Quality Attributes of Some Vegetables and Fruits Preserved by Sun and Oven Drying Methods

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ABSTRACT

Drying is one of the most appropriate techniques for producing of shelf stable food products. However, drying can result in significant loss of available bioactive compounds. This study investigated the effect two methods of drying (sun and oven) on the quality characteristics of vegetables (onions and garlic) and fruits (dates and figs). The vegetables and fruits of both types were dried by the two methods. In comparative to the fresh sample, the dried samples showed a highly significant (P< 0.01) difference was observed in moisture between fresh and dried vegetables and fruits. The oven dried samples had the lowest moisture. In contrast, protein, ash, crude fat, fiber and carbohydrates of fresh samples exhibit the least among the three samples in each type of vegetables and fruits. Also, the results showed a highly significant (P<0.01) difference between fresh, sun and oven dried date in potassium and slightly significant (P<0.05) in fig but no significant difference in garlic and date regarding potassium. Sodium content recorded highly significant difference (P<0.01) between the three crops (onion, date and fig) except garlic. Also, iron content the highest value revolved significant only in the oven drying. There was generally significant (P<0.01) difference between the three types in each vegetables and fruit in phosphorous. Physical evaluation showed significant differences among sun and oven drying in all samples except in onion. In this study observed the oven dried vegetables and fruits were rated lowest by the panelists in all the sensory attributes and overall acceptability. However, there was significantly difference (P<0.05 and P<0.01) between the sun and oven drying from the fresh vegetables and fruits in all the sensory attributes. Sun and oven drying have a significant effect on water absorption capacities (WAC) of dried samples except the fig. The highest value of oil absorption capacities (OAC) and swelling capacity was noticed in oven dried samples followed by the sun dried samples. All sun dried samples have low foaming properties compared with oven dried samples. The drying techniques did not significantly (P>0.05) affect the bulk density of drying samples. Dried vegetables and fruits showed low emulsion properties in which oven drying slightly improved the emulsion activity and emulsion stability over sun drying. Sun drying samples formed gel quickly at low concentration while oven dried samples formed gel at high concentration. The highest gelatinization temperature was observed for oven dried samples and the lowest for sun dried samples.

Key words: sun and oven drying, quality characteristics, WAC, OAC.

INTRODUCTION

Among the many methods used to preserve food, drying technique is an early technique but it is still very much used nowadays. Drying is particularly appropriate for developing countries (Rwubatse et al., 2014). Also, drying technique affect on other properties as aroma, flavor, tasty of food, hardness, viscosity, microbial spoilage and activity of enzymes (Caparino et al., 2012). It is a process through which water is removed from food by circling hot air through it, thus reducing the water available for reduction reactions of chemical, microbial enzymatic or nature (Muliterno et al., 2017). Dried foods are tasty, nutritious, lightweight, easy-to-prepare, and easy-to-store and it will be use (Guine, 2010). Drying methods are commercially accepted and economic of the raw and intermediate vegetables and fruits to preserve by reducing the bulk weight. Vegetables and fruits dried are high in fiber and carbohydrates and low in fat, making them healthy food choices for the diet (Naseer et al., 2013).

In the sun drying, the fruits are safe to dry due to their high sugar and acid content. A minimum temperature of 86° F is needed with higher temperatures being better. It takes many days to dry foods out-of-doors. Vegetables and fruits dried in the sun are placed on trays made of screen or wooden dowels. Also, an oven is ideal for drying of fruit and vegetables for preserving excess produce. By aggregation the factors of heat, air flow and low humidity, an oven can be used as a dehydrator (Raquel, 2018).

Onion (*Allium cepa L.*) is very important plant crops grown all over the world. Among the plant crops listed by FAO, onions are second in terms of annual world production. The bulb of onion is rich in minerals, protein, and ascorbic acid. The onion bulb is now part of the daily diet throughout the year (Endalew et al., 2014). The moisture content in onions are dried for about 86% (wb) to 7% (wb) or less for effective storage and treatment. Dried onion in the form of powder or slices in expanded demand in many parts of the world (Vidyavati et al., 2010). Fresh and dried onions are important parts of the human diet because they contain large amounts of non-essential micronutrients called phytochemicals (Sharma et al., 2015). Dried onion is used as a food

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compenents in many formulation of food such as soups, sauces, salads, sausages and other appropriate foods (Kaymak-Ertekin and Gedik, 2005).

Garlic (*Allium sativum L.*) is a herbal plant, that has been used all over the world as flavoring agent, spices and herbal remedies (FAOSTAT, 2015). Garlic considers one of the best preventive foods for diseases, depending on the therapeutic effects (Sobenin et al., 2010). These medical properties in garlic are mainly attributed to the chemical composition, and more specifically with its content of phenolic and sulfur-containing compounds (Calın-Sanchez et al., 2013). This due to the probability benefits of garlic in preventing and therapeutic medicine (Spyridon et al., 2018).

Dates fruits are used as staple food in the Middle East for thousands of years. Dates are rich in carbohydrates, consisting of 70±80% glucose and fructose. Date also contains fiber, vitamins and minerals (Sultana et al., 2015). Several beneficial health effects have been linked to date fruit, including antioxidant, anti-inflammatory activity, and anti-mutagenic, and protect the gastric mucosa against the harmful effects of gastric acid. This effect was found by phenol compounds found inside the fruit (Arshad et al., 2014). Dried fruits are rich in iron and fibre in the diet. The current recommendation from NHS England is to consume dried fruit with a meal and never as a snack due to its 'sticky' nature (Sadler, 2016).

Fig (*Ficus carica L.*), is one of the oldest cultivated fruit trees and an important crop in over the world for consumption fresh or dry (Veberic et al., 2008). Figs are rich source of amino acids. They are also free of fat and cholesterol (Oliveira et al., 2010). Fresh and dried figs are particularly rich in fiber, minerals, antioxidant polyphenols, proteins, sugars, organic acids, and volatile compounds that provide a pleasant characteristic aroma. Dried figs can be stored for 6-8 months (Annavarapu, 2018). The exposure to the sun directly destroys the color, vitamins, and oven-dried flavor. Therefore, mechanical drying of air is important because of its many advantages over sun-drying like the sanitary conditions, due to the low pollution from dust and other foreign matter, drying parameters can be controlled, and dehydration is not conditioned by rain or weather changes (Chimi et al., 2008).

However, there is no comparison in quality characteristics between fresh and dried vegetables and fruits. Fresh vegetables and fruits are not available throughout year. Many consumers often choose dried vegetables and fruits instead. Therefore, the objectives of this study were determination and compared the physicochemical, functional and nutritional composition of fresh and (sun and oven) dried onions; garlic, dates and figs. Hence the proximate composition, functional characteristics such as water and oil absorption capacity, foaming properties, swelling power and bulk density of fresh and dried vegetables and fruits were analyzed.

MATERIALS AND METHODS

Materials and samples preparation

From a local market in Assuit raw vegetables (yellow onions, garlics), and fruits (yellow dates and figs) without any physical damage were purchased as samples. Onion and garlic were peeled manually and then all samples were cleaned under running tap water, cut into thin slices of (3 and 7 mm in thickness), followed by drying at room temperature for 5-6 hours to remove all of the remaining water. Then, every type of vegetables and fruits samples was divided into three portions: one portion was used as fresh sample, another portion was sun dried (35± 2ºC) to constant weight (48h) (Peter and John, 2012) except figs (5 days) (Ana et al., 2011) and the third portion was dried in the oven at 60 ± 1ºC 7-10 hours and relative air humidity ranged from about 40% (initially) and 10% (at the end) (Saadeddine et al., 2013) except figs 62-64 ºC (Ana et al., 2011) depending on the quantity until reaching a safe moisture level (Bharathkumar et al., 2018). The dried samples were milled in an attrition mill and sieved through 0.2 mm mesh sieve. The samples in powder form were packed in high density polyethylene bags in dark, and stored in a freezer at -20°C until analyzing for functional and nutritional properties. All drying experiments were performed in triplicate.

Proximate composition of fresh and dried samples

Proximate analysis was done on fresh and dried samples. Moisture, crude protein, ash, crude fat and crude fiber were determined according to (AOAC, 2000). These analyzes were estimated in the Central Laboratory for Chemical Analysis, Faculty of Agriculture, Assiut University. Percentage of carbohydrate content was determined by the following formula: % Carbohydrate=100− (moisture% ash + % fat + % protein + % fiber content) and the energy values were evaluated using following formula. Energy value (Kcal/100g) = (2.62 × % protein) + (8.37 × % fat) + (4.2 × % carbohydrate) (Crisan and Sands, 1978).

Minerals determination of fresh and dried samples

Potassium and sodium were estimated as described by (AOAC, 2010) method by a flame photometer. The other minerals were determined according to (Isaac and Johnson, 1985). These analyzes were estimated in Central Laboratory for Chemical Analysis, Faculty of Agriculture, Assiut University.

Physical evaluation of fresh and dried samples

Dried samples recovery (%)

The weight of fresh samples before drying and the weight at the end of drying from each treatment were noted and dried recovery was calculated using the formula:

$$\text{Dried recovery (\%)} = \frac{W_2}{W_1} \times 100$$

Where, W_2: Weight of dried samples (g), W_1: Weight of fresh samples (g) (Bharathkumar et al., 2018).

Time taken (hours)

The total time taken by the dried samples for reaching a safe moisture level of 12-17% was recorded in hours (Bharathkumar et al., 2018).

Sensory evaluation

The fresh and dried samples were evaluated for skin color, taste, texture, flavor, chewing ability, aroma and overall acceptability. A committee of trained panel consisting of 20 faculty members and non-members of the Department of Home Economics, Faculty of Specific Education, at Assiut University were asked to evaluate the samples. The samples were classified on a 9 point Hedonic scale according to Stone and Sidel (1992). The evaluation was performed in a sensory laboratory under white light. Clean water was provided for the judges to rinse their mouths among samples.

Functional properties of the dried samples flour

Water and oil absorption capacities (%)

Water and oil absorption capacities of the dried samples were estimated (Chandra and Samsher, 2013) and calculated using the equations:

$$\text{WAC \%} = \frac{\text{Weight of absorbed water}}{\text{Weight of flour}} \times 100$$

$$\text{OAC \%} = \frac{\text{Weight of absorbed oil}}{\text{Weight of flour}} \times 100$$

Swelling index and solubility (%)

The method of Abbey and Ibeh, (1998) was employed for the determination of the swelling indices of the flour samples. Put the sample in graduated cylinder and fill to 10 ml mark. Then, add distilled water to give 50 ml for a total volume. The upper part of the graduated cylinder was tightly covered and mixed by turning the cylinder. The suspension was reversed again after 2 min and left for another 8 min to stand and the volume occupied by the sample was taken after the 8th min.

Water solubility capacity for the samples was determined by the method of Aoki et al., (1981). Dried samples (2.5 g each) were distributed in 30 ml of distilled water, using a glass rod, and cooked in a water bath for 15 min at 90°C. Then cooled it to the room temperature and transferred to the centrifuge tubes, then centrifuged for 10 min at 3000xg. The supernatant was decanted to estimate its solid content in a vaporized saucer and the sediment was weighed. The weight of dry solids was recovered by evaporation of the supernatant at 110°C all night.

Foaming capacity (FC) and foam stability (FS) (%)

The foaming capacity of the dried samples was estimated and calculated using the equation:

$$\text{FC (\%)} = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{Volume of foam BW}} \times 100$$

Where, AW = after whipping, BW = before whipping. Two grams of dried samples were added to 50ml distilled water at 30± 2°C in a 100ml graduated cylinder. The mixture was shaken for 5 min for the foam. The volume of foam was expressed as FC at 30 seconds after whipping. The volume of foam was recorded one hour after whipping to determine FS as percent of the initial foam volume (Chandra et al., 2015).

Bulk density (g/mL)

Bulk density was determined according to the method of Yellavila et al., (2015). A 10 gram sample was put into a measuring cylinder (100 ml). The cylinder was tapped many times on a wooden plank to constant volume. The packed bulk density (g/ml) was calculated as weight of flour (g) per unit volume (ml).

Emulsion activity and stability (EA, ES) (%)

Emulsion activity and emulsion stability were estimated by the method of Okaka and Potter (1977). The emulsion (one g dried samples, 10ml distilled water and 10ml refined soybean oil) was prepared in calibrated centrifuged tube. Then centrifuged the emulsion for 5 min at 2000 ×g. The ratio of the height of the emulsion layer was calculated to the height of the liquid layer as the emulsion activity expressed in percentage. Stabilization of the emulsion was determined after heating the emulsifier in the standard centrifuge tube in a water bath for 30 min at 80°C, cooling for 15 minutes under tap water and centrifuging in a centrifuge for 15 min at 2000 xg. The stability of the emulsion, expressed as a percentage, was calculated as the ratio of the height of the emulsified layer to the height of the liquid layer.

Least gelation concentration (LGC, %) andgelatinization temperature (GT, °C)

The least gelation concentration was estimated as described by Sathe and Salunkle (1981). Dried sample dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20% (w/v) were prepared in 5ml of distilled water in test tubes and heated for one hour in water bath at 100°C. The heated dispersions were cooled rapidly under tap water and then at 10± 2°C for two hours in a refrigerator. The least concentration of gel was estimated as that concentration when it did not slip. The temperature of the gelatin was determined as outlined by Shinde (2001). One g of dried sample was weighed in a 20 ml screw tube. Ten ml of water was added per sample. The samples were heated in a water bath until the gel was formed. At complete gel formation, the relative temperature was measured and taken as gelatin temperature.

Statistical analysis

Data were analyzed using analysis of variance (ANOVA) procedure (Steel and Torrie, 1980). Means where significant were separated by the least significant difference (LSD) test. Significance was accepted of P <0.05. Analysis was carried out in three replicates.

RESULTS AND DISCUSSION

The fresh and drying samples appeared as shown in Figure 1.

The chemical composition of fresh samples and dried samples prepared by sun and oven drying are tabulated in Table 1. Highly significant (P< 0.01) difference could be traced in moisture content between fresh and dried samples. The oven dried samples had lower moisture content than the sun dried samples, probably due to the high temperature of oven dryer at a moderately short time compared to sun drying (Fana et al., 2015). The drying increased the dry matter content of fresh vegetables and fruits. Sun and oven-dried sample exhibited low moisture content being less than that for fresh samples. Results obtained in the current study agree with the recommended moisture contents for onion (Jurgiel et al., 2015), garlic (Spyridon et al., 2018), date (Sultana et al., 2015) and fig (Khan et al., 2011), but differ with (Reyhaneh, 2017) in garlic. Food products with high moisture content are susceptible to microbial attack as well as spoilage and therefore have limited shelf life (Muyanja et al., 2012). Hence the low moisture content of the dried samples indicates their stability against microbial attack and potential longer shelf life (Nishant and Neeraj, 2018). The protein content in fresh, sun and oven dried samples ranged from (16.75±0.04% to 52.50±0.05%) in onion, (16.04±0.04% to 34.01±0.04%) in garlic, (2.10±0.01% to 4.91±0.01%) in date and (4.60±0.01% to 8.42±0.012%) in fig. Highly significant (P< 0.01) difference was observed among these three samples in each type of vegetables and fruits. Fresh samples possessed significantly (P< 0.01) the least protein content among the three samples in each type of vegetables and fruits. The oven dried samples recorded the highest protein content (52.50±0.05%, 34.01±0.04%, 4.91±.012% and 8.42±.017%) in (onion, garlic, date and fig) respectively. This result can be explained by high water content in the food matrix, which decreased the nutrient concentration (Morris et al., 2004). It was obvious that sun drying reduced crude protein content compared to oven dried due to the protein denaturation and prolonged drying in uncontrolled environment (Olapade and Ogunade, 2014). Although dates and figs are not a good source of protein, it may contribute to the human diet with high quality of some essential amino acids (Sultana et al., 2015). The obtained data are in close agreement with those values reported by Gamal et al., (2009).

Ash content of a food product is an index to the nutritive value (mineral content, safety, and quality). The ash content in fresh samples was significantly (P<0.01) lower than those of sun and oven dried samples. In addition, the samples showed a significant increase in ash content after drying due to water removal, thereby increasing the nutrient concentration (Morris et al., 2004). Moreover, the increased ash content after drying can also be explained by the low volatility of minerals, which are not destroyed by heating. The ash content represents the total amount of minerals present in a food (Agoreyo et al., 2011). The ash content was highly significant (P<0.01) different among the three groups in each type of vegetables and fruits. It is very close to the study of (Jurgiel et al., 2015) in onion, (Spyridon et al., 2018) in garlic, (Sultana et al., 2015) in date and (Khan et al, 2011) in fig.

A highly significant (P<0.01) difference was detected between fresh samples and the sun and oven dried samples. The fresh vegetables and fruits samples recorded significantly (P<0.01) the least crude fat content (0.98±0.02 %, 0.25±0.01%, 0.45±0.01% and 0.36± 0.01%) in (onion, garlic, date and fig) respectively, whilst the oven dried sample recorded the highest crude fat content (3.01± 0.01%, 1.02± 0.01%, 0.98±0.01% and1.28±0.01%) in (onion, garlic, date and fig) respectively. The low crude fat content recorded for the fresh sample could be due to the high moisture of the fresh pulp. The fat content in food can be related to the oxidative rancidity, which may affect the storage life of food (Ojo et al., 2014).

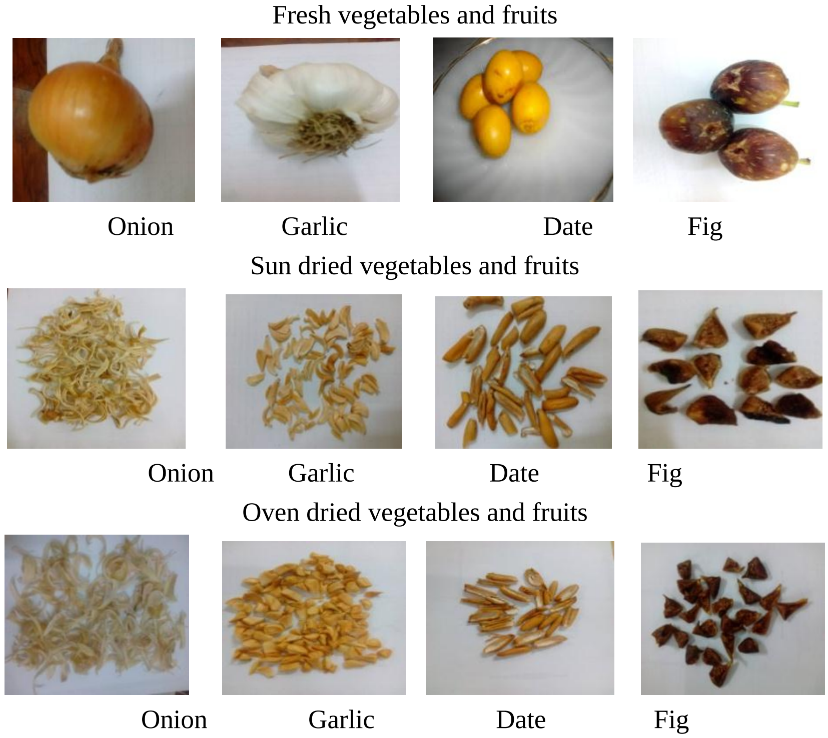

Figure 1.The fresh and dried samples

Table 1. Proximate compositions of fresh and dried samples (% on DWT)

Fresh and dried samples	Onion			Garlic			Date			Fig		
	Fresh	sun drying	oven drying	fresh	sun drying	oven drying	fresh	sun drying	oven drying	fresh	sun drying	oven drying
Moisture (%)	68.80± 0.01 ^{A}	8.02± 0.09 ^{B}	6.62± 0.02 ^{C}	42.38 ±0.65 ^{A}	16.69± 0.05^{B}	14.21± 0.58 ^{C}	13.40± 0.01^{A}	8.90± 0.02^{B}	6.03± 0.02^{C}	19.61± 0.01^{A}	6.96± 0.01^{B}	3.10± 0.02^{C}
Protein (%)	16.75± 0.04 ^{A}	49.0± 0.01 ^{B}	52.50± 0.05 ^{C}	16.04± 0.04 ^{A}	32.0± 0.03 ^{B}	34.01± 0.04^{C}	2.10± 0.01^{A}	3.98± 0.01^{B}	4.91± 0.01^{C}	4.60± 0.01^{A}	7.45± 0.02^{B}	8.42± 0.02^{C}
Ash (%)	1.53± 0.02 ^{A}	1.98± 0.01^{B}	2.09± 0.01 ^{C}	1.53± 0.02 ^{A}	0.99± 0.01^{B}	0.86± 0.01^{C}	2.14± 0.01^{A}	1.01± 0.02^{B}	1.96± 0.01^{C}	1.84± 0.02^{A}	5.69± 0.05 ^{B}	7.30± 0.05^{C}
Crude fat (%)	0.98± 0.02 ^{A}	2.09± 0.03^{B}	3.01± 0.01^{C}	0.25± 0.01^{A}	0.98± 0.01^{B}	1.02± 0.01^{C}	0.45± 0.01^{A}	0.78± 0.01^{B}	0.98± 0.01^{C}	0.36± 0.01^{A}	0.98± 0.01^{B}	1.28± 0.01^{C}
Crude fiber (%)	6.07± 0.01^{A}	12.0± 0.02^{B}	14.05± 0.01^{C}	22.10± 0.0^{A}	40.53± 0.02^{B}	42.07± 0.03^{C}	6.60± 0.01^{A}	10.9± 0.01^{B}	12.0± 0.01^{C}	2.68± 0.02 ^{A}	8.92± 0.01^{B}	9.21± 0.02^{C}
Carbohyd-rate (%)	23.30± 0.0^{A}	28.3± 0.09^{B}	34.84± 0.06^{C}	18.42± 0.83^{A}	25.50± 0.11^{B}	22.04± 0.09^{C}	76.68±0 .07 ^{A}	83.32±0 .04^{B}	80.1±0. 04^{C}	70.77±0 .06^{A}	76.9± 0.08^{B}	73.7± 0.09^{C}
Energy (kcal/100g)	264.80± 0.89 ^{A}	281.8± 0.12^{B}	292.23± 0.01^{C}	153.94± 4.29 ^{A}	199.14± 0.14^{B}	190.21± 0.21^{C}	332.78± 0.35^{A}	366.9±0 .10^{B}	357.6±0 .07^{C}	315.99± 0.1^{A}	350.95±0. 25 ^{B}	342.6±0. 27 ^{C}
Total Solids	31.2± 0.01^{A}	91.9± 0.0 ^{B}	93.38± 0.02^{C}	57.62± 0.65 ^{A}	83.31± 0.05 ^{B}	85.79± 0.58 ^{C}	86.60± 0.01 ^{A}	91.10± 0.02^{B}	93.97± 0.02^{C}	80.39± 0.01^{A}	93.04± 0.01^{B}	94.90± 0.02^{C}

* Dwt basis= dry weight basis. ** TC= Total carbohydrate was calculated by difference.

In each raw different Latin letters mean significant differences between samples ($p < 0.05$).
P .values < 0.05 were considered significant. P. values < 0.01 were considered highly significant

The low fat content of the samples indicates their stability against rancidity *via* lipolytic reactions hence enhanced shelf stability (Nishant and Neeraj, 2018). Numerous studies have shown that sun dried root and tuber crops had high fat than other drying methods (Ngozi et al., 2013). Fat contributes to the total energy content of a food product. Hence its value is important in estimating the caloric value of a food product (Nishant and Neeraj, 2018).

Human dietary fiber comes from plant sources, such as vegetables and fruits. A highly significant ($P<0.01$) difference in crude fiber content was observed among fresh samples, dried samples by sun, and dried samples by oven, with the fresh samples containing the lowest fiber content, and oven samples showed the highest fiber content. These values are similar to those previously reported by Jurgiel et al., (2015) in onion, Spyridon et al., (2018) in garlic, Sultana et al., (2015) in date and Khan et al., (2011) in fig. Dietary fiber is good for preventing or controlling diabetes, heart diseases and obesity (Ojo et al., 2014). Dietary fiber also gives a feeling of satiety; therefore, the plant foods could be applied in the production of lower glycaemic index foods for Type-II diabetics (Mohammed et al., 2011).

The carbohydrates are higher in dried samples than the fresh vegetables and fruits (Table 1). Also, the oven-dried samples recorded the highest value whilst the sun dried samples recorded the least available carbohydrate value. The higher carbohydrate content pointing to the dried samples are a good source of energy for the body. Hence, dieticians could recommend the application of the dried food in energy foods. Carbohydrates also play a role in the functional properties of the dried food by associating with water molecules *via* hydrogen bonding which results in water absorption and swelling. Hence the dried food could serve as humectants and thickeners in food products (Sultana et al., 2015).

The value of food energy measures its value to the body as a fuel and it measures the inherent chemical energy in the organic compounds of foods their carbohydrate, protein, and fat components, as well as secondary constituents such as organic acids. The energy contents were found in the range of 153.94±4.289 kcal/100g in fresh garlic to 357.65±.07 kcal/100g in oven dried dates. Dates are a rich source of energy (Fouteye et al., 2014). The chemical properties of date are important in the grading, preservation, storage and processing of dates. Differences in the content of energy are result of the differences in protein content, carbohydrate, and fat content (Raquel, 2018).

Mineral composition of fresh and (sun and oven) dried samples are shown in Table 2. There was highly significant difference ($P<0.01$) among fresh, sun and oven dried date in potassium and differed significantly ($P<0.05$) in fig but no significant difference in garlic and date could be trace for potassium. These values agree with (Jurgiel et al., 2015) in onion but higher than those reported by (Bello et al., 2013). Also, potassium was significantly high in dates. This value was nearly with Sultana et al., (2015). Potassium is nutritionally important in the pH regulation in the body, maintenance of cellular water balance, and it is also linked to metabolism of protein and carbohydrate. A diet rich in potassium seems to lower blood pressure, getting enough potassium from diet may benefit bones (Onibon et al., 2007).

Both of the sun and oven drying concentrated the levels of these minerals (Na, Ca, Fe and Mn) except garlic in (Fe) the dried samples, with oven drying exerting greater effect. There are highly significant ($P<0.01$) difference between three groups in (onion, date and fig). Sodium was the highest in oven drying. It is suggested that the sodium amount in the diet should be limited because sodium helps to increase blood pressure and tendency to retain fluids. Also, Onimawo and Akubor, (2012) recommended an average daily intake of less than 200 mg per day. Overall analysis of minerals revealed that dates were relatively rich in potassium and low in sodium was also found by Agboola and his group (Ekpo and Ugbenyen, 2011) especially in oven drying. This low sodium: potassium ratio made the date a desirable food for persons suffering from hypertention (Oboh and Omofoma, 2008). Potassium, a nutrient that is great in the maintenance of a healthy and balancing of nervous system and in balancing the body’s nervous system.

Calcium and iron were significantly highest in the oven drying followed by the sun drying and least in the fresh vegetables and fruits. Calcium is the main component of bone and helps in teeth development. Present findings regarding iron content are the highest in the oven drying. Iron is the constituents of hemoglobin which is used in respiratory processes; incorporation of this part in food ingredients could assist in prevention of iron deficiency anemia (Bello et al., 2015).

Manganese, an essential element for hemoglobin formation (Shovon et al., 2013). Zinc which plays a vital role in the proper functioning of the reproductive system and nucleic acid metabolism. Zn is also beneficial as a membrane stabilizer and a stimulator of the immune response (Hambidge, 2006).

There was generally significant difference ($P<0.01$) between the three types in each vegetables and fruit in phosphorous. Present findings regarding phosphorous content are lower than the recommended daily intake. The recommended daily allowance for both men and woman is 700mg, which means that one has to take in much of these dried food in order to achieve this value for the proper functioning of the body hence there is the need to complement these dried samples with phosphorous rich sources. Phosphorous helps build and protect bones and teeth, as part of DNA and RNA, helps convert food into energy (Kathirvel and Kumudha, 2011). The values of the aforementioned minerals are nearly similar to those previously reported by (Jurgiel et al., 2015 and Shovon et al., 2013) in onions, (Spyridon et al., 2018) in garlic, (Sultana et al., 2015; El-Sohaimy and Hafez, 2010) in date and (Khan et al., 2011) in fig.

The data in Table 3 reveal on dried vegetables and fruits recovery significant ($P<0.01$) differences among sun and oven drying in all samples except onion. Similar results obtained by Bharathkumar et al., (2018). Oven drying has a positive influence on the drying time of vegetables and fruits dried samples. Significantly lowest time taken for oven drying was recorded in garlic and date. This might be due to lowest cut surface. Similar results obtained by Borah et al. (2015).

The sensory properties of fresh and (sun and oven) dried vegetables and fruits are presented in Table 4. The oven dried vegetables and fruits were rated as the lowest by the panelists all the sensory attributes and overall acceptability. The scores for all the sensory attributes of the samples decreased steadily with drying of fresh samples. This may be due to the effect of heat. However, there was significantly ($P<0.05$ and $P<0.01$) difference between the sun and oven drying from the fresh vegetables and fruits in all the sensory attributes including over all acceptability. Similarly, scores for all the attributes also decreased with the level of oven dried samples.

Table 2. Minerals determination of fresh and dried samples (mg %)

Fresh and dried samples	Onion			Garlic			Date			Fig		
	Fresh	sun drying	oven drying	fresh	sun drying	oven drying	fresh	sun drying	oven drying	fresh	sun drying	oven drying
Potassium (K)	12.98± 0.046 ^{A}	18.05±0 .6^{B}	22.4± 0.58 ^{C}	446.± 27.14 ^{A}	502.± 19.63 ^{A}	508.01± 8.48 ^{A}	678.0± 24.25 ^{A}	694.0±2 4.83 ^{A}	700.0±1 9.63 ^{A}	314.0± 8.14 ^{A}	460.2±8 .78 ^{B}	582.43± 6.96 ^{B}
Sodium (Na)	26.34± 0.58 ^{A}	31.24±0.! 2^{B}	35.9± 0.23^{C}	35.0± 2.02 ^{A}	39.1± 1.44 ^{A}	40.2± 1.33 ^{A}	1.01± 0.01 ^{A}	2.03± 0.02 ^{B}	4.01± 0.01 ^{C}	16.2± 0.58 ^{A}	20.1± 0.29 ^{B}	23.2± 0.40 ^{C}
Calcium (Ca)	25.22± 0.029 ^{A}	29.9± 0.231^{B}	33.89± 0.58^{C}	221.0± 33.49 ^{A}	238.0± 22.52 ^{A}	242.0± 23.67 ^{A}	47.02± 0.59 ^{A}	52.0± 1.16 ^{B}	57.01± 0.62 ^{C}	83.2± 0.6 ^{A}	94.2± 0.59 ^{B}	102.1± 0.52 ^{C}
Iron (Fe)	1.05± 0.00 ^{A}	3.51± 0.058 ^{B}	5.42± 0.01^{C}	3.45± 0.21 ^{A}	4.9± 0.15 ^{B}	5.05± 0.012 ^{B}	1.09± 0.01 ^{A}	2.91± 0.023 ^{B}	3.21± 0.023 ^{C}	2.6± 0.1 ^{A}	3.9± 0.01 ^{B}	5.2± 0.01 ^{C}
Manganese (Mn)	3.04± 0.012 ^{A}	5.28± 0.058 ^{B}	7.98± 0.17^{C}	364.0± 25.98 ^{A}	364.± 25.98 ^{A}	389.0± 24.83 ^{A}	1.02± 0.17 ^{A}	2.5± 0.02 ^{B}	3.7± 0.23 ^{C}	21.9± 0.59 ^{A}	28.9± 0.58 ^{B}	33.2± 0.87 ^{C}
Zinc (Zn)	-	-	-	17.5± 0.69 ^{A}	19.3± 0.81^{B}	21.4± 0.69 ^{B}	0.73± 0.00 ^{A}	1.4± 0.01 ^{B}	2.9± 0.05 ^{C}	0.16± 0.00 ^{A}	1.01± 0.01^{B}	2.1± 0.01 ^{C}
Phosphor (P)	30.3± 0.62 ^{A}	30.35±0 .619 ^{A}	38.1± 0.62^{B}	135.0± 18.8 ^{A}	142.0±1 7.90 ^{A}	150.0±1 6.74 ^{A}	55.0± 0.2 ^{A}	62.1± 0.59 ^{B}	66.5± 0.6 ^{C}	29.9± 0.59 ^{A}	35.0± 0.58 ^{B}	42.7± 1.16 ^{C}

Mean in a row for each crop having different letters are significantly different at ($P<0.01$)

Table 3. Physical evaluation of dried samples

Dried samples	Onion		Garlic		Date		Fig	
	sun drying	**oven drying**	**sun drying**	**oven drying**	**sun drying**	**oven drying**	**sun drying**	**oven drying**
Dried samples recovery (%)	15.04± 0.58 ^{A}	15.73± 0.35^{A}	38.28± 0.21^{A}	33.32± 0.24^{B}	47.61± 0.32^{A}	45.46± 0.28^{B}	20.47± 0.24^{A}	22.29±0 .15^{B}
Time taken (hours)	19.2± 0.21^{A}	18.49± 0.27^{A}	14.69± 0.25^{A}	12.59± 0.28^{B}	3.68± 0.08^{A}	2.53± 0.26^{B}	2.74± 0.13^{A}	2.4± 0.16^{A}

Mean in a row for each crop having different letters are significantly different at ($P<0.01$)

The extent to which changes take place in fruits during heat treatment depends upon the type and quality of the fruit and the condition of processing (Odim, 2002). The sun and oven drying of the vegetables and fruits was prolonged. The sun and oven drying may be caused loss of color of the flour. This led to the low appreciation of the color and flavor attributes of the sun and oven dried samples. These results agree with Peter and John, (2012). Also, the low scores of sensory attributes for vegetables and fruits dried may be due to fats and oils are important in food systems since they contribute to the organoleptic properties (mouthfeel, aroma, appearance) of food products (Borja et al., 2013).

Enzymatic browning is one of the important browning reactions in fruits and vegetables during thermal processing and that includes drying. Heat originates losses in volatile components from the food, according to the processing temperature, the vapor pressure of the volatile substances, their solubility in water vapor and the concentration of solids in the food (Guine, 2015). The dehydration temperature and rate have great affect on the food texture and, generally, the fast processes and high temperatures cause many changes. The water that migrates to the surface carries solutes from the food, originating tensions in the structure, variable according to the type of food, its composition. The drying may cause physico-chemical alterations on the surface of the foods (Guine, 2015; Zielinska and Michalska, 2016).

The functional properties of the dried vegetables and fruits are shown in Table 5. Sun and oven drying have a significant effect on water absorption capacity of dried samples with fig being exception. Dried vegetables and fruits possessed higher ability to absorb and retain water than oil. The water absorption capacity of the oven dried samples was higher than that of the sun dried. The hydrophilic constituents such as carbohydrate and crude fiber in the samples may have contributed to the high water absorption capacity. Water absorption capacity of samples is dependent mainly on the amount and nature of the hydrophilic constituents and to some extent on pH and nature of protein (Peter and John, 2012). The fiber in the dried samples might have been responsible for the high water absorption capacity of the dried samples (Rwubatse et al., 2014). The sun dried samples had the low water absorption capacity may be due to low amount of fiber it contained. The oven dried samples had the highest water absorption capacity may be due to high amount of fiber Table 1. The highest WAC of dried samples could be due to presence high amounts of fiber and carbohydrates in them (Suresh and Samsher, 2013). Dried samples with high (WAC) can be recommended as a humectants in food products (Dossou et al., 2014).

The highest value of (OAC) was observed for oven dried samples followed by the sun dried samples. The (OAC) of dried samples may have been contributed by fiber they contained as discussed for (WAC). In addition to fiber content, the oven dried samples had higher (OAC) than the sun dried samples probably due to their higher bulk densities (Rwubatse et al., 2014). The (OAC) of food ingredients could be used as a measure of the dried samples. It is also a measure of the amount of oil absorbed by the food material during cooking (Adebowale et al., 2011). Data presented have suggest that oven and sun dried samples would be useful in foods such as bakery products which require hydration to improve handling characteristics. The (OAC) of dried samples is important because of improving the mouth feel and retaining the foods flavor. The (OAC) is useful in sausages and bakery products, suggesting that the dried samples would be useful in this regards (Akubor and Eze, 2012).

The swelling capacity value was found highest for oven dried samples followed by sun drying samples. The swelling capacity of drying samples flours depends on the temperature, particles size, water availability , starch species , range of starch damage due to mechanical and thermal processes and other carbohydrate and protein (Yellavila et al., (2015); Suresh and Samsher, (2013). The proteins and carbohydrates associate with water molecules *via* the formation of hydrophilic bonds (Dossou et al., 2014). The high swelling powers of the drying samples could be attributed to their relatively high carbohydrate and crude fiber content which have the ability to absorb water molecules and swell. The presence of strong attractive forces within the structures of these molecules results in swelling as water is absorbed leading to an increased viscosity of the medium. Dried samples with high swelling capacity as well as water absorption capacity are recommended as functional ingredients in the production of viscous foods like baked products, dough, pasta and food gels (Dossou et al., 2014).

All sun drying samples have low foaming properties compared with oven drying samples, probably due to the high carbohydrate and low protein contents of drying samples. (Peter and John, 2012) reported that the foaming capacity of cowpea flour was influenced by the amount of the protein in the flour which keeps the bubbles of air in suspended and slows down the coalescence rate (Moses et al., 2012). Good foam ability is linked with flexible protein molecule that can decrease tension of surface. Foaming capacity is important for assessing the suitability of incorporating a food ingredient into a food system. Food products such as cakes, sponges, ice creams, sausages, mayonnaise, salad dressing, and bread require food ingredients with high foaming capacity (Atuonwu and Akobundu, 2010).

Table 4. Sensory evaluation of fresh and dried samples

Fresh and dried samples	Onion			Garlic			Date			Fig		
	fresh	sun drying	oven drying	Fresh	sun drying	oven drying	Fresh	sun drying	oven drying	fresh	sun drying	oven drying
Taste	8.2± 0.06^{A}	7.7± 0.06^{B}	7.6± 0.25^{B}	7.6± 0.06^{A}	6.9± 0.06^{B}	6.8± 0.06^{B}	8.6± 0.06^{A}	7.4± 0.06^{B}	7.3± 0.06^{B}	8.6± 0.06^{A}	7.9± 0.06^{B}	8.1± 0.06^{C}
Chewing ability	7.9± 0.06^{A}	6.4± 0.06^{B}	6.5± 0.06^{B}	7.3± 0.06 ^{A}	6.4± 0.06^{B}	6.6± 0.06^{C}	7.8± 0.06^{A}	7.2± 0.06^{B}	7.5± 0.06^{C}	7.1± 0.06^{A}	6.8± 0. 06^{B}	7.2± 0.06^{C}
Texture	8.0± 0.06^{A}	7.1± 0.06^{B}	7.2± 0 .06^{B}	7.9± 0.06^{A}	7.1± 0.06B	7.3± 0.06C	8.4± 0.06^{A}	7.9± 0.06^{B}	7.8± 0.06^{B}	8.4± 0.06^{A}	8.5± 0.06^{B}	7.5± 0.06^{B}
Aroma	8.7± 0.06^{A}	7.3± 0.06^{B}	7.5± 0.06^{C}	7.93±0.(9^{A}	7.6± 0.06^{B}	7.6± 0.06^{B}	5.9± 0.06^{A}	5.0± 0.06^{B}	4.9± 0.06^{B}	7.5± 0. 06^{A}	5.2± 0.06^{B}	5.0± 0.06^{C}
Color	8.6± 0.06^{A}	8.1± 0.06^{B}	8.2± 0.06^{B}	8.4± 0.06^{A}	7.6± 0. 06^{B}	7.8± 0.06^{C}	8.8± 0.06^{A}	6.9± 0.06^{B}	7.2± 0.06^{C}	8.6± 0.06^{A}	7.0± 0.06^{B}	7.2± 0.06^{C}
Appearance	8.8± 0.06^{A}	7.4± 0.06^{B}	7.2± 0.06^{C}	7.8± 0.06^{A}	7.43± 0.09^{B}	7.3± 0.06^{B}	8.5± 0.06^{A}	7.5± 0.06^{B}	8.13± 0.12^{C}	8.5± 0.06^{A}	7.5± 0.06^{B}	7.17± 0.09^{C}
Overall acceptability	8.6± 0.06^{A}	7.5± 0.06^{B}	7.3± 0.06^{C}	8.17±0.(9^{A}	7.4± 0.06^{B}	7.2± 0.06^{B}	8.47±0. 09^{A}	7.4± 0.06^{B}	7.66± 0.12^{B}	8.6± 0.06^{A}	7.73± 0.12^{B}	7.13± 0.12^{C}

Mean in a row for each crop having different letters are significantly different at (P<0.01)

Table 5. Functional properties of the dried vegetables and fruits flour

Dried samples	Onion		Garlic		Date		Fig	
	sun drying	oven drying	sun drying	oven drying	sun drying	oven drying	sun drying	oven drying
WAC (%)	162.8± 6.0 ^{A}	196.53± 8.26 ^{B}	124.0± 6.99 ^{A}	182.3±7 .1^{B}	68.14±5 .83^{A}	96.4± 6.45^{B}	56.51± 5.79 ^{A}	72.12± 6.47^{A}
OAC (%)	140.16± 6.47 ^{A}	163.7± 5.89 ^{A}	102.4±5 .83^{A}	151.1±5 .77 ^{B}	49.51±5 .66^{A}	83.5± 5.78^{B}	39.01± 5.72^{A}	55.14± 5.19^{A}
Swelling index (v/v)	1.98± 0.06 ^{A}	2.53± 0.01^{B}	3.04± 0.01^{A}	4.67± 0.01^{B}	1.15± 0.01^{A}	1.56± 0.01^{B}	0.99± 0. 01^{A}	1.04± 0.01^{B}
Solubility (%)	21.01± 0.02^{A}	23.02± 0.02^{B}	24.6± 0.03^{A}	25.71±0 .03^{B}	19.05±0 .03^{A}	19.97±0 .02^{B}	16.37± 0.02^{A}	18.71± 0.03^{B}
Foaming capacity (FC) (%)	40.0± 0.19^{A}	42.01± 0.25^{B}	35.01±0 .17^{A}	36.7± 0.19^{B}	9.01± 0.03^{A}	10.2± 0.01^{B}	11.29± 0.29^{A}	13.21± 0.29^{B}
Foam stability (FS) (%)	110.01± 0.59^{A}	111.2± 1.17^{A}	102.5±1 .17^{A}	103.01± .59^{A}	95.0± 0.09^{A}	97.21±0 .08^{B}	96.51± 0.09^{A}	98.62± 0.10^{B}
Bulk density (BD) (g/mL)	0.89± 0.03^{A}	0.97± 0.05^{A}	0.79± 0.03^{A}	0.81± 0.03^{A}	0.72± 0.05^{A}	0.79± 0.04^{A}	0.78± 0.05^{A}	0.80± 0.05^{A}
Emulsion activity (EA) (%)	65.17± 1.18^{A}	68.21± 1.17^{A}	55.75±0 .58^{A}	58.75±0 .59^{B}	9.71± 0.29^{A}	10.11±0 .40^{A}	14.62± 0.59^{A}	15.91± 0.59^{A}
Emulsion stability (ES) (%)	57.0± 2.32^{A}	59.66± 1.74^{A}	48.76±1 .36^{A}	51.39±1 .81^{A}	8.49± 0.40^{A}	8.84± 0.61^{A}	12.79± 0.82^{A}	13.92± 0.61^{A}
Least gelation concentration (LGC, %)	14.21± 0.02^{A}	15.4± 0.03^{B}	12.41±0 .29^{A}	13.61±0 .04^{B}	18.65±0 .04^{A}	19.12±0 .05^{B}	16.07± 0.04^{A}	17.2± 0.05^{B}
Gelatinization temperature (GT, °C)	66.71± 0.05^{A}	65.41± 0.02^{B}	62.41± 0.01^{A}	59.11± 0.02^{B}	73.42± 0.29^{A}	72.36± 0.14^{B}	63.17± 0.12^{A}	62.72± 0.09^{B}

Mean in a row for each crop having different letters are significantly different at (P<0.01)

However, food ingredients with low foaming capacity are suitably applied in biscuits, crackers, and cookies (Borja et al., 2013). Foam capacity and foam stability is a function of the type of protein, pH, viscosity, processing methods, and tension of surface (ADA, 2002). These results disagree with data published by Peter and John, (2012) but for sun and oven dried carrot flour and Akubor and Eze (2012) who reported that the foaming capacity of orange fruit peel flours decreased with an increase in the level of the oven, solar and sun dried orange fruit peel flours. This may be due to the low amount of protein in orange fruit peel flours when compared to that of wheat flour. Foaming capacity of a food material varies with the type of protein, solubility and other factors.

The drying techniques did not significantly (P>0.05) affect the bulk density of drying samples. However, the sun dried samples exhibited slightly lower bulk density than the oven dried samples because of the fast rate of oven drying. Also, this may be due to the difference of variety and temperature and drying method used (Fana et al., 2015). Bulk density is an indicator of the product porosity which affects package design and can be used to determine the type of material packing and handling in the food industry due to fast rate of oven drying (Peter and John, 2012). Also, bulk density depends on size of particle and initial moisture content of dried samples. The high bulk density of dried samples indicates its suitability for use in food preparations. The higher bulk densities in the oven dried samples are advantageous since larger flour quantities can be contained in smaller packages. A factor that contributes to variation in the bulk densities of dried samples has been observed to be particle size and shape (Appiah et al., 2011). The porosity of the dried samples also causes variation in bulk density where highly porous usually have lower bulk densities. But low bulk density is an advantage in the formulation of complementary foods (Suresh and Samsher, 2013). Bulk density is also related to the mouth feel and flavor of the food the dried samples is incorporated in (Onimawo and Akubor, 2012). The values in the present study are in agreement with values obtained for ackeearil flour and wheat flour (Dossou et al., 2014; Oppong et al., 2015).

Drying vegetables and fruits dried samples showed low emulsion properties in which oven drying slightly improved the emulsion activity and emulsion stability over sun drying. The emulsification efficiency of drying samples differs by type, solubility and concentration of the protein. There are no significant difference between sun and oven drying in emulsion activity. The low protein content and high carbohydrate contents of sun drying samples may result in the observed low emulsion properties of sun drying samples (Peter and John, 2012).

Sun drying samples formed gel quickly at low concentration while oven drying samples formed gel at high concentration. Differences in the least gelation concentration due to the relative proportions of different constituents such as protein, carbohydrate, fat in the orange fruit peel flours. The oven and sun dried vegetables and fruit would be useful in food systems which require thickening and gelling. The gel structure of such food systems provides a matrix for retaining moisture, fat and other added ingredients (Rwubatse et al., 2014). Carbohydrates gelatinization and swelling crude fiber may have occurred during the oven drying of vegetables and fruits, which increased the (WAC) of the dried samples over the oven dried samples. These results suggest that sun and oven dried samples uses in product of bakery because of hydration to improve handling characteristics is needed and in products as cakes, formations of minced meat and doughnuts (Peter and John, 2012). The temperature that glutted is known the gelatinization temperature. The highest gelatinization temperature was observed for oven drying samples and the lowest for sun drying samples. The study revealed that the oven dried samples which were higher in carbohydrate content exhibited the lowest temperature for gelatinization. These results agrees with Suresh and Samsher, (2013).

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الملخص العربي

محددات جودة بعض الخضروات والفواكه المحفوظة بطريقتي التجفيف الشمسي والفرن

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التجفيف هو واحد من أكثر التقنيات الملائمة لإنتاج المنتجات الغذائية الجاهزة التي تعد للعرض علي الأرفف. ومع ذلك ، غير أن التجفيف قد يؤدي إلى فقد كبير للمركبات النشطة بيولوجيا الموجودة بالأغذية. هذه الدراسة قدرت تأثير اثنين من طرق التجفيف وهما (التجفيف الشمسي والتجفيف بالفرن) على خصائص الجودة في الخضار مثل (البصل والثوم) والفاكهة مثل (البلح والتين). تم تجفيف الخضار والفاكهة من كلا النوعين بطريقتين مختلفتين. تم تحليل العينات الطازجة والمجففة من حيث التركيب الكيميائي، والتقييم الفيزيائي والحسي و(الخصائص الوظيفية ولكن فقط في العينات المجففة). بالمقارنة مع العينة الطازجة ، أظهرت العينات المجففة وجود فرق كبير بين الخضار والفواكه الطازجة والمجففة عند الدلالة (< ٠.٠١) في الرطوبة، حيث كانت العينات المجففة بالفرن محتوية على أقل رطوبة من العينات الطازجة والمجففة بالشمس. وعلي العكس ، في محتوي (البروتين ، الرماد ، الدهون الخام ، الألياف والكربوهيدرات) كانت العينات المجففة بالفرن الأعلي . كما أظهرت النتائج بالنسبة للبوتاسيوم في البلح والتين وجود فروق معنوية ذات دلالة عند (< ٠.٠٥ و < ٠.٠١) بين الطازج والمجفف بالشمس وبالفرن ولكن لم توجد فروق ذات دلالة بالنسبة للثوم والبلح في البوتاسيوم بين العينات الطازجة والمجففة. أما محتوي الصوديوم فقد سجل فروقاً ذات دلالة عالية عند (< ٠.٠١) بين العينات الثلاث في كل من (البصل والبلح والتين). أيضا كان محتوي الحديد الأعلي في التجفيف بالفرن. كذلك كانت هناك فروق ذات دلالة أحصائية عند (< ٠.٠١) بين العينات الثلاث لكل من الفواكه والخضروات موضع الدراسة في الفوسفور. أشارت النتائج الي وجود فروق معنوية بين التجفيف الشمسي وتجفيف الفرن في جميع العينات ماعدا البصل في التقييم الفيزيائي. أيضا لوحظ في التقييم الحسي أدني قبول للخضروات والفواكه المجففة بالفرن في جميع الصفات الحسية من قبل المقيمين. وكذلك كان هناك أختلافات ذات دلالة واضحة عند (< ٠.٠٥ و < ٠.٠١) بين الخضار والفواكه الطازجة وبين المجففة في جميع الصفات الحسية. أظهرت النتائج أيضا أن التجفيف الشمسي وبالفرن لهما تأثير واضح علي قدرة أمتصاص الماء للعينات المجففة ماعدا التين. أيضا سجلت أعلي قيم للقدرة علي أمتصاص الزيت والقدرة علي الأنتفاخ في العينات المجففة بالفرن يليها المجففة بالشمس. أتصفت جميع العينات المجففة بالشمس بخصائص رغوة ولكن أقل من العينات المجففة بالفرن. أيضا لوحظ أن طريقتي التجفيف لم تؤثرا بشكل كبير علي الكثافة الظاهرية للعينات.

أيضا سجلت عينات الخضروات والفواكه المجففة خواص مستحلب منخفضة في التجفيف بالفرن التي تحسنت تحسناً طفيفا في العينات المجففة بالشمس. العينات المجففة بالشمس كونت جلاً هلامياً بسرعة عند تركيز منخفض بينما العينات المجففة بالفرن تطلبت تركيزاً مرتفعاً. كذلك لوحظ أن أعلى درجة جيلاتينية كانت في العينات المجففة بالفرن أما أقلها فكانت للعينات المجففة بالشمس.

الكلمات المفتاحية: خصائص الجودة، التجفيف الشمسي وبالفرن، القدرة علي أمتصاص الماء، القدرة علي أمتصاص الزيت