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HOME DRYING OF TOMATOES BY MICROWAVES.

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ABSTRACT

Tomatoes is highly perishable and drying is one of the convenient methods of extending its shelf life and minimizing postharvest losses. Drying of tomatoes slices by normal microwave oven (home microwave oven) was investigated to determine the optimal drying conditions (either microwave powers or pretreatment) to produce a good quality product. So the effects of microwave powers and pretreatments on the drying time and quality of dried product in terms of moisture, TSS, polyphenol, lycopene, Ascorbic acid, carotenoids and rehydration ratio, were investigated. The experiments performed with three levels of microwave powers (750w , 1200w and 1500w) and four pretreatments (control, 0.1% kHso3 , 1% CaCl2 and 1% citric acid). The results indicated that, drying time was 44, 54 and 90 mn for 1500w , 1200w and 750w, respectively. Aso the results showed that, all studied microwave powers and pretreatments led to slight changes in moisture, TSS, acidity and rehydration ratio (for both 32C°, 50C° and 70C°). While lycopene, carotenoids, polyphenols and ascorbic acid contents obviously affected either by microwave powers and pretreatments. The balanced effect on rising lycopene, carotenoids and polyphenols contents and in the same time on degradation of ascorbic acid was observed for microwave power of 1200w, while the most effective pretreatment on rising lycopene, carotenoids and polyphenols contents and in the same time on degradation of ascorbic acid was CaCl2 treatment for each power separately.

Keywords : Tomatoes dehydration , drying time and Quality parameters

INTRODUCTION

Tomatoes crop (*Lycopersicon esculentum*) is noted to be the second most important vegetable crop next to potato [FAO, 2010]. Globally, China is by far the largest producer of tomatoes, followed by the USA, India, Egypt and Turkey [FAOSTAT, 2010]. Many developing countries still face enormous challenges of post harvest losses of tomatoes due to inadequate processing and storage facilities. Studies show that tomato contains a large amount of lycopene, which is the major carotenoid, accounting for 90% of the total carotenoids [Shi, *et al*., 2009]. Lycopene's antioxidant activity is reported to be higher than β-carotene, γ-carotene, and α-tocopherol, which provides effective scavenging effects on cancer causing free radicals. Epidemiological studies have shown that lycopene in tomato is particularly effective in fighting prostate cancer, cervical cancer, cancer of the stomach and rectum as well as pharynx and oesophageal cancers Egydio, *et al*., 2010 and Levelly and Torresani, 2011].

The basic objective in dying food products is the removal of water from the solid material to certain moisture content where microbial spoilage is avoided. Longer shelf life and significant reduction in the volume of the products are major reasons for the popularity of dried food material. The objectives of energy efficient process and the highest possible product quality are conflicting in many cases in that most energy-saving measures are harmful for quality aspects and vice versa [Cernîşev, 2010]. Thermal damage incurred by a product during drying is directly proportional to the temperature and time involved [Vadivambal and Jayas, 2007]. Even though hot-air drying is the most common method to preserve foods, many researchers believe that hot-air drying leads to degradation of products flavor, colour, nutrients, and case hardening, due to their long drying times and high temperatures employed in practice [Vadivambal, and Jayas, 2007- Contreras *et al*., 2008]

Tomatoes come in various sizes and colours and there are hundreds of varieties. They can weigh a fraction of an ounce on the smaller scale and well over two pounds on the larger scale. The most common colour of tomato of course is red but they also come in yellow, purple, green and black. They can even come in mixed colours or stripes (Van den Berg, *et al*., 2000). However, tomato is highly perishable in the fresh state leading to wastage and losses during the harvesting periods. Therefore, the prevention of this losses and wastage is of major interest, especially when there is subsequent imbalance in supply and demand at the harvesting off season (Akanbi, *et al.,* 2006). Tomatoes are vegetable that add detectable flavor to any dish to which they are added.

Dried form of tomato is very popular as it is extensively used in the preparation of various items like pizzas, soups and other lip-smacking snacks. It has a distinct flavor because of acid concentration. Over the last few years, fresh tomatoes and tomato products, due to their antioxidant activities, have aroused new scientific interest. Fresh ripe tomatoes fruit are refreshing and appetizing and its consumption as contribute immensely to the vitamines and mineral content of human diets. A large proportion of the crop is used in the preparation of tomatoes soup, pickles, ketch-up, sauces, paste, puree and juice and other products (FAO, 2007).

Drying is the most common method of preservation; it involves drum drying, vacuum drying, spray drying and foam-mat drying which as been embarked upon as an effort to produce dried tomatoes slices. The sprays drying have been reported to be very useful where the desired characteristics in the dried tomatoes slices are required (Giovanelli, *et al*., 2002). While the principle of spray drying is quite simple, its technological realization is difficult. In addition, the technology involve are generally capital intensive and are not suitable for small scale farmers, particularly in Africa and the developing world. Hence oven drying an alternative to spray drying would be employed. The demand for dehydrated tomatoes is increasing rapidly both in domestic and in international markets with major portion of it being used for preparation of convenience foods (Davoodi, 2007)

Microwave energy is rapidly absorbed by water molecules which, consequently, results in rapid evaporation of water and thus higher drying rates. Therefore, the microwave drying offers significant energy savings accompanied by a potential reduction in drying times of up to 50% and the addition to the inhibition of surface temperature of treated material (Mcloughlin, *et al.,* 2003).

Microwave drying can also improves product quality in some cases (Prabhanjan,*et al*., 1995). This method has been combined with hot air drying, vacuum drying, freeze drying, etc., and applied in numerous drying practices (Orsat *et al*., 2006; Raghavan, *et al*., 2005; Vadivambal, and Jayas, 2007 and Zhang *et al*., 2006). The vacuum microwave drying process (VMD) can accomplish drying tasks in a shorter time at lower temperature (Xu, *et al*., 2004).

The objective of this research is the optimization of normal microwave oven (home microwave oven) to produce high-quality tomato slices could be produced at home and anywhere when the price of tomatoes is low and the quantities are high.

MATERIALS AND METHODS

Materials:

Tomatoes (Agyad cultivar) were collected from El-Maghara Research Station - Desert Research Center. In North Sinai.

Chemicals and reagents

All solvents were of reagent grade without any further purification. Gallic acid, was purchased from Sigma Chemical Co. (St. Louis, MO, USA). Citric acid (C6H8O7H2O) E330 manufacture : TTCA OC., Ltd China, calcium chloride, sodium metabisulfite, Folin-Ciocalteu's phenol reagent and methanol were purchased from El-Gomhoria Co. Cairo, Egypt.

Drying processes

Tomatoes fruits were further washed with water to remove dirts and soils, then tomatoes were cut into slices with thickness of 10mm.

The sliced tomatoes (700g) were subjected to microwave drying (in Normal microwave oven) with 3 different powers (1500 W , 1200 W and 750 W) after treating by four pretreatments included:

- without any treatments (as control)(T1)
- dipping in 0.1% Potassium metabisulphite (KHSO3)(T2) solution for ten minutes at room temperature after which it was drained
- dipping in 1% Calcium Chloride (CaCl2) (T3)solution for ten minutes at room temperature after which it was drained
- dipping in 1% citric acid solution (T4) for ten minutes at room temperature after which it was drained

The drying was continued until a final moisture content of(12% $\pm$ 1%) g per 100 g dried tomatoes was reached.

Chemical analysis:

- Total acidity was determined according to the *AOAC, (1970)* and expressed as citric acid.
- Polyphenols: were estimated as total polyphenols using the method described in the *AOAC(1970)*.
- Moisture content: were determined according to the *AOAC (1990)* .
- Carotenoides were determined by using the method of *Wettestein (1957)*.

Determination of Total Soluble Solids

10g of sample was mixed with 20g of water, it was then filter through small filter paper . The first running was rejected. A drop of the filtrate was spread on the digital refractometer (Models 10430, 0- 30 °Brix, Cambridge Instruments Inc, USA) *(AOAC, 1990)*.

Determination of Ascorbic Acid (Vitamin C)

Ascorbic Acid(Vitamin C) content was determined by method described by Pearson (1973). Standard ascorbic solution was prepared by dissolving 50ml of the pure ascorbic acid in 60ml of 20% metaphosphoric acid and would be diluted to 250ml.

Ascorbic content would be calculated as:

$$\text{Mg Ascorbic acid per 100g of sample} = \frac{V \times T \times 100}{W}$$

V= ml dye used for titration of aliquot of diluted sample

T= Ascorbic acid equivalent of dye solution expressed as mg/ml of dye

W = gram of sample aliquot that will titrated.

Determination of Lycopene Content:

1.0g of tomatoes sample was weighed into a conical flask. It was transferred into 100ml volumetric flask and made up to mark with distilled water. It was mixed well, transferred into a separating funnel and 25ml of petroleum ether was added. It was shook vigorously for about 15 minutes.

The aqueous layer was run off and the absorbance of petroleum ether layer was taken at 505nm (Gould and Gould, 1988)

$$\text{Calculation} = \frac{1000e \times 100}{282 \times 1.42 \times 4}$$

E= the absorbanc at 550nm

282=constant

Rehydration Ratio

Dried tomato slices were weighed (W0) and immersed for 50 min in distilled water (100 mL of water per gram of dried tomato) at room temperature, 50C and 70C. Following this, the water was drained during 2 min and the slices were weighed again (W1) (Lewicki & Michaluk, 2004). The rehydration ratio was calculated as the ratio of the weight of gained water (W1 _ W0) over the initial sample weight (W0),

$$\text{Rehydration ratio} = \frac{W1 - W0}{W0}$$

W1= the weight of gained water

W0= the initial sample weight

Statistical analysis:

All determinations were carried out in triplicate and data is reported as mean. Significant differences ($p<0.05$) were calculated using Duncan's multiple range test, followed the method reported by *Steel and Torrie, (1980)*.

RESULTS AND DISCUSSION

1- The Effect of Microwave power on moisture content and drying time:

Moisture contents during drying time (drying curve) at different microwave powers (750w, 1200w and 1500 w) were determined and presented in Fig. (1).

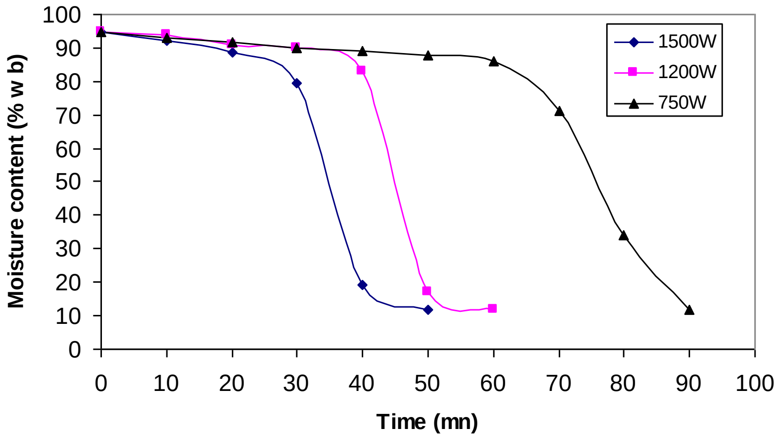


Fig. (1): Effect of Microwave power on drying time

From the presented data in Fig.(1), it could be noticed that, the initial moisture content of tomatoes slices was 94.95 % for fresh tomatoes. Drying process was halted when final moisture content reached to 12 %. There was inversely relationship between drying time and microwave powers, where when 1500w microwave power was used the recorded drying time was 44 mn (approximately), while using of 1200 w and 750w microwave powers led to increase drying time to 54 mn (approximately) and 90 mn , respectively.

2-The Effect of Microwave power and pretreatments on quality parameters of dried tomatoes:

Moisture, Total solids (T.S.) and Total soluble solids (T.S.S.) contents:

Moisture, total solids (T.S.) and total soluble solids (T.S.S.) contents were determined for dried tomatoes slices by different drying treatments and the results were presented in Table (1).

Table (1): The effect of different drying treatments on moisture, TS and TSS contents (%) of dried tomato slices.

Treatments \ Constituents		Moisture	T.S	T.S.S.
Fresh		94.95^{a}	5.05^{f}	4.1^{g}
750 w	Control (T1)	12.24^{d}	87.76^{d}	71.2^{e}
	KHSO3 (T2)	12.13^{d}	87.87^{d}	71.8^{c}
	Ca cl2 (T3)	11.85^{ef}	88.15^{bc}	72.5^{a}
	Citric acid (T4)	11.89^{ef}	88.12^{bc}	72.5^{a}
1200 w	Control (T1)	12.66^{b}	87.44^{e}	70.8^{f}
	KHSO3 (T2)	12.46^{c}	87.54^{e}	71.4^{de}
	Ca cl2 (T3)	11.79^{ef}	88.21^{bc}	71.8^{c}
	Citric acid (T4)	11.95^{e}	88.05^{c}	71.4^{de}
1500 w	Control (T1)	12.25^{d}	87.75^{d}	71.3^{de}
	KHSO3 (T2)	11.71^{f}	88.29^{b}	71.5^{d}
	Ca cl2 (T3)	11.20^{g}	88.80^{a}	72.1^{b}
	Citric acid (T4)	11.82^{ef}	88.18^{bc}	71.8^{c}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

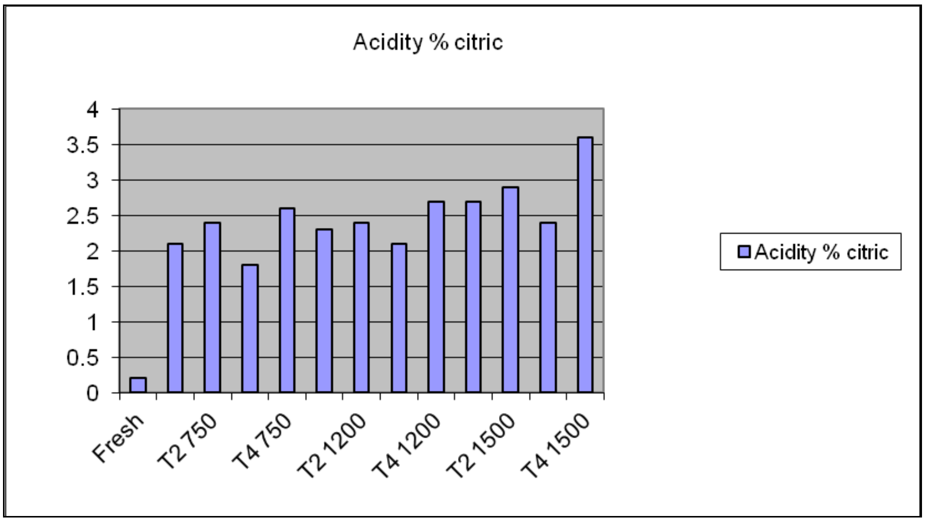
The tabulated results in table (1), showed that, all studied microwave powers (750 w , 1200 w and 1500w) had no effect on both moisture , T.S. and T.S.S. contents.

From the presented data in table (10), it could be noticed that, moisture contents decreased from 94.95% in fresh sample to approximately 12 ± 0.8 % depending on pretreatments, where the highest moisture content were recorded for control sample(T1) followed by potassium metabislufite (KHSO3)(T2) treated sample, while the lowest moisture content was recorded calcium chloride (Ca Cl2) treated sample(T3) followed by citric acid (CA) treated sample (T4)

TS and TSS are negatively related with moisture content, since TSS represent the main part of TS. The highest TSS and TS contents were recorded for CaCl2 treatments, this may be due to the partial effect of CaCl2 in enhancing removal of water through osmotic dehydration (Owureku,-Asare *et al*., 2014).

Acidity (% Citric acid):

Both different microwave powers and drying pretreatments had a noticeable effect on tetratable acidity of dried tomato slices, where the higher the microwave powers the higher the acidity, since it was ranged from 1.922 to 2.620% for 750w microwave power and from 2.136 to 2.732 % for 1200w microwave power and from 2.408 to 3.664 % for 1500w microwave power. In the same time the presented data showed that, citric acid treatments recorded the highest acidity followed by KHSO3)(T2) comparing with control sample(T1) for each microwave power separately, while CaCl2 treatments(T3) recorded the lowest acidity. .



Fig(2) The effect of different drying treatments on dried tomatoes acidity

These findings are in agreement with those reported by Sharareh and Reihaneh, 2011, who found that, tomatoes slices pretreated with KMS and Na Cl showed slightly more acidity as compared to control sample, while tomato slices pretreated with CaCl2 had lower acidity.

Lycopene and Carotenoid contents:

Lycopene and carotenoid contents of dried tomatoes slices were determined and the obtained results were tabulated in table (2)

From the tabulated results, it could be noticed that, lycopene levels of the dried tomatoes slices increased from an initial value of 5.181 (mg/100g dw) in fresh sample to higher values ranged from 7.429 to 13.859 (mg/100g dw) for 750 w and from 10.987 to 15.987 (mg/100g dw) for1200 w (microwave drying power) and ranged from 16.150 to 21.674 (mg/100g dw) for 1500 w (microwave drying power). This increment in lycopene content as a result of microwave drying, may be due to a progressive conversion from all-trans lycopene to a less strongly colored, less intensely absorbing cis form. (Abano, *et al*., 2013).

On the other hand, all studied pretreatments, had a positive effect on increasing lycopene level comparing with control treatment, where KHSO3 treatment recorded the highest lycopene content followed by CaCl2 treatment, this may be due to the protective effect of potassium metabisulphite on lycopene degradation (Sharareh and Reihaneh, 2011).

Table (2): The effect of different drying treatments on Lycopene and carotenoid contents (mg/100g dw) of dried tomatoes slices.

Fresh		**Lycopen**	**Carotenoids**
		5.181^{g}	1.528^{g}
750 w	Control (T1)	7.429^{f}	2.429^{f}
	KHSO3 (T2)	13.859^{d}	2.451^{f}
	Ca cl2 (T3)	13.293^{d}	2.857^{e}
	Citric acid (T4)	10.610^{e}	2.877^{e}
1200 w	Control (T1)	10.987^{e}	7.191^{d}
	KHSO3 (T2)	15.737^{c}	8.691^{c}
	Ca cl2 (T3)	15.987^{c}	8.166^{c}
	Citric acid (T4)	13.803^{d}	7.978^{cd}
1500 w	Control (T1)	16.150^{c}	12.101^{b}
	KHSO3 (T2)	21.674^{a}	13.657^{a}
	Ca cl2 (T3)	21.175^{a}	13.243^{a}
	Citric acid (T4)	20.040^{b}	12.630^{b}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

Regarding to carotenoids,content the same trend of lycopene was observed for total carotenoids, the higher the microwave power the higher the total carotenoid contents, but the pretreatments slightly affected the total carotenoids in the same microwave power, this may be as a result of formation of some flavor compounds in dried tomatoes such as terpenoids, which are primarily drive from oxidative degradation of carotenoids (Christensen, *et al*., 2007).

Ascorbic acid and polyphenol contents:

Ascorbic acid and polyphenol contents of fresh and dried tomatoes slices were measured and the obtained results are presented in table (3)

The results of ascorbic acid indicated that, ascorbic acid content decreased from an initial value of 6.0 (mg/100g dw) of the fresh tomatoes to lower values ranged from 2.50 to 3.50 (mg/100g dw) for 750 w, and from 2.00 to 2.50 (mg/100g dw) for 1200 w, and from 1.25 to 1.50 (mg/100g dw) for 1500 w (microwave drying power). These results are harmony with those reported by Abano, *et al*., 2013, who found that , ascorbic acid content decreased from an initial mean value of 2.72$\pm$ 0.29 (mg/100g dw) of fresh tomatoes to the least value of 0.91 $\pm$ 0.04 (mg/100g dw) after drying at 500 w and 0.06 MPa (vacuum- drying). They reported also that, the reduction of ascorbic acid content observed during microwave-vacuum drying may be due to the destruction of vitamin.C. by the electromagnetic waves of microwave power as the samples were dried.

Table (3): The effect of different drying treatments on Ascorbic acid and polyphenols content of dried tomato slices.

Fresh		Ascorbic acid mg/100g	Polyphenols (ppm)
		6.00^{a}	250^{g}
750 w	Control (T1)	2.50^{d}	330^{f}
	KHSO3 (T2)	3.50^{b}	380^{e}
	Ca cl2 (T3)	2.50^{d}	320^{f}
	Citric acid (T4)	3.10^{c}	335^{f}
1200 w	Control (T1)	2.00^{f}	490^{d}
	KHSO3 (T2)	2.50^{d}	505^{d}
	Ca cl2 (T3)	2.25^{e}	500^{d}
	Citric acid (T4)	2.25^{e}	490^{d}
1500 w	Control (T1)	1.25^{h}	750^{c}
	KHSO3 (T2)	1.50^{g}	755^{c}
	Ca cl2 (T3)	1.25^{h}	825^{a}
	Citric acid (T4)	1.35^{h}	780^{b}

Values bearing the same superscript within the same column are not significantly different (P> 0.05)

Concerning to the results of total polyphenol contents of different dried samples presented in Table (3), it could be noticed that all studied microwave powers had obviously effect on increasing polyphenol content of dried samples. The highest increase was observed for microwave power of 1500 w followed by 1200 w and then 750 w. These results are in harmony with those of Mechlouch *et al*., 2012, who found that, total phenolic content for fresh tomatoes were significantly lower than dried samples. On the other hand, Santos-Sanchez, *et al*., 2012, found that drying tomatoes fruits led to decrease total polyphenol content by 2.1 % to 21.6 % depending on drying temperature.

The high levels of polyphenols observed in dried tomatoes may be due to greater exposure to microwave field for tomato fruits, in fact the disruption to plant tissue increased with a rise in the intensity of the microwave field or solar radiation , causing more phenolic compounds libration (Mechlouch *et al*., 2012).

Rehydration Ratio:

The rehydration ratio at three different temperatures (32C°, 50C° and 70C°) of dried tomatoes by different treatments were determined and the results were tabulated in table (4).

Rehydration can be considered as a measure of the injury to the material caused by drying and treatments preceding dehydration (McMinn and Magee, 1997).

From the presented data in Table (4), it could be noticed that, increasing rehydration temp. led to increase the rehydration ratio with some exceptions related to 70C° (which could be attributed to separating of small particles in the rehydration solutions by the high temp).

From the same table, it could be observed that, rehydration ratio ranged from 2.069 to 2.747, when rehydration process was achieved at room temp. (32C°) and ranged from 2.349 to 3.079, when rehydration process was achieved at 50C° and ranged from 2.245 to 3.097 when rehydration process was achieved at 70C°. distilled water.

Table (4): The effect of different drying treatments on rehydration ratio of dried tomatoes slices at three different temperatures.

Treatments \ Temprature		32C°	50 C°	70 C°
750 w	Control (T1)	2.069^{f}	2.349^{h}	2.371^{g}
	KHSO3 (T2)	2.411^{cd}	2.621^{e}	2.850^{d}
	Ca cl2 (T3)	2.484^{c}	2.836^{c}	2.922^{c}
	Citric acid (T4)	2.286^{e}	2.467^{g}	2.635^{f}
1200 w	Control (T1)	2.355^{de}	2.550^{f}	2.962^{b}
	KHSO3 (T2)	2.604^{b}	2.837^{c}	2.886^{d}
	Ca cl2 (T3)	2.641^{ab}	2.992^{b}	2.245^{h}
	Citric acid (T4)	2.427^{cd}	2.671^{d}	2.690^{e}
1500 w	Control (T1)	2.326^{de}	2.562^{f}	2.661^{ef}
	KHSO3 (T2)	2.741^{a}	3.065^{a}	2.941^{bc}
	Ca cl2 (T3)	2.747^{a}	3.079^{a}	3.097^{a}
	Citric acid (T4)	2.730^{a}	2.860^{c}	2.928^{c}

Values bearing the same superscript (small letter) within the same column are not significantly different (P> 0.05)

In relation to the effect of pretreatments on rehydration ratio, the presented data showed that, CaCl2 treatment had the highest effect on rehydration ratio followed by KHSO3 treatment and then Citric acid treatment comparing with control treatment either for different microwave powers or different rehydration temperatures. These results agreed with those reported by Sharareh and Reihaneh, 2011, who found that, both Cacl2, KHSO3, NaCl and Cacl2 + KMS had a positive effect on increasing the rehydration ratio of dried tomatoes slices.

CONCLUSION

Using of normal microwave oven (home microwave oven) in dehydration of tomatoes slices could be applicable anywhere (specially at home). The optimal conditions of tomatoes drying by microwave oven are: microwave power of 1200 w for a period of 54 min after dipping of 700g (tomato slices) in 1% $CaCl_2$ solution for 10 min, leading that to produce good quality product in terms of moisture, TSS, lycopene, polyphenols and ascorbic acid contents in addition to relatively high rehdration ratio.

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التجفيف المنزلى للطماطم بالميكروويف

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الطماطم احد الحاصلات ذات القدرة العالية على التلف ، ويعتبر التجفيف أحد الطرق الشائعة والمستخدمة فى اطالة عمرها التخزينى وتقليل الفاقد بعد الحصاد ثم دراسة تجفيف شرائح الطماطم باستخدام فرن الميكروويف العادى (المنزلى) تم دراسته للوقوف على انسب ظروف التجفيف (سواء من حيث طاقة الميكروويف او المعاملات الأولية) لانتاج منتج عالى الجودة . لذلك تم دراسة تأثير طاقة الميكروويف مع بعض المعاملات الأولية على وقت التجفيف وجودة المنتج المجفف من حيث محتوى الرطوبة والمواد الصلبة الذائبة والبولى فينول والليكوبين وحمض الاسكوربيك والكاروتينويدات ونسبة الاسترجاع. ولقد اجرى البحث على ثلاث مستوايات من طاقة الميكروويف (٧٥٠ وات ، ١٢٠٠ وات ، ١٥٠٠ وات) مع اربع معاملات أولية (مقارنة ، ٠.١ % بوتاسيوم ميتا بيسلفيت ، ١% كلوريد كالسيوم ، ١% حمض ستريك) . ولقد بينت النتائج المتحصل عليها ان وقت التجفيف كان ٤٤ دقيقة ، ٥٤ دقيقة ، ٩٠ دقيقة عند التجفيف على ١٥٠٠ وات ، ١٢٠٠ وات ، ٧٥٠ وات على الترتيب. كما أظهرت النتائج ايضا أن كل مستويات طاقة الميكروويف المستخدمة فى التجفيف وكل المعاملات الأولية موضع الدراسة ادت إلى تغيرات طفيفة فى محتوى الرطوبة والمواد الصلبة الذائبة والحموضة ونسبة الاسترجاع (سواء على درجة ٣٢ م (الغرفة) أو ٥٠ م أو ٧٠ م) . بينما كان تأثيرها واضح على كل من محتوى الليكوبين والكاروتينويدات والبولى فينولات وحمض الأسكوربيك. ولقد سجلت طاقة الميكروويف ١٢٠٠ وات تأثير متوازن (مقارنة بباقى الطاقات) على رفع كل من محتوى الليكوبين والكاروتينويدات والبولى فينولات وفى نفس الوقت على خفض حمض الأسكوربيك . بينما سجلت المعاملة الأولية بكلوريد الكالسيوم أكبر تأثير (مقارنة بباقى المعاملات المبدئية) على رفع الليكوبين والكاروتينويدات والبولى فينولات وفى نفس الوقت على تكسير حمض الأسكوربيك ، بغض النظر عن طاقة الميكروويف المستخدمة.