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IMPACT OF OSMOTIC DEHYDRATION ON QUALITY OF TOMATO SLICES

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ABSTRACT: This work was carried out to study the effect of three mixture immersion solutions on the quality of osmotic dehydration of tomato (*Solanum lycopersicum*) slices. The first mixture was sugar syrup 30°Brix, 50° Brix and 60° Brix. The second mixture was sugar and calcium chloride ($CaCl_2$) (500ppm) in sugar syrup 30° Brix, 50° Brix and 60° Brix. The third blending 10% salt (NaCl) in sugar syrup 50° Brix as osmotic agents on osmotic dehydration of tomato slices with immersion duration (6 and 8 hours) at constant tomato ratio of (1:4). After this step the tomato slices in three mixtures were laid on the drying cabin for sun drying of tomato at 30 - 45°C. The moisture content and some chemical properties such as (total soluble solids TSS^{o} Brix, total titratable acidity TA (%) and pH-value) of tomato slices were determined. The results obtained showed that the lowest pH value was obtained from the treatment with 50° Brix sucrose with NaCl 10% (3.18), the highest content of total soluble solids was obtained from the treatment with 50° Brix sucrose with NaCl 10% and the highest total titratable acidity treatment was due to reatment with 50° Brix sucrose with NaCl 10% (0.720) consequently, the best treatment was that of 50° Brix sucrose with NaCl 10%. There were high significant differences between it and other treatments. From the obtained results, it could be concluded that the osmotic dehydration have highly impact on the quality control of tomato slices.

Key words: Tomatoes, osmotic dehydration, sun drying, pH value, total soluble solids, total titratable acidity.

INTRODUCTION

Tomatoes (*Lycopersicon lycopersicum*) belong to the genus *Lycopersicum* under solanaceae family. Tomatoes are an herbaceous sprawling plant growing to 1-3 m in height with weak woody stem. The flowers are yellow in colour and the fruits of cultivated varieties vary in size from cherry tomatoes, about 1–2 cm in size to beefsteak tomatoes, about 10 cm or more in diameter **(Baba *et al*., 2017).**

Most cultivars produce red fruits when ripe. The species originated in South American Andes and its use as a food originated in Mexico, and spread throughout the world following the Spanish colonization of the Americas **(Siddartha, 2017)**. Tomatoes are one of the most important "protective foods" because of its special nutritive value. It is one of the most versatile vegetable with wide usage in culinary tradition. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces and in many other ways, its also used as a salad vegetable **(Souza *et al.,* 2007)**.

Tomatoes are the second most important vegetable crop next to potato but it tops the list of canned vegetables. Global tomatoes production reached 183 million ton in 2017 according to **FAO (2019)** and therefore it considered the most important vegetable grown in the world. The leading tomatoes producing countries in the world are China, India, USA, Turkey, Egypt, Iran, Italy, Spain, and Brazil. It is a rich source of minerals, vitamins, organic

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acid, and dietary fiber. Tomatoes are rich in photochemical lycopene which is a powerful antioxidant **(Baba *et al*., 2017)**. Egypt is another one of the top most tomatoes growing countries. It has earned its place at the 5th position. It produces 7,297,108 tons of tomatoes every year according to **FAO (2017)**. The marketing of fresh tomato during the season is a great problem because of its short post-harvest life, which leads to high post-harvest losses **(Jayathunge *et al.*, 2012)**. Short post-harvest life and inadequate processing facilities result in heavy revenue loss reach 25 to 50%. In tropical countries, there is a loss of 20–50%, from harvesting to consumption **(Zanatta *et al*., 2015)**.

Tomatoes present high water content, 93–95% mn **(Shi and Le Maguer, 2000**) and **(Nemeskéri *et al.,* 2019)**. It is low in calories and rich in vitamin A, C, and E and minerals such as calcium, potassium, and phosphorus. In a rank of 10 vitamins and minerals, tomato is the first in terms of contribution in the diet **(Zanatta *et al.*, 2015**). Therefore, it is advantageous to develop a preservation method for tomatoes. Tomatoes are processed in a range of products, such as concentrated juice and pulp, which needs high technology for good quality products. Therefore, development of low-cost processing methodologies to produce shelf-stable convenience products is the prime requirement of the present competitive market.

Drying is one of the oldest known food preservation techniques. The process involves the slow removal the majority of water in the fruit or vegetable tissues, so that the moisture content of the dried product is below 20% **(Afolabi, 2014)**. The primary objective of drying is to extend the shelf-life of foods by reducing their water content. This prevents food from microbiological spoilage as well as from the occurrence of chemical reactions such as enzymatic and non-enzymatic browning. In addition to preservation, drying is also used to reduce the cost or difficulty of packaging, handling, storage and transportation, by converting the raw food into a dry product (**Raj *et al.,* 2006**).

Lewicki *et al.* (2002) reported that traditional sun-drying is a slow process compared with other drying methods and quality losses may result from high moisture content, colour degradation microbial growth. Sun drying requires 7 to 12 days, and the resultant product has typically 12% to 24% moisture and robust taste. Therefore, a pretreatment, before sun-drying, such as osmotic dehydration can lower the moisture content of the fresh fruit. The osmotic dehydration is a method of partial removal of water from plant food stuff.

Akbarian *et al.* (2013) reported that the osmotic dehydration is process of immersing cellular materials into a concentrated solution for partial removal of water while increasing soluble solid content.

Silva *et al.* (2013) stated that the osmotic dehydration of pineapple in sucrose solutions with added calcium significantly increased the calcium content of the pineapple and reduced the incorporation of sugar in the fruit. Samples osmotically dehydrated for 6 hours in a solution containing 4% calcium lactate presented the highest calcium content, such that the consumption of 100 g of this product would provide an intake of 10% of the daily requirement for calcium. However, after just 2 hours of osmotic dehydration, the fruit already presented higher calcium contents with the advantage of lower sucrose contents in comparison with samples treated in a solution without calcium. Moreover, pretreatment with $CaCl_2$ increased by 20% the amount of water removal during osmotic.

The aim of present study was to adaptation of osmotic dehydration process as pre-treatment for dehydration of tomatos and the idea behind this study is to provide the rural with a simple productive project from which the family income could be enhanced.

MATERIALS AND METHODS

Materials

Raw material

Tomato (*Solanum lycopersicum*) fruits variety (STAR 9064) which characterized by very high quality blocky cylindrical fruit with an average weight of 110-130 g. Fruit quality is exceptional with a deep red colure, thick walls, good flavour and without green shoulders present. The fruits were harvested at firm ripe stage from a private farm in Elmesalmia, Zagazig District, Sharkyia Governorate, Egypt.

Chemicals

All the chemicals that used in experiments and analysis were of analytical food grade, such as sugar from El-Osra Company. Calcium chloride, sodium chloride were purchased from Al-Gamhoria chemical company, Zagazig, Sharkyia Governorate, Egypt.

Design of drying Cabin

Perforated sample trays were used in sun drying experiments, these trays were assembled to wooden frame in the size of 80x100 cm on 80 cm stands covered with polyethylene to prevent contamination. During the drying of tomato slices, the ambient air temperature were determined by a digital thermocouple.

Methods

Preparation of tomato slices

The fresh tomatoes were washed to remove the dust. The upper part of the tomatoes was removed. The remaining part was cut in slices by a slicer (cuts perpendicular to each other) (5 mm thickness).Then the slices were again weighed to record the yield.

Sugar syrup preparation

Sucrose syrup of three different concentrations 30°Brix, 50° Brix and 60° Brix was prepared using distilled water. The second mixture syrup of sugar and calcium chloride was prepared by blending of sugar syrup (30°Brix, 50° Brix and 60° Brix) separately with calcium chloride ($CaCl_2$) up to 500 ppm concentration. The third mixture syrup, sugar and sodium chloride (NaCl) was prepared by blending 10% salt in sugar syrup 50° Brix.

Osmotic dehydration of tomato slices

One kg of tomato slices were dipped in the three mixture syrup solutions, at a ratio of 1:4 tomatoes to syrup, respectively and allowed to continue osmosis treatment for 6 and 8 hours at (4°C) in stainless steel tank. During the process of osmosis, water flows out of the tomato pieces to the syrup and fraction of solute moves into the tomato slices. At the end of the treatment for a particular osmotic duration, the fruit slices were taken out of the osmotic solution and were rinsed quickly with water in order to remove the sugar coating adhering to the surface of the slices. The osmosed tomato slices were weighed to know the extent of water removal from the slices by osmosis, A treatment with distilled water was used as control.

Sun drying of osmotic dehydrated tomato slices

After taking samples for analysis, known weight of osmosed slices of tomato were spread thinly on stainless steel trays which were kept in cabin of drying for dehydration. Tomato slices were thoroughly sun dried at 30-45°C till the tomato reached to required moisture content (12-24%).

Analytical Methods

Determenation of total soluble solids

Total soluble solids content was determined by using a hand refractometer (ATAGO) at 25ºC for dehydrated samples, **AOAC (2000).** 5g each of the dried tomato slices were weighed and mixed with 50 ml of distilled water in a clean beaker. Each was filtered through a sieve of 1mm pore size according to the methods described by **Nielsen (2010)**.

Determenation of total titratable acidity

Titratable acidity was determined according to the method described in **AOAO (2000)** as citric acid.

Determination of pH

The pH of each sample was determined by a pH meter (Orion research digital ionalyerr Wdel 501 96309-USA).

Sensory evaluation

Sensory evaluation of osmotic treated tomato slices obtained after drying under sun was performed by 35 untrained panelists, who were the under-graduate students in the Food Science Department, Faculty of Agriculture, Zagazig University with the age of 20–22 years and were familiar with dry tomato consumption. In addition, the acceptance test was used for determining the quality and consumer acceptability of osmodried tomato slice samples, based on their colour, appearance, flavour, texture and overall acceptability. Colour was evaluated by visual observation. Texture was evaluated by eating. Flavour was evaluated by smell and taste. The samples were presented to a test panel on a white plate labeled with 0-9 point, where (0 = dislike extremely, 1 = dislike very much, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor dislike, 5= like slightly, 7 = like moderately, 8= like very much, 9 = like extremely). The sensory evaluation of osmotic treated tomato slice was determined according to the methods that described by **Phisut *et al.* (2013)**.

Statistical Analysis

The analysis was carried out in three replicates for all determinations. The mean and standard deviation of means were calculated. Statistical analyses of data were performed using SPSS software (17.0 for windows). The data were analyzed by one-way analysis of variance (ANOVA). A multiple comparison procedure of the treatment means was performed by Duncan's New Multiple Range Test **(Duncan, 1955)**. Significance of the differences was defined as $P<0.05$.

RESULTS AND DISCUSSION

Total Soluble Solids (TSS)

The sugars and acids, together with small amounts of dissolved vitamins, fructans, proteins, pigments, phenolics, and minerals, are commonly referred to as total soluble solids **Kader (2008)**.

The result of TSS content in fresh tomato was 5.5˚ Brix. Fig. 1 shows that TSS content in control osmatic dehydrated tomatoes sample was 2.8˚ Brix and in control sample after sun drying was 6.2˚ Brix. The highest TSS of osmotic dehydrated tomatoes soaking in osmotic solution 60˚ Brix for 6 and 8 hours was 19.6 and 23.9˚ Brix, respectively.

The results showed that the highest sample in total soluble solids was sample treated with osmotic solution 60˚ Brix with $CaCl_2$ was 18.9˚ Brix for 6 hr., and samples treated with osmotic solution 50˚ Brix with $CaCl_2$ was 21.8˚ Brix for 8 hr. The lowest sample was that treated with osmotic solution 30˚ Brix with $CaCl_2$ it was 13 and 14˚ Brix for 6 and 8 hr., respectively.

While, comparing osmotic dehydration tomatoes with osmotic sun drying tomato slices in Fig. 2 showed that the highest sample in total soluble solids was sample treated with osmotic solution 60˚ Brix with $CaCl_2$ and valued 24.2 and 26.6˚ Brix for 6 and 8 hr., respectively. The lowest sample in total soluble solids, was the sample treated with osmotic solution 30˚ Brix with $CaCl_2$ it valued 19.90 and 20.2˚ Brix for 6 and 8 hr., respectively. These results agree with the results obtained by **Singh *et al.* (2016)** who explained that cell wall porosity of apple gets reduced due to impregnation of calcium resulting sucrose inhibition. Calcium acts as a partial barrier to the diffusion sucrose into the tissue **(Barrera *et al.*, 2009; Silva *et al.*, 2013)**.

On the other hand, the highest TSS were recorded in treatment 50˚ Brix with 10% NaCl for 6 and 8 hr., and valued 24.2 and 28˚ Brix, respectively. The sun dried osmotic dehydration tomato 50˚ Brix with 10% NaCl for 6 and 8 hr., increased to 30 and 32.1˚ Brix, respectively. Followed by osmotic dehydration tomato treatment with 60˚ Brix for 6 and 8 hr., was 19.6 and 23.9˚ Brix respectively. In sun dried osmotic dehydration tomato 60˚ Brix 6 and 8 hr., were 25.4 and 28.1, respectively. While in osmotic dehydration treatment with addition of calcium, the results were closed between 50˚ Brix with $CaCl_2$ for 6 and 8 hr., and valued 18.8 and 19.2, respectively, and 60˚ Brix with $CaCl_2$ 6 and 8 hr., 18.9 and 19.1, respectively. Total soluble solids of sun dried osmotic dehydration tomato slices were slightly higher in treatment [60˚ Brix with 500 ppm $CaCl_2$ for 6 and 8 hr., (24.2 and 26.2, respectively) than treatment (50˚ Brix with 500 ppm $CaCl_2$ for 6 and 8 hr., (24.0 and 24.8 Brix)].

In general, dried tomatoes which were immersion in osmotic solution contain sodium chloride before sun drying had higher TSS content than those treated isotonic solution. The results of this study are in agreement with the results obtained by **Arthey and Philip (2005)**. The results showed high considerable increase in TSS of all treatments. This may be due to the loss of weight by water evaporation during sun drying and the height migration of solid contents from the solution to the tomatoes during the osmotic step. It may be also due to the conversion of carbohydrates to sugar, organic

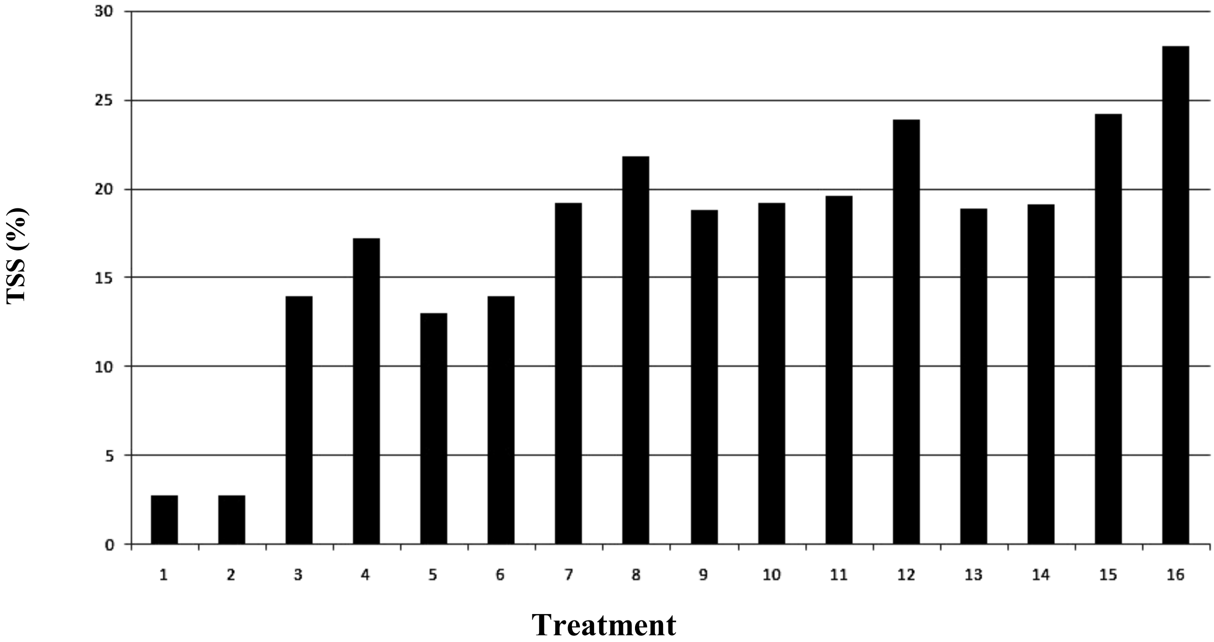

Fig. 1. Effect of different osmotic mediuam on total soluble solids in osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

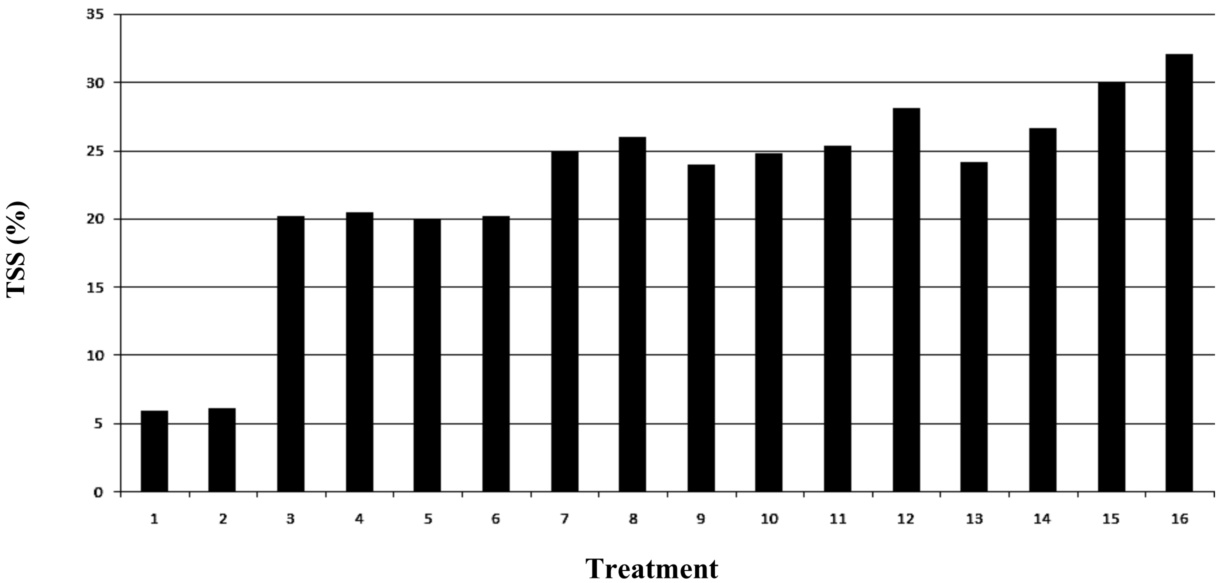

Fig. 2. Effect of different osmotic medium on total soluble solids in dried osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

acids and other soluble materials by metabolic process and hydrolic changes in starch converting starch into sugars during the osmotic process. **Idah and Obajemihi (2014**) noted also that the TSS content of samples pre-treated was higher than those in control because it had been shown from earlier studies that increase in sugar solution concentration can lead to increase in sugar content. These results confirming that the fact of treatment actually influenced the value of the total soluble solids.

This increase is due to the loss of water during the dehydration of the tomatoes and the transfer of solutes during the pre-dehydration. The presence of sodium chloride in the solution can favour the sucrose incorporation in the tomato, due to the increase of the cell membrane permeability, caused by physical alterations provied by the sodium chloride (**Tonon *et al.,* 2007**).

From the obtained results it could be shown that there were high significant differences between the effect of the interactions drying methods, treatments, treatment duration time and treatments with treatment duration. The mean squares of methods were (654.43), treatments were (624.64), treatment duration time were (63.001), the interaction between methods and treatments were (3.12), while the interaction between treatments and treatment duration time were (4.15). It followed by two interactions treatments without significant differences between them (Table 1). On the other hand, results in table 2 show significant difference in TSS between dried osmotic dehydrated tomato slices (22.50) and osmotic dehydrated tomato solices treatments (17.25 Brix).

Furthermore, the results that obtained from the statically analysis, showed that there were significant differences between the treatments. The treatment treated by 50˚ Brix with NaCl 10% had the highest value of TSS compared with control and the treatment with 30˚ Brix $CaCl_2$ 500 ppm. Whereas there were no significant differences between the other treatments under investigation as shown in Table 3.

Results in Table 4 show that there are significantly differences in TSS of osmotic dehydration tomato slices with duration time, where the TSS was 20.69 Brix for 8 hr., treatment and 19.07 Brix for 6 hr., treatment.

Total titratable acidity (TA)

Acidity is considered one of the important quality factors which directly affect taste through the sugar/ acid ratio and enhanced the final flavour of the dried product (**Doymaz, 2007**).

The total titratable acidity was 0.45% in fresh tomatoes (as citric acid). Results in Fig. 3 showed that samples soaking in osmatic solution 30, 50 and 60˚ Brix had the highest TA. while samples treated with 60˚ Brix was 0.56% and 0.57% for 6 and 8 hr., respectively. The lowest sample was 30 ˚Brix 0.52% and 0.53% for 6, 8 hours. While, in sun osmotic drying tomato slices samples, the highest sample in TA the sample treated with 60 ˚Brix it was 0.74% and 0.75% for 6 and 8 hr. While the lowest sample in 30˚Brix was 0.6% and 0.62% for 6 and 8 hr., respectively. While in sample soaking in sugar solution with addition of $CaCl_2$ the highest sample in TA the sample 30˚ Brix with $CaCl_2$ for 6 and 8 hr., it was 0.41 and 0.40 while the lowest sample in TA the sample treated with 60˚ Brix with $CaCl_2$ for 6 and 8 hr., was 0.30% and 0.31%, respectively.

In sun drying osmotic tomato slices in Fig. 4 shown the highest sample in TA also was 30˚ Brix with $CaCl_2$ for 6 and 8 hr., it was 0.56% and 0.55%, respectively. Also the lowest sample was 50˚ Brix with $CaCl_2$ for 6 and 8 hr., it was 0.48% and 0.49% respectively. In osmotic sample soaking in osmotic solution 50˚ Brix with NaCl the TA was 0.65% and 0.67% for 6 and 8 hr. The treatment that treated by sun osmotic drying tomato slices it was 0.78% and 0.79% for 6 and 8 hr.

From the results above, it is clear that 0.65%, and 0.67% was recorded in treatment 50˚ Brix with 10% NaCl for 6 and 8 hr., respectively compared to control treatment which recorded 0.38%. While, osmodehydrated sample treated with 60˚ Brix for 6 and 8 hr., showed increments in titratable acidity 0. 56% and 0.57%, respectively compared with sample treated with 30˚Brix sucrose 6, 8 hours which showed the lowest TA. While, in osmodehydrated sample treated with 30˚Brix with $CaCl_2$ for 6 and 8 hr.,

Table 1. Variance of mean squares and sum of squares of the response of TSS of osmotic dehydrated tomato and dried osmotic dehydrated tomato

Source	df	Sum of Squares	F Ratio	Mean Square	Prob> F	
Model	44	5146.7782	230.1395	116.972	<.0001	
Error	51	25.9216		0.508	<.0001	
Method	1	654.4315	1287.575	654.4315	<.0001	
Treatment	7	4372.4841	1228.962	624.640	<.0001	
Treatment duration	1	63.0018	123.9542	63.0018	<.0001	
Method with treatment	7	21.8527	6.1421	3.121	<.0001	
Method with treatment duration	1	1.8621	3.6635	1.8621	0.0612	Ns*
Treatment with treatment duration	7	29.0970	8.1782	4.156	<.0001	
Treatment duration with Reps	2	0.0496	0.0488	0.0248	0.9525	Ns*

*Ns: Non significant significantly different at $p \leq 0.05$

Table 2. LS Mean value between the methods interaction of the TSS

Level			Least Sq Mean
Dried osmotic dehydrated tomato	A		22.500000
Osmotic dehydrated tomato		B	17.278125

Levels not connected by same letter are significantly different.

LS Means differences student's t α=0.050 t=2.00758

Table 3. LS Mean value between interactions of the treatments in the TSS

Level								Least Sq Mean
T 50˚ Brix sucrose with NaCl 10%	A							28.733333
T 60˚ Brix sucrose		B						24.060000
T 50˚ Brix sucrose			C					22.988333
T 60˚ Brix sucrose with $CaCl_2$ 500ppm				D				22.216667
T 50˚ Brix sucrose with $CaCl_2$ 500ppm				D				21.715833
T 30˚ Brix sucrose					E			18.175000
T 30˚ Brix sucrose with $CaCl_2$ 500ppm						F		16.748333
Control							G	4.475000

Levels not connected by same letter are significantly different.

LS Means differences student's t α=0.050 t=2.00758

Table 4. LS Mean between the interactions of the duration time of the treatments in the TSS

Level			Least Sq Mean
8 hrs.	A		20.699167
6 hrs.		B	19.078958

Levels not connected by same letter are significantly different.

LS Means differences student's t α=0.050 t=2.00758

was the highest TA compared with 50, 60˚Brix with $CaCl_2$ for 6 and 8 hr., record the same result. On the other hand, in sun dried samples the highest TA 0.78%, 0.79% was recorded in treatment 50˚Brix with 10% NaCl for 6 and 8 hr., respectively compared to control treatment that recorded 0.40% and 0.41%.

The results of this study are in agreement with the results that obtained by **Thippana (2005) and Suhasini (2014)** who explained that the NaCl solution contained the additional 0.3% acidity, increased acidity in final product. As the salt solution contained the additional 0.3% acidity, this added acidity played significant role in the increased acid content of the final product.

The results that obtained from statistical analysis showed that sum of squares and mean squares of the response of TA of tomato under control and osmotic dehydration and dried osmotic dehydration tomato treatments have significant differences and the other interactions were no significant.

Statistical results showed that there were high significant differences between the interactions of methods, treatment and methods with treatment. The mean squares of methods were (0.46) while treatments were (0.19). The interaction between methods with treatment was also highly significant (0.009), it followed by three interactions treatments that were have no significant differences between them Table 5. As clearly in Table 6 showed highly significant differences of the interaction methods of the dried osmotic dehydrated tomato TA was (0.60 A) that was highly significant than the osmotic dehydrated tomato treatments (0.46 B).

Furthermore, results of the interaction of treatment of the interaction TA indicated that the best treatment was treatment treated with 50˚ Brix sucrose with NaCl 10% (0.72 A) that has the highest TA. Also, there was a highly significantly different between it and other treatments. While, the lowest TA was obtained from treatment control (0.39 E), and treatment treated with 30˚ Brix sucrose with $CaCl_2$ 500 ppm (0.48 D). Whereas there were no significant differences between the other treatments under investigation as shown in Table 7.

pH value

The osmotically dehydrated tomato slices drying reduced the pH value of the tomato significantly compared to the control and fresh tomato. The reduction of the pH value reduces the microbial proliferation, favoring the conservation of the product reported that **Andrés-Bello *et al.* (2013) and Semicenkova *el al.* (2019)**.

Results in Figs. 5 and 6 presented the effect of treatments on the pH value in tomato slices. Results indicated that the fresh tomato pH value were 4.4. In osmotic tomato slices that treated with sugar solution 30, 50, 60˚ Brix the highest sample in pH value was that treated with 30˚ Brix it was 4.36, 4.37 for 6 and 8 hr., while the lowest sample was the sample treated with 60˚ Brix 4.33 for 8 hr.

In sun drying osmotic tomato slices, pH value for same sample the highest sample was in treatment 30˚ Brix for 6 and 8 hr., 4.35. The lowest sample was in treatment 50˚ Brix for 8 hr., 4.32. The results of this study were close agree with the results obtained by **Castro *et al.* (2016)** that can be attributed to a concentration of hydrogen ions caused by the elimination of water. In osmotic tomato slices that treated with sugars solution with added $CaCl_2$ showed that the highest sample were sample treated with 30˚ Brix with $CaCl_2$ for 8 hr., it was 4.39. The

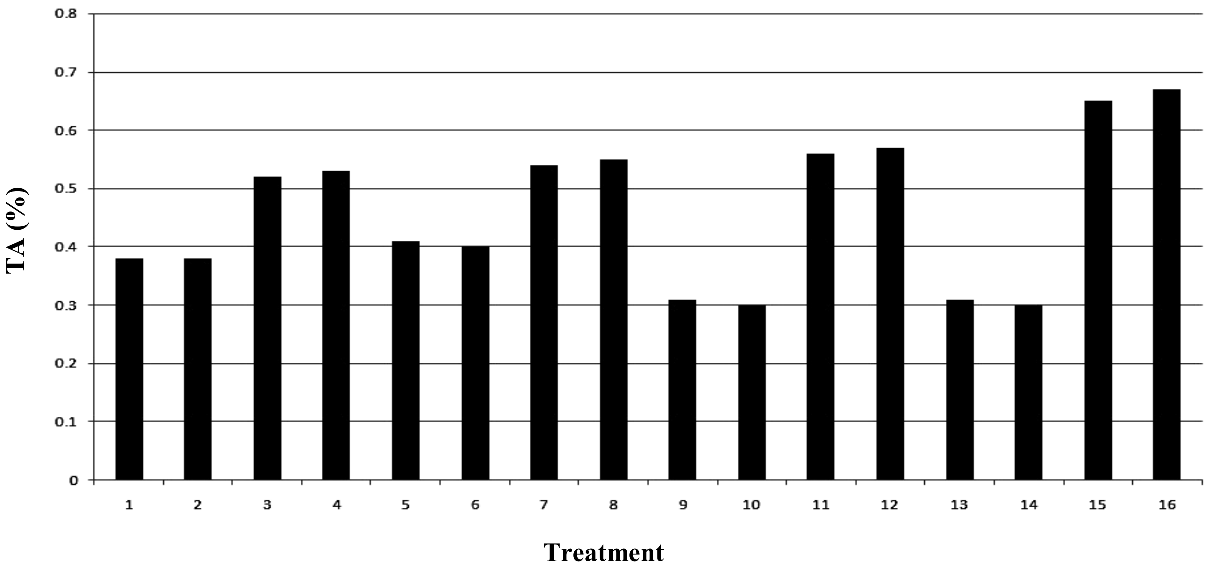

Fig. 3. Effect of different osmotic medium on total titratable acidity in osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

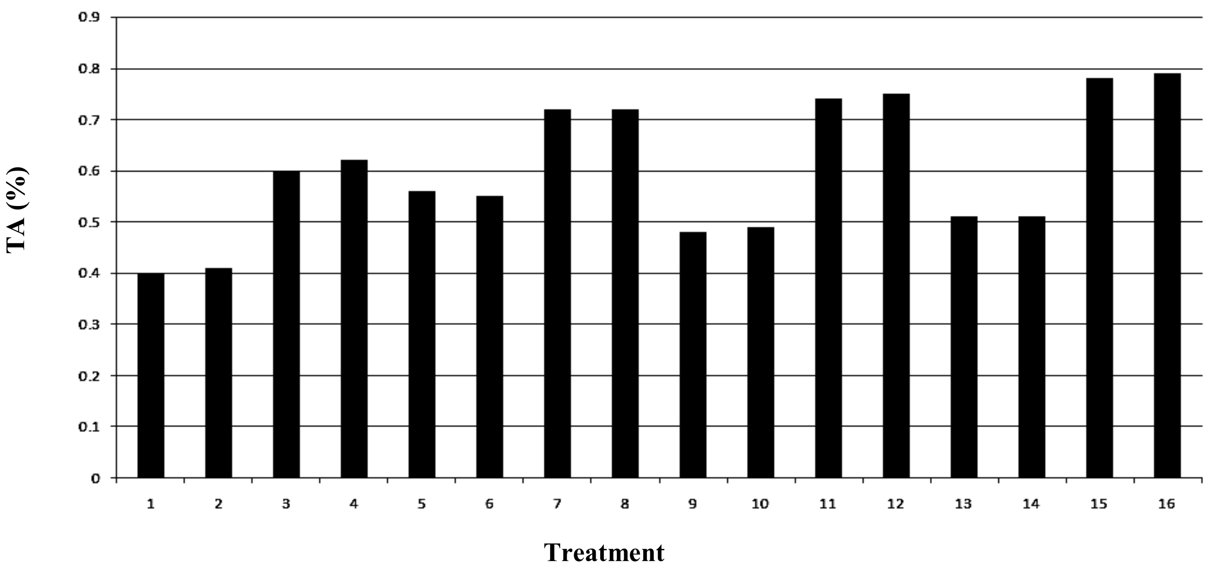

Fig. 4. Effect of different osmotic medium on total titratable acidity in dried osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

Table 5. Variance of mean squares and sum of squares of the response of TA of osmotic dehydrated tomato and dried osmotic dehydrated tomato

Source	df	Sum of Squares	F Ratio	Mean Square	Prob> F	
Model	44	1.9561042	44.2149	0.044457		
Error	51	0.0512792		0.001005	<.0001	
Method	1	0.4648167	462.2862	0.4648167	<.0001	
Treatment	7	1.3920000	197.7746	0.1988	<.0001	
Treatment duration	1	0.0010667	1.0609		0.3079	Ns
Reps	2	0.0102521	5.0981	0.005126	0.0096	
Method witht reatment	7	0.0684000	9.7182	0.00977	<.0001	
Method with treatment duration	1	0.0000000	0.0000		1.0000	Ns
Treatment with treatment duration	7	0.0007833	0.1113	0.000111	0.9973	Ns

* Ns: Non significant significantly different at $p \leq 0.05$

Table 6. LS Mean value between the interactions of method in the treatment in the TA

Level			Least Sq Mean
Dried osmotic dehydrated tomato	A		0.60416667
Osmotic dehydrated tomato		B	0.46500000

Levels not connected by same letter are significantly different.

LS Means differences student's t α=0.050 t=2.00758

Table 7. LS Mean value between the interaction of treatment in the in the TA

Level						Least Sq Mean
T 50° Brix sucrose with NaCl 10%	A					0.72000000
T 60° Brix sucrose		B				0.65500000
T 50° Brix sucrose		B				0.63666667
T 30° Brix sucrose			C			0.57583333
T 30° Brix sucrose with $CaCl_2$ 500ppm				D		0.48000000
T 60° Brix sucrose with $CaCl_2$ 500ppm					E	0.41166667
T 50° Brix sucrose with $CaCl_2$ 500ppm					E	0.40083333
Control					E	0.39666667

Levels not connected by same letter are significantly different.

LS Means differences student's t α=0.050 t=2.00758 lowest sample was 60˚ Brix with $CaCl_2$ it was 4.32 and 4.33 for 6 and 8 hr., while in dried osmotic dehydrated tomato in Fig. 7 showed that sun drying osmotic samples for same treatments pH value the highest sample for 30˚ Brix with $CaCl_2$ and 50˚ Brix with $CaCl_2$ for 6, 8 hrs it was 4.39. And the lowest sample in pH value was in treatment 60˚ Brix with $CaCl_2$ it was 4.35 and 4.36 for 6 and 8 hr.

In osmotic tomato slices that treated with sugar solution 50˚ Brix with added NaCl showed that was 4.32 and 4.33 for 6, 8 hours but in sun drying osmotic tomato it was 3.29 and 3.18 for 6 and 8 hr., respectively.

These results agree with the results obtained by **Wilson *et al.* (2011)** which concluded that the highest pH value found in control was 4.45 followed by 30˚ Brix sucrose with $CaCl_2$ for 6 and 8 hr., it was 4.38 and 4.39, respectively. While, the lowest pH was found in treatment 50˚ Brix with 10% NaCl for 6 and 8 hr., 3.19 and 3.08, respectively. On the other hand, in sun dried sample the results were closed also between all other treatments.

The Results obtained from statistical analysis showed that sum of squares and mean squares of the response of pH value of tomato under control and osmotic dehydrated and dried osmotic dehydrated tomato treatments have significant differences and the other interactions were no significant.

Statistically results showed that there were high significant differences among the interactions treatment and treatment with treatment duration. The mean squares of treatments were (2.13). The interaction treatment with treatment duration was also highly significant between the control and treatments (0.0028), it followed by six interactions treatments without significant differences between them (Table 8).

The results indicated that the best treatment was treatment by 50˚ Brix sucrose with NaCl 10% (3.18 C) that had low pH value, there was a highly significantly different between it and other treatments, whereas the lowest treatment was control at (4.48 A) Table 9.

Sensory Evaluation

Sensory evaluation plays significant role in measuring characteristics and acceptability of foods and food products (**Krzysztof *et al.*, 2019).** The results that obtained from sensory evaluation (colour, taste and overall acceptability) of tomato slices by the panelists in fig 7 showed that the highest sample in overall acceptability treated with 50˚ Brix sugar solution for 6 hrs was (25.64) followed by sample treated with 50˚ Brix sugar solution for 8 hrs was (24.57). In sample treated with sugar solution with $CaCl_2$ were lower than sample with sugar solution only because high concentration of calcium chloride may result in the bitter taste of product accordance with **Phisut *et al.* (2013)**. While, sample treated with sugar solution with NaCl it was low for over all acceptability because when NaCl was used, the taste of product becomes salty that was not desirable. These results are consistent with **Azouble and Murr (2004) and Ali *et al.* (2010)**. On the other hand, control sample was the lowest sample in over all acceptability where there was a change in the colour and lost part of the samples on the drying cabin where it becomes fragile and the taste become undesirable and missing the taste of tomatoes.

Conclusion

The results that obtained from this study ,it could be concluded that there were highly important for study of the acidity of the tomato and the solution that used during pretreatment of tomato slices because they have highly effect on the quality factors such as sugar/acid ratio and effect on the enhanced on the final flavour of the dried product

On the other hand, the results suggested the possibility of drying of tomato slices by osmotic dehydration with (50˚ Brix sucrose with NaCl 10% completed with sun dry and this methods is applicable in the rural home in the Egyptian village.

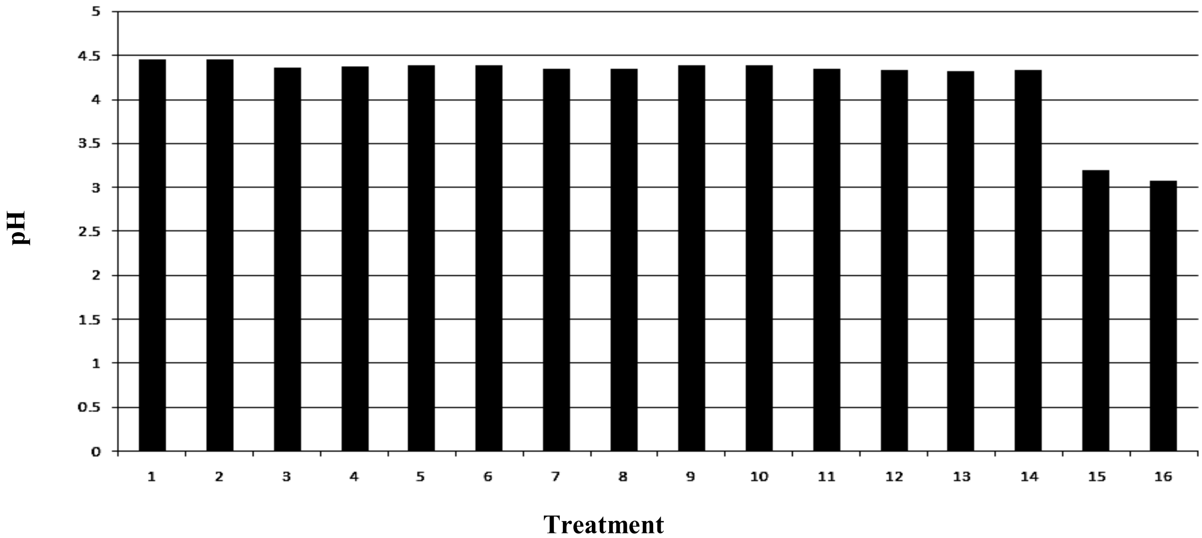

Fig.5. Effect of different osmotic medium on pH value in osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

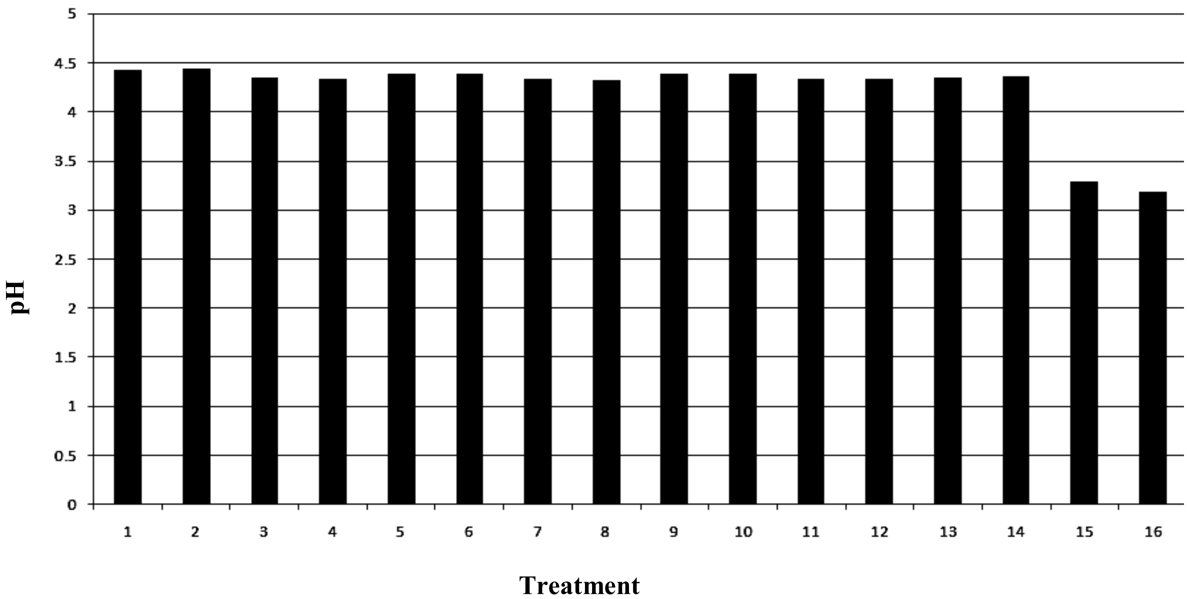

Fig. 6. Effect of different osmotic medium on pH value in dried osmotic tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

Table 8. Variance of mean squares and sum of squares of the response of pH value of osmotic dehydrated tomato and dried osmotic dehydrated tomato

Source	df	Sum of Squares	F Ratio	Mean Square	Prob> F	
Model	44	15.158213	97.6979	0.344505	<.0001	
Error	51	0.179838		0.003526	<.0001	
Method	1	0.014017	3.9750	0.014017	0.0515	ns
Treatment	7	14.976317	606.7320	2.139	<.0001	
Treatment duration	1	4.16667	0.0012	4.16667	0.9727	ns
Method with treatment	7	0.038017	1.5402	0.00542	0.1751	ns
Method with treatment duration	1	0.001838	0.5211	0.001838	0.4737	ns
Treatment with treatment duration	7	0.059596	2.4144	0.00298	0.0325	
Treatment*Reps	14	0.053758	1.0889		0.3894	ns
Treatment duration with Reps	2	0.005908	0.8378		0.4385	ns

* Ns: Non significant significantly different at $p \leq 0.05$.

Table 9. LS Mean value between the interactions of treatment in the pH value

Level				Least Sq Mean
Control	A			4.4833333
T 30° Brix sucrose with $CaCl_2$ 500ppm		B		4.3783333
T 50° Brix sucrose		B		4.3658333
T 50° Brix sucrose with $CaCl_2$ 500ppm		B		4.3600000
T 30° Brix sucrose		B		4.3533333
T 60° Brix sucrose with $CaCl_2$ 500ppm		B		4.3441667
T 60° Brix sucrose		B		4.3375000
T 50° Brix sucrose with NaCl 10%			C	3.1875000

LS Means differences student's tα =0.050 t=2.00758

Levels not connected by same letter are significantly different.

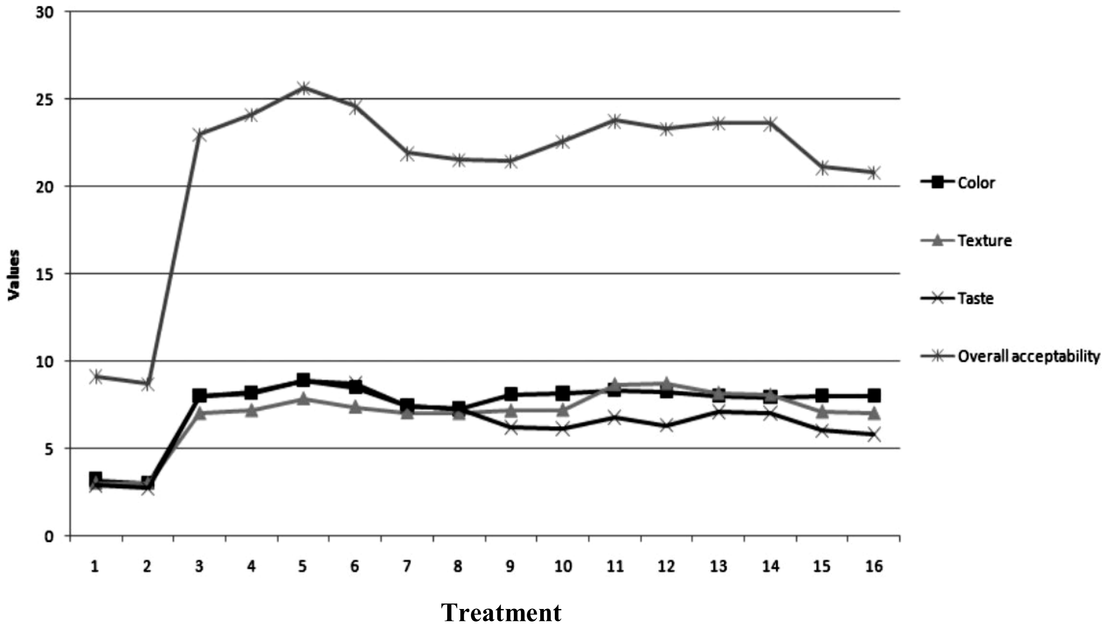

Fig. 7. The effect of different pre- treatments and drying methods on sensory characteristics of dried tomato slices

1,2)-Distilled water for 6 and 8 hr., at 4˚C (control), **3,4)-**30˚ Brix sucrose solution for 6 and 8 hr., at 4˚C, **5,6)-** 30˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6.8 hr., at 4˚C **7,8)-** 50˚Brix sucrose solution for 6 and 8 hr., at 4˚C **9,10)**- 50˚ Brix sucrose solution with 500 ppm $CaCl_2$ for 6 and 8 hr., at 4˚C **11,12)-** 60˚ Brix sucrose solution for 6 and 8 hr., at 4˚C **13.14)-** 60˚ Brix sucrose solution with 500 ppm $CaCl_2$for 6 and 8 hr., at 4˚C **15,16)-** 50˚Brix sucrose solution with 10% NaCl for 6.8 hr., at 4˚C.

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تأثير التجفيف الاســـــموزي علي شـــرائح الطماطم

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أجرى هذا البحث لدراسة تأثير ثلاثة مخاليط من محاليل النقع علي جودة شرائح الطماطم (*Solanum lycopersicum*) المجففة اسموزيا، حيث كان الخليط الأول شراب السكر ٣٠ درجة بريكس و ٥٠ درجة بريكس و ٦٠ درجة بريكس و كان الخليط الثاني كلوريد الكالسيوم ٥٠٠ جزء في المليون في الشراب سكر ٣٠ درجة بريكس و ٥٠ درجة بريكس و ٦٠ درجة بريكس على حد سواء، والخليط الثالث ١٠٪ ملح طعام في شراب السكر ٥٠ درجة بريكس كعوامل اسموزيه تساعد على الجفاف الاسموزي لشرائح الطماطم مع نقع شرائح الطماطم لمدة (٦ و ٨ ساعات) بمعدل الطماطم إلى المحلول (١:٤)، وبعد المعاملة الاسموزية لشرائح الطماطم في الثلاثة مخاليط ، وضعت هذه المعاملات على مقصورة التجفيف لتجفيف الطماطم بأشعة الشمس عند درجة حرارة تراوحت بين ٣٠ و٤٥ درجة مئوية حتى الوصول الي المحتوى الرطوبي النهائي وقياس بعض الخواص الكيميائية مثل (المواد الصلبة الذائبة الكلية، الحموضة الكلية للمعايرة وقيمة الرقم الهيدروجيني)، أظهرت أهم النتائج التي تم الحصول عليها أن أدنى قيمة للرقم الهيدروجيني كانت مع المعاملة ١٠% ملح كلوريد الصوديوم في محلول سكري تركيزه ٥٠ بركس (٣,١٨) وكان أعلى محتوى للمواد الصلبة الذائبة مع المعاملة ١٠% ملح كلوريد الصوديوم في محلول سكري تركيزه ٥٠ بركس وكان أعلى محتوي من الحموضة بالمعايرة الكلية مع المعاملة ١٠% ملح كلوريد الصوديوم في محلول سكري تركيزه ٥٠ بركس (٠,٧٢)، وبالتالي ، فإن أفضل المعاملات هي المعاملة ١٠% ملح كلوريد الصوديوم في محلول سكري تركيزه ٥٠ بركس مع جميع الخواص الكيميائية والتي لها اختلاف كبير للغاية بينها وبين المعاملات الأخرى، من خلال النتائج التي تم الحصول عليها يمكن أن نستنتج أن التجفيف الاسموزي له تأثيراً كبيراً على جودة شرائح الطماطم المجففة اسموزيا.

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