

Effects of Different Drying Techniques on Some Nutritional Components of Tomato (*Lycopersicon esculentum*)*

Füsun HASTÜRK ŞAHİN¹, Poyraz ÜLGER², Türkan AKTAŞ², Hülya ORAK³

¹Namık Kemal University, Vocational School of Hayrabolu, Program of Agricultural Machinery

²Namık Kemal University, Faculty of Agriculture, Department of Agricultural Machinery

³Namık Kemal University, Vocational School of Technical Sciences, Program of Food Technology Tekirdag, Turkey
fhasturk@nku.edu.tr

Received (Geliş Tarihi): 19.07.2010

Accepted (Kabul Tarihi): 17.08.2010

Abstract: In this research, four drying techniques were applied for tomato (*Lycopersicon esculentum*) namely, hot air drying using tunnel type dryer, vacuum drying, freeze drying and sun drying and changes of food components of the vitamin C, lycopene, sodium (Na), and potassium (K) content were examined. As a result of drying applications, the initial moisture content of 94.73% of fresh tomato, dried tomato samples were found to range from 9.33% to 11.11%. Losses of nutritional contents of hot air dried samples increased with rising drying temperature. Loss of lycopene and Potassium content of vacuum dried samples at 75 °C were found lower compared to hot air dried samples at the same drying temperature. On the other hand increasing of drying time for vacuum drying increased loss of vitamin C. Vitamin C and lycopene content of sun dried samples were found higher compared to those of hot air dried and vacuum dried samples. Freeze drying method gave the best results in respect of all nutritional value criteria.

Key words: Tomato, drying techniques, vitamin C, lycopene, mineral matter

INTRODUCTION

Tomato contains 5.7% dry matter; low concentration of vitamin C, provitamin A and it is rather rich fruit in respect of minerals (especially potassium) compared to other commercially important fruit species (Akanbi and Oludemi, 2004). Tomatoes and tomato-based foods are considered healthy foods for several reasons. They are low in fat and calories, cholesterol-free and a good source of fibre and protein (Shi, 2000). Vitamin C is an important vitamin that is high in antioxidant activity and tomato is the one of the important sources of this vitamin. Some recent papers report consumption of tomato products has been associated with decreased risk of some cancer types, and the tomato antioxidant, lycopene, is thought to play an important role in the observed health effects (Takeoka *et al.*, 2001; George *et al.*, 2004; Brandt *et al.*, 2006). Tomatoes are also rich in minerals and minerals constitute about 8% of the dry matter content of tomatoes. Potassium and phosphate are the two major minerals among them. Minerals have an effect on pH, titratable acidity therefore they influence the taste of tomatoes (Yılmaz, 2001).

Potassium is an important also for healthy nervous system and regular heart rhythm. At the same time it controls body fluid balance with sodium.

Tomato which is extremely valuable in respect of nutritionally, especially ripe tomato is not suitable for long term storage after harvest. Due to high content of water (about 95%), tomato can be deteriorated very quickly because of either chemical or microbiological effects. Therefore, no applying of any conservation method will be cause of fast decaying of tomato and discarding of significant portion of tomato (Demiray and Tulek, 2008). This situation leads to significant losses in terms of both nutritional and economic. Because tomato is a product that has high economic value in Turkey.

According to the tomato production amount between 2001 and 2007, China, USA, Turkey and India are the major producer countries in the world (FAO, 2010). Tomato production was over 10 million tons in our country in 2005 and tomato production rate stayed at this level at the following years. Total tomato production was closer to 11 million tons in 2008 (TUIK, 2010).

Tomato must be evaluated by processing into different products during high production season and drying is the one of the major tomato processing technology. The aim of drying to stop or limit the development of biochemical reaction and microorganisms in products by removing the free water from fresh products and decrease the microorganism rate until they can not grow to extent shelf life of food materials (Cemeroglu *et al.*, 2003). Drying of food materials helps to extend shelf-life, decrease of product volume significantly, increase of product diversity, increase of food process applications and improve the product quality (Maskan, 2001). However drying can accelerate some reactions that can adversely affect the product quality (Demiray and Tulek, 2008). Some of these effects are shrinkage during drying, decreasing of porosity, damage on the natural tissue of product, loss of nutritional value and changes in physical properties such as texture and colour (Atares *et al.*, 2009).

In recent years, important increase has been occurred in dried tomato production and exports in our country. Dried tomato exporting began in 1990s in our country and the amount of export reached 4275 tons in 2000. Tomato export value is more than 68% of dried vegetables export. Today, dried tomatoes are exported to 27 countries and major dry tomato importer countries are USA, Italy and England (Akdeniz and Bagdatlioglu, 2007).

Dried vegetables sector had became one of the important sub-sector of food industry with using modern drying methods in addition to traditional sun drying methods. Many kinds of dried vegetables that produced in Turkey are used by food industry companies in many countries especially in European Union Countries and USA (Karabayir, 2007).

In this research, drying techniques were applied for drying of selected tomato variety namely hot air drying, vacuum drying, freeze drying and sun drying, and also effects of these drying methods on nutrient contents of tomato were investigated.

MATERIAL and METHOD

Material

Tomato

In this research, 8354 tomato variety (*Lycopersicon esculentum*) that is widely cultivated in Thrace Region was used.

Hot air dryer

In hot air dryer, galvanized metal sheet 2 mm in thickness was used as cabinet material and two electrical heaters with serpentine were used to provide hot air (Figure 1). Heaters can be activated separately by two stage control switch. When the switch is in zero stage, one heater works and both heaters can also be activated when the switch is in first stage. A centrifugal blower, having a max power of 82 W, was used to accelerate drying air in hot air dryer. This blower can be worked at different speeds by 5-stage speed switch. An analogue heat control unit with digital indicator was used to fix up air temperature. This unit can operate at 0-400 °C temperatures. Drying chamber and air heating chamber was isolated with 30 mm glass wool and aluminium foil to prevent heat losses. Tomatoes were placed on perforated tray to provide the adequate ventilation (Hasturk Sahin *et al.*, 2009).



Figure 1. Hot air dryer

Vacuum dryer

The vacuum drying process was conducted in MMM Medcenter Vacucell 22 Blue Line Vacuum Dryer that have 22 litter capacity stainless steel chamber (Figure 2). Ambient temperature in vacuum dryer can be adjusted between 5-200 °C.

Vacuum dryer is connected with KNF Laboport N810 FTP Diaphragm Vacuum Pump to obtain vacuum. This pump can be reached the value of 10 kPa ultimate vacuum.



Figure 2. Vacuum dryer

Freeze dryer

Freeze Drying was carried out with fluid bed freezer (Armfield-Blast FT 36) and vacuum freeze dryer (Armfield FT 33) (Hasturk Sahin *et al.*, 2009). Drying was carried out by sublimation of ice crystals under vacuum (Figures 3 and 4).



Figure 3. Fluid bed freezer



Figure 4. Freeze dryer



Figure 5. Sun drying tables

Sun drying tables

Perforated sample trays as drying platform were used in sun drying experiments. These trays were assembled to wooden frame in the size of 80x100 cm and they are on the stands of 80 cm height to prevent from dust, soil, insects, rodents (Figure 5). The airflow velocity during hot air drying and sun drying experiments was measured by Lutron-AM 4202

anemometer in the measurement range of 0,4-30 m/s and accuracy of $\pm(2\%+1 \text{ digit})$.

Method

The fruits were sorted by hand to ensure colour uniformity, then washed used fresh water and they were cut into slices of 15 mm thickness by a slicer which can be adjusted to obtain different slice thickness. Finally, tomato samples were dried using different methods that were mentioned below. During the experiments, no pretreatment was applied.

Drying methods

Hot air drying experiments of sliced tomato samples were performed at three drying temperatures that were 65, 75, 85 °C and at two air velocities that were adjusted as 1.5 and 2.5 m/s. Tomatoes were placed on the drying shelves in two rows. Tray was removed from dryer and weighed per hour and data were recorded.

Vacuum drying experiments were carried out at the drying temperatures of 65, 75 °C and vacuum chamber pressure of 10 kPa.

Tomatoes were prepared as mentioned before. Before freeze drying, the samples were frozen by blast and fluid bed freezer at -40 °C and at 10 m/s air velocity. After this process, frozen tomato slices were transferred to the drying chamber of freeze dryer immediately. Drying of samples was carried out at 30 °C in drying chamber.

During sun drying applications, tomato samples were arranged in rows on the sun drying table and drying processes was continued from 09:30 to 18:30. During the experiments, there were no rainy or closed weather. Determination the weight change of samples was carried out by weighing process per hour. After 18:30 o'clock, samples and drying tables were collected together, covered and kept in the closed environment to prevent the negative effects of samples from the moisture of open air.

In all experiments, the moisture loss of samples was determined by means of a digital electronic balance (AND-GX 4100) having an accuracy of 0.01 g.

Analyses methods

Analyses of vitamin C (Ascorbic Acid)

Ascorbic acid was determined by using a spectrometric method according to the Cemeroglu (2007). The basis of metod is crushing and extraction

of samples at cold condition with metafosforic acid. After that, obtained extracts colored with indicator solution (2.6 diclorofenolindofenol) at medium acetat buffer and then seperated extract with xylene was assesed at 500 nm by spectrophotometer (Hitachi 121-002 Model). Evaluation of ascorbic acid was made by using different concentration of standart ascorbic acid solutions (Cemeroglu, 2007).

Analyses of lycopene

Lycopene analyses of drying tomato samples assayed according to the method HPLC at The Scientific and Technological Research Council of Turkey (TUBITAK) Marmara Research Center Food Istitute Department (Zakaria *et al.*, 1979).

Analyses of sodium (Na), potassium (K)

Sodium (Na) and potassium (K) contents of samples were determined by AOAC (1990) methods. Na and K contents of samples were determined after the preparing of samples by dry ash. For determination Na and K, we were used stock solutions at different concentrations from 1000 ppm standard stock solution that were prepared with dried NaCl and KCl. Na and K contents of samples were determined by using a flame photometer (PFP 7, Jenway). The results were calculated by using standard curves that were obtained from standard Na and K solutions.

Determination of dry matter

Dry matter and water content of tomatoes were determined a vacum dryer at 70 °C and 10 kPa pressure (Cemeroglu, 2007).

Statistical analysis

Statistical analysis were made by using the MSTAT statistical program.

RESULTS

During the experiments in sun drying, the ambient air temperature, relative humidity and wind speed values were determined between 28-34.8 °C, 32.2-40.5%, 0.4-2.9 m/s, respectively.

Initial moisture content of tomatoes was found to be 94.73% and moisture content of dried tomatoes changed between 9.33% and 11.11%, depending on the drying methods. While drying process in hot air dryer lasted for 13 hours at 65 °C-1.5 m/s conditions, 12 hours at 65°C-2.5 m/s conditions, 12 hours at 75 °C-1.5 m/s conditions, 11 hours at 75 °C-2.5 m/s conditions, 10 hours at 85 °C-1.5 m/s conditions, 8 hours at 85 °C-2.5 m/s conditions, , it was lasted in vacuum dryer about 51 hours at 65 °C and 47.5 hours at 75 °C conditions. Drying process took 23 hours in freeze drying and 57 hours in sun drying. As understood from drying duration, increasing of air velocity in hot air drying decreased the drying time about 1-2 hours. Nutrient contents of dried tomatoes were shown in Table 1. Due to the fact that vitamin C among the nutritional components can be broken down very quickly with effects of heat, light, presence of oxygen, pH in medium and metal ions, there is very important relationship between keeping of vitamin C by preservation methods and product quality. In this research, it was found that the highest vitamin C content of tomato samples that were dried by different drying techniques was found at freeze dried tomatoes. The lowest vitamin C content was found in vacuum dried tomatoes at 75 °C drying temperature. It was determined that vitamin C content of freeze dried tomato samples was about 2.2 times of vitamin C content of fresh tomato samples. While all drying methods except freeze drying caused to significant

Table 1. Nutrient contents of dried tomatoes (mg/100 g tomato)

Drying methods	Vitamin C	Lycopene	Sodium	Potassium
<i>Fresh tomato</i>	18.715	7.410	5.560	196.400
Hot air drying, 65 °C-1,5 m/s	9.165	39.760	37.790	1832.890
Hot air drying, 65 °C-2,5 m/s	10.160	29.350	36.920	1894.440
Hot air drying, 75 °C-1,5 m/s	7.220	21.930	39.320	1790.920
Hot air drying, 75 °C-2,5 m/s	7.915	23.960	38.270	1782.130
Hot air drying, 85 °C-1,5 m/s	3.695	24.780	35.020	1724.640
Hot air drying, 85 °C-2,5 m/s	3.980	23.040	36.570	1718.160
Vacuum drying, 65 °C	5.485	35.740	44.400	1803.020
Vacuum drying, 75 °C	3.605	37.560	44.380	1796.330
Freeze drying	41.155	59.840	50.930	1986.360
Sun drying	12.520	39.310	40.300	1800.290

vitamin C loss compared to vitamin C content of fresh tomato samples, freeze drying method could prevent highly vitamin C loss. This result indicates that drying process in low temperature (30 °C) and oxygen-free environment in freeze drying method is an important factor for preventing the loss of vitamin C. If vitamin C contents of hot air dried tomatoes were checked, it can be seen that values of vitamin C in dried tomato at low temperature were found higher than vitamin C content of tomato samples that were dried at high temperature. This result indicates that vitamin C is significantly affected from high temperature applications. Zaroni *et al.* (1999) reported that vitamin C loss occurs mainly due to high temperature. Similarly, Marfil *et al.* (2008) searched vitamin C degradation kinetics in tomatoes during different drying conditions, reported that loss of vitamin C is affected specially by high temperature. Destruction of vitamin C depends on various factors such as oxygen, light, temperature and humidity (Rojas and Gerschenson, 2001). pH, presence of enzymes and metallic catalysers can be added these environmental factors (Santos and Silva, 2008). Erenturk *et al.* (2005) reported that raising the temperatures decreases the retention of vitamin C for the fruits that cut into pieces, especially at the beginning of the drying. Increasing of contact surface area with air increased also loss of vitamin C. In this research, occurrence a significant decrease in vitamin C content under hot air drying at 85 °C is similar finding with the relevant literature. On the other hand, if hot air drying and vacuum drying method were compared, it was expected result that lower vitamin C degradation is occurred in vacuum drying that was performed at same temperatures with hot air drying. However, research findings have revealed the opposite of this result. Therefore; as much as increasing of temperature, exposure time to air with this temperature is also important factor to increase loss of vitamin C. Despite of the fact that drying time was also rather long in sun drying method similar to vacuum drying, low drying temperature was effective on preservation of vitamin C content. In this research laboratory type vacuum dryer used in the vacuum drying process could not remove moisture from drying chamber sufficiently so this caused to increase of drying time. But this problem can be eliminate in industrial type vacuum dryers therefore more

successful results can be obtained and preserved of quality using vacuum drying method for fruits and vegetables.

As a result of statistical analyses it was determined that drying methods have significant effect on vitamin C values ($P < 0.01$).

In all drying methods, lycopene contents of tomatoes were increased. As a result of drying processes, the highest lycopene content was found in freeze dried tomatoes, hot air dried samples at 65 °C temperature 1.5 m/s air velocity conditions, vacuum dried samples at 75 °C and sun dried samples followed the freeze dried samples, respectively. When we compare hot air and vacuum drying techniques it was seen that lycopene content of vacuum dried samples could be kept better (Table 1). This situation shows that lycopene is rather sensitive to both heat and presence of oxygen. While oxygen free medium increased drying time, lycopene content could be kept better under the drying condition with oxygen free medium. Wilcox *et al.* (2003) reported that the processing of tomatoes in different ways may significantly affect the bioavailability of lycopene, beta-carotene, potassium, vitamin C, and vitamin E. Homogenization, heat treatment and the incorporation of oil in processed tomato products lead to increase lycopene bioavailability. Roldan-Gutierrez and Luque de Castro (2007) indicated that, the concentration of lycopene is in the range of 0.88-4.20 mg/100 g in fresh tomato, 46.5 mg/100 g in sun dried tomato in oil and in the range of 112.63-126.49 mg/100 g in drum or spray dried tomato powder. Research findings of this search were found to be agree with the results of other researches.

As a result of statistical analyses, it was determined that drying methods have significant effects on lycopene values ($P < 0.01$).

In this research, changing of sodium and potassium content were taken into account as criteria for determining of drying methods effects on mineral matters. Important increase were occurred in sodium and potassium content of dried tomato samples compared to fresh tomato as a result of water loss from tomato samples during drying. The highest sodium and potassium contents were found in freeze dried samples among the all samples that were dried by different methods. Performing of freeze drying

application at low temperature and vacuum conditions supplied to keep of sodium and potassium contents. Vacuum dried samples followed to freeze dried samples in respect of high sodium content values. From this results, it can be concluded that drying process performed in oxygen free medium has positive effect on sodium content of dried tomato samples. If sodium content values of hot air dried samples were checked it can be seen that increasing of drying temperature from 75 °C to 85 °C decreased the sodium content. Sodium content of sun dried samples were found to be lower than those vacuum dried samples and to be higher than those hot air dried samples (Table 1). Sodium content of sun dried tomato samples was found higher than sodium content of hot air dried samples. This can be explained that performing of sun drying process at low temperature conditions.

Potassium content could be kept in freeze dried samples and sun dried samples followed it. Increasing of drying temperature increased the loss of potassium during hot air drying and vacuum drying processes. According to these results it can be said that effect of temperature is more effective on potassium content compared to drying time (Table 1).

According to statistical analyses, effects of drying methods on the contents of sodium and potassium were found to be significant at $P < 0.01$ significance level.

Values of vitamin C, lycopene, sodium and potassium of dried samples were shown as graphically in Figures 6, 7, 8 and 9, respectively (AD: Hot air drying; VD: Vacuum drying; FD: Freeze drying; SD: Sun drying).

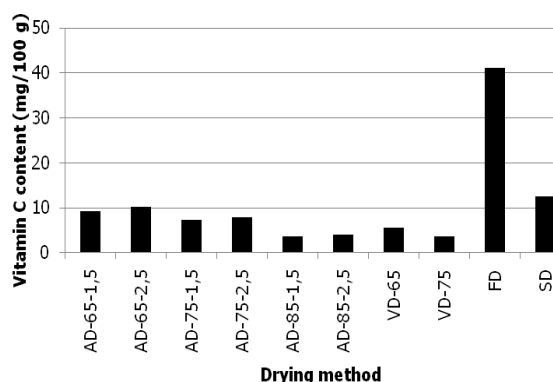


Figure 6. Vitamin C contents of dried tomatoes

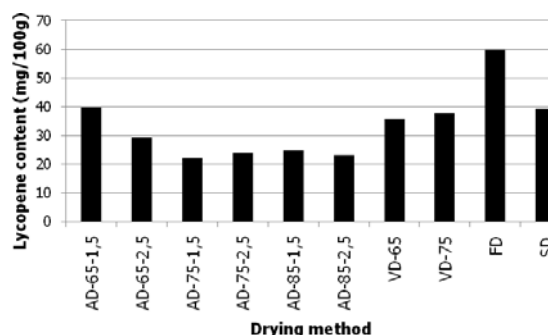


Figure 7. Lycopene contents of dried tomatoes

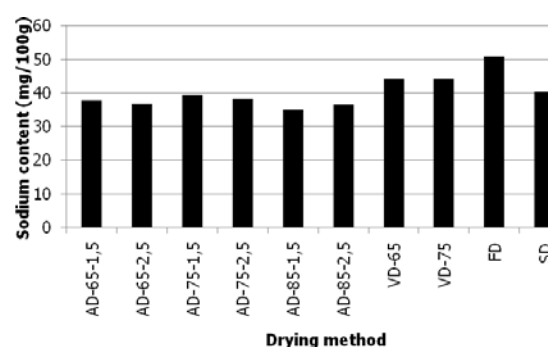


Figure 8. Sodium contents of dried tomatoes

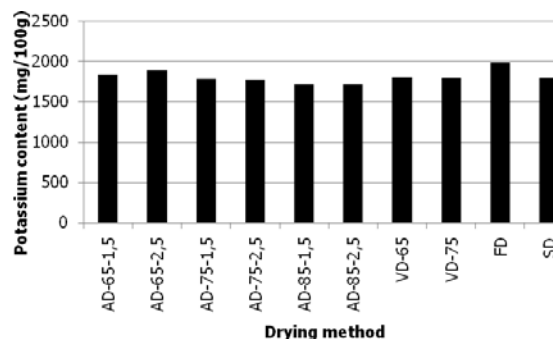


Figure 9. Potassium contents of dried tomatoes

RESULT and DISCUSSION

In this research, tomato that is important exporting product was dried by four different methods and dried samples were investigated in respect of some nutritional contents such as sodium, potassium, vitamin C and lycopene. The highest values of nutritional components in dried tomato samples were found in freeze dried samples. It was concluded that nutritional losses could be prevent significantly in freeze dried samples because freeze dried samples were dried at oxygen-free medium and low temperature. Sun dried samples followed the freeze dried samples

in respect of contents of vitamin C and sodium. Lycopene and potassium contents of samples that were dried by hot air dryer at 65 °C-1,5 m/s conditions were found higher compared to those of sun dried samples. For why colour is one of the most important quality criteria in dry tomato technology, results obtained from hot air drying at 65 °C-1,5 m/s are important on account of tomato drying technology. Although drying of tomato by sun drying method took the longest time among the all drying methods, tomato samples did not induced to high temperature and this situation supplied effective preservation of nutritional values. In hot air drying, increasing of drying temperature generally increased the losses in nutritional values. Especially vitamin C loss among these losses was found rather high because this vitamin is one of the most sensitive vitamins to heat processes and long drying periods. It was found that drying of tomato in vacuum dryer namely oxygen free medium supplied some advantages in respect of some nutritional contents. On the other hand rather long drying period in vacuum drying method increased the loss of vitamin C. From these results it was concluded that more successful results can be obtained using industrial type driers that can remove moisture fastly from

drying chambers. It was thought that these types dryers combined with stronger vacuum and moisture remove systems can be more effective in dry tomato technology to keep vitamin C in addition to color.

In Turkey, almost all of tomatoes were dried under sun by spreading of tomato slices on the sheets due to low cost of this method. In this research it was also seen that sun dried tomatoes had good results in respect of vitamin C and lycopene retention that are among the important antioxidants. On the other hand sun dried tomatoes induced to dust, soil, rain, insect and some rodents etc. Freeze drying method gave the best results in respect of the investigated nutritional values but freeze drying systems have rather high installation cost. Also in vacuum drying method, lycopene, high losses of sodium and potassium content of samples could be prevented due to oxygen-free medium but long drying period caused to big loss of vitamin C. If these points take into account, using of hot air drying method that is suitable in respect of cost at low temperature using air velocity application that can decrease drying time is suggested firstly. If vacuum drying will be applied, it is proposed that using of big capacity vacuum dryers. It is suggested that using of freeze drying method if production factors, technology and cost are suitable.

REFERENCES

- Akanbi, C. T., F. O. Oludemi, 2004. Effect of Processing and Packaging on the Lycopene Content of Tomato Products. *International Journal of Food Properties*, 7: 139-152.
- Akdeniz, B. D., N. Bagdatlıoğlu, 2007. Some Quality Properties of Sun-Dried Tomatoes on Different Storage Atmosphere-Temperature-Time Conditions. *Electronic Journal of Food Technology*, 1: 1-6. (In Turkish)
- AOAC, 1990. *Official Methods for the Analysis* (15th ed.) Arlington, Washington DC: Association of Official Analytical Chemists.
- Atares, L., A. Chiralt, C. Gonzalez-Martinez, 2009. Effect of the Impregnated Solute on Air Drying and Rehydration of Apple Slices (*cv.* Granny Smith). 91:305-310.
- Brandt, S., Z. Pek, E. Barna, A. Lugasi, L. Helyes, 2006. Lycopene Content and Colour of Ripening Tomatoes as Affected by Environmental Conditions. *Journal of the Science of Food and Agriculture*, 86: 568-572.
- Cemeroglu, B., F. Karadeniz, M. Ozkan, 2003. *Fruit and Vegetable Processing Technology 3*. The Association of Food Technology Publications, Number 28, 541p Ankara. (In Turkish)
- Cemeroglu, B., 2007. *Food Analysis*. The Association of Food Technology Publications, Number 34, Ankara. (In Turkish)
- Demiray, E., Y. Tulek, 2008. Tomato Dehydration Technology and the Effect of Dehydration on Some Antioxidant Compounds of Tomatoes Process. *Electronic Journal of Food Technology*. 3:9-20. (In Turkish)
- Erenturk, S., M. S. Gulaboglu, S. Gultekin, 2005. The Effects of Cutting and Drying Medium on the Ascorbic Acid Content of Rosehip During Drying. *Journal of Food Engineering*, 68: 513-518.
- FAO, 2010. *Statistics, Faostat-Agriculture*. <http://faostat.fao.org/site/339/default.aspx>, Accessed: January, 2010.
- George, B., C. Kaur, D. S. Khurdiya, H. C. Kapoor, 2004. Antioxidants in Tomato (*Lycopersicon esculentum*) as a Function of Genotype. *Food Chemistry*, 84: 45-51.
- Hasturk Sahin, F., P. Ulger, T. Aktas, H. Orak, 2009. Determination of Convective Hot Air and Vacuum-Freeze Drying Kinetics of Tomato (*Lycopersicon esculentum*). 25th National Congress on Agricultural Mechanization, 1-3 October, Suleyman Demirel University, Isparta, P.341-347.
- Karabayır, C., 2007. *Dried Vegetables*, Undersecretariat of the Prime Ministry for Foreign Trade, Export Promotion Center of Turkey (IGEME). <http://www.iso.org.tr/tr/Documents/MKRaporlar/KurutulmusSebze%20igeme.pdf>, Accessed: July, 2008.

Effects of Different Drying Techniques on Some Nutritional Components of Tomato (*Lycopersicon esculentum*)

- Marfil, P. H. M., E. M. Santos, V. R. N. Telis, 2008. Ascorbic Acid Degradation Kinetics in Tomatoes at Different Drying Conditions. *LWT-Food Science and Technology*, 41: 1642-1647.
- Maskan, M., 2001. Drying, Shrinkage and Rehydration Characteristics of Kiwifruits During Hot Air and Microwave Drying. *Journal of Food Engineering*. 48:177-182.
- Rojas, A. M., L. N. Gerschenson, 2001. Ascorbic Acid Destruction in Aqueous Model System: An Additional Discussion. *Journal of the Science of Food and Agriculture*, 81: 1433-1439.
- Roldan-Gutierrez, J. M., M. D. Luque de Castro, 2007. Lycopene: The Need for Better Methods for Characterization and Determination. *Trends in Analytical Chemistry*, 26(2): 163-170.
- Santos, P. H. S., M. A. Silva, 2008. Retention of Vitamin C in Drying Processes of Fruits and Vegetables-A review. *Drying Technology*, 26(12): 1421-1437.
- Shi, J., 2000. Lycopene in Tomatoes: Chemical and Physical Properties Affected by Food Processing. *Critical Reviews in Biotechnology*, 20(4): 293-334.
- Takeoka, G. R., L. Dao, S. Flessa, D. M. Gillespie, W. T. Jewell, B. Huebner, D. Bertow, S. E. Ebeler, 2001. Processing Effects on Lycopene Content and Antioxidant Activity of Tomatoes. *J. Agric. Food Chem.*, 49(8), 3713-3717.
- TUIK, 2010. Crop Production Statistics, Vegetables Cultivated for their Fruits, Turkish Statistical Institute. http://www.tuik.gov.tr/VeriBilgi.do?tb_id=45&ust_id=13, Accessed: January, 2010. (In Turkish)
- Wilcox, J. K., G. L. Catignani, S. Lazarus, 2003. Tomatoes and Cardiovascular Health. *Critical Reviews in Food Science and Nutrition*, 43(1): 1-18.
- Yılmaz, E., 2001. The Chemistry of Fresh Tomato Flavor. *Turkish Journal of Agriculture and Forestry*, 25(3): 149-155.
- Zakaria, M., K. Simpson, P. R. Brown, A. Krstulovic, 1979. Use of Reversed-phase High-performance Liquid Chromatographic Analysis for the Determination of Provitamin A Carotenes in Tomatoes. *Journal Of Chromatography A*, 176(1): 109-117.
- Zanoni, B., C. Peri, R. Nani, V. Lavelli, 1999. Oxidative Heat Damage of Tomato Halves as Affected by Drying. *Food Research International*, 31(5): 395-401.