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The Effect of Different Drying Processes on Some Nutritional and Quality Criteria in Tomato Powder

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ABSTRACT: This study was conducted on the quality of tomato powders obtained from tomatoes dried in the sun (SD), microwave (MD) and in the oven at three different temperatures (55°C (OD 55), 65°C (OD 65) and 75°C (OD 75)). Drying processes lasted 20 days, 40 minutes, 8, 7 and 5 hours, respectively, for SD, MD, OD 55, OD 65 and OD 75. The dry matter (DM) rate in dried products was between 86.50 and 88.31%. Ash amounts of dried products were determined between 7.64 and 9.57%. At the end of the drying processes, pH values were between 4.40 and 4.64, and the difference was statistically significant ($p<0.05$). Water activity (aw) values in dried products were between 0.31 and 0.35. In addition, there was an increase in the amount of lycopene in all samples after the drying processes. The highest lycopene content was determined in the SD process at 387.83 mg/100 g DM, and the lowest amount was in the OD 65 at 349.59 mg/100 g DM. Regarding the total carotenoid matter, the highest loss was found in the SD process at 43%, and the most negligible loss was in MD at 0.05%. Moreover, the difference between the processes in the total phenolic matter was statistically significant ($p<0.05$). The lowest loss was 38% in the OD 55 process, and the highest was 46% in the MD process. The highest loss in the total flavonoid matter was in the MD sample at 57%, while the lowest was in the SD at 37%.

Keywords – *Tomato powder, drying, criteria of quality, food, nutritional*

1. Introduction

The tomato belongs to the Solanaceae family and is named Lycopersicum esculentum Mill and is known to have passed from its homeland Mexico and Peru, to Europe in the early 16th century. The introduction of tomatoes to Turkey coincides with the years of World War I. Tomato is a product consumed with its unique taste and aroma and a very high nutritional value. (Düzyaman and Duman 2003). Approximately 25-30% of tomatoes produced in Turkey are processed in the food industry, and the remaining amount goes to fresh consumption. 80% of the total amount processed is used for tomato paste production, 15% is used for canned tomato production, and the remaining part is used for producing tomato products such as ketchup, tomato juice, etc. (Ertürk and Çirka 2014). Tomatoes account for approximately 68% of dried vegetable exports (Akdeniz and Bağdatlıoğlu 2007).

In addition to fresh consumption, tomatoes have a wide variety of uses in the food industry, such as frozen, tomato paste, sauce, ketchup, pickles, tomato juice, tomato puree, peeled tomatoes, sliced tomatoes, cubed tomatoes, dried tomatoes, canned tomatoes (Kazak et al. 2018). Dried tomato products are used in various vegetables, spicy dishes, the ready-made soup industry, salads, and as pizza ingredients (Demiray, 2009).

Drying is one of the oldest known methods of food preservation. With drying, the water activity of the food is reduced. In this way, the deterioration of the product can be prevented by preventing the enzymes from working with microbial development. Since the free water in the food is removed by drying, volume shrinkage and significant weight loss also occur in dried fruits and vegetables. This decrease in volume and weight loss creates an advantage in transportation and storage (Yamashita, 2017). Drying food is one of the most commonly used techniques to extend shelf life, reduce storage-transport costs, and minimize quality loss (Nazghelichi et al., 2010; Sincere Akhijahani & Arabhosseini, 2018).

However, since drying has an accelerating effect on some reactions that will adversely affect the quality of the product, the drying conditions significantly affect the quality characteristics of the dried product. It affects the structural properties of the dried product such as drying conditions such as temperature, airspeed, relative humidity of the air, density, porosity, optical properties such as colour, appearance, sensory properties such as aroma, taste, smell, and properties such as water holding capacity and rehydration rate (Demiray, 2009).

Different methods are used for drying tomatoes. The most common drying method is sun-drying, and most of the tomatoes in Turkey are dried by this method (Demiray, 2009).Drying in the sun takes a long time, hygienic problems can be experienced, especially due to the temperature difference between day and night, and there may be microbial development in the product. To prevent microbial development, sulphurization, salt treatment, or adding preservatives are on the agenda. At the same time, uncontrollable colour changes in sun-dried tomatoes, inadequate water recovery, increased microbial load and some nutrient and vitamin losses may also be important problems. The supply of clean, hygienic and always of the same quality dried products can only be possible with special dryers (Günhan 2005). It has been found that daylight positively affects the quality characteristics of the products, but it has not been preferred in terms of long drying time and microbial risks (Mustayen et al., 2014). For this reason, the drying of foods can be conducted today with many laboratory or industrial-scale artificial drying methods. With the artificial drying methods developed, the drying time of the product is shortened, the products are dried more cleanly and in standard quality, and nutrient and vitamin losses occur less. In addition to such advantages of the artificial drying method, the fact that the initial investment and operating costs are very high compared to drying in the sun encourages the drying of agricultural products in the sun in countries rich in solar energy, such as our country. It greatly limits the use of special artificial dryers (Demiray 2009).

Additionally, there are many studies on the drying of foods in the literature. These studies investigate drying techniques and the effects of drying on nutritional values (Abe et al.,1997; Vega-Galvez et al., 2012). The study conducted by Ayan (2010) examined the characteristics of artificially dried tomatoes at different temperatures (40°C, 50°C, 60°C) in the sun and air-powered ovens. Kocabıyık et al. (2012) investigated the usability of the infrared drying technique to improve energy efficiency in drying tomato slices and to obtain quality dried tomatoes. In the literature, some studies examined the physical properties of tomato slices, such as drying time, specific energy consumption, shrinkage rate, rehydration rate, colour properties and texture, and chemical (nutrient) properties such as vitamin C and lycopene. They also investigated the effects of drying variables on these properties (Chawla et al., 2008).

Şahin (2010) compared tomatoes where four different drying methods were applied. These drying methods included sun drying, hot air cabin-type drying in the dryer, vacuum drying and freeze drying. Drying applications were carried out in both non-pre-treatment and pre-treatment. Freeze-drying has yielded the best results in terms of many criteria. Also, this method found the highest nutritional values, such as ascorbic acid, potassium and lycopene, in tomatoes. The prolongation of the time in hot air drying and the increase in drying temperatures decreased lycopene amounts (Şahin, 2010).

Tomato powder is obtained by grinding dried tomatoes. It is commonly used as a sweetener in seasoning, pastries, and dishes (Baloch et al., 1997).

This study produced tomato powder by drying Rio Grande tomatoes in the sun at different temperatures (55 ^{o}C, 65 ^{o}C and 75 ^{o}C) in the incubator and then grinding. The study aimed to determine the effect of different drying processes on tomato powders' nutritional elements and quality criteria.

2. Material and Methods

2.1. Material

The study obtained fresh tomatoes, Rio Grande varieties, from Urla district of İzmir province.

Tomato Powder Production

The tomatoes were washed and divided into quarters and were dried by sun drying, oven drying and microwave drying processes. It was applied to sliced tomatoes in the sun drying (GK) method using 30 g salt per 1 kg method. In the oven drying method, 3 different temperatures, 55°C, 65°C and 75°C, were applied to sliced tomatoes. Due to the high initial moisture level in the tomatoes during microwave drying, the power was gradually reduced, and the amount of moisture was brought to the desired level.

700W, 600W, 460W, 350W, 120W were applied in microwave drying of tomatoes, respectively. In the production of tomato powder, dried tomatoes reduced to at least 15% moisture level, have been subjected to the grinding process. The dried tomatoes were ground in a hammer mill and stored at -18 °C in polyethene bags.

Analyses

Dry matter of tomato powders obtained with fresh tomatoes with SD, MD, OD 55, OD 65 and OD 75 was determined according to Cemeroğlu (2007). 5 gr of Tomato powders and fresh tomato samples homogenized in a blender were put into moisture containers and left to dry in the drying cabinet (Wiseven) at 105°C until they reached the fixed weighing.

Water activity (aw) analysis was performed according to Cemeroğlu (2007). Homogenized fresh tomatoes and obtained tomato powders are placed on the partition surface of the device.

Ash determination in the samples was made according to Cemeroğlu (2007). 3 g of the powder and homogenized fresh sample were taken into crucibles and burned in an ash oven (Nüve MF 120) at 550°C until white ash formed.

pH analysis of the samples was performed according to Cemeroğlu (2007). 10 g of tomato powders were put into distilled water and measured by dipping a pH meter directly in fresh tomatoes.

Salt was determined according to Cemeroğlu (2007). 5 g of tomato powders and homogenized fresh tomato samples were filled to the line with distilled water in a 100 ml volumetric flask and then filtered. 100 ml of distilled water and a few drops of phenolphthalein were added to 10 ml of the filtrates, and then they were neutralized with 0.1 N NaOH until turning pink. After the neutralization process, 2 ml of 5% K_2 CrO_4 was added to these herbicides and titrated with 0.1 N $AgNO_3$ until a brown colour formed.

$$\text{Amount of salt}, \% = V \times (f) \times (0.005844) \times (sf) \times 100$$

V= amount of 0.1 N 0,1 N $AgNO_3$ spent in titration (ml)
(f) = Factor of 0.1 N 0,1 N $AgNO_3$ solution
Df= Dilution factor = $(V_1 /M).(1/V_2)$ (1)
V_1 = volume (ml) to which the sample is diluted
M= amount of sample taken initially (g)
V_2 = amount of filtrate taken for titration (ml)

Lycopene analysis in the samples was performed according to Abdollahi (2008). 0.3 g samples were taken from tomato powders, and homogenized fresh tomato samples into centrifuge tubes. 3 g of maize starch and 20 ml of acetone were added. Likewise, all samples were mixed with the blank solution prepared without a sample at 150 rpm for 20 minutes and then centrifuged at 3000 rpm for 3 minutes. The obtained supernatants were measured in a spectrophotometer at a wavelength of 503 nm.

The total amount of carotenoids was arranged according to Kirk and Allen (1965). 2 g of each sample was put into 40 ml of 80% methanol and then homogenized (Braun, MR 404). After homogenization, the samples were centrifuged at 4000 rpm for 10 minutes at 4 °C centrifuge and filtered through coarse filter paper. The filtrates were measured in a 4747nm wavelengths.

Chlorophyll a (Kl a) = (15.69.A666) - (7,340.A653)
Chlorophyll b (Kl b) = (27,05.A653) - (11.21.A666)

$$Total\ carotenoid = [(1000 \times \text{A470}) - (2{,}860\ \text{Kl a}) - (129{,}2\ \text{Klb})] \div 245 \qquad 2)$$

The total amount of phenolic substances was analyzed according to the Folin-Ciocalteu method proposed by Singleton and Rossi (1965). 50 ml of methanol (Sigma 24229) of 80%was added to the samples of 0.5 g and kept in the ultrasonic bath for 20 minutes. Later, 2 ml of extract was taken from each and centrifuged at 14000 rpm for 5 minutes (Nucleus NF 800R). 1 ml of the centrifuged samples and 75 ml of water were put in 100 ml volumetric balloons. 5 ml of Folin-Ciocalteu (Merck 64271) reagent was added into the balloon and kept for 3 minutes. Next, 10 ml of saturated sodium carbonate was added and filled with distilled water up to the line of the measuring balloon and kept for 60 minutes. Absorbance was measured at 720 nm wavelength against the control group prepared similarly.

To calculate the total phenolic content in the samples, 25 mg gallic acid was dissolved in 50 ml absolute ethyl alcohol, and a gallic acid solution with a concentration of 500 mg/Lwas prepared. From this prepared stock solution, solutions with a concentration of 50, 100,200, 300, and 400 mg/L were obtained, and after the processes applied to the samples, measurements were made at 720 nm wavelength.

Total flavonoid amount analysis was performed according to Zhuang et al. (1992). 1 ml of solutions of the extracts or standard catechin solution (20, 40, 60, 80 and 100 mg/L) was added to a 10 ml container containing 4 ml of water. 0.3 ml of 5% $NANO_2$ Merck (Germany) solution, and 5 minutes later, 0.6 ml of 10% $AlCl_3$ (Merck 85662) were added. In the 6th minute, 2 ml of 1 M NaOH (Sigma 00376) was added, and the total volume was obtained as 10 ml adding distilled water. After mixing the solution, the absorbance value corresponding to the blank solution was measured at 510 nm wavelength.

Colour values of the samples (L*, a* and b*) were made with a Minolta Cr-400 color reader.

The analyzes were performed as 2 repetitions and 3 parallels. Duncan's multiple comparison test determined the significance level of the differences between the applications.

SPSS (ver.18) package program was used for statistical analysis.

3. Results and Discussion

Table 1 gives the moisture dry matter amount and ash amount results of tomato powders obtained by different methods.

No statistical difference was found between drying applications ($p>0.05$). After the analysis, the MD application was found to have the highest total dry matter (TDM) rate (88.31%). The study found the TDM rate of tomatoes used as raw materials was 6.22%.

The study by Abdollahi (2008) expressed the mean TDM of tomatoes as 5.15%. While the amount of ash in the fresh sample was 0.53%, there were close results in tomato powders. (Table 1.)

Table 1. *Moisture, total dry matter and ash amounts of tomato powders*

Sample	Moisture,(%)	Total Dry Matter, (%)	Ash Amount,(%)
OD 55	$13.46^a \pm 0.56$	$86.54^a \pm 0.56$	$8.14^a \pm 0.04$
OD 65	$13.27^a \pm 0.39$	$86.72^a \pm 0.39$	$8.08^a \pm 0.32$
OD 75	$12.80^a \pm 0.21$	$87.20^a \pm 0.21$	$9.57^a \pm 2.93$
SD	$13.50^a \pm 0.05$	$86.50^a \pm 0.05$	$8.03^a \pm 0.15$
MD	$11.68^a \pm 0.09$	$88.31^a \pm 0.09$	$7.64^a \pm 0.65$

At the end of the drying processes, TDM values were between 86.50-88.31% as close values. Drying processes did not affect the amount of ash, and an increase in SD was determined in pH values, which was thought to be due to salt application. After drying, tomatoes with an initial moisture content of 94-95% reached a moisture content of 10-12% (Vural and Duman, 2000).

Additionally, there was a statistical difference in the samples of dried tomato powders analyzed for pH, salt and water activity ($p < 0.05$). While MD was detected to have the lowest pH value of 4.40, the highest value was found to be 4.64 in the SD application. On the other hand, the SD application's highest salt rate was 3.47%, and the lowest salt rate was 1.162 in the MD application. After the drying processes, the highest a w value among the tomato powders was the OD 55 and OD 75 samples with a value of 0.35, while the lowest aw value was the MD sample with a value of 0.31. (Table 2)

Table 2. *pH, salt and water activity values of tomato powders*

Samples	pH	Salt value, (%)	a_w
FT	4.50 ^{b} ±0.01	1.93^{c} ±0.02	-
OD 55	4.40 ^{a} ± 0.01	1.74 ^{b} ± 0.02	0.35 ^{d} ± 0.01
OD 65	4.42 ^{a} ± 0.07	1.76 ^{b} ± 0.01	0.33 ^{d} ± 0.01
OD 75	4.41 ^{a} ± 0.28	1.17 ^{a} ± 0.01	0.33 ^{d} ± 0.01
SD	4.64 ^{c} ± 0.01	3.47 ^{d} ± 0.07	0.35 ^{d} ± 0.01
MD	4.40 ^{a} ± 0.02	1.16 ^{a} ± 0.01	0.31 ^{d} ± 0.01

Also, the amount of salt in the sample was naturally high due to the sprinkled salt added to prevent microbial development during drying due to slow drying in SD application. In the study, the aw value in fresh tomatoes was found to be 0.93, close to 0.954, the average a w value presented by Pose et al. (2010) in the literature. The aw values of tomato powders were reduced to a level close to microbial development and other biochemical changes.

Table 3 presents L*, a*, and b* values obtained from the colour analysis results. There was a statistical difference between tomato powders obtained by different drying methods ($p<0.05$). Regarding the L value, the positive effect of drying was determined with low heat application. As the drying temperature and time increased, the L value decreased in the sun drying. Also, the maximum L value decreased depending on the process in the OD application. In changing a value, prolonged sun drying was the most effective factor. The b value decreased with the effect of MD application on tomatoes. In the literature, it is seen in the study by Fengxia et al. (2010) that the drying temperature decreased L a and b values.

Table 3 *Color analysis results*

Samples	L	a	b
FT	48.87 ^{d} ± 3.06	20.12 ^{d} ± 1.76	16.18 ^{d} ± 1.17
OD 55	50.15 ^{e} ± 1.77	20.73 ^{d} ± 1.32	17.01 ^{d} ± 0.01
OD 65	48.05 ^{dc} ± 0.44	20.02 ^{d} ± 0.09	16.34 ^{d} ± 0.05
OD 75	47.11 ^{c} ± 0.88	15.87 ^{b} ± 0.76	14.71 ^{c} ± 0.28
SD	42.80 ^{b} ± 0.01	13.23 ^{a} ± 0.34	11.80 ^{b} ± 0.51
MD	31.50 ^{a} ± 0.18	18.91 ^{c} ± 0.00	7.60 ^{a} ± 0.36

As the drying temperature and time increased, the L* value decreased in sun drying. Also, the maximum L* value decreased depending on the process in the MD application. In the change of value, prolonged sun drying time was the most influential factor. The b* value decreased with the effect of MD application on tomatoes.

Since the L and b values decreased as the temperature increased, the highest loss occurred in the MD application, and the highest value occurred in the OD 55 application. The highest "a" value was determined in the OD 55, among other applications. It is thought that the value of low-temperature application positively affected the a value. The drying temperature decreased L a and b values in the study by Vega et al. (2009).

Table 4 gives the ascorbic acid contents and lycopene amounts of tomato powders. The ascorbic acid in fresh tomato was measured as 19.25 mg/100g, DM. Among the tomato powders, the highest ascorbic acid loss was determined in the MD application at 60%, and the lowest loss was determined in the SD application at 47%. The amount of lycopene in fresh tomatoes was calculated as 229.23 (mg/100g, DM). When the dried tomatoes are compared within themselves, the highest amount of lycopene substance was in SD with 387.83 (mg/100g, DM), and the lowest amount is OD 65 application with the amount of 349.59 (mg/100g, DM).

Although the drying time was short according to the principle of the procedure, the highest ascorbic acid loss was observed in the MD application, with a value of 60%. It is predicted that this loss may be due to overheating compared to other applications. In a study, a 58.71% decrease in ascorbic acid in the drying process at 60 oC and 1.5 m/s air velocity supports our results (Ozen and Kar, 2018). The increase in the drying temperature on ascorbic acid loss shows that it is more effective than oxidation. The lowest loss in ascorbic acid occurred in SD application at 47%.

Table 4. *Ascorbic acid and lycopene values of tomato powders*

Samples	**Ascorbic acid (mg/100g, DM)**	**Amount of lycopene (mg/100g, DM)**
OD 55	$9.35^{b} \pm 0.14$	384.03 c ± 1.09
OD 65	$8.63^{b} \pm 1.84$	$349.59^{a} \pm 0.00$
OD 75	$8.38^{b} \pm 1.61$	$380.77^{c} \pm 1.20$
SD	$10.12^{c} \pm 0.99$	$387.83^{c} \pm 0.76$
MD	$7.63^{a} \pm 0.42$	$369.42^{b} \pm 23.74$

It was determined that the amount of lycopene increased in the drying processes. The highest increase was in SD, and the lowest was in MD. According to the applications in the amount of lycopene, the change was parallel with ascorbic acid changes. In the study by Kerkhofs et al. (2005), the average amount of lycopene in fresh tomatoes was calculated as 37 mg/100g DM. The average amount of lycopene in dried tomatoes was 50 mg/100g DM, and then the increase in lycopene in drying was determined. It showed that lycopene in processed tomato products had a higher bioavailability than raw tomatoes. It may be because the lycopene in the trans form in tomato turned into cis-form during cooking or similar processes. Kerkhops et al. (2005) calculated the average amount of lycopene in fresh tomato as 37 mg/100g DM and the average amount of lycopene in dried tomato as 50 mg/100g DM and determined the increase in the amount of lycopene in drying. The study by Ayan (2010) examined the characteristics of artificially dried tomatoes at different temperatures (40°C, 50°C, 60°C) in the sun and air-powered ovens. As a result of the oven and sun drying process, lycopene contents in tomato samples were higher than in the fresh tomato sample. Another study observed that lycopene losses increased as the drying temperature increased in experiments using a tray dryer (Hastürk et al, 2012). These results in the literature supported the lycopene values we obtained.

Table 5 gives the total carotenoid, phenolic and flavonoid amount values in the dry matter as a result of the analyses. The total carotenoid substance in the fresh tomato sample was measured as 5.46 (mg/100g, DM). Total carotenoid substances decreased in all applications compared to the fresh sample. Regarding the total amount of carotenoid substance in tomato powders, the highest loss was seen in the SD sample at 43%. This suggests that oxidation and light may be more effective than drying temperature on the degradation of carotenoids. Due to the long drying time, water activity decreased late; therefore, carotenoid degradation occurred in the SD samples exposed to oxidation more. The slightest loss was calculated in the MD sample with a rate of 0.05%. The fresh sample's total amount of phenolic substance was determined as 75.4 (mg/100g, DM). In terms of total phenolic amount, the lowest loss rate among drying applications was OD 55 application with 38%, while the highest loss rate was in MD application with 46%.

Table 5. *Analysis results of total carotenoid, phenolic and flavonoid amounts of tomato powders*

Samples	**Total carotenoid matter amount (mg/100g, DM)**	**Total phenolic (mg/100g, DM)**	**Total flavonoid (mg/100g, DM)**
OD 55	3.6 ^{b} ± 0.13	46.5 ^{c} ± 0.78	6.9 ^{c} ± 0.85
OD 65	3.8 ^{b} ± 0.29	45.7 ^{b} ± 1.06	6.4 ^{bc} ± 0.42
OD 75	3.5 ^{b} ± 0.03	45.3 ^{b} ±1.06	6.1 ^{b} ± 0.14
SD	3.1 ^{a} ±0.19	46.1 ^{c} ±0.35	7.8 ^{d} ± 1.13
MD	5.01 ^{c} ±0.42	40.1 ^{a} ±0.99	5.3 ^{a} ± 0.35

In total carotenoid substance amounts, MD was found to have the highest value and SD to have the lowest value. The lowest total amount of carotenoid substance in SD application was due to the decrease in aw in a slow period and more exposure to oxidation. The SD application was completed in as long as 20 days.

The total phenolic substance was higher in moderate drying temperature (OD 55; 46.5 mg/100g DM and SD; 46.1 mg/100g DM) applications and the lowest (40.1 mg/100g MC) in MD application where the temperature was more. It may be because the temperature had a degradation effect on phenols. While the loss in MD was 46%, it was 38% in OD 55. The total phenolic substance in the fresh sample was 75.4 (mg/100g, DM). The study conducted by Marinova et al. (2005) obtained a close measure of the total amount of phenolic substance (76.9 mg/100g, DM) in the fresh tomato.

In the study by Marinova et al. (2005), the flavonoid substance was 12.8 mg/100g DM in fresh tomatoes. In this study, the total amount of flavonoid substance measured in freshtomatoes was 12.4 mg/100g DM, which was close to the literature study. In total flavonoid substance, parallelism was noted to the total phenolic substance change. In the same procedures, OD 55 (6.9 mg/100g) and SD (7.8 mg/100g KM), which were applied at moderate drying temperature, had the highest flavonoid content. In contrast, MD (5.3 mg/100g DM), which was exposed to high temperature, had the lowest flavonoid content. Among the drying applications, the SD application had the lowest loss at 37%, while the highest loss was in the MD application at 57% due to exposure to high temperature.

Although the application of MD significantly reduced the drying time, ascorbic acid, total phenolic substance and total flavonoid substance were the most loss-making drying process.

4. Conclusion

-The results of this study, in which tomato powder was obtained with different drying methods, and quality criteria were measured, are given below.
-In the study, the drying time decreased due to the increase in the drying temperature during the drying processes.
-Although the drying time was not short, the high heating during OD application caused the loss in ascorbic acid to be higher than in other applications.
-Additionally, in the SD application, ascorbic acid was better preserved.
-The fact that the applied drying methods were different did not cause a change in the total amount of dry matter in the samples.
-Using salt as a preservative in the SD application only increased the ash and salt in that sample.
-After drying and grinding, acceptable results in terms of L, a and b values were obtained with OD 55. The low temperature used in the application minimized negative changes in colour values.
-It is known that the lycopene in the tomato turns into an extractable form more easily during the drying process. This study determined that the amount of lycopene in tomato powders obtained with SD application was higher.
-Regarding the total amount of carotenoids, tomato powders obtained with SD application had the lowest value. The reason for this is thought to be the excessive exposure of the samples to light and oxidation during the duration of SD application.
-Also, the total phenolic and flavonoid substance amounts were higher in moderate temperature applications such as OD 55 and SD, and the loss was very high in OD applications. High temperatures are thought to alter structures.

Drying times decreased due to increased drying temperature in tomato powder, and drying was completed concisely in microwave application compared to other applications.

In the general examination of the effect of all drying processes on nutritional elements such as ascorbic acid, lycopene, total carotenoid substance, total phenolic substance and total flavonoid substance, this study determined that the best drying process was OD 55 and SD processes. Since these two processes took place at moderate temperatures than the others, the low drying temperature showed better protection in nutrients.

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