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# The Impact of Sun and Electric Oven Drying Methods on the Chemical Composition of Some Fruits and Vegetables

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## Abstract

Fruit and vegetable samples as carrot, orange flesh sweet potato, apple and strawberry are considered high nutritional and economic value. The aim of this investigation studying the effect of sun or electric oven at 55$^{o}$C drying methods on nutritional quality and phenolic compounds. The results showed that the Moisture, lipids, protein, ash and pH of all samples are decreased more after sun drying compared to electric oven drying but carbohydrates, crude fiber, total sugars, reducing and non-reducing sugars and acidity are more increased in all samples after drying electric oven drying as compared to sun drying. Vitamin C and β-carotene are higher in fresh and dried carrot compared to other fresh and dried samples, also fresh and dried strawberry have highest level of total phenolic compound and total amino acids content compared to the others. The fresh carrot contains the highest contents of calcium, iron and magnesium and fresh orange sweet potato contain highest contents of zinc compared to other fresh fruits and vegetables. Drying process caused decreased in phenolic compound, vitamins, and amino acids content in all fruits and vegetables This is because the drying temperature caused denaturation of proteins and also caused the activity of the polyphenol oxidase enzyme, then vitamins are sensitive to heat, they were also lost after drying. besides the sun drying caused more decreased compared to electric oven drying. In contrast the electric oven drying caused more increase in minerals content compared to sun drying. Dried fruits and vegetables have high nutritional value and natural flavors in food industries.

**Keywords:** Carrot; Orange flesh; Sweet potato; Apple; Strawberry; Drying Methods; Phenolic Compounds

## Introduction

Fruits and vegetables contain different phytochemicals, dietary fiber, protein, carbohydrates, vitamins, carotenoids, flavonoids, and other components **[1].** Fruits and vegetables food pigment sources for example, chlorophyll (green), carotenoids (orange -yellow) and anthocyanin's (red) [**2].** Eating a balanced diet containing vegetables and fruits is considered the best way of ensuring good health and enhance the immune system of our body for presentation chronic diseases. Accumulating evidences demonstrate that fruit and vegetable consumption have health benefits **[3]**. Also, Fruits are a gift of nature. Each fruit has its own health benefits. Fruits are edible portion of a plant or tree which contains seeds. Fruits are very healthy and important for proper functioning of body and help in the prevention of many diseases **[11].** There are different and varied types of fruits that differ in their shapes, colors and tastes from each other, but they all agree in their richness in nutrients, antioxidants and important vitamins **[12].**

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Root vegetables include carrot, radish, potato, sweet potato, ginseng, celery, parsley, and horseradish. Edible roots have some similar nutritional features. All of them constitute a good source of fiber **[4].** Carrot (*Daucus carota L*) is the most important crop of family Apiaceous. It having high levels of vitamins carotene, sugar, and essential macro- and micronutrients which are necessary for human body **[5].** Also, carrot is rich in dietary fibres and trace mineral molybdenum, which is uncommon in vegetables Molybdenum is necessary for iron absorption and helps in fat and carbohydrate metabolism Carrots also contain minerals **[6].** Moreover**,** carrots are high in Vitamin C and provitamin A, and Collagen is a kind of protein all is necessary for skin's so keep human skin looking young and healthy **[7].**

Orange sweet potato (*Ipomoea batatas*) is an important root crop belonging to the Convolvulaceae family. It is rich in dietary fibre, minerals (potassium, copper, calcium, zinc) vitamins (provitamin A, vitamin C, B-vitamins (B2, B3, and B6), and antioxidants, such as phenolic acids, anthocyanin, tocopherol, and β-carotenes **[8].** Also, orange sweet potatoes are considered to be an antioxidant and anti-cancer food and annihilation and orange sweet potatoes have the ability to protection against free radical **[9].** Similarly, orange sweet potato contain anthocyanin which is supports cardio vascular are also associated with anti-inflammatory effects that reduce the risk of heart disease. Additionally, the fiber in orange sweet potato reduces cholesterol, while the high potassium levels of sweet potatoes keep blood pressure down also fibres content in orange sweet potatoes can help prevent constipation and promote regularity for a healthy digestive tract **[10].**

Apple, *(Malus domestica*) is one of crops have high nutritional value in Rosaceae family. It forms an important part of human diet as they are a rich source of sugars, minerals, dietary fibre and functional compounds such as ascorbic acid and phenolic compound **[13].** Similarly, apple is a rich source of soluble fibres, especially pectin, which helps control insulin levels by slowing the release of sugar into the bloodstream (low glycemic index). Pectin is also known to help reduce cholesterol levels by lowering insulin secretion **[14]**.

Strawberry (*Fragaria ananassa*) is a soft fruit crop which belongs to the family *Rosaceae* and genus *Fragaria*. It is one of the most consumed berries in world wide are a source of B-vitamins, vitamin C, vitamin E, potassium, folic acid, carotenoids, and flavonoids, such as, pelargonidin, quercetin, and catechin. Strawberries also contain amounts of elegiac acid, tannins **[15]**. The anthocyanin in strawberries reduces the risk of heart attack, the fibre and potassium found in strawberries also support heart health, and the antioxidants in strawberries work against free radicals which inhibit tumour growth and also decrease inflammation in the body also potassium content in strawberries benefits to people who have a raised risk of high blood pressure by helping to offset the effects of sodium in the body **[16]**.

Drying is one of the earliest methods of preserving fruits and vegetables. The main process is to remove enough moisture from the fruits and vegetables to make it unlikely that it would deteriorate. it can do this by using the warm heat of the sun, a dehydrator, or an oven. After drying, store the produce in a place that is dry. The flavor and nutritional content of fresh fruits and vegetables are change after it is dried **[17].** Also, low moisture content in dried fruits and vegetables was a desired quality for longer shelf life since it prevented the growth of mold **[18].**

Therefore, the aim of this study was to determine the chemical composition of fresh fruits (apple and strawberry) and fresh vegetables (carrot and orange sweet potato) and comparing the chemical composition of fruits and vegetables on fresh and when using sun, or electric oven drying methods.

## 2- Materials and Methods:

### 2.1- Materials:

Vegetables as carrots *(Daucus carota L)*, orange flesh sweet potato *(Ipomoea batatas)* and fruit as strawberries *(Fragaria x ananassa),* apples *(Malus domestica)* were purchased from local markets at Aswan Governorate.

### 2.2- Methods:

#### 2.2.1-Technological Methods:

#### 2.2.1.1- Samples preparation and Drying: -

Vegetables as carrots *(Daucus carota L)*, orange sweet potatoes *(Ipomoea batatas)* and fruit as strawberries *(Fragaria x ananassa),* apples *(Malus domestica)* (about 10 kg of each kinds) were washed under running water, peeled and sliced to average thickness of 1 mm. These slices have been divided to two parts, the first part dried by an electrical oven at 55$^{o}$C. The drying times for carrots, orange sweet potatoes, apples, and the second part dried by sun after covered by muslin (cheese) cloth.

#### 2.2.1.2- Drying methods:

The sun-drying process started and continued for one week In May 2022, all dried slices were ground and sieved through a 60 µm mesh sieve and were kept in plastic bags in deep-freezer at -18°C for further analysis.

#### 2.2.2- Chemical Methods:

Moisture, protein, lipids, ash, crude fiber, reducing and total sugars, mineral elements, pH, and acidity were determined according to official methods of analysis **[19].** While total carbohydrates were calculated by difference. Also, non-reducing sugars percentage was computed by calculating the differences between total and reducing sugars.

**% carbohydrates = 100 – {% protein + % lipid + % ash+ % crude fiber}**

Amino acids were determined as methods described by [**20], [21].**

The minerals (calcium Ca, magnesium Mg, iron Fe, zinc Zn) were measured according to the method outlined by **[19].**

The β-Carotene content was measured according to the method outlined by **[22].** The method for extracting vitamin C was described by **[23].**

Phenolic compounds were determined by using HPLC according to the method described in **[24].**

#### 2.2.3- Statistical analysis:

Using IBM SPSS Statistics 27, a PC statistical program, the statistical analysis was performed. At the 5% probability levels, the LSD multiple range test was utilized to evaluate significant variations in means. At least two replications of each triplicate experiment were conducted, and the results

are shown as means + standard error. The means of the same column that have different letters (a, b, c, and d) differ significantly at $p < 0.05$, while the means of the same letters are not statistically different. Moreover, one-way ANOVA statistical analysis was used to assess significant differences at the 5% and 1% levels **[25].**

**3- Results and Discussion:**

**3.1- Chemical composition of fresh and dried fruits and vegetables as affected by electric oven and sun drying:**

The results in Table (1) indicated that the fresh strawberry has the highest moisture content (89, 84 %), followed by apple (86.25 %), carrot (83.53%) and orange sweet potato (77.67 %). Also results in the same Table indicated that the fresh carrot and apple have contained the highest percentage of protein (5.56 and 4.79 %, on dry weight basis), compared to fresh strawberry and orange sweet potato (3.29 and 2.67%, on dry weight basis) and we found the crude fibre content was (18.36, 8.29, 2.54 and 2.51 %) for fresh carrot, strawberry, orange sweet potato and apple respectively. In addition, the fresh carrot has the highest ash content (3.67 %) followed by strawberry (3.66 %), apple (2.87 %) and orange sweet potato (2.52%). Also, we indicated that the fresh strawberry has the highest lipids content (3.55 %), followed by apple (3.35 %), carrot (1.95 %), and orange sweet potato (1.67 %) and fresh orange sweet potato, has highest carbohydrates content (90.60 %) followed by apple, (86.48%), strawberry (81.21%) and carrot (70.46%). These results of chemical composition of fresh fruits and vegetables are in agreement with those of **[34], [35], [36], [37], [38], [6], [29] and [39].**

Results in the same Table showed that the drying process caused decreased in protein, ash, lipid, content of fruits and vegetables. These results might be due to protein interacts with other food components when the temperature increases, resulting in changes in solubility, texture, and nutritional values so, the high temperatures and long drying times of sun drying method that caused protein degradation **[40].** Sun drying caused more decreasing in minerals content compared to electric oven drying method. So, ash content is decrease in fruits and vegetables dried by sun compared to that dried by electric oven methods. Results showed that the decreased in lipids content due to the oxidation of lipids during drying, made the oxygen reacts with unsaturated fatty acids and fat loss also fat-soluble vitamins **[41].**

In contrast the results showed that the sun drying caused more decreased in moisture content compared to electric oven methods of fruits and vegetables. These results might be due to there is moisture gained because of the fluctuation of temperatures to which fruits and vegetables are exposed during the day and night in sun drying **[9].** Besides results in Table (1) exposed that the electric oven and sun drying lead to increase the crude fibre content of fruits and vegetables however the electric oven drying caused more increased in crude fibre compared to sun drying. These results might be due to decreased moisture lead to increase the total solids so fibre content was increased **[42].** The results of chemical composition of these fruits and vegetables as affected by electric oven and sun drying methods were in agreement with those of **[43], [39], [44], [45] and [17]**.

The tabulated data in Table (1) showed that there is a highly significant difference at ($p \leq 0.01$) variation in chemical composition there are decrease in moisture, protein, lipids, and ash contents but there are increase in crude fiber and carbohydrate between fresh and dried fruits and vegetables. Also, there was a highly significant difference at ($p \leq 0.01$) variation between two drying methods (electric oven and sun drying). The sun drying methods caused more decreased in protein, lipids, ash, contents but sun drying caused more increased in carbohydrate content compared to electric oven drying methods. In contrast the electric oven drying methods caused more decreased in moisture content compared to sun drying methods. Also, the electric oven drying methods caused more increased in crude fiber content compared to sun drying.

**Table (1):** Chemical composition of fresh and dried fruits and vegetables as affected by electric oven and sun drying "on dry weight basis".

| Sample | | Moisture % | Protein % | Fiber % | Ash % | Lipids % | Carbohydrates % |
|---|---|---|---|---|---|---|---|
| Carrot | Raw | 83.53±0.39$^{a}$ | 5.56±0.37$^{a}$ | 18.36±0.41$^{c}$ | 3.67±0.39$^{a}$ | 1.95±0.05$^{a}$ | 70.46±0.39$^{bc}$ |
| | ED* | 4.65±0.47$^{c}$ | 4.43±0.34$^{b}$ | 19.10±0.31$^{a}$ | 3.64±0.42$^{b}$ | 1.88±0.03$^{b}$ | 70.95±0.42$^{b}$ |
| | SD** | 5.52±0.43$^{b}$ | 4.11±0.15$^{bc}$ | 18.92±0.33$^{b}$ | 3.60±0.42$^{bc}$ | 1.81±0.03$^{c}$ | 71.56±0.26$^{ab}$ |
| Orange sweet potato | Raw | 77.67±0.50$^{a}$ | 2.67±0.42$^{a}$ | 2.54±0.36$^{b}$ | 2.52±0.42$^{a}$ | 1.67±0.04$^{a}$ | 90.06±0.41$^{bc}$ |
| | ED | 3.30±0.22$^{c}$ | 2.22±0.42$^{ab}$ | 2.65±0.33$^{a}$ | 2.44±0.42$^{b}$ | 1.55±0.01$^{b}$ | 91.14±0.40$^{ab}$ |
| | SD | 4.05±0.11$^{b}$ | 2.19±0.35$^{abc}$ | 2.49±0.40$^{c}$ | 2.37±0.33$^{bc}$ | 1.50±0.03$^{c}$ | 91.45±0.33$^{a}$ |
| Apple | Raw | 86.25±0.36$^{a}$ | 4.79±0.63$^{a}$ | 2.51±0.34$^{c}$ | 2.87±0.33$^{ab}$ | 3.35±0.03$^{b}$ | 86.48±0.33$^{c}$ |
| | ED | 2.51±0.43$^{c}$ | 3.62±0.38$^{b}$ | 3.20±0.43$^{a}$ | 2.84±0.32$^{a}$ | 3.31±0.02$^{c}$ | 87.03±0.29$^{ab}$ |
| | SD | 3.52±0.38$^{b}$ | 3.50±0.40$^{bc}$ | 2.95±0.39$^{b}$ | 2.80±0.21$^{c}$ | 3.67±0.02$^{a}$ | 87.08±0.17$^{a}$ |
| Strawberry | Raw | 89.84±1.03$^{a}$ | 3.29±1.19$^{a}$ | 8.29±0.13$^{c}$ | 3.66±0.43$^{a}$ | 3.55±0.04$^{a}$ | 81.21±0.33$^{c}$ |
| | ED | 4.56±0.35$^{bc}$ | 3.19±0.18$^{b}$ | 9.11±0.40$^{a}$ | 3.63±0.43$^{b}$ | 3.48±0.01$^{b}$ | 81.59±0.33$^{ab}$ |
| | SD | 5.21±0.31$^{b}$ | 3.15±0.15$^{bc}$ | 8.89±0.22$^{b}$ | 3.60±0.58$^{ac}$ | 3.38±0.08$^{c}$ | 81.98±0.35$^{a}$ |

ED*; Electric oven drying, and SD**; Sun drying. Means with different letters (a, b, c, d) in the same column different significantly at $p \leq 0.05$, while those with similar letters are not significant by different.

### 3.2- Sugar contents, PH and acidity values of fresh and dried fruits and vegetables as affected by Electric oven and Sun drying methods:

Results in Table (2) showed that the fresh carrot has the highest content of total sugars (63.21 %), followed by orange sweet potato (25.59 %), strawberry (20.48 %), and apple (10.60 %) furthermore we found the fresh orange sweet potato has the highest reducing sugars content (19.62%) followed by carrot and strawberry (13.51%), (10.13%), while apple was the lowest (8.69 %) "on dry weight basis". Also results in the same in Table indicated that the highest content of non-reducing sugars content was (49.70%) of carrot, followed by strawberry (10.35%), followed by (5.97 %) of orange sweet potato and (2.17%) of apple. These results of sugar contents of fresh fruits and vegetables are in agreement with those of [6], [46], [47] and [9].

Also, Table (2) illustrated that the electric oven drying caused more increased in total, reducing and non-reducing sugars compared to sun drying. These results might be due to the conversion of total sugars into simple sugars also the increase in total, reducing and non-reducing sugars concentration after the moisture content were decreases during the drying process and as a result of moisture content of electric oven dried fruits and vegetables is lower than those dried in the sun, so the concentration of sugars in them after drying is higher than that are dried in the sun. These results are in agreement with those [48] and [30]. Also, the results of total sugar contents of these fruits and vegetables as affected by electric oven and sun drying process are in agreement

with those of [30] and [49]. In contrast disagree with [44]. Who found that the total sugar contents of verities kinds of fruits were decreased after sun drying process this is because the drying was done at a higher temperature compared to that at fruits and vegetables are exposed during the dried process in this study.

**Table (2):** Sugar content, PH and acidity values of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods.

| Sample | | Total sugar (%) | Reducing Sugar (%) | Non-Reducing Sugar (%) | pH | Acidity % |
|---|---|---|---|---|---|---|
| Carrot | Raw | 63.21±0.77$^{c}$ | 13.51±0.27$^{c}$ | 49.70±0.51$^{c}$ | 6.33± 0.01 $^{a}$ | 1.88±0.05$^{c}$ |
| | ED* | 66.24±0.05$^{a}$ | 15.43±0.23$^{a}$ | 50.81±0.26$^{a}$ | 6.30± 0.01 $^{b}$ | 1.92±0.20$^{ab}$ |
| | SD** | 64.97±0.02$^{b}$ | 14.35±0.23$^{b}$ | 50.62±0.21$^{ab}$ | 6.27±0.02$^{c}$ | 1.69±0.25$^{a}$ |
| Orange sweet potato | Raw | 25.59±0.12$^{c}$ | 19.62±0.05$^{c}$ | 5.97±0.06$^{cb}$ | 5.47±0.02$^{a}$ | 0.20±0.02$^{c}$ |
| | ED | 29.27±0.06$^{a}$ | 22.44±0.08$^{a}$ | 6.83±0.14$^{a}$ | 4.89±0.02$^{b}$ | 0.25±0.03$^{ab}$ |
| | SD | 27.19±0.03$^{b}$ | 21.26±0.05$^{b}$ | 5.93±0.07$^{ab}$ | 4.83±0.04$^{c}$ | 0.30±0.04$^{a}$ |
| Apple | Raw | 10.60±0.06$^{c}$ | 8.69±0.07$^{c}$ | 2.17±0.43$^{cb}$ | 3.82±0.04$^{a}$ | 0.24±0.05$^{c}$ |
| | ED | 14.96±0.02$^{a}$ | 10.91±0.03$^{a}$ | 4.05±0.03$^{a}$ | 3.51±0.16$^{b}$ | 0.35±0.03$^{ab}$ |
| | SD | 12.52±0.07$^{b}$ | 9.63±0.03$^{b}$ | 2.89±0.06$^{b}$ | 3.47±0.17$^{bc}$ | 0.41±0.03$^{a}$ |
| Strawberry | Raw | 20.48±0.23$^{c}$ | 10.13±0.03$^{c}$ | 10.35±0.23$^{abc}$ | 3.94±0.04$^{a}$ | 0.52±0.02$^{c}$ |
| | ED | 24.65±0.28$^{a}$ | 12.92±0.05$^{a}$ | 11.73±0.32$^{a}$ | 3.85±0.03$^{ab}$ | 0.82±0.02$^{b}$ |
| | SD | 22.12±0.07$^{b}$ | 11.54±0.11$^{b}$ | 10.58±0.13$^{ab}$ | 3.78±0.08$^{abc}$ | 1.12±0.025$^{a}$ |

ED*; Electric oven drying, and SD**; Sun drying. Means with different letters (a, b, c, d) in the same column different significantly at $p \leq 0.05$, while those with similar letters are not significant by different.

As shown in Table (2), there are a highly significant difference at ($p \leq 0.01$) variation in total sugars between fresh and dried fruits and vegetables by electric oven and sun drying methods and there is significant difference at ($p \leq 0.05$) variation in reducing and non-reducing sugars. There are increase in reducing and non-reducing sugar between fresh and dried fruits and vegetables. Besides, there are a highly significant difference at ($p \leq 0.01$) variation in total, reducing and non-reducing sugars between drying methods (electric oven and sun drying methods).

Results in Table (2) showed that the pH value of fresh carrot and orange sweet potato were (6.33 and 5.47) besides pH are 3.94 and 3.82 of fresh strawberry and apple. Also results in Table (2) indicated that the fresh carrot has the highest acidity (1.88%), followed by strawberry (0.52%), apple (0.24 %), and orange sweet potato (0.20 %). These results agree with those reported by [26], [27], [28], and [29]. Also, electric oven and sun drying methods lead to increase the acidity value in contrast lead to decrease the pH value for all fruits and vegetables. These results might be due to high temperature in drying process caused generation of acids as a result of sugars interconversion and other chemical reactions during drying process [30]. As well as the results of the pH and acidity value of these fruits and vegetables as affected by electric oven and sun drying method are in agreement with those of [31], [32] and [33].

Analysis of variance for pH and acidity value of these fruits and vegetables that there is a highly significant difference at ($p \leq 0.01$) variation in pH and acidity value (%) there are decrease in pH value but there are increase in acidity value (%), between fresh and dried fruits and vegetables dried by (electric oven and sun drying). Also, there are highly significant difference at ($p \leq 0.01$) variation between drying methods (electric oven and sun drying) in all fruits and vegetables. The sun drying methods caused more increased in acidity value in contrast caused more decreased in pH value compared to electric oven drying methods in all fruits and vegetables.

### 3.3- Mineral content of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods:

The results in Table (3) showed that the fresh carrot contain the highest contents of iron (17.02) followed by orange sweet potato (5.56), apple (3.88) and strawberry (0.66) and it was found that the fresh carrot contain the highest contents of magnesium (116.90mg/100g) followed by orange sweet potato (90.20mg/100g), apple (28.60mg/100g), and strawberry (19.05mg/100g). Also, from results in the same Table, indicated that orange sweet potato has the highest contents of zinc (2.16mg/l00 g) followed by, carrot (2.08mg/l00 g), followed by, strawberry (0.31 mg/l00 g) and apple (0.27 mg/l00 g). These results of minerals content of these fruits and vegetables are agree with those of [55], [34], [37] and [56]. Also, in the same Table reported that in generally the electric oven and sun drying methods cause low decreased in minerals content in all dried fruits and vegetables and sun drying methods caused more decreased compared to electric oven drying methods. The results of minerals contents of these fruits and vegetables as affected by electric oven and sun drying are greening with those of [55], [57] and [58].

**Table (3):** Minerals and Vitamins (β-carotene and vitamin C) content (mg/100g) of fresh and dried fruits and vegetables samples after drying by electric oven and sun.

| Sample | Treatment | Iron (Fe) | Magnesium (Mg) | Zinc (Zn) | Calcium (Ca) | Vitamin C | β - carotene |
|---|---|---|---|---|---|---|---|
| Carrot | Raw | 17.02 | 116.90 | 2.08 | 150.20 | 49.22 | 77.22 |
| | ED* | 16.12 | 114.38 | 2.02 | 149.33 | 37.12 | 70.42 |
| | SD** | 15.95 | 113.22 | 1.95 | 148.26 | 33.11 | 67.47 |
| Orange sweet potato | Raw | 5.56 | 90.20 | 2.16 | 119.33 | 29.82 | 70.11 |
| | ED | 4.85 | 89.65 | 2.12 | 117.55 | 21.33 | 60.64 |
| | SD | 4.32 | 88.65 | 2.10 | 116.42 | 19.45 | 65.67 |
| Apple | Raw | 3.88 | 28.60 | 0.27 | 43.22 | 21.13 | 22.12 |
| | ED | 3.95 | 27.33 | 0.14 | 41.82 | 18.22 | 18.63 |
| | SD | 2.10 | 26.32 | 0.12 | 40.02 | 15.33 | 16.33 |
| Strawberry | Raw | 0.66 | 19.05 | 0.31 | 26.02 | 40.22 | 24.34 |
| | ED | 0.64 | 18.53 | 0.30 | 25.44 | 32.45 | 17.71 |
| | SD | 0.62 | 18.20 | 0.29 | 25.97 | 27.12 | 15.23 |

ED*; Electric oven drying, and SD**; Sun drying.

The result in Table (3) showed that the fresh carrot has the highest β-carotene content (77.22 mg/100g) followed by orange sweet potato (70.11mg/100g), strawberry (24.34 mg/100g), and apple (22.12 mg/100g). The results of β-carotene contents of these fruits and vegetables are in agreement with those of [59], [60], [35] and [61]. Also, the result indicated that the fresh (carrot and strawberry) have the highest values of vitamin (C) content (49.22 and 40.22 mg/100g) followed by orange sweet potato (29.82 mg/100g), and apple (21.13 mg/100g). The obtained results are agreed with [62], [55], [6] and [61]. As well as we found sun drying caused more decreased in β-carotene and vitamin (C) content of these fruits and vegetables compared to electric oven drying. These results might due to dried by sun caused in exposed the fruits and vegetables to heat, light, oxygen, enzymes, pH, high moisture and metal ions for a longer time with repeated exposure to oxidizing agents during the drying process [63]. Also, the ascorbic acid is reversibly oxidized to dehydro-ascorbic acid and further oxidation leads to the irreversible formation of physiologically inactive diketogulonic. The Photolysis of carotenoids and loss of

provitamin A activity also occur during oxidation processes and free radical formation [64]. The results of β-carotene and vitamin (C) content of these fruits and vegetables as effected by electric oven and sun drying are agree with those of [60], [65], [39], [63] and [17].

**3.4- Amino acids content of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods:**

Data in Table (4) and (5) showed that the fresh carrot contain the highest percentage of valine (3.28 g/100g), lucien (4.67 g/100g) and phenylalanine (3.12 g/100g) from essential amino acids then fresh carrot contained the highest content of glutamic acid (7.87 g/100g) and proline (3.74 g/100g) from non-essential amino acids, compared to the other fruits and vegetables, and fresh orange sweet potato has the highest contents of histidine (3.09 g/100g), and methionine (3.59 g/100g) from essential amino acids. Also it was found fresh apple enclose the highest percentage of isoleucine (4.41 g/100g) from essential amino acids then apple contained the highest level of serine (7.67 g/100g), glycine (7.22 g/100g), arginine (3.87 g/100g), aspartic acid (7.93g/100g) and tyrosine (8.33 g/100g) from non-essential amino acids and fresh strawberry contain the highest percentage of lysine (3.79 g/100g), and threonine (6.46 g/100g) from essential amino acids and strawberry have the highest level of alanine (8.25 g/100g) from non-essential amino acids. The results of essential and non-essential amino acids content in fresh fruits and vegetables are in agreement with those of [50], [51], [52], and [7].

Also results in the same Tables (4) and (5) indicated that the total amino acids content (essential and non-essential) of (carrot, orange sweet potato, apple and strawberry) as effected by drying methods (electric oven and sun drying methods) are decreased after drying. However, sun drying caused more decreased in total amino acids compared to electric oven drying in all fruits and vegetables. These results might be due to a high temperatures and long drying times in sun drying method that lead to the release of amino acids from the protein and occurrence the Millard reaction and decreased of amino acids content [53]. Also, the results of the total amino acids content of dried fruits and vegetables as effected by drying method are in agreement with those of [54]. Who reported that the the contents of amino acids have been changed by all drying process. The decrease about 30% was noted, probably due to temperature-related changes in breakdown of proteins.

**3.5- Phenolic compounds content of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods:**

From results in Table (5) indicated that the fresh carrot contain the highest percentage of ferulic acid (38.55 µg/g ), sinapic acid (25.22 µg/g ), chrysin (3.88 µg/g ), p-Coumaric acid (98.22 µg/g ) and cinnamic acid (26.54µg/g) compared to the other fruits and vegetables besides results in the same Table showed that the fresh orange sweet potato has the highest level of protocatechuic acid (84.22 µg/g ), caffeic acid (93.15 µg/g ) and p- hydroxybenzoic acid(93.22 µg/g) and fresh apple contain the highest levels of rosmarinic acid (39.24 µg/g ) , and gentistic acid (5.99 µg/g ). Also we found that the fresh strawberry has the highest level of gallic acid (93.08 µg/g), vanillic acid (17.22 µg/g), rutin (112.05µg/g), catechin (20.11 µg/g), apigenin_7glucoside (66.12 µg/g), and kaempferol (22.96µg/g) compared to the other fruits and vegetables. The results of phenolic compound content of these fruits and vegetables are in agreement with those of [35], [66], [14] and [67].

**Table (4):** Amino acids content (g/100g) of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods.

| Amino Acids | Treatment | Carrot | Orange sweet potato | Apple | Strawberry |
|---|---|---|---|---|---|
| Histidine | Raw | 2.04 | 2.09 | 1.08 | 2.40 |
| | ED* | 1.41 | 1.22 | 0.91 | 1.93 |
| | SD** | 1.12 | 1.04 | 0.59 | 1.12 |
| Leucine | Raw | 4.67 | 1.31 | 2.47 | 2.83 |
| | ED | 3.84 | 1.22 | 1.94 | 1.54 |
| | SD | 3.15 | 0.95 | 1.13 | 0.98 |
| Lysine | Raw | 3.16 | 2.75 | 3.27 | 3.79 |
| | ED | 2.87 | 1.65 | 2.88 | 2.52 |
| | SD | 1.88 | 0.98 | 2.22 | 1.94 |
| Isoleucine | Raw | 3.44 | 2.77 | 4.41 | 3.67 |
| | ED | 2.28 | 1.53 | 3.22 | 2.88 |
| | SD | 1.75 | 0.87 | 3.02 | 1.95 |
| Valine | Raw | 3.28 | 2.07 | 1.91 | 1.36 |
| | ED | 3.22 | 1.22 | 1.33 | 0.97 |
| | SD | 2.54 | 1.04 | 1.04 | 0.22 |
| Phenylalanine | Raw | 3.12 | 2.44 | 1.08 | 1.68 |
| | ED | 2.74 | 1.54 | 0.88 | 0.99 |
| | SD | 2.13 | 1.10 | 0.20 | 0.42 |
| Threonine | Raw | 3.46 | 1.04 | 1.51 | 6.46 |
| | ED | 2.94 | 0.98 | 0.95 | 4.94 |
| | SD | 2.09 | 0.22 | 0.42 | 3.75 |
| Methionine | Raw | 1.46 | 3.25 | 3.80 | 2.47 |
| | ED | 1.22 | 2.22 | 2.98 | 1.32 |
| | SD | 0.84 | 1.95 | 2.18 | 0.94 |
| Total Essential amino acids (T.E.A.A) | Raw | 24.63 | 17.72 | 19.53 | 22.19 |
| | ED | 20.52 | 11.58 | 15.09 | 17.09 |
| | SD | 15.52 | 8.15 | 9.76 | 11.32 |
| | | | | | |
| Alanine | Raw | 3.67 | 2.19 | 6.05 | 8.25 |
| | ED* | 2.32 | 1.22 | 4.95 | 7.12 |
| | SD** | 2.05 | 0.98 | 4.05 | 6.66 |
| Aspartic acid | Raw | 4.34 | 1.43 | 7.93 | 5.21 |
| | ED | 3.62 | 0.66 | 5.22 | 4.22 |
| | SD | 3.19 | 0.22 | 4.13 | 3.38 |
| Glutamic acid | Raw | 7.87 | 2.81 | 3.89 | 5.20 |
| | ED | 6.33 | 1.23 | 2.42 | 4.53 |
| | SD | 5.03 | 0.82 | 2.04 | 3.22 |
| Serine | Raw | 3.20 | 2.59 | 7.67 | 6.10 |
| | ED | 2.87 | 1.98 | 5.87 | 4.54 |
| | SD | 2.12 | 1.22 | 4.15 | 3.10 |
| Glycine | Raw | 1.94 | 1.22 | 7.22 | 3.07 |
| | ED | 1.12 | 1.05 | 6.22 | 2.29 |
| | SD | 0.95 | 0.98 | 5.95 | 1.95 |
| Total amino acids (T.A.A) | Raw | 56.38 | 35.33 | 63.74 | 54.11 |
| | ED | 45.06 | 22.86 | 51.37 | 44.87 |
| | SD | 34.98 | 15.44 | 39.11 | 36.99 |

ED*; Electric oven drying, and SD**; Sun drying

From results in Tables (5) that the sun drying caused more decreased in phenolic compounds compared to electric oven drying in all fruits and vegetables. These results might be due to activity of polyphenol oxidase enzyme under direct sunlight, which lead to decrease in phenolic compoundsls also, long drying period and high temperatures to that the fruit and vegetables is exposed in the sun drying method cause occurrence of oxidation processes that result in a decrease in phenolic compoundsls. The effect of drying methods on phenolic compounds content of fruits and vegetables are in agreement with those of [68], [69], [49] and [17].

**Table (5):** Phenolic compounds content (µg/g) of fresh and dried fruits and vegetables as affected by electric oven and sun drying methods part (1).

| Compound | Treatment | Carrot | Orange sweet potato | Apple | Strawberry |
|---|---|---|---|---|---|
| Gallic acid | Raw | 8.22 | 90.55 | 20.33 | 93.08 |
| | ED* | 3.09 | 79.75 | 16.05 | 84.85 |
| | SD** | 0.90 | 85.63 | 14.03 | 31.47 |
| Protocatechuic acid | Raw | 45.66 | 84.22 | 25.66 | 52.66 |
| | ED | 40.44 | 69.92 | 11.36 | 44.22 |
| | SD | 26.07 | 25.32 | 2.28 | 38.66 |
| Gentisic acid | Raw | 2.06 | 2.74 | 5.99 | 3.02 |
| | ED | 0.15 | 0.82 | 1.08 | Nd |
| | SD | Nd | 0.12 | Nd | Nd |
| Caffeic acid | Raw | 82.65 | 93.15 | 83.87 | 44.52 |
| | ED | 77.61 | 85.45 | 77.61 | 32.01 |
| | SD | 42.33 | 68.22 | 20.49 | 20.94 |
| Vanillic acid | Raw | 4.05 | 7.66 | 5.08 | 17.22 |
| | ED | 2.21 | 2.78 | 1.24 | 9.22 |
| | SD | Nd | 1.56 | 0.36 | 5.33 |
| Ferulic acid | Raw | 38.55 | 29.55 | 8.33 | 11.66 |
| | ED | 25.12 | 24.95 | 4.91 | 8.92 |
| | SD | 20.22 | 22.17 | 3.52 | 6.66 |
| Sinapic acid | Raw | 25.22 | 3.09 | 15.03 | 9.33 |
| | ED | 22.74 | 1.74 | 11.78 | 3.22 |
| | SD | 19.11 | Nd | 9.22 | 1.78 |
| Rutin | Raw | 1.05 | 2.41 | 10.66 | 112.05 |
| | ED* | 0.75 | 1.19 | 6.09 | 99.46 |
| | SD** | 0.22 | 0.28 | 5.20 | 88.02 |
| Apigenin_7glucoside | Raw | 1.66 | 1.77 | 32.75 | 66.12 |
| | ED | Nd | 0.25 | 23.58 | 44.15 |
| | SD | Nd | 0.12 | 18.80 | 29.18 |
| Rosmarinic acid | Raw | 2.55 | 2.05 | 39.24 | 20.21 |
| | ED | 0.74 | 0.44 | 29.18 | 13.17 |
| | SD | 0.12 | 0.17 | 19.15 | 8.93 |
| Chrysin | Raw | 3.88 | 2.22 | 1.88 | 3.78 |
| | ED | 1.33 | 0.27 | 0.84 | 1.58 |
| | SD | 0.22 | 0.08 | 0.07 | 0.34 |

***Continue Table (5) …..***

| Compound | Treatment | Carrot | Orange sweet potato | Apple | Strawberry |
|---|---|---|---|---|---|
| Catechin | Raw | 2.08 | 3.05 | 18.22 | 20.11 |
| | ED | 1.06 | 1.44 | 11.59 | 11.65 |
| | SD | 0.28 | 1.15 | 2.28 | 6.28 |
| Cinnamic acid | Raw | 26.54 | 5.22 | 4.98 | 6.22 |
| | ED | 16.39 | 2.17 | 2.65 | 2.02 |
| | SD | 12.65 | 1.14 | 0.18 | 1.59 |
| Kaempferol | Raw | 20.14 | 1.06 | 1.88 | 22.96 |
| | ED | 17.22 | 0.52 | 0.13 | 19.40 |
| | SD | 15.13 | 0.12 | Nd | 13.31 |
| p-Coumaric acid | Raw | 98.22 | 15.02 | 8.55 | 2.55 |
| | ED | 88.25 | 11.40 | 3.08 | 1.22 |
| | SD | 74.09 | 8.65 | 2.47 | 0.57 |
| p- hydroxybenzoic acid | Raw | 20.22 | 93.22 | 36.33 | 10.54 |
| | ED | 16.12 | 89.54 | 29.36 | 6.22 |
| | SD | 12.17 | 25.33 | 25.12 | 4.63 |
| Total phenolic compound (T.p.c) | Raw | 277.18 | 419.98 | 314.65 | 522.66 |
| | ED | 223.15 | 312.66 | 220.17 | 412.62 |
| | SD | 202.19 | 253.14 | 202.11 | 388.57 |

ED*; Electric oven drying, and SD**; Sun drying, Nd = not detected

## Conclusion:

Drying is one of the important and necessary preservation methods to increase the shelf life of fruits and vegetables, but it is necessary to choose the appropriate drying method that brings the fruits and vegetables to an appropriate moisture level with the least possible loss of nutrients, vitamins, minerals, phenolic compounds and antioxidants necessary to strengthen immunity, grow the body and provide it with energy. The study showed us that the method of drying fruits and vegetables in an electric oven lead to an appropriate moisture level with less loss in the chemical composition, amino acids, minerals, vitamins and phenolic compounds. It also resulted in a greater increase in the content of crude fibers and sugars compared to the natural drying method in the sun.

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