 2017) (SeaLand, 1991). Another experiment (Saldanha, 1995) found that the optimum temperature and relative humidity are 10-13 °C and 60-70%, respectively, when storing pumpkins for 2-5 months. (Yo'lchiev, 2022) discovered squash needed to be stored at -18 °C for a prolonged shelf life. In this study, pumpkin fruits were stored at 23-32 °C and 38-96 % relative humidity (well above recommended storage conditions) throughout the storage period due to the prevalent weather condition in the area. During the first month of storage, gourd fruits was stored at a temperature of 23-29 °C and a relative humidity of 38 to 72% but when the temperature rose two months after harvesting and the three months after harvesting, the temperature was 30 to 32 °C, and the relative humidity was 85-89%. High temperatures (29-32 °C) and

relative humidity (85-96%) in the storage room can be a major cause of stringy pulp and rapid fruit deterioration that occurred on the gourd fruits. Rotting is the leading cause of pumpkin storage loss. Deterioration began when the bottom of the crust softened and then other parts softened and oozed out liquid, which quickly developed into a multicolored mold (Jeffrey, 2004).

Storage interactions with nutrients

Changes in crude protein content

The protein content results, evaluated in Table 2, were 12.67% for the first MAH and 11.54% for the second MAH, not significantly different ($p>0.05$). The first MAH result was higher when compared to the findings of (Adubofor, 2016) with crude protein of pumpkin fruit pulp of 2.58% and pumpkin-pineapple juice blends of 2.42%. The crude protein (CP) content of the samples gradually decreased with increasing storage time. The decrease in protein content during storage is due to hydrolysis of peptide bonds by protease enzymes, which can lead to cleavage of protein molecules. A similar decrease in protein content with increasing storage time was also reported for orange and tomato fruit, showing a 20% and 50% decrease in values for tomatoes and oranges, respectively (Idah, 2010; Ozuna, 2017). Table 3 shows that there is no significant difference in crude protein content between orange and green cultivars, suggesting that the two cultivars are excellent sources of dietary plant-based protein. CP contents observed in orange and green cultivars were 9.28% and 9.83%, respectively. These values compare favorably with CP values of yams (7.31-9.67%) (Behera, 2009) and *Zanthoxylum zanthoylides* (Hercules crab, nika) (8.74%) (Nnamani, 2009), suggesting that pumpkin may be another preferred vegetable protein source for marginal commodities in Nigeria. Due to its low cholesterol content, it is suitable for the diet of overweight and hypertensive patients. However, its high protein makes it serve as an excellent supplement to grains or as a substitute for meat in poor rural areas (Bhat, 2013; Matlhare, 1999).

Table 1. The average weekly temperature and relative humidity during storage

| Morning temperature (°C) | Evening temperature (°C) | Morning RH (%) | Evening RH (%) |
|--------------------------|--------------------------|----------------|----------------|
| 26.6 | 27.3 | 47.1 | 52.4 |
| 26 | 27 | 68.9 | 69.9 |
| 23.3 | 27 | 79.7 | 85.7 |
| 23.9 | 26.6 | 82.4 | 77 |
| 27.3 | 27.6 | 85.1 | 82.7 |
| 29.3 | 29.4 | 88 | 85.6 |
| 29.4 | 29 | 86.4 | 85.4 |
| 31 | 30.6 | 88.1 | 87 |
| 29.9 | 30.9 | 88.1 | 87.9 |
| 29.6 | 30 | 86.9 | 89 |
| 31 | 31 | 87.9 | 88.1 |
| 30.3 | 30.9 | 86.4 | 87.1 |
| 30 | 31 | 83.9 | 84.9 |
| 28.4 | 28.4 | 84.9 | 83.7 |
| 28.3 | 27.9 | 84 | 81.6 |
| 28.3 | 28.3 | 83.6 | 83.9 |
| 28.4 | 28.4 | 83.9 | 84.9 |
| 29.3 | 29.3 | 83 | 82 |
| 29.4 | 28.6 | 83.9 | 84.9 |
| 28 | 28.3 | 84.9 | 83.7 |
| 28.1 | 27.6 | 82.4 | 82.5 |
| 26.9 | 27 | 84.6 | 78.1 |
| 27.3 | 27.1 | 80.7 | 81.3 |
| 29.4 | 29.9 | 81.9 | 83.6 |
| 28.1 | 28.1 | 79.4 | 80.9 |
| 28.5 | 28 | 84.5 | 84.5 |

Changes in fat

The fat content of pumpkin fruit decreased significantly between the 1st and 4th MAH (Table 2). Fat content decreased continuously with increasing storage time. A decrease of approximately 0.5 percent was recorded for fat content between the 1st MAH (12.3%) and the 4th MAH (6.16%). A cutback in fat content could be due to the binding effect of fiber on fat (Ali, 2015). These results are consistent with those of (Sornu, 2013) who showed a six-fold increase in pumpkin from young to mature stages, but a final decrease as ripening progressed. In Table 3, there was a little difference in fat content between orange and green varieties. The fat content of the orange variety was 8.61% and that of the green variety was 8.41%, contradicting reports in (Antia, 2006) that a diet providing 1-2% of calories in the form of fat is considered sufficient for humans. Excessive fat intake is associated with certain cardiovascular diseases such as atherosclerosis, cancer, and aging. These values are by no means low in terms of nutritional value.

Change in crude fiber

Large differences in crude fiber content were found throughout the storage period due to the difference in cultivar and storage period. Crude fiber content in preserved squash increased gradually and significantly with increasing preservation time ($P < 0.05$). As shown in Table 2, the crude fiber content increased continuously from 2.36% to 11.82% from the 1st to the 4th MAH. Although, (AlJahani, 2017) had a value greater in crude fiber (20.65%) in *C. pepo* cake. The high fiber content is due to high levels of insoluble fibers such as cellulose, hemicellulose and lignin in the squash (Ptitchkina, 2011). In Table 3, the difference between orange and green cultivars was statistically significant. The green variety has a higher crude fiber content (8.97%) compared to the orange variety which has an ash content of 7.00%. Crude fiber is part of the diet that is not digested by humans, but normal functioning of the intestinal tract depends on the presence of sufficient dietary fiber. Stool volume increases and waste products spend less time in the digestive tract. Dietary fiber helps maintain human health and is known to lower cholesterol levels in the body (Bello, 2008). A low-fiber diet is also associated with heart disease, colon and rectal cancer, varicose veins, phlebitis, obesity, appendicitis, diabetes, and even constipation (Saldanha, 1995). Green varieties are therefore recommended as a source of crude fiber in the diet due to their relatively high crude fiber content.

Changes in ash content

In Table 2, the ash content evaluation results show a gradual increase with longer storage times. From the 1st MAH to the 4th MAH, ash content increased significantly from 5.82% to 12.73%. It shows a similar trend to crude fiber content increasing with longer storage times. However, other authors evaluated the change in quantity of crude ash of pumpkin with an increase in content of pumpkin after storage (Akwaowo, 2000) (Bressani, 2013; Jarienè, 2015). The result obtained by (Akwaowo, 2000) revealed ash content to be 6.45%. The ash percentage reflects the high mineral elements in pumpkin fruit (Nnamani, 2009; Omotosho, 2006). In Table 3, there was no significant difference in ash content between orange and green cultivars.

Changes in carbohydrate

The results showed a gradual decrease in carbohydrate content during storage. In Table 2, carbohydrate content decreased significantly from 72.59% in the 1st MAH to 59.17% in the 1st MAH. The decrease in carbohydrate was because of conversions of starch to sugar as storage increases (Philip, 1946). In Table 3, the results obtained for carbohydrate show that the two cultivars were high in carbohydrate content compared to the average carbohydrate content of tomatoes and orange fruits estimated at 23.49% and 12.23% respectively (Idah, 2010). It is revealed that it can be classified as a carbohydrate fruit. Starch is the most important storage carbohydrate during the early stage of development and is broken down as ripening begins. In the present study, the cumulative intensity of pumpkin fruit approximately doubled until early stages and then decreased towards maturity.

Table 2. The effect of storage period on the proximate composition of pumpkin evaluated % (dry weight basis)

| Storage period | Crude protein% | Fat % | Crude Fiber % | Ash % | Carbohydrate |
|----------------|--------------------|-------------------|--------------------|--------------------|--------------------|
| 1st MAH | 12.67 ^a | 12.3 ^a | 2.36 ^c | 5.82 ^c | 72.95 ^a |
| 2nd MAH | 11.54 ^a | 8.25 ^b | 6.42 ^b | 7.88 ^{bc} | 67.41 ^b |
| 3rd MAH | 8.03 ^b | 7.33 ^b | 11.33 ^a | 9.25 ^b | 60.60 ^c |
| 4th MAH | 6.0 ^b | 6.16 ^c | 11.82 ^a | 12.73 ^a | 59.17 ^c |
| LSD | 2.12 | 1.14 | 1.86 | 2.54 | 4.24 |

Table 3. Comparing the proximate content of the two cultivars of pumpkin

| Cultivar | Crude protein % | Fat % | Crude fibre % | Ash % | Carbohydrate % |
|----------|-------------------|-------------------|-------------------|-------------------|--------------------|
| Orange | 9.83 ^a | 8.61 ^a | 7.00 ^b | 8.43 ^a | 66.13 ^a |
| Green | 9.28 ^a | 8.41 ^a | 8.97 ^a | 9.41 ^a | 63.93 ^a |
| LSD | NS | 0.81 | 1.31 | 1.79 | 3.00 |

Changes in the antioxidant content (Vitamin A, C, and E)

Vitamin A (β-carotene)

The result in Table 4 reveals that there is no significant ($P>0.05$) difference in the β-carotene content of pumpkin fruit during the whole storage period. This result is inconsistent with a report from (38) that degradation of β-carotene occurred in gourd fruit stored under ambient conditions for 120 days, the decrease being attributed to increasing temperature and relative humidity (%). However, the findings of (Ali, 2015) shows that the values for β-carotene and vitamin C were higher in pumpkin juice. The biosynthesis and metabolism of carotenoids in vegetables can be significantly influenced by differences in growing environment such as temperature, nutrient availability, soil, sunlight intensity, stage of maturity and post-harvest (Saldanha, 1995) (Cazzonelli, 2010). As a result, it was found that temperature and relative humidity did not affect β-carotene degradation of squash during storage. Table 5 shows that there is no significant difference in the orange and green cultivars. This suggests that further research is needed to determine the storage system and duration for an optimal and satisfactory supply of beta-carotene to *C. pepo* fruits.

Table 4. Effect of storage period on the vitamins a, c and e content of the two cultivars of pumpkin

| Storage period | Vitamin A (β-carotene) I. U | Vitamin C (mg/100 g) | Vitamin E (mg/100 g) |
|----------------|-----------------------------|----------------------|----------------------|
| 1st MAH | 2664 ^a | 11.63 ^a | 1.82 ^a |
| 2nd MAH | 2667.4 ^a | 12.08 ^a | 1.30 ^b |
| 3rd MAH | 2561.4 ^a | 9.94 ^b | 1.32 ^b |
| 4th MAH | 2605.7 ^a | 9.59 ^b | 1.10 ^b |
| LSD | NS | 2.03 | 0.31 |

NS – Not significant at $P<0.05$

Table 5. Effect of cultivar on the vitamins A, C and E content of the two cultivars of pumpkin

| Cultivar | Vitamin A (β-carotene) I.U | Vitamin C (mg/100 g) | Vitamin E (mg/100 g) |
|----------|----------------------------|----------------------|----------------------|
| Orange | 2594.0 ^a | 10.99 ^a | 1.37 ^a |
| Green | 2663.8 ^a | 10.72 ^a | 1.36 ^a |
| LSD | NS | NS | NS |

LSD - Least significant difference at $P < 0.05$

NS - Not Significant

Vitamin C (ascorbic acid)

Result shows that ascorbic acid content decreased continuously and significantly with increasing storage time. The value of vitamin C decreased gradually over the storage period, reaching a minimum value (9.59 mg/100 g) at the end of the storage period. This was in accordance with the findings of (Muzzaffar, 2016) that vitamin C content was only retained for two months of storage period. Also, (Rakcejeva, 2011) experienced a double decrease in values of ascorbic acid during pumpkin drying process. The gradual decline in ascorbic acid levels may be due to peaks in temperature and humidity within the storage room. (Maiti, 2006) reported a rapid decrease in ascorbic acid content with increasing storage temperature. This reduction is indicative of oxidative deterioration, thus exposing the fruit to uncontrolled decomposition and oxidation processes. This has nutritional implications as most of the complex nutrients are broken down. There is no significant difference in ascorbic acid content between orange and green varieties over the storage period (Table 4). Pumpkin is a valuable source of ascorbic acid, which plays an important role in nutrition in the form of vitamin C (Pandey, 2003).

Vitamin E (α -tocopherol)

Longer storage times significantly reduce the vitamin E content. As shown in Table 4, it decreased from 1.82 mg/100 g in the first MAH to 1.30 mg/100 g in the second MAH and became less stable at the end of the storage period. As shown in Table 5, there was no significant difference in vitamin E between the two pumpkin fruit cultivars. Long shelf life is an indicator of antioxidants. Vitamins E and C are antioxidants that can fight free radicals and protect brain cells (Ravindra, 2004). Ascorbic acid (vitamin C) and alpha-tocopherol (vitamin E) act as potent and perhaps most important hydrophilic and lipophilic antioxidants, respectively. They work individually in each location and have a synergistic effect. Beta-carotene (vitamin A) is less reactive to free radicals than alpha-tocopherol and acts as a weak antioxidant in solution. It is more lipophilic than α -tocopherol and is thought to reside inside membranes or lipoproteins and can scavenge free radicals in lipophilic compartments more efficiently than α -tocopherol. A cooperative interaction should be highly probable and an interaction between vitamin C and β -carotene is unlikely, but an interaction between vitamin E and β -carotene is possible (Niki, 1995).

Conclusions

Important information was obtained on the nutritional characteristics of two squash cultivars stored under traditional storage system. *Cucurbita pepo* featured higher content of crude fiber and crude ash but experienced a decrease in other nutrient content after four months of storage. However, differences in the level of nutrient content were insignificant amongst the green and orange cultivars. This study serves as a guide to what nutritional and vitamin values you can expect from preserved pumpkin fruit without artificial cooling in hot climatic conditions. Storing squash requires low humidity and relatively dry conditions, as high humidity accelerates spoilage. Precooling methods for storage must be introduced to conserve nutrients of squash in tropical climatic conditions. Additionally, the nutrients in pumpkin fruit are safe at temperatures below 20 °C and relative humidity below 70%. Further research is required to optimize storage condition and to know the effects of long storage periods on pumpkin quality parameters such as antioxidants, bioactive compounds and medicinal properties. It is strongly encouraged to explore the potential of this fruit as a crop that can meet the challenges of climate change. It is recommended that the productivity of squash be improved and prevent post-harvest loss by adopting modern storage systems (curing, precooling and quick-freezing) to retain its nutritional value.

Authors' Contributions

Both authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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