# Chemical, Microbiological and Organoleptic Studies on Onion Slices Dehydrated by Steam and Microwave Techniques

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# Chemical, Microbiological and Organoleptic Studies on Onion Slices Dehydrated by Steam and Microwave Techniques

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**Abstract:** The objective of this analysis was to determine the effects of various dehydration technologies (steam and microwave) on the chemical, microbiological and organoleptic effects of onion slices (*Allium cepa* L.). Specimens for onion cutouts were dried by using a three-phase microwave power from 290 W to 800 W and a steam dehydration method from 4 hours in 3 parts (130 ºC/60 min, 100 ºC/60 min and 80 ºC/120 min) on the microwave floor. Dehydrated onion strips have decreased to a humidity value of 4.91 -5.78% equivalent to 86.14% of fresh onion pieces due to substantial moisture loss. Other nutrients such as crude fat , total protein, crude fiber , ash and carbohydrate contents of dehydrated onion slices have been concentrated. As a result, their nutritional values improved compared to fresh pieces of onion. The discrepancies between the chemical composition content of steam and microwave dried onion slices were not statistically important, but other variables like pungency and sugar levels as well as microbial parameters were significant ($p \leq 0.05$). In addition, the production power levels in the microwave oven used in the test did not impact the main components (total protein, crude fat , ash, crude fibre and carbohydrate) and other nutrients (vitamins, pungency and sugar) of the dried samples, but had a substantial impact on the organoleptic and microbial parameters. As regards the physical appearance, the dehydrated samples showed that microwave dehydrated slices at 480 W and 800 W had discolored to brownish tint, but the transition was slightly

more pronounced in the case of steam dehydrated and microwave dehydrated slices at 210 W. However, the steam-dehydrated slices were lighter in colour and appropriate in appearance. In conclusion, more research will be required on microwave food dehydration and the implementation of such technology in Egyptian factories to reduce the loss of water-soluble components during dehydration, minimize drying time and energy consumption, and have no significant effect on the sensory characteristics of dried onion slices.

**Keywords:** *Allium cepa*, steam dehydration; microwave, chemical composition, vitamins, pungency, physical appearance.

## Introduction

Onion (*Allium cepa* L.) refers to the *Lilliaceae* family and is cultivated all around the world. They are the second more horticultural vegetable after tomatoes (Griffiths et al., 2002 and Mogren *et al.*, 2007). It has been commonly used in old times as seasonings, food and medicinal uses. At present, onion is an essential vegetable to serve as ingredients in sauces, as toppings on burgers, as seasonings, as chip coatings, etc. (Sharma *et al.*, 2005). It has been appreciated by several cultures across the globe for their medicinal qualities. Numerous health benefits have been linked to vegetables, including cancer prevention and cardiovascular disease. Scientific studies have shown a positive association between the consumption of vegetables and the incidence of these common diseases. This led many researchers to test whether the suggested medicinal attributes of onions are accurate. Some of these studies have shown that having onion in the diet has been associated with reduced risk of stomach, brain and liver cancer, inhibited platelet-mediated thrombosis, reduced blood cholesterol levels, triglycerides and thromboxanes, and reduced symptoms associated with osteoporosis (Hertog *et al.*, 1995; Ali *et al.*, 1999; Geo *et al.*, 1999; Hu *et al.*, 1999 and Mahran *et al.*, 1999).

For all of these benefits and others, onion ranks third highest in production in the world among seven major vegetables, namely onion, garlic, cauliflower, green peas, cabbage, tomato

and green beans (Kumar and Tiwari, 2007).. The world production of onion was 64.48 million tonnes from 3.45 million ha area (FAO, 2009). In Egypt, onion is the third vegetable more consumed (15 kg per capita$^{-1}$.year$^{-1}$), after potato and tomatoes, and it is cultivated all over the country concentration in delta area and Upper Egypt (84.3 % of total area) and new land areas (15.7 %), being white (Giza-6) and red (Giza-20) onions the most produced varieties. The actual production area is about 122,552 Feddan, with a total capacity of 2.2 million metric tones (FAO , 2012). Depending on the physical and chemical properties, the red onion is predominant in the Egyptian diet, while the white onion is used for dehydration. Dehydrated production of onion has increased by at least 40% over the last 10 years, with current production at about 10,000 metric tones per year-1. Dry onions are a commodity of significant importance in world trade and are manufactured in many forms: ringed, flaked, minced, chopped and powdered. A significant part of the dehydrated onion production is used as seasoning in the production of catsup, chilli sauce and meat casserole as well as cold cuts, sauces, broth, mayonnaise, salad dressing, sweet pickles, dog food, potato chips, crackers and other snack products. Food service outlets often use dehydrated onion due to its simplicity in storage , preparation and use (Kumar *et al.*, 2006).

Among the different drying methods techniques followed worldwide for onion, mostly solar (Bhatnagar and Ali, 1989; Bennamoun and Belhamri, 2003; Sarsavadia, 2007), and hot air drying predominate (Sharma and Nath, 1991; Sarsavadia *et al.*, 1999 and Kaymak-Ertekin and Gedik, 2005) and steam dehydration (Anon, 1994). However, these methods demand long drying time, high energy and water consumption, and affected by daily fluctuation of weather, making it difficult to maintain the product moisture content and quality properly because of air borne dirt and dust (Lee *et al.*, 2006 and El-Beltagy *et al.*, 2007). Some other methods experimented recently are infrared drying, alone or as a multimode combination and osmotic dehydration (Sharma *et al.*, 2005; Pathare and Sharma, 2006 and Essohouna *et al.*, 2018).

A potentially useful technique called microwave drying is attempted to fight the adverse effects of these drying methods and to enhance both consistency and nutritional value. Microwave drying results in increased thermal efficiency, shorter drying period and better product goodness compared with traditional hot air drying. Microwave drying helps extract moisture from food items without the issue of case hardening (Prabhanjan *et al.*, 1995 and Muhammad *et al.*, 2016). Microwave drying thus results in higher drying rates compared to traditional methods, lower drying temperatures and an oxygen-deficient processing atmosphere (Ren and Chen, 1998 and Muhammad *et al.*, 2016).

The present study was aimed primarily to assess the applicability of microwave technology in dehydration and preservation of onion with better quality. In addition, comparative study between steam dehydration (mostly predominate in Egypt) and microwave dehydration process of onion regarding many biochemical, microbiological and quality aspects will be in the scope of this investigation.

## Materials and Methods

### Materials

Fresh onion samples (*A. cepa* L), variety Giza-6 were procured from a local market in Bani Mazar city, Minia Governorate, Egypt. All solvents, analytical grade, were purchased from Merck, Germany. Sugars and sodium pyruvate standards were purchased from Fluka Chemical Co., Switzerland, while vitamins standards from Sigma Chemical Co., St. Louis, Mo.

### Methods

### Drying of the onion slices

Steam oven drying: onion samples were drying in New Bani Suef Company for Preservation, Dehydration and Industrization of Vegetables, Bani Suef El-Goudida City, Nile east, Bani Suef, Egypt according to the following steps: peeling, selection, washing, cutting, slices washing, putting on dryer belt, dehydration for 4 hrs in three stages, 130 $^{0}$C, 100 $^{0}$C and 80 $^{o}$C.

Microwave furnace drying: a programmable household microwave oven (GOLDSTAR, MD El-535, USA) with a maximum output for 210, 480 and 800 watts ( W) was used for drying tests. The duration of the microwave cavity was 310 (L) x 300(W) x 200(H) mm. One dish (280 mm in diameter) containing 500 g of the onion sample after peeling, harvesting, washing, cutting and washing as follows in the steam oven drying process was put at the center of the turntable within the microwave cavity and processed until the slices were fully dried. The microwave oven was controlled by a control terminal capable of monitoring the amount of microwave power and the time of emission.

**Analytical instruments**

In the present research, the SP Thermo Separation Products Liquid Chromatograph (Thermo Separation Products, San Jose, CA, USA) was used with the Consta Metvic 4100 pump, the Spectra Series AS100, the Spectra System UV 1000 UV / Visible Spectrophotometer Detector, the Spectra System FL 3000 and the PC 1000 system programme. Columns used (Alltech, Baltimore, USA) were The column used was Adsorbosil C18 (5 µM, 100 mm × 4.6 mm I.d., Alltech USA) for vitamin C research. The columns used (Alltech, Deerfield, IL) were the reverse phase water Adsorbosil C18 (5 µmol / L, 100 mm × 4.6 mm internal diameter) for water soluble vitamins and the standard Ultrasphere Si (5 µmol / L, 250 mm × 4.6 mm internal diameter) for study of fat soluble vitamins.

Chemical composition of the material. Moisture, protein (T.N. × 6.25, micro-kjeldahl method using semi-automatic apparatus, Velp Scientifica Company, Italy), fat (Soxhelt semi-automatic apparatus, Velp Scientifica Company, model SER 148/3, Italy, petroleum ether solvent), fibre (automatic extractor, Velp Scientifica Company, model FIWE 6, Italy) and ash contents were determined using the methods listed in A.O.A.C. (1995). Carbohydrates measured on the basis of differences:

Carbohydrates (percent) = 100-(% moisture + % protein + % fat + % ash + % fiber).

***Vitamins:*** All water soluble vitamins ($B_1$, $B_2$, $B_6$, niacin, folate and C) and fat soluble vitamin (E) were extracted according to methods previously detailed by Hung *et al*., (1980), Epler *et al*., (1993), and Moeslinger *et al*., (1994) and were analyzed by HPLC techniques. For water soluble vitamins, the chromatographic conditions were as follows: flow rate, 1 mL/min; detection, UV absorption at 254 nm, volume of injection, 20 µL; temperature, room temperature, and mobile phase composition was an isocratic system of 100% methanol. For fat soluble vitamins the condition were: flow rate, 1.5 mL/min; detection, UV absorption at 265 nm, volume of injection, 20 µL; temperature, room temperature; and the mobile phase composition was an isocratic system of isopropanol:hexane (1:99). Retention times and absorbance ratio against those of standards were used to identify the separated vitamins. Quantitative determination of each vitamin was determined from its respective peak area and corresponding response factor. The percent recoveries of vitamins were also studied by adding each vitamin to onion extract after sample preparation and HPLC determination. Under such chromatographic conditions, mean values (±SD) of vitamins $B_1$, $B_2$, $B_6$, niacin, folate and C and E recoveries were 90.33±3.01, 87.23± 2.65, 86.43± 4.66, 79.55± 7.98, 81.88± 5.91, 92.22± 2.09, 89.90±4.08%, respectively.

***Pungency:*** The concentration of pyruvic acid was calculated using the Schwimmer and Weston (1961) methods. A representative sample (15 quarters, one of each bulb) of each cultivar was crushed in an electrical mincer, incubated with 2,4-dinitrophenylhydrazine, and read the spectrophotometer absorbance at 420 nm for the total pyruvate concentration measured against the typical sodium pyruvate curve.

***Sugars:*** To determine fructose, glucose and sucrose, 1 g of fresh onions was added to $CH_3CN/H_2O$ (4:1) up to 10 mL and homogenized in an Ultra Moulinex blender. After, the samples were centrifuged, filtered and analysed in HPLC according to Gennaro *et al*. (2002). The chromatographic conditions were flow rate, 4 ml/min; detection, RI, volume of injection, 20 µl;

temperature, room temperature, and mobile phase composition was an isocratic system of acetonitril : water (75:25).

**Microbiological examination**

***Total bacterial counts:*** Total bacterial counts of onion samples were determined by plating suitable dilution in duplicates using nutrient agar medium (Difco Manual 1966). This medium consists of 3 $g.l^{-1}$, beef extract, 5 $g.l^{-1}$ , bacto peptone, 5 $g.l^{-1}$, agar, 15 $g.l^{-1}$, sodium chloride and distilled water to 1000 ml, pH 7. Plates were incubated at 32ºC for 3 days before counting and recording the results.

***Mould and yeast:*** Potato dextrose agar recommended by the Oxoid Manual (1962) was used for the enumeration of mould and yeast's. This medium consists of 4 $g.l^{-1}$, Potatoes extract, 15 $g.l^{-1}$ , agar and distilled water to 1000 ml, pH 5.6. Plates were incubated at 20 – 25 º before counting.

***Coliform bacteria counts:*** The coliform bacteria counts in the examined onion samples were enumerated using the method described in the Standard Method for the Examination of Milk and Dairy Products (1960). Mackonky agar were prepared as described in Oxoid (1982). The following ingredients were used: 20$g.l^{-1}$, pepton, 5 $g.l^{-1}$ , bile salt, 5 $g.l^{-1}$, sodium chloride, 2.5 $g.l^{-1}$, Bromcresol purple, 15 $g.l^{-1}$, agar and distilled water to 1000 ml, pH 6.8. Plates were incubated at 37º C for 16 – 18 hours before counting.

**Organoleptic evaluation**

Sensory evaluation of color, aroma, taste, texture and overall acceptability was carried by aid of one ten panelists according to Molander, (1960). Scores for judging scale were as follows: very good (8-9, good (6-7), fair (4-5), poor (2-3) and very poor (0-1).

***Statistical analysis***

An analysis of variance was performed to compare differences between varieties using Student *t* test. The correlation

studies were performed by using MINITAB 12 computer program (Minitab Inc., State College, PA).

## Results and Discussion

### Chemical composition of fresh and dehydrated onion slices

The gross chemical composition of fresh and dehydrated onion slices was illustrated in Table (1). Moisture content of dehydrated onion slices were reduced to 4.91 -5.78% from 86.14% for fresh onion slices due to considerable loss in moisture content. Other nutrients such total protein, crude fat, ash, crude fiber and carbohydrate contents of the dehydrated onion slices got concentrated. Hence their nutritive values increased in comparison to the fresh onion slices. The differences between chemical composition contents of steam and microwave dried onion slices were non-statistically significant. The highest components values were determined in microwave dehydrated samples. Also, the levels of output power in microwave oven used in the assay did not significantly affect the components content of the dried samples.

Our previous data indicated that raw onion data slices have the following composition (g/100g) moisture 84.92, crude fat 1.77, ash 0.78, fiber 1.17, and carbohydrates 11.24 (Elhassaneen, 2006). The chemical composition of Póvoa white and Póvoa red onions (*Allium cepa* L.) were assessed by Rodrigues *et al*., (2003). Onions have higher water content that can interfere negatively with storage capacity. This variation between data in the present study and the other studies explained that the effect of regional varieties, environment and the genetic factors (Rodrigues *et al.*, 2003, Elhassaneen and Sanad, 2009 and Elhassaneen and Al-Abassy, 2012; and Essohouna *et al.*, 2018).

**Table 1.** Chemical composition (g/100g) of fresh and dehydrated onion slices

| Component | Fresh | Steam dehydration | Microwave dehydration | | |
|---|---|---|---|---|---|
| | | | 210 W | 480 W | 800 W |
| Moisture | 86.14 ± 1.11 [a] | 5.78 ± 0.9 [b] | 5.13 ± 1.03 [b] | 4.99 ± 1.08 [b] | 4.91 ± 0.98 [b] |
| Total protein (T.N × 6.25) | 1.93 ± 0.22 [b] | 12.98 ± 0.79 [a] | 13.52 ± 1.78 [a] | 14.16 ± 2.65 [a] | 14.43 ± 2.09 [a] |
| Crude fat (Pet. ether extract) | 0.19 ± 0.04 [b] | 1.31 ± 0.15 [a] | 1.41 ± 0.14 [a] | 1.47 ± 0.28 [a] | 1.52 ± 0.20 [a] |
| Ash | 0.92 ± 0.14 [b] | 8.30 ± 1.10 [a] | 9.08 ± 2.02 [a] | 8.91 ± 1.21 [a] | 8.87 ± 1.23 [a] |
| Crude fiber | 1.54 ± 0.12 [b] | 4.11 ± 1.05 [a] | 4.94 ± 0.78 [a] | 4.96 ± 0.87 [a] | 5.17 ± 1.14 [a] |
| Carbohydrates | 9.28 ±1.23 [b] | 67.52 ± 2.67 [a] | 65.92 ±1.98 [a] | 65.51 ±2.78 [a] | 65.1 ±3.03 [a] |
| Total energy (Kcal/100g) | 47 ±3 [a] | 334 ± 5 [a] | 330 ±4 [a] | 332 ±6 [a] | 332 ±4 [a] |

*Different superscript letters in the same raw means significantly different at $p \leq 0.05$.

## Vitamins contents of fresh and dehydrated onion slices

The vitamins contents of fresh and dehydrated onion slices are given in Table (2). The differences between vitamins $B_1$, $B_2$, folate and C contents of steam and microwave dried onion slices were statistically significant ($p \leq 0.05$). The highest vitamin values were determined in microwave dehydrated samples. Steam dehydrated method led to lower increases in vitamin values than the microwave dehydration method even the moisture loss of steam dehydrated samples were lower. Also, the levels of output power in microwave oven used in the assay did not significantly affect the vitamins content of the dried samples. The convective style of energy, wave strength and longtime consumed of steam drying method could induce destructive effects in water soluble vitamin than the microwave drying. It is also noted that the large drying period for which the product is exposed to the atmospheric oxygen has an adverse effect on some quality aspects like reduction in ascorbic acid, etc. (Sarsavadia, 2007). In nutritional point of view, vitamins are essential for life because we need them for good health and for growth. All dried onion slices are a good source of almost water-soluble vitamins. The consumption of 100 g of each different dried onion slices cover the all requirements of adults for folate (200 mg/day) and vitamin C (40 mg/day). The opposite direction was observed for some fat-soluble vitamins such as vitamin E.

From a dietary point of view, folate is involved in the synthesis of many amino acids, including histidine, serine, glycine and methionine. The role of folate and vitamin B12 in converting

homocysteine to methionine, along with the role of vitamin B6 in converting homocysteine to cystathionine, continues to receive considerable attention. Because low intakes of these three vitamins, particularly folate, are inversely associated with plasma homocysteine concentrations and increased plasma homocysteine concentrations (> 15 μ) are associated with premature coronary artery disease as well as premature occlusive vascular disease and cerebral or peripheral vascular disease (Shimakawa *et al*., 1997; and Verhaar et al., 2002). Another condition being investigated as possibly linked to poor folate status is dementia, including Alzheimer's dementia (Ravaglia *et al.,* 2005). Memory and abstract thinking appear to be influenced by folate. Cognitive dysfunction and dementia have been shown to correlate with plasma homocysteine concentrations, which in turn are influenced in part by folate status (Clarke *et al*., 1998 and Selhub, 2002). Folate deficiency or poor folate status is also suspected in the development (initiation) of some cancers, especially colon and colorectal cancers (Hine, 1993 and Mason and Levesque, 1996). Vitamin C has very complex functional roles in the body. It is required in several reactions involved in body processes, including collagen synthesis, carnitine synthesis, tyrosine synthesis and catabolism, and neurotransmitter synthesis . (Basu and Schorah, 1982 and Levine, 1986). In these reactions, vitamin C functions as a reducing agent (antioxidant) to maintain the iron and copper atoms in the metalloenzymes in the reduced state. The interaction between iron and vitamin C is related not only to the vitamin's effect on intestinal absorption of nonheme iron but also to the distribution of iron in the body. Specifically, ascorbate improves the intestinal absorption of nonheme iron either by reducing the iron to ferrous (Fe2 +) form of ferric (Fe3 +) or by forming a soluble iron complex at the alkaline pH of the small intestine, thereby enhancing the absorption of iron (Hoffman *et al.*, 1991).In addition to its role as a reducing agent in enzymatic reactions, vitamin C functions in other capacities as an important antioxidant in the body. Its water solubility allows it to be widely available in both the extracellular and intracellular spaces in most biological systems (Halliwell and Gutteridge 1990). Vitamin C may react in blood or intracellularly with a variety of reactive oxygen and

nitrogen species and give the radicals an electron in the form of a hydrogen ion. Examples of reactive oxygen species that vitamin C may reduce include: hydroxyl radical (•OH), a very reactive oxygen centered radical; hydroperoxyl radical ($HO_2$ •), an oxygen-centered radical;superoxide radical ($O_2$ •), an oxygen-centered radical; alkoxyl radical (R $O_2$ •), an oxygen centered radical; and peroxyl radical (R $O_2$ •), an oxygen-centered radical **(**Jacob, 1995 and Halpner *et al.*, 1998**).** Vitamin C also protects plasma lipids against peroxidation induced by activated neutrophils (Frei. 1991), and protects against oxidants present in cigarette smoke. (Halliwell and Gutteridge 1990).

**Table 2.** Vitamins content (mg/100g.) of fresh and dehydrated onion slices.

| Vitamins | Fresh | Steam dehydration | Microwave dehydration | | |
|---|---|---|---|---|---|
| | | | 210 W | 480 W | 800 W |
| Vit $B_1$ | 0.057 ± 0.012 $^{c}$ | 0.19 ± 0.09 $^{b}$ | 0.25 ± 0.07 $^{a}$ | 0.29 ± 0.07 $^{a}$ | 0.23 ± 0.09 $^{ab}$ |
| Vit $B_2$ | 0.031 ± 0.010 $^{c}$ | 0.37 ± 0.08 $^{ab}$ | 0.44 ± 0.06 $^{a}$ | 0.49 ± 0.09 $^{a}$ | 0.47 ± 0.06 $^{a}$ |
| Niacine ($B_3$) | 0.145 ± 0.013 $^{c}$ | 3.56 ± 0.68 $^{b}$ | 5.12 ± 1.11 $^{a}$ | 4.11 ± 0.98 $^{ab}$ | 3.87 ± 0.59 $^{b}$ |
| Vit $B_6$ | 0.23 ± 0.03 $^{b}$ | 0.91 ± 0.08 $^{a}$ | 0.98 ± 0.17 $^{a}$ | 0.92 ± 0.16 $^{a}$ | 1.03± 0.13 $^{a}$ |
| Folate ($B_9$) | 0.031 ± 0.010 $^{c}$ | 0.22± 0.06 $^{b}$ | 0.31 ± 0.03 $^{a}$ | 0.27 ± 0.06 $^{a}$ | 0.25 ± 0.09 $^{b}$ |
| Vit C | 14.91 ± 2.10 $^{c}$ | 99.23 ± 7.43 $^{b}$ | 112.67 ± 10.34 $^{a}$ | 114.89 ± 10.67 $^{a}$ | 109.54 ± 8.89 $^{ab}$ |
| Vit E | 0.031 ± 0.006 $^{b}$ | 0.15 ± 0.01 $^{a}$ | 0.11 ± 0.03 $^{a}$ | 0.09 ± 0.001 $^{a}$ | 0.09 ± 0.003 $^{a}$ |

*Different superscript letters in the same raw means significantly different at p≤0.05.

## Sweetness (pungency and sugars) levels in fresh and dehydrated onion slices

Pungency and sugars levels in fresh and dehydrated onion slices were illustrated in Table (3). The differences between pungency level of fresh and dehydrated onion slices were statistically significant (p≤0.05). The highest pungency level was determined in microwave dehydrated samples due to considerable loss in moisture content. The levels of output power in microwave oven used in the assay did significantly affect the pungency levels of the dehydrated samples. In a related study, Adam et al . ( 2000) stated that the pyruvate content of onions (garlic and onions) during drying is mainly affected by drying temperature and time. Loss of pungency is highly influenced by water activity during storage, as indicated by Samaniego-Esguerra et al. (1991). Nutritional research studies have shown that the intake of more pungent onion has resulted in a more pronounced reduction in

overall blood cholesterol, low-density lipoprotein and triglyceride than milder pungous cultivars (Gabler et al., 2003).

While onions are essential vegetables and have nutritional value in diets around the world, they are primarily consumed for their distinctive flavour or ability to enhance flavours in other foods (Hanelt, 1990 , FAO, 1994 and Kopsell and Randle, 1997). While compounds such as water-soluble carbohydrates (sugars) and organic acids may contribute to the sensory experience of onion consumption, onion flavour is dominated by a special class of biologically active organosulfur compounds (Darbyshire and Steer, 1990). Organosulphur compounds resulting from the enzymatic decomposition of S-alk(en)yl-L-cysteine S-oxide precursors and primary products produced include pyruvate, ammonia and sulphenic acids (Ketter and Randle, 1998). The pyruvate content or concentration of thiolsulphinate is also known to be an indicator of onion flavourings. Sweetness in onion is a compromise between single sugars and pungency and onions can be graded as pungency in: very sweet (1-4µmol pyruvic acid / g FW); sweet (5-7µmol pyruvic acid / g FW); intermediate pungency (8-10µmol pyruvic acid / g FW); pungent (11-15µmol pyruvic acid / g FW) very pungent (> 15µmol pyruvic acid / g FW).

**Table 3.** Pungency and sugars levels in fresh and dehydrated onion slices

| Component | Fresh | Steam dehydration | Microwave dehydration | | |
|---|---|---|---|---|---|
| | | | 210 W | 480 W | 800 W |
| **Pungency** | | | | | |
| (µmol of Pyruvic acid) | 8.71 ± 0.57$^{c}$ | 29.09 ± 4.11 $^{ab}$ | 33.55 ± 2.30 $^{a}$ | 30.33 ± 3.98$^{a}$ | 25.17 ± 1.54 $^{b}$ |
| **Sugars (g/100g d.b.)** | | | | | |
| Glucose | 1.21 ± 0.08$^{d}$ | 21.08 ± 3.14$^{a}$ | 19.78 ± 1.12$^{b}$ | 16.99 ± 2.09$^{c}$ | 16.87 ± 3.12$^{c}$ |
| Fructose | 1.04 ± 0.04$^{c}$ | 16.23 ± 1.05$^{a}$ | 15.01 ± 2.77$^{a}$ | 13.92 ± 2. 50$^{b}$ | 13.08 ± 1.60$^{b}$ |
| Sucrose | 1.32 ± 0.12$^{b}$ | 23.12 ± 3.44$^{a}$ | 24.78 ± 1.07$^{a}$ | 24.90 ± 3.33$^{a}$ | 25.98 ± 4.62$^{a}$ |

*Different superscript letters in the same raw means significantly different at p≤0.05.

On the other side, the total single sugars detected in dehydrated onion slices (ranged 13.08 -25.98 g/100g) are significantly superior to in fresh slices (1.04-1.32 g/100g) (Table 3). Glucose and fructose levels are higher in steam dehydrated onion slices than the microwave dehydrated once and the opposite

with sucrose. The levels of output power in microwave oven used in the assay did not significantly affect the sugars level of the dehydrated samples. According to our opinion, the microwave drying process induced decreasing in monosaccharide's content (glucose and fructose) through increasing the rate of non-enzymatic browning reaction which consists of the interaction of aldehyde, ketones and reducing sugars with amino compounds such as amino acids and proteins (Proudlove, 1989 and Kaymak-Ertekin and Gedik, 2005). From a nutritional spot of view, sugars are considered to be very significant for anthocyanin biosynthesis and may serve as a substrate for synthetic pathways (Gennaro et al., 2002). Several flavonoids, including flavonoids and anthocyanins, often show a wide variety of biological impacts, including antiviral ,antibacterial, anti-allergic, antithrombotic anti-inflammatory and vasodilatory (Cook and Sammon, 1996).

**Microbial examination of fresh and dehydrated onion slices**

The microbial examinations of fresh and dehydrated onion slices are given in Table (4). Data revealed that the almost of microbial parameters including total plate count, moulds &yeasts and *Coliforms* of fresh onion slices were extremely higher as compared to all dehydrated slices. The differences between all microbial parameters measured of steam and microwave dried onion slices were statistically highly significant. The highest total plate count, moulds &yeasts and *Coliforms* values were determined in steam dehydrated samples. Also, the levels of output power in microwave oven used in the assay partially significantly ($p \leq 0.05$) affect the microbial parameters values of the dried samples.

In general, freshly harvested and stored onion bulbs are used for dehydration. During processing, handling and storage, the onion bulbs bear a heavy load of harmful bacteria, fungi yeast and mould (Anon, 2000). There is every likelihood of moving these microbes to the final items, like dehydrated onion slices. ES (2017) indicates that the amount of different microbes in raw onion bulbs (A.cepa) should be at tolerable amounts as follows: aerobic plate count < 500.000 / g, yeast and mould < 5000 / g, coliforms < 200 / g, and in dehydrated onion slices as follows: aerobic plate count < 100.000 / g, yeast and mould < 1000 / g, coliforms < 25 / g, E. In the present analysis, the amount of different microbes of fresh and dehydrated onion slices is

lower than those values which are subsequently healthy for human consumption.

**Table 4.** Microbial examination of fresh and dehydrated onion slices

| Parameter | Fresh | Steam dehydration | Microwave dehydration | | |
|---|---|---|---|---|---|
| | | | 210 W | 480 W | 800 W |
| Total plate count (cfu/g) at 30 $^0$C | $161x10^3 \pm 3500^a$ | $64.89 x10^3 \pm 2400^b$ | $41.25 x10^3 \pm 2500^c$ | $37.01 x10^3 \pm 3700^d$ | $34.97 x10^3 \pm 3100^d$ |
| Moulds &Yeasts (spores/g) at 25 $^0$C | $2430 \pm 200^a$ | $650 \pm 160^b$ | $405 \pm 90^c$ | $281 \pm 70^d$ | $225 \pm 35^d$ |
| *Coliforms* (cfu/g) | $40 \pm 10^a$ | $< 10 \pm^b$ | $< 10 \pm^b$ | Absent | Absent |

*Different superscript letters in the same raw means significantly different at p≤0.05.

## Physical appearance of fresh and dehydrated onion slices

The physical appearance of fresh and dehydrated onion slices by steam and microwave method is shown in photo (1). The physical appearance of the dehydrated samples showed that microwave dehydrated slices at 480 W and 800 W had discoloured to brownish tint, but the transition was significantly more noticeable in the case of steam dehydrated and microwave dehydrated slices at 210 W. However, the steam-dehydrated slices were lighter in colour and appropriate in appearance. Color darkening at higher output power in the microwave oven used in the assay (480 W and 800 W) is due to non-enzymatic browning.

The non-enzymatic browning reaction, consisting of the interaction of aldehyde, ketones and reducing sugars with amino compounds such as amino acids and proteins, is caused by the drying process and results in loss of suitable colour, off-flavour production and loss of biological protein value (Proudlove, 1989 and Ibarz et al., 2000). The rate of browning is highly affected by the temperature and moisture content of food during drying (Saguy and Karel, 1980; Labuza and Saltmarch, 1981 and Kaymak-Ertekin and Gedik, 2005). Lewicki et al . , ( 1998) and Adam et al., (2000 ) reported that drying temperatures above 65 ° C had a major effect on the colour of the dried onion. Kaymak-Ertekin and Gedik, (2005 ) studied kinetics of non-enzymatic browning and thiolsulphinate (pungency compound) losses in onion slices during drying at various temperatures (50, 60, 70, 75 0C) and at air velocity (0.6, 1.0, 1.2, 1.5 m / s). Non-enzymatic

browning was found to follow a zero order reaction while thiolsulphinate loss was followed by a second order reaction during drying. Temperature dependency of response rates may be modified with moisture content and water behaviour.

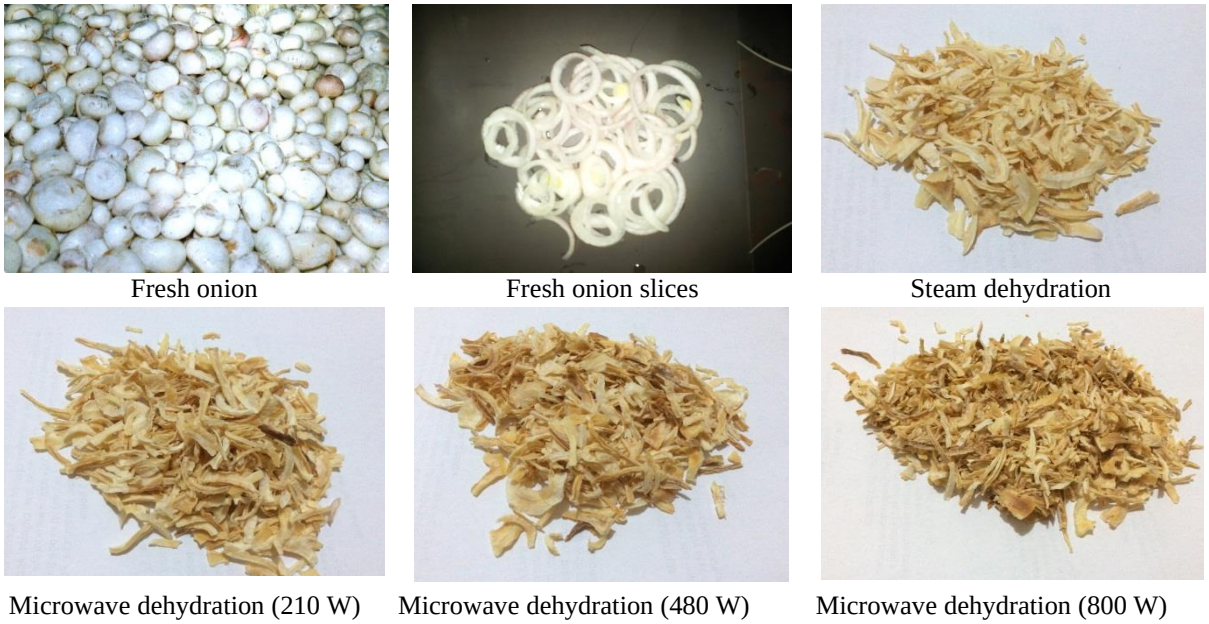


**Photo 1.** Fresh and dehydrated onion slices.

**Organoleptic evaluation of fresh and dehydrated onion slices**

As shown in Table (5), fresh and dehydrated onion strips under sensory assessment by a panel of 10 verdict showed that the overall acceptability for dehydrated onion strips was marginally higher (6.79-8.66) compared to fresh strips (6.62). Even so, there was no difference in overall acceptability among dehydrated steam and dehydrated microwave (210 W and 480 W). Microwave specimens at 800 W were ranked as lowest among dehydrated onion strips (6.79) in terms for overall acceptability scores. This can be due to the explanation that, at this energy level, the slices were little brown to blackish in colour, with little hard texture (high crunchy). In other words, the output power levels in the microwave oven used in the assay have had a relatively important effect on all the organoleptic parameters of the dried samples.

**Table 5.** Organoleptic evaluation of fresh and dehydrated onion slices.

| Parameter | Fresh | Steam dehydration | Microwave dehydration | | |
|---|---|---|---|---|---|
| | | | 210 W | 480 W | 800 W |
| Look and Color | 6.89 ± 1.02 [b] | 9.10 ± 0.78[a] | 8.65 ± 1.14 [a] | 7.19 ± 1.03 [b] | 6.63 ± 1.03 [b] |
| Flavor | 6.67 ± 0.32 [b] | 8.14 ± 0.99 [a] | 7.96 ± 0.78 [a] | 7.81 ± 0.66 [a] | 6.65 ± 0.77 [b] |
| Aroma | 6.10 ± 1.06 [c] | 8.01 ± 1.00 [a] | 8.71 ± 0.99 [a] | 8.21 ± 0.98 [a] | 7.19 ± 1.56 [b] |
| Crunchy | 4.11 ± 1.20 [c] | 7.31 ± 0.59 [b] | 7.98 ± 1.03 [a] | 8.02 ± 0.89 [a] | 8.83 ± 1.03 [a] |
| Over all acceptability | 6.32 ± 0.67 [b] | 8.66 ± 0.88 [a] | 8.51 ± 1.24 [a] | 8.11 ± 0.95 [a] | 6.79 ± 0.92 [b] |

[*] Different superscript letters in the same raw means significantly different at $p \leq 0.05$.

In conclusion, the drying methods/techniques were found to have a significant effect on the chemical, microbial and organoleptic properties as well as the physical appearance of the onion slices samples. Microwave dehydration provides higher drying rate compared to steam method (commonly used in Egypt) i.e. lower drying time, an oxygen deficient processing environment and high microbiological parameters. The levels of output power in microwave oven used in the assay did not significantly affect the main components content (total protein, crude fat, ash, crude fiber and carbohydrates) and micronutrients (vitamins) of the dried samples. Therefore, further research will be needed on food dehydration by microwave and introducing such technology in the Egyptian factories for reducing the loss of water soluble component during dehydration, minimizing the drying time and energy consumption and has non-significant influence on sensorial attributes of dried onion slices.

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# دراسات كيميائية وميكروبيولوجية وحسية على شرائح البصل التي تم تجفيفها بواسطة تقنيات البخار والميكروويف

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## المستخلص

تهدف الدراسة الدراسة الحالية إلى اجراء دراسات كيميائية وميكروبيولوجية وحسية على شرائح البصل (*Allium cepa* L.) التى تم تجفيفها بواسطة تقنيات البخار والمكروويف. لذلك تم تجفيف عينات شرائح البصل في فرن الميكروويف باستخدام ثلاثة مستويات مختلفة من الطاقة تتراوح بين 290 – 800 وات وعينات أخرى باستخدام عملية التجفيف بالبخار لمدة 4 ساعات على ثلاث مراحل (130 درجة مئوية لمدة 60 دقيقة، 100 درجة مئوية لمدة 60 دقيقة، 80 درجة مئوية لمدة 120 دقيقة). ولقد أدت عمليات التجفيف بوجه عام الى انخفاض محتوى الرطوبة لشرائح البصل المجففة إلى 4.91 –5.78 ٪ مقارنة بـ 86.14 ٪ لشرائح البصل الطازجة، كما تم تركيز العناصر الغذائية الأخرى مثل البروتين الكلي والدهون الخام والرماد والألياف الخام ومحتويات الكربوهيدرات لشرائح البصل المجففة، وبالتالي زادت قيمها الغذائية بالمقارنة مع شرائح البصل الطازجة. كانت الاختلافات بين محتويات التركيب الكيميائي لشرائح البصل المجففة بالبخار والميكروويف غير معنوية إحصائياً ، لكن هناك عوامل أخرى مثل مستويات الحرافية والسكريات وكذلك المقاييس الميكروبية كانت معنوية ($p\leq0.05$) . كذلك فإن مستويات الطاقة المستخدمة في فرن الميكروويف لم تؤثر بشكل كبير على محتوى المكونات الرئيسية (البروتين الكلي والدهون الخام والرماد والألياف الخام والكربوهيدرات) وكذلك المواد المغذية الأخرى (الفيتامينات والحرافية والسكريات) بالعينات المجففة وفى المقابل كان هناك تأثير كبير على المقاييس الحسية والميكروبية. فيما يتعلق بالمظهر الحسى ، لوحظ أن شرائح البصل المجففة بالميكروويف عند 480 وات ، 800 وات أصبحت مائلة نحو اللون

البني، ولكن التغيير كان أكثر قليلاً في حالة العينات المجففة بالبخار وشرائح البصل المجففة بالميكروويف في 210 وات، كذلك العينات التى تم تجفيفها بالبخار كانت أفتح في اللون ومقبولة في مظهرها العام. وفي النهاية ، فإنه ينصح بأن تكون هناك حاجة إلى مزيد من البحوث حول تجفيف المواد الغذائية بإستخدام الميكروويف وإدخال هذه التكنولوجيا في المصانع المصرية للحد من فقدان المكونات القابلة للذوبان في الماء أثناء التجفيف، وتقليل وقت التجفيف واستهلاك الطاقة ، كما أن له تأثير غير معنوى على الصفات الحسية لشرائح البصل المجففة.

**الكلمات الدالة:** البصل ، التجفيف بالبخار، الميكروويف ، التركيب الكيميائي ، الفيتامينات ، الحرافية ، المظهر الطبيعى.