Effect of Drying and Storage Methods on Vitamin C in Specific Fruits and Vegetables

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Abstract

This study investigated the effects of drying and storage on vitamin C content in nine samples of fresh fruits and vegetables. The vitamin C content in fresh samples, estimated by spectrophotometry, ranged from 1.6 mg/100 g in red apples to 76.6 mg/100 g in sweet peppers. During increased vitamin C content, dried sweet pepper has the highest value, 238.2 mg/100 g ,and dried spearmint has the lowest value, 3.8 mg/100 g. In the first week, the vitamin C content for oranges, apples, kiwis, sweet peppers, hot peppers, cab-bage, dill, parsley, and spearmint was measured respectively at 28, 8.8, 21, 181, 72.8, 17.6, 13.2, 38, 2 ,and 2. After four weeks, these values decreased to 12, 3.4, 11, 23, 8, 1, 3, 12.8, and 1 mg/100g dry sample. The highest vitamin C concentrations were observed in spearmint, dill, orange, and apple, with values reaching 322, 320, 315, and 309 mg/kg. Conversely, the lowest concentrations were detected in sweet peppers and parsley, amounting to 262 and 280 mg/kg. Furthermore, it was noted that vitamin C levels declined across all samples examined after a storage period of four weeks, with measurements of 215, 218, 220, 125, 182, 195, 213, 185, and 214 mg/kg. The highest rehydration ratio percentage was observed in dried cabbage, reaching 8.41, while the lowest was noted in oranges, amounting to 2.32. During the storage period, the rehydration ratio increased for samples of parsley, bell pepper, apple, orange, kiwi, and dill, from 3.32, 6.40, 3.35, 3.32, 3.00, to 2.96. In the initial period, it rose to 3.98, 6.74, 4.45, 4.57, 3.30, and 3.00 after four weeks of storage. The rehydration ratios for spearmint, hot pepper, and dried cabbage samples decreased after the four-weeks.

Ascorbic acid, Rehydration, Spectrophotometer, Titration, **keywords:** Dried fruits and vegetables, Vitamin C.

Introduction

Vitamins are organic compounds required in small quantities to build the body and main-tain overall functionality. However, excessive intake, particularly of fat-soluble vitamins (A, E, D, K), may cause toxic conditions and adverse health effects. Their deficiency also goes beyond the required limit, leading to the emergence of various diseases. Vitamin C, also known as ascorbic acid, is an organic compound that dissolves in water. It is a white and odorless crystal with a mild acidic taste. The compound has a molecular weight of 176.12 g/mol with chemical formula $C_6H_8O_6$ and exhibits a specific polarized light rota-tion at +24 degrees at a temperature of 20°C. The acidity of vitamin C is attributable to the presence of the Endiol group between carbon atoms 2 and 3, which behave acidically. Unlike

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substances with a carboxyl group (COOH), vitamin C does not contain this group and is not synthesized in the human body due to the absence of the enzyme L-glucono oxidase [1];[2];[3]. Vitamin C plays a key role in enhancing the absorbance of iron in the body and can be obtained through food sources or nutritional supplements. The source of the biological activity of vitamin C is in the form of two compounds: L-ascorbic acid and Dhydroascorbic acid. forms of vitamin C are considered as food additives, including L-ascorbic acid E300, E301, E302, E304, and others. Vitamin C offers a wide range of health benefits. It strengthens the immune system, helping to protect against various infections and viruses, and is effective in treating influenza and colds because of its role in producing collagen. It also helps reduce the appearance of signs of aging on the skin. Additionally, vitamin C reduces nasal and mouth congestion, aids in healing sunburn, and helps prevent heart at-tacks and atherosclerosis. It supports blood pressure regulation and promotes the produc-tion of good cholesterol in the body. Further, it boosts energy and vitality by facilitating dopamine production, promotes healthy growth in children, aids in weight management by breaking down excess fat, and reduces hair loss and breakage. It protects the body from oxidative stress and contributes to enzymatic reactions, including collagen synthesis reactions. One of the symptoms of vitamin C deficiency is scurvy. [4];[5];[6]. Vit-amin C plays a role in oxidation and reduction reactions within the body. It is oxidized to L-dehydroascorbic acid, which facilitates iron absorption in the gastrointestinal tract. Fur-thermore, it has a role in electron transport, contributes to wound healing, and aids in the synthesis of collagen. Vitamin C is also essential for forming and maintaining of intercel-lular materials that connect bone cells, teeth, and blood vessel walls. The recommended daily doses of ascorbic acid differ according to the age stage of the person. Adults require 60 mg for men and 50 mg for women. In addition, children typically need 40 mg, and infants need 35 mg. It is important to avoid excessive doses of vitamin C since this can lead to side effects such as diarrhea, feeling nauseous, and stomach cramps [7] ; [8]. The drying process can influence the vitamin content of fruits and vegetables. Some vitamins, such as carotene and ascorbic acid, are lost during drying, with the extent of the loss depending on the factors like the preparation of the raw material, the drying method used, and the storage conditions of dried produce. However, pre-boiling vegetables before drying can help reduce the vitamin loss rate [9]. Many treatments are applied to fruits and vegetables before drying to inhibit the activity of the polyphenol oxidase enzyme and prevent color changes, including treatment with citric acid, sulfation, and boiling. For instance, treating apple slices with a 10 g/L citric acid solution for 10 minutes effectively stops enzymatic browning by inhibiting the responsible enzyme. These treated dried fruits are incorporated into therapeutic baby food mixtures to boost their nutritional value [10]; [11]; [12]. The drying method and chemical treatments affect the rehydration ratio. Carrot samples dried in a mechanical dryer and treated with 1% potassium metabisulphite (KMS) achieved the highest rehydration ratio of 3.70. This was closely followed by samples dried in a solar dryer and treated with 0.2% KMS, which attained a rehydration ratio of 3.65 [13]. You may make dried fruits by taking out most of the water while keeping as much of their nutritional value and flavor as feasible. This technique makes them more energy-dense and lets them be stored for longer than fresh fruits, so you always have healthy snacks on hand [14]. One of the oldest and best ways to keep fruits fresh for a long time is to dry them. Sunlight and oven drying have been the most common ways to do this in the past [15]; [23]. Osmotic pressure, lyophilization, vacuum drying, steam drying, spray drying, vacuum-microwave drying, and convection-microwave drying are some of the most efficient new ways to dry things [17]; [18]. These innovative techniques provide great performance and higher quality dried goods [19]; [20]. Solar dryers may help you get the most of solar energy ([21]. Adding dried fruits to your diet is an excellent approach to make it more nutritious since they include a lot of healthful nutrients. Dried fruits are a great source of dietary fiber, which helps with digestion, controls blood sugar levels, lowers cholesterol and weight, and has antioxidants [22]; [14]. Research indicates that the antioxidant concentrations in dried fruits are comparable to those in fresh fruits, providing substantial defense against free radicals associated with several illnesses, including cancer and cardiovascular conditions [23]; [24]. Dried fruits are also full of important vitamins and minerals, such vitamins A, K, E, choline, and folic acid. They also provide you important minerals like calcium, iron, magnesium, potassium, and phosphorus, which are good for your health and well-being. Dried fruits and vegetables are easy to transport, light, and stable when stored. They occupy minimal space, have an extended shelf life, and can be stored using different places and methods [25]. However, they are sensitive to heat and oxygen during the drying and storage processes [17]. Recent studies focus on developing advanced drying methods, including ultrasound, infrared, and electrohydrodynamic techniques, to achieve more efficient, shorter, and energy-saving drying processes with enhanced control over the quality of the final product [26]. Three methods are used to estimate vitamin C content: the descriptive spectrophotometer method, the quantitative analysis involving denaturation under aqueous acidic conditions, and the (HPLC-UV) method at a wavelength of 265 nm [27]; [28]. Many spectrophotometer methods over recent decades have been developed for the determination of the vitamin C content in fruits and juices. One of the modern methods is the high-performance chromatography (HPLC) method. It is fast, accurate, time-saving, and low-cost. Therefore, the research aims to know the effect of drying and storage on vitamin C content in foods, measured using two analytical and spectrophotometric methods, and to know its ability to be absorbed as one of the critical qualitative criteria for dried foods..

Material and Methods

The study used selected fruits and vegetables from the local markets of Basrah , including kiwi, apples, oranges, cabbage, sweet and hot peppers, dill, spearmint, and parsley. Only fresh, fully ripe and intact samples were chosen to ensure the reliability of the results.

Preparing fruits and vegetables:

The samples underwent thorough washing with water, were sliced into pieces, and allowed to dry naturally at room temperature, stirring consistently until fully dried. They were then placed in glass containers and stored at room temperature for four weeks.

Estimation of Rehydration Ratio:

The rehydration ratio of the dried samples was measured during the storage period using the method described by [29] as a reference in [30]. A 2 g sample was placed in a glass container, to which 150 ml of distilled water was added. The container was covered and heated for boiling for 3 minutes. Afterward, it was allowed to cool for 10 minutes before being filtered under

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pressure for 5 minutes. The samples were then weighed, and the rehydration ratio was calculated using the following equation:

$$Rehydration\ Ratio = \frac{Wr}{Wd}$$

Where: Wr represents weight sample(g) after rehydration. Wd is weight sample (g) before rehydration.

Estimation of Vitamin C (ascorbic acid) in two ways

Estimation of vitamin C by spectrophotometer method

Ascorbic acid reduces the blue dye used in staining - di chloro phenol indo phenol 2,6- From blue to colorless, the appearance of pink indicates the end of the reaction. Prepare the acidic mixture from 15g of HPO3 metaphosphoric acid or oxalic acid, add 40ml of CH_3COOH acetic acid to it, and fill the volume to 500ml with distilled water. Prepare a solution of the dye 2,6-dichlorophenolindophenol by dissolving 5 mg of the dye in 250 ml of water. Preparing a standard vitamin C solution: Prepare by dissolving 10 mg of vitamin C [standard ascorbic acid] in 250 ml of the previously prepared acidic mixture. Estimating the strength of the dye: Take 1 ml of standard vitamin C and swish it with the dye until the pink color appears. Usually, the strength of the dye is 0.1 [31].

$$Dyestrength = \frac{VolumeStandardVitaminCUsed(ml)}{Thevolumeofdyeused \in thetreatment}$$

Preparing the sample: Weigh 5 grams of the sample before and after drying, place it in a blender, add 20 ml of the acid mixture, and mash it for 1-2 minutes.The process of burette: Sweep the leachate solution with the dye until a light pink color appears, which lasts for 15 seconds. The burette is read to determine how much dye has been consumed to neutralize the filtrate solution according to the following equation:

$$W = TheReadingofburette \times (0.1)Dyestrength \times \frac{100}{Sizeorweight}$$

W: Number of milligrams of ascorbic acid (Vit.c) in 100g of sample

Burette reading: The number of cubic centimeters of dye needed for neutralization.

Estimation of vitamin C using a spectrophotometer

The concentration of vitamin C was measured using the spectrophotometer method described by [14]. the procedure involved taking 100 mg of the sample and placing it in 1% HPO3 meta-phosphoric acid, and then 10 ml of acid was added and left at room temperature for 45 minutes. Afterward, 1 ml of the filtered mixture (No.9 filter paper) was combined with 9 ml of the 2,6-dichlorophenolindophenol dye. The absorbance was measured at a wavelength of 515 nm within 30 minutes of preparation. Standard vitamin C concentrations of 50, 100, 200, 300, and 400 mg/ml were prepared, and the vitamin C concentrations were calculated according to the equation

$$Y = 3.2453X – 0.0703,\ r2 = 0.9440.$$

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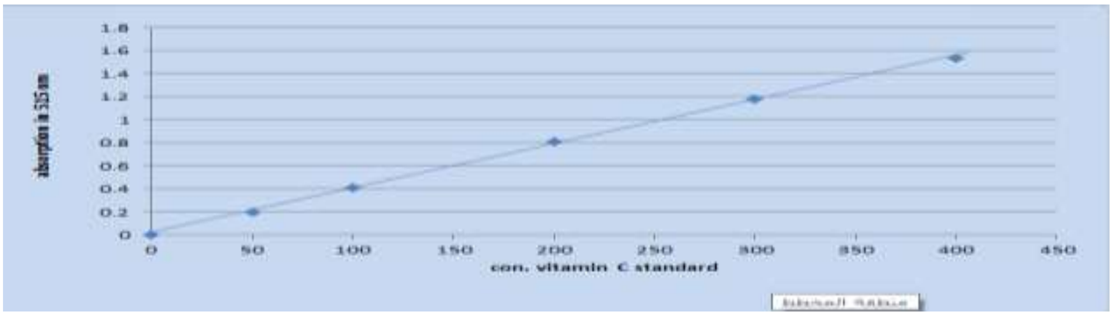

Figure 1: Standard curve for prepared standard vitamin C concentrations

Statistical analysis:

The statistical analysis of the data was conducted based on the Complete Randomized Design (CRD) and based on a one-factor experiment. The data were analyzed using the ready statistical program. The factors under study were tested using the Least Significant Difference (L.S.D.) test at the probability level of P < 0.05.

Results and discussion

The results in Table 1 highlight the vitamin C (ascorbic acid) content in the studied fresh fruits and vegetables. No significant differences were observed between the vitamin C values in fresh hot and sweet pepper samples using titration. Sweet peppers had the most vitamin C of all the veggies, with 76.6 mg/100 g. Hot peppers came in second with 75 mg/100 g. Oranges had the most vitamin C of all the fruits, at 32 mg/100 g. Dill has 21 mg of vitamin C per 100 g of leafy green. Red apples and spearmint had the least vitamin C, with amounts of 1.6 mg/100 g and 3.2 mg/100 g, respectively. [12] found that leafy vegetables had 90.53 µg/ml of vitamin C, oranges had 49.42 µg/ml, and apples had 9.55 µg/ml. These numbers were lower than those. The vitamin C levels in pepper, on the other hand, were lower than in their research, at 50.27 µg/ml. This difference is due to the different ways of measuring vitamin C, which was done by measuring it in both L-ascorbic acid and dehydroascorbic acid forms to get a total vitamin C value. This evaluation was performed using both spectrofluorometric and spectrophotometric analytical methods. [32] investigated the vitamin C content in fresh fruits and vegetables by analytical methods, revealing 2.2 mg/100 g in red apples, 12.2 and 42.7 mg/100 g in oranges, and 25.3 mg/100 g in cabbage. They said that the method's accuracy depended on oxidation and reduction processes. Food may have things in it that reduce the dye, such phenols, sulfates, and ions like iron and copper. This can make it harder to analyze the food. [33] found that oranges had 35.72 mg of vitamin C per 100g and cabbage had 17.42 mg of vitamin C per 100g. These findings were quite similar to those. However, there were differences for kiwi and red pepper, which had 33.71 mg/100 g and 14.84 mg/100 g of vitamin C, respectively. [34] highlight the disparity in vitamin C measurements between the spectrophotometric and photometric techniques. The spectrophotometric approach gave greater readings because it measures both L-ascorbic acid and L-dehydro ascorbic acid. The photometric method only measures L-ascorbic acid. The variation in vitamin C levels was also ascribed to variables such

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as elevated temperature, storage conditions, and length, which significantly influence vitamin stability. Prolonged storage and exposure to high temperatures diminish vitamin C levels, perhaps leading to discrepancies in findings from other studies, such as [12]. The findings demonstrated that the drying procedure substantially influenced the vitamin C levels in the examined dried fruits and vegetables. It was noted that the vitamin C levels rose in all samples after the drying process (zero duration). This effect may be due to the samples losing moisture, which caused the remaining parts of the meal, including vitamin C, to become more concentrated [9]. This outcome is regarded as favorable, resulting in an enhancement of the nutritional value of dried foodstuffs, as dried fruits in Bulgaria are recognized as a significant source of dietary fiber and essential nutrients, which are crucial for the health and nutrition of the Bulgarian populace, particularly during the winter months [22]. The results are different from what [15] found, which said that the percentage of vitamin C in oven-dried tomatoes dropped at 40°C, measuring 199.42 mg/100 g of dry matter, compared to fresh tomatoes, which had 194.42 mg/100 g of dry weight. Dried sweet peppers had the most vitamin C, at 238.2 mg/100g, which is a lot more than the fresh sample. This is followed by dried hot peppers at 114.8 mg/100g, and subsequently by spearmint, kiwi, and oranges with respective concentrations of 74 mg/100g, 51.6 mg/100g, and 41.4 mg/100g. Conversely, apples and spearmint exhibit the lowest vitamin concentrations post-drying, with values of 3.8 mg/100g and 4.4 mg/100g, respectively. The variance observed in the results obtained compared to the research can be attributed to the variation in the drying methods employed, as the drying technique significantly influences the vitamin C content in food products. It has been determined that the utilization of a solar dryer is more effective than natural solar drying, which, in turn, surpasses the effectiveness of a mechanical oven dryer [35].

Table 1: shows the levels of ascorbic acid (mg/100 g) in fresh and dried fruits and vegetables after being stored at laboratory temperature for four weeks.

samples	The scientific name	The amount of vitamin C in fresh samples mg/100g	The amount of vitamin C in samples after drying mg/100g				
			Aperiod Zero From Storage	After 1 week From storage	After 2 week From storage	After 3 week From Storage	After 4 week From Storage
Apple	*Malusdomestica*	1.6^{h}	4.4^{b}	8.8^{a}	8^{a}	5.2^{b}	3.4^{b}
Orang	*Citrus sp.*	32^{b}	41.4^{a}	28^{b}	27^{b}	20.6^{c}	12^{d}
Kiwi	*Actinidiadeliciosa*	10.6^{e}	51.6^{a}	21^{b}	21.4^{b}	12.6^{c}	11^{c}
Cabbage	*Barassicaoleracea*	13.4^{d}	22^{a}	17.6^{b}	14^{c}	2^{d}	1^{d}

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Pepper sweet	*Capsicum annum*	76.6[a]	238.2[a]	181[b]	170[c]	26[d]	23[e]
Hot pepper	*Capsicum*	75[a]	114.8[a]	72.8[b]	72.4[b]	15[c]	8[d]
Dill	*Anethumgraveolens*	4.6[f]	11.6[b]	13.2[a]	7.4[c]	5.8[d]	3[e]
Parsley	*Petroslinumcrispum*	21[c]	74[a]	38[b]	30[c]	13[d]	12.8[d]
Spearmint	*Menthaspicata*	3.2[g]	3.8[a]	2[b]	1.2[b]	1[b]	1[b]

*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($p<0.05$). LSD for comparison of fresh fruits and vegetables means (before drying) = 1. LSD for comparison of interaction of dried fruits and vegetables storage time = 1.1332

According to the research conducted by [16], lyophilized fruits and vegetables exhibit higher concentrations of vitamin C compared to those dried through solar methods. Their findings revealed a significant reduction in vitamin C levels in dried fruits and vegetables correlated with prolonged storage durations, reaching its peak reduction at four weeks under room temperature conditions. Through the titration method, it was observed that no substantial differences existed in the vitamin C content between storage periods 1 and 2 for samples of apple, orange, kiwi, spearmint, and hot pepper. Furthermore, there were no considerable differences noted in the vitamin C levels during storage periods 3 and 4 for samples of apple, kiwi, cabbage, spearmint, and parsley. The vitamin C content diminished after the initial week of storage in oranges, apples, and kiwis to 28, 8.8, and 21 mg/100 grams of dry fruit, respectively. The levels also went down in cabbage, sweet pepper, and spicy pepper, reaching 17.6, 181, and 72.8 mg/100 g of dry sample, respectively. In leafy plants including dill, parsley, and spearmint, the levels of vitamin C also went down to 13.2, 38, and 2 mg/100 g of dry samples, respectively. During the third week of storage, there was a big and sudden drop in the amount of vitamin C, especially in sweet peppers, spicy peppers, parsley, and cabbage, which had 26, 15, 13, and 2 mg/100g of dry sample, respectively. The vitamin C levels in oranges, apples, kiwi, sweet peppers, spicy peppers, cabbage, dill, parsley, and spearmint similarly went down after four weeks of storage. The amounts were 12, 3.4, 11, 23, 8, 1, 3, 12.8, and 1 mg/100g of dry sample, respectively. The findings align with those of [7], who reported a decrease in the vitamin C levels of fresh fruit juices, such as tiny apples, oranges, red melons, and tomatoes, while held at room temperature for seven days. The vitamin C levels specifically dropped to 42.18, 31.50, 21.63, and 15.63 mg/100 ml, respectively, from their original levels of 49.38, 39.75, 27.50, and 19.13 mg/100 ml. The way the food is stored affects how much it loses nutrients, including vitamins. The loss of nutrients in dried fruits and vegetables during storage depends on things like the temperature, pH, oxygen levels, light exposure, and the presence of organic acids. [17]. Numerous studies indicated that certain pre-drying processes

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could help retain vitamins. A study evaluated boiled dried cabbage (Brassica oleracea L. var. acephala) after 12 months of storage at room temperature (18-20°C) and in colder conditions (8-10°C). The findings showed that boiling prior to drying reduced vitamin levels by 8-45% while allowing for their preservation over the 12-month storage period. The vitamin losses for B1, B2, and total tocopherol in dried pre-boiled materials were between 3 to 10%, 1 to 4%, and 1 to 16%, respectively. In contrast, non-boiled dried products experienced higher losses, ranging from 10-17%, 8-16%, and 4-17%, respectively. Utilizing freeze-drying and cold storage enhances vitamin preservation [36]. The results presented in Table 2 indicate no significant differences in the rehydration ratios of kiwi, cabbage, and sweet pepper samples during the storage periods. In contrast, significant differences were noted in the rehydration ratios of the spearmint samples. It was also observed that there were no significant differences in the absorption of orange and parsley samples between storage periods (2, 3 and 4 weekes), as well as for parsley between 0 and 1 day. Similarly, apple samples showed no significant differences between periods 1,2, and 3, while dill samples exhibited no significant differences between 1 and 3 and periods 0 and 4 days. For hot pepper samples, no significant differences were observed across storage periods 0, 1, and 2, as well as between periods 3 and 4. The highest rehydration ratio among dried fruits and vegetables was observed in dried cabbage, reaching 8.41mgL/100ml, while the oranges had the lowest rehydration ratio at 2.32. [37] stated that vegetables dried in a shorter timeframe achieved an excellent rehydration ratio. For example, parsley dried for 65-80 minutes reached a rehydration ratio of 7.2mg/100ml after 5 minutes, while celery dried for 90 minutes reached a rehydration ratio of 5 after 10 minutes. Furthermore, dried vegetables with a moisture content of 6-10% were found to yield a high rehydration ratio quality. [29] found that the optimal rehydration ratio for wild asparagus (*Asparagus maritimus*) was by using different hot air drying methods at temperatures of 40, 50, 60, and 70°C, as well as natural drying and freeze-drying at-20°C and - 40°C) is freeze-drying - 40 °C, and that the naturally dried samples had the lowest rehydration ratio compared to the rest of the samples. The difference in the rehydration ratio for dried fruits and vegetables can be attributed to the chemical changes in their texture, including cellulose crystallization, starch gelatinization, and pectin degradation. Additionally, the drying method and drying conditions affect the texture of the dried products [17]. Table 2 shows that the rehydration ratio for most samples increased during the four-week storage period at laboratory temperature. Specifically, parsley, bell pepper, apple, orange, kiwi, and dill reached ratios of (3.32, 6.40, 3.35, 2.32, 3.0, 2.96), respectively, at the start of storage. After four weeks, these ratios increased to (3.98, 6.74, 4.45, 4.57, 3.3, 3.0), respectively. This is due to the higher rehydration ratio of water absorbed by the samples during rehydration imbibition, which results in an increase in the rehydration ratio. The results aligned with [38]. The researchers noticed an increase in rehydration ratio over one month of storage at laboratory temperature for carrot and onion slices dried at 50°C and 60°C, particularly those impregnated for 30 and 60 minutes. In contrast, the samples dried at 70°C and 80°C exhibited a decline in rehydration ratio due to rapid drying of the outer surface while the bound water remained trapped inside. Meanwhile, the rehydration ratio of dried spearmint samples decreased with the storage period continuing, reaching values of 7.26, 6.71, 6, 5.28, and 4.99 after 0, 1, 2, 3, and 4 weeks of storage at laboratory temperature. [39] indicated that the rehydration ratio of dried spearmint leaves increases with high temperatures and decreases as the temperature lowers. Their study examined the effect of drying conditions, including a one-minute boiling treatment followed by drying in a desiccator at 45, 55, and 65 °C. They observed that the samples not subjected to boiling had the highest rehydration ratio. These results were consistent with those of [40], who reported a decline in the rehydration ratio of dried spiny gourd slices stored for 180 days after being dried in a mechanical dryer at 60°C. The highest rehydration ratio was observed in samples preserved in aluminium foil, decreasing from 3.50 on the first day to 2.60 after 180 days. This reduction was attributed to the absorption of moisture from the air by the dried samples. The results showed fluctuations in the rehydration ratio of dried hot peppers and cabbage samples during the storage period. Initially, the rehydration ratios were 6.79 and 8.41, respectively. After the first week of storage, these values slightly decreased to 6.64 and 8.06, and by the fourth week, they reached 6.20 and 8.26, respectively. This variation may be attributed to temperature changes, as the rehydration ratio tends to decrease at lower temperatures and increase at higher temperatures [39]. The results in figure 1 indicated that the vitamin C content estimated by the spectrophotometer method in samples of fresh fruits and vegetables, namely orange, apple, kiwi, sweet pepper, hot pepper, cabbage, dill, parsley, and spearmint, reached values of 250, 259, 253, 239, 243, 246, 244, 242, and 241 mg/kg, respectively. It was noted that there were no significant differences in the vitamin C content among fresh hot pepper, dill, parsley, and spearmint samples according to the spectrophotometer method.

Table 2: Shows the rate of rehydration ratio of dried fruits and vegetables stored for four weeks at laboratory temperature

Samples	The scientific name	Rehydration Ratio after drying and storage				
		Aperiod Zero From Storage	After 1 week	After 2 week	After 3 week	After 4 week
Apple	*Malusdomestica*	3.35^{c}	5.25^{a}	4.96^{a}	4.48^{a}	4.45^{b}
Orang	*Citrus sp.*	2.32^{c}	3.05^{b}	4.11^{a}	4.33^{a}	4.57^{a}
Kiwi	*Actinidiadeliciosa*	3^{a}	3.11^{a}	3.64^{a}	2.85^{a}	3.3^{a}
Cabbage	*Barassicaoleracea*	8.41^{a}	8.06^{a}	8.65^{a}	7.76^{a}	8.26^{a}
Pepper sweet	*Capsicum annum*	6.40^{a}	6.48^{a}	6.03^{a}	5.7^{a}	6.74^{a}

Hot pepper	*Capsicum*	6.79[a]	6.64[a]	6.79[a]	5.84[b]	6.20[b]
Dill	*Anethumgraveolens*	2.96[c]	3.51[b]	4.66[a]	3.48[b]	3[c]
Parsley	*Petroslinumcrispum*	3.32[b]	3.25[b]	4.6[a]	4.28[a]	3.98[a]
Spearmint	*Menthaspicata*	7.26[a]	6.71[b]	6[c]	5.28[d]	4.99[e]
*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($p<0.05$). LSD for comparison of interaction of dried fruits and vegetables storage time = 0.4389						

Higher vitamin C values were noted after drying (zero period) compared to fresh ones. The highest levels were found in spearmint, dill, oranges, and apples, reaching 322, 320, 315, and 309 mg/kg, respectively. The lowest values were observed in sweet peppers and parsley, which reached 262 and 280 mg/kg, respectively, while kiwi, hot pepper, and lhana had similar amounts at 295, 297, and 298 mg/kg, respectively. It was also noted that all the samples studied showed a decrease in vitamin C levels during a storage period of four weeks. Oranges, apples, kiwis, sweet peppers, hot peppers, cabbage, dill, parsley, and spearmint reached levels of 215, 218, 220, 125, 182, 195, 213, 185, and 214 mg/kg, respectively. These results varied according to [41]. The con-centration of vitamin C in oranges and apples reached 49.42 and 9.55 mg/ml, respectively, and these results were higher than those reported by [42], particularly in hot peppers, parsley, kiwi, and sweet peppers, which had levels of 100.5, 110.2, 99.8, and 14.4 mg/100 g, respectively. The results indicated that the vitamin C content in sweet peppers and cabbage was measured at 239 and 246 mg/kg, respectively, which is higher than the findings reported by [43], where the levels were 17.416 and 1.557 mg/10 g for both cabbage and fresh sweet peppers, respectively. This difference was attributed to the researcher's use of the method of measuring total vitamin C content (ascorbic acid + dehydroascorbic acid), which can lead to oxidation and de-composition of the vitamin. The same principle also applies to fresh fruits and vegetables, where vitamin C activity may decrease over time [44]. The findings obtained in this study were significantly higher than what was found by [12], who found that vitamin C content measured by the UV spectropho-tometry method for cabbage, kiwi, orange, and sweet red pepper were 1.11, 17.93, 18, and 0.67 mg/L, respectively. This variation in vitamin C concentration resulted from the effects of temperature and storage conditions [45]. The findings align with those of [46], which indicate that storage time impacts the decrease in vitamin C values during prolonged storage periods, as high temperatures during manufacturing and storage adversely affect vitamin C preservation. This analysis examined the influences of storage time, temperature, and packaging materials on the degradation of vitamin C in samples of chive, chicory, nettle, tomato, carrot, cucumber, red and white pepper, and cabbage juice. Low temperatures of 4 °C and storage in glass containers are optimal for maintaining vitamin C content. The study concluded that stor-ing juices under refrigeration in glass containers designated for food helps to reduce vit-amin C degradation. [47], in their work on the effect of drying method and storage conditions on the quality and content of selected bioactive com-pounds of green legumes, found that the vitamin C content in both dried beans and peas declined over

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time. Its retention was lower when stored in room condition. In air-dried samples, vitamin C content decreased by 10% after 4 months and by up to 33% after 12 months compared to freshly dried materials. Additionally, in materials stored at room conditions, vitamin C loss ranged from 22% to 44%.

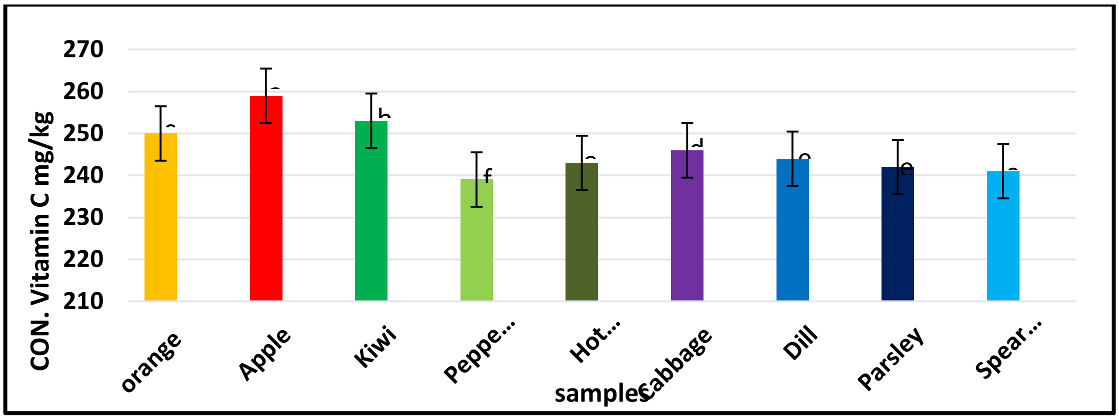

Figure 1: concentration of vitamin C in fruits and vegetables fresh.

*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($p<0.05$). LSD for comparison of fresh fruits and vegetables means (before drying) = 1.715

Figure 2 shows the concentration of vitamin C in dried fruits and vegetable samples, measured immediately after drying (zero period) and before storage. The results showed higher vitamin C levels compared to fresh samples, where vitamin C levels of oranges, apples, and kiwis reached 315, 309, and 295 mg/kg, respectively. For vegetables, sweet pepper, hot peppers, and cabbage contained on 262, 297, and 298 mg/kg, respectively. Among leafy green, dill, parsley, and spearmint exhibited vitamin C levels of 320, 280, and 322 mg/kg, respectively. The vitamin C concentration in dried parsley was lower compared to the results of [48], who reported a concentration of 170.14 mg/g using the spectrophotometer method. Similarly, for dill dried using the freeze-dried method, the vitamin C content was recorded at 123.15 mg/g. Additionally, [49], reported that dried sweet pepper contained 31.5 mg/100 g of vitamin C, a result higher than the values obtained in this study. However, the results for dried cabbage exceeded those reported by [50], how documented a vitamin C concentration of 53.33 g.

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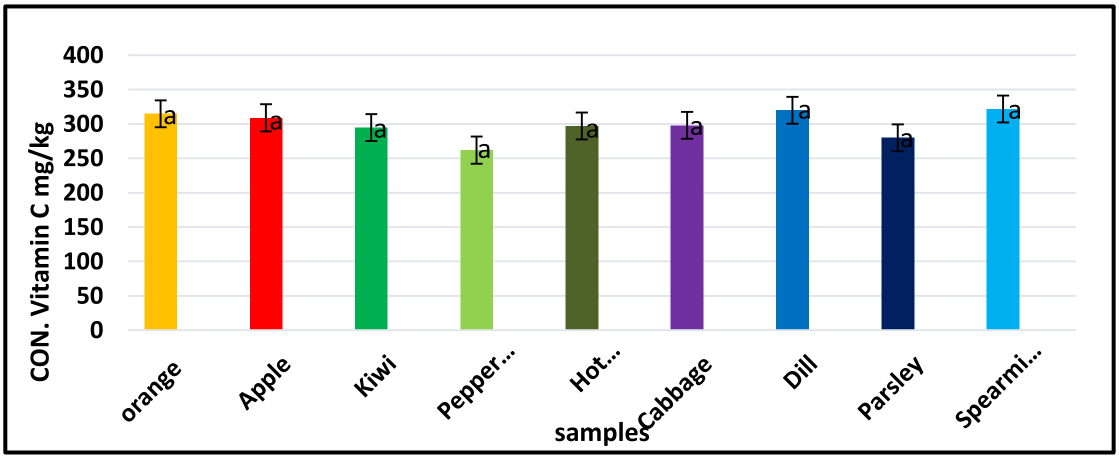

Figure 2: concentration of vitamin C in fruits and vegetables dried in zero time.

*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability (p<0.05). LSD for comparison of fresh fruits and vegetables means (before drying) = 1.715. LSD for comparison of interaction of dried fruits and vegetables storage time = 1.6221

Figures 3, 4, 5, and 6 show decreased vitamin C levels for naturally dried fruits and vegetables stored for four weeks at laboratory temperature. Using the spectrophotometer method, significant differences in the value of vitamin C content were observed across all samples during all storage periods, except for the kiwi. In the case of kiwi, no significant differences were found between storage periods 1 and 2. Overall, vitamin C levels decreased from the zero period to the end of four weeks of storage. The vitamin C concentrations for oranges, apples, and kiwi were documented as 218, 215, and 220 mg/kg, respectively. In relation to sweet peppers, hot peppers, and cabbage, the measured values were 125, 182, and 195 mg/kg, respectively. Vitamin C levels for dill, parsley, and spearmint reached 213, 185, and 214 mg/kg, respectively. We observe from the results a decrease in the percentage of vitamin C in the fourth week of storage, attributed to the loss of a large portion of vitamin C during drying, storage, heat, and light [25]. The findings indicated that the vitamin C content in the samples estimated by the spectrophotometric method was higher than that measured by the spectrophotometric method in all samples and across all storage periods used, likely due to the potential oxidation of vitamin C when using the dye in the spectrophotometric method. Additionally, the spectrophotometric method is considered more sensitive, economical, practical, and less time-consuming than other methods [48]. Studies focus on developing techniques that utilize ultrasound, infrared, and electrohydrodynamic methods to achieve more adequate, shorter, and energy-efficient drying processes with improved control over the final product [26].

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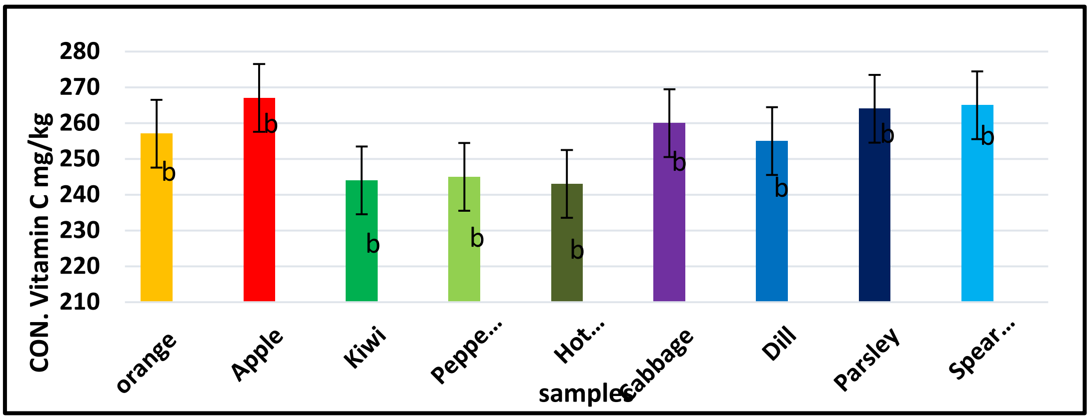

Figure 3: concentration of vitamin C in fruits and vegetables dried and stored for a week
*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability (p<0.05). LSD for comparison of interaction of dried fruits and vegetables storage time = 1.6221

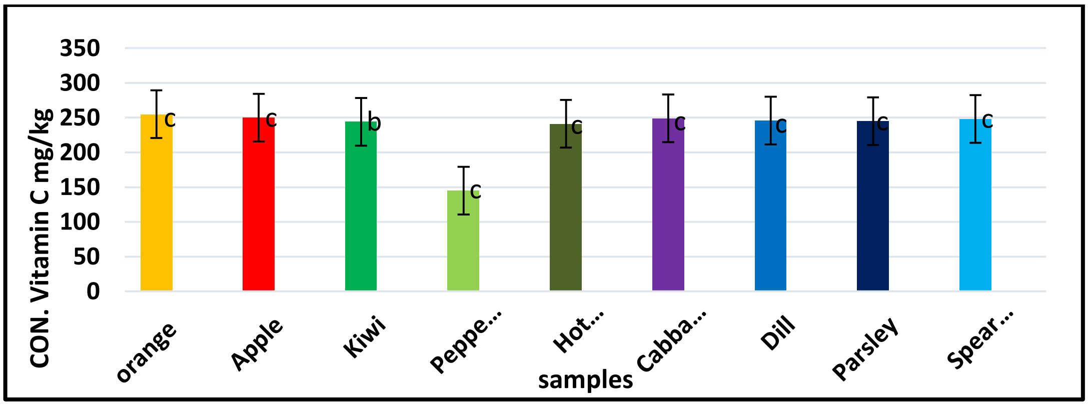

Figure 4: Concentration of vitamin C in fruits and vegetables dried and stored for two weeks
*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability (p<0.05). LSD for comparison of interaction of dried fruits and vegetables storage time = 1.6221

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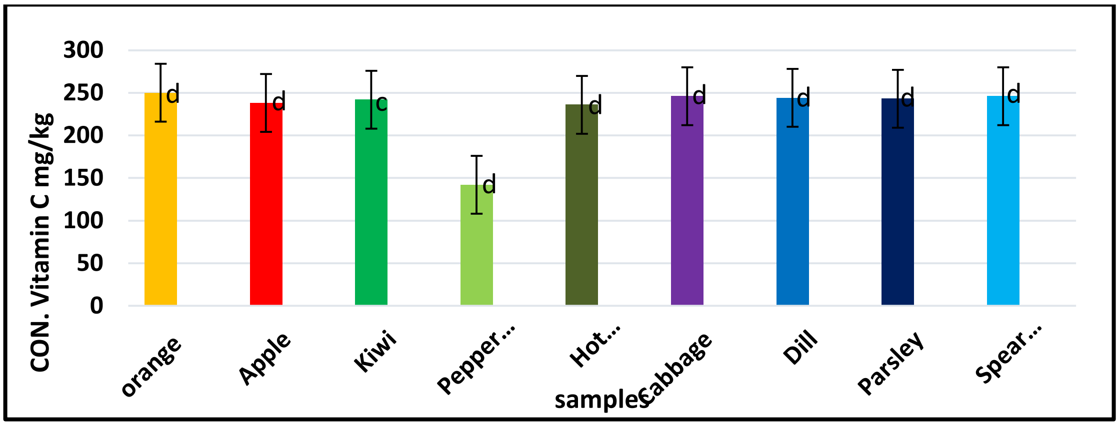

Figure 5: Concentration vitamin C in fruits and vegetables dried and stored for three weeks
*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($p<0.05$). LSD for comparison of interaction of dried fruits and vegetables storage time = 1.6221

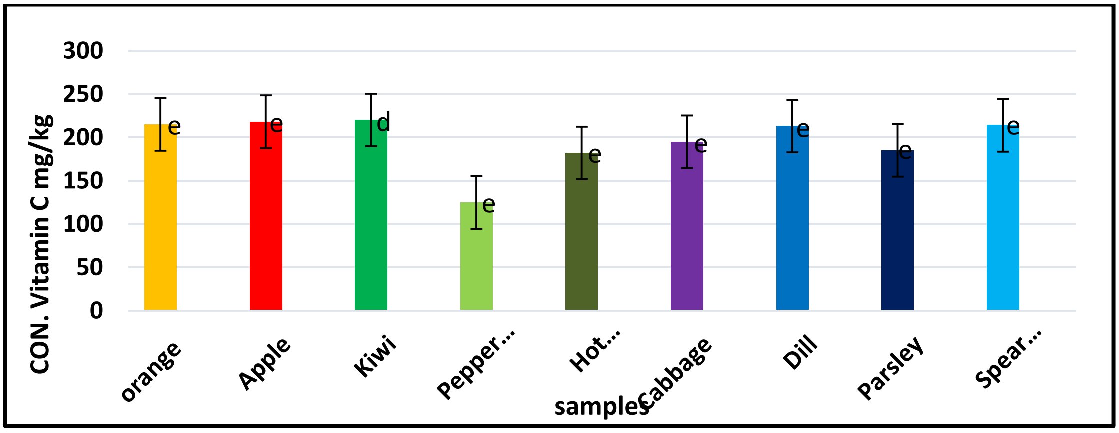

Figure 6: Concentration of vitamin C in fruits and vegetables dried and stored for four weeks
*Different letters indicate the presence of significant differences, and similar letters indicate no significant differences between the treatments at the level of probability ($p<0.05$). LSD for comparison of interaction of dried fruits and vegetables storage time = 1.6221

Conclusions

Based on the data above, it can be said that drying fruits and vegetables keeps their vitamin C level high, making them a good source of this important vitamin that is good for health and nutrition. On the other hand, storing vitamin C for a long time makes it less effective, especially at high temperatures. The rehydration ratio for several samples was quite high and became better with time, which led to dried items that looked and rehydrated well. The sun drying process used worked well to keep the ascorbic acid content in fruits and vegetables after they were dried, which made them more nutritious. The zesting technique was also used to figure out how much vitamin C was in the samples. In all samples and for every storage time evaluated, this approach exhibited greater results than the spectrophotometric method. The dye employed in the spectrophotometric approach may have caused vitamin C to oxidize, which might

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explain the disparity. The smear approach, on the other hand, is a sensitive, cost-effective, practical, and quicker option than other methods.

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Finding

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Author Contributions:

N.K.A. contributed to the development of the theory and performed the experiment computations. He worked out almost all of the technical details, performed the experiment, analyzed data, and wrote the manuscript.

A.A.A. contributed to the idea sketch of the original research. She verified the spectrophotometer method and supervised the project details.

RRA: Analyzed data, statistical analysis, and laboratory methodology. She also provided critical feedback on manuscript writing.

M.M.G. assisted with experimental measurements and contributed to interpreting the results. She also provided critical feedback on manuscript writing.

Conflicts of Interest: The authors declare no conflict of interest

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