

# Some Applications to Retain the Quality of Fruits and Vegetables during Drying and Storage in Turkey

Turkan AKTAS

*Department of Biosystem Engineering, Namik Kemal University, 59030, Tekirdag, Turkey*

Drying process is very important preservative method for foods and usually brings about some degradation of the final products. For this reason, some handlings such as pretreatments (physical, thermal, chemical *etc.*) are generally required to preserve the product quality either during drying or storage. One of the most important exporting stuff of Turkey is dried fruits and vegetables and the most acceptable dried grape (raisin), apricot, fig, tomato, hazelnuts over the world are produced in Turkey. In this article, some traditional and commercial applications to decrease quality losses during drying and storage of fruits and vegetables in Turkey and some constraints about these applications were explained and discussed. In addition to these applications, some results of recent researches performed in Turkey to keep the quality of dried fruits and vegetables and decrease the activity of molds and yeasts were explained.

**Keywords:** drying, fruits, vegetables, sulphuring, alkaline solutions

## 1. Introduction

Production and consumption of fruit and vegetables are getting to be more important depend on economic growth and changes in dietary patterns. However, sectors related to fruits and vegetables suffer greatly from postharvest losses. One of the most important traditional processing technologies is drying that is widely applied for fruits and vegetables at various levels and scales to decrease the postharvest losses. Drying process is rather important postharvest process and has a long tradition as a preservation method also in Turkey. It is the most common form of food preservation and extends the food shelf life. It is a simultaneous heat and mass transfer operation in which moisture is removed from food material and carried away by hot air [1, 2].

The most acceptable dried grape (raisin), apricot, fig, and tomato over the world are produced in Turkey. Turkey covers the production amount of about 30–35% for raisin, 65–80% for dried apricot and 50–55% for dried fig [3]. Also, 93% of total vegetable exportation of Turkey is dried tomato exports [4]. So these products are very important for Turkey to improve exportation income from agricultural products.

Many of the conventional drying techniques applied in the preservation of fruits and vegetables lead to losses in

nutritional value, color, flavor, aroma and texture. A considerable volume of research is therefore currently focused on the development of alternative drying technologies which are economic in use and which retain product quality. Natural sun drying is well known food preservation technique that reduces the moisture contents of agricultural product, and thereby prevents deterioration within a period of time regarded as the safe storage period. It is practiced widely in the World and also in Turkey in addition to using solar dryers and hot air dryers. On the other hand, it has some problems related to the contamination by dirt and dust and infestation by insects, rodents and other animals. Furthermore, the intensive solar radiation causes several quality reductions like vitamin losses or color changes in dried crops. Therefore many applications had been using to decrease these losses occurring during both natural sun drying process and drying processes performed by the others drying techniques.

In this paper, information on some traditional applications to retain the quality during drying as much as possible and to decrease quality losses during storage of fruits and vegetables in Turkey was given. Also, issues and constraints to retain the quality of fruits and vegetables during drying and storage processes were also discussed and some methods to overcome these constraints were given while citing several successful researches performed in Turkey.

## 2. Problems, Pre-treatments to Retain the Quality of Dried and Stored Fruits and Vegetables in Turkey

Main exported dried fruits by Turkey are grape, fig, apricot, apple, plum, peach while main exported dried vegetables are tomato, red pepper, mushroom, oca, eggplant, fresh bean. Preparation stages are generally similar for fruits and vegetables before drying and after drying until shipping of them as seen in Fig. 1.

One of difference for vegetable drying is using of blanching process before drying of most of vegetables to prevent enzymatic browning occurred due to oxidation. Recently, blanching process was started to be applied for also some fruits but it is not so common method. Preservation against oxidation in food during drying and storage has become an increasing priority in the food

industry. In fact, oxidation is the second most important cause of food deterioration after that induced by microbiological contamination. The main oxidative reactions are enzymatic browning. They involve two oxidoreductases enzymes: polyphenoloxidase and peroxydase. All physical pre-drying affects such as cutting, slicing, halving, loss of firmness *etc.* lead to the starting of browning reactions which induce losses or changes of flavor, odor and nutritional value [5]. Numerous methods and applications to prevent enzymatic browning were discussed in the literature. These methods are mainly based on physical, chemical, controlled atmosphere and coating treatments using natural or unnatural preservatives and it was aimed to preserve the color using these methods [6-8]. Blanching process is a simple and widely used method to prevent enzymatic browning for especially vegetables. It is made using boiling water or steam for

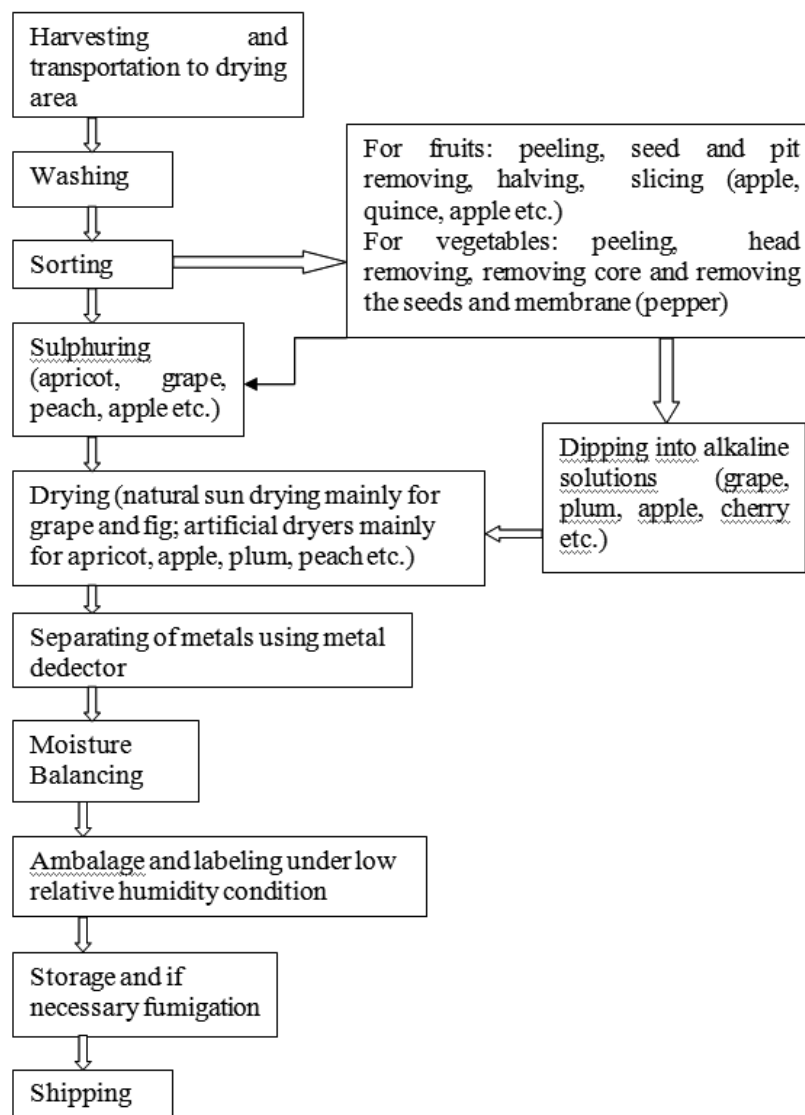


Fig. 1 Stages of fruits and vegetables before drying and after drying.

different period depend on type of vegetable.

Applications of sulphuring and dipping into alkaline solutions are used for both fruits and vegetables. Some details for these applications for some fruits and vegetables that are dried in Turkey were explained under related following titles.

Process of dipping into alkaline solutions (especially  $K_2CO_3$ +olive oil solution) is used generally for grape drying in Turkey to decrease drying time by removing of waxy layer and keep the color of fruits.

One of the most important problem for fruits and vegetables that are both fresh and dried during storage is loss of these products by microbiological contamination in addition to enzymatic and non-enzymatic browning. High air temperatures and relative humidity during the drying season promote the insect and mold development in harvested crops in addition to several quality reductions like vitamin losses or color changes in dried crops. For example, the total amount and relative proportion of individual aflatoxin production and accumulation are influenced by the interaction of these environmental factors (temperature and humidity), the prevalence of aflatoxin producing strains in the fungal flora of the crop and their relative toxigenicity. Many countries including the European Union (EU) have imposed vigorous regulations to limit the presence of aflatoxin B<sub>1</sub> and total aflatoxins in food products. For this reason, these products exported to the EU are sometimes rejected or recalled because of high levels of aflatoxins and alert notifications are published weekly on the internet to inform other member states by the Rapid Alert System, which causes significant economic losses for exporting countries [9]. Therefore, some pre-treatments and chemical applications before drying are applied to agricultural products to prevent occurrence of mold growth and quality losses during drying and storage. These applications also increase the drying rate. One of the mostly used method is sulphuring to prevent microbiological contamination and both enzymatic and nonenzymatic browning. It is made using SO<sub>2</sub> gas (mostly preferred method), sulphite or bisulfite solutions. SO<sub>2</sub> had been using widely in many area due to antioxidant and preservative effects also. It has been using especially before drying (apricot, peach and pear *etc.*), during drying and after drying of fruits. There are some applications on using of it both before and during drying of apple. Also it is used during drying and after drying of grape before it is shipped. As a sulphur compounds, sulfite salts, bisulfate salts, SO<sub>2</sub> gas or powder sulphur are being used. Advantages of sulphur-

ing process are to keep natural color by preventing of enzymatic browning, to stop microorganism activity due to yeasts and molds, to keep vitamins of A and C, to decrease drying time due to increasing temperature due to the formation of enzymatic and non-enzymatic reactions, to protect dried fruits and vegetables from insects and harms during storage. On the other hand, it has some disadvantages if it is used higher dosage than allowed amount such as occurring corrosion on the used equipments, bad effect on health, taste and aroma, degradation of some vitamins such as B1 [10].

### 3. Main Dried Fruits and Vegetables in Turkey

#### 3.1 Apricot

One of the major dried fruits is apricot in Turkey. Apricot was first brought to Anatolia in the fourth century BC during the military expeditions of the Great Iskender. Today apricot is spread almost all over the world, but the main places are Mediterranean Countries, Europe, Middle Asia, America and Africa [3]. In Turkey, apricot variety that is grown in the Malatya region and harvested from July to mid August is used to obtain dried apricot and exported to many countries. Apricot could be dried halved or whole after either unsulphured or sulphured. Sulfur dioxide (SO<sub>2</sub>) has antioxidant and antimicrobial properties and is used to prevent growth of microorganisms as well as to preserve the color and flavor in foods especially for dried fruits (apricot, plum, apple, grape *etc.*) [11].

Sulfuring process has been applied before drying of apricot to shorten drying time, to preserve the natural color, to prevent the product from getting infested with bugs and also to increase the storage period of apricot [3].

For sulfuring process; sulphur is burned in the outside and delivered to the sulfuring rooms. Whole or half apricots are subjected to sulphur gas for about 14 to 18 hours. Air circulation system in sulfuring rooms is usually not available therefore apricots are exposed to different amounts of sulphur gases depend on the conditions. During sulfuring process, hot sulphur gas causes serious thermal damage on the fruits. Temperature on the some part of apricots in the sulfuring rooms can increase to 50°C during the process. Therefore the apricot skin exposed to high temperature gets softer. Oztekin *et al.* [12] cited that liquid sulphur treatment was suggested by Haeuser *et. al.* [13] to prevent this negative influence. So during sulfuring process, apricots were dipped in a 10% Natriummethabisulphide (Na<sub>2</sub>SO<sub>2</sub>0<sub>5</sub>) solution for 15 min-

utes. This method can easily be applied to apricots and has no drawback. After the SO<sub>2</sub> application, apricots are placed on dryer screens and dried generally using solar drying method either under the sun or by solar dryer to reach the safe storage moisture content of 20–24% [14]. The color of dried apricots may be any of the following colors: light yellow, yellow orange, orange, reddish orange and light red [3]. The spreading rate is 20 kg for whole apricots and 10–12 kg for halved apricots [15]. The stones are removed after drying process completed and finally dried. They are graded by size according to their diameter [14] and count per kilo and packaged [3].

One of the biggest problem for Turkish dried fruit sector also for dried apricot during exporting of them is limitation in maximum levels of sulfur dioxide (SO<sub>2</sub>). The content of sulfites and sulphur dioxide in sulphured fruit must not exceed the acceptable tolerances. According to CODEX General Standard for Food Additives (CODEX STAN 192-1995), sulfite levels for dried apricot and raisin are allowed maximum 2000 and 1500 mg/kg, respectively. Also, according to European Directive 95/2/EC (1995) on food additives, the maximum permitted level of sulfur dioxide (SO<sub>2</sub>) for dried fruits (apricots, peaches, grapes, prunes and figs) was given as 2000 mg/kg [11]. Due to this limitations, amount of sulfur used for sulfuration and sulfuring time that are effective parameters on the sulfur content changes [16]. In practical applications in Turkey, 1600–1800 g sulfur is burned for 1000 kg apricot to obtain 2000 mg/kg SO<sub>2</sub> after 12 hours.

### 3.2 Grape

Grape is the one of the most common agricultural product due to its promiscuous soil and climate requirements, nutritional content and diversity of its consumption method. Turkey is among the major producers of dried grape in the world. It exports approximately 70% of the annual raisin production to number of over hundred countries. EU countries such as England, Germany, The Netherlands, Italy, France and also Australia are the most important destinations for Turkish raisins. Mostly dried grapes are seedless grapes known as Sultanas. Fresh grapes are harvested by hand at dry matter content of 22–23%. Hand picked bunches of grapes are dipped in a special solution for half an hour that is an alkaline olive oil emulsion. The most common used solution is prepared with water and consists of 5–7% K<sub>2</sub>CO<sub>3</sub> and 0.4–0.5% olive oil. An alternative suggestion of this traditional solution consisted of 4% K<sub>2</sub>CO<sub>3</sub> and 2% Ethyleat [12]. The fruit cuticle is composed of hydro-

phobic biopolymers (cutin) between which there are waxes. It is a natural barrier to external attacks and also to water and solutes transported to and out of the plant. It represents the main limitation to the diffusion of molecules used in chemical treatments or physical treatments. By dipping process of grapes the mentioned solutions, the paraffin wax coating surface is dissolved. Thus, the moisture vaporization from the product is simplified and drying time is shortened. After the dipping process is completed, the color of the grapes becomes very attractive. If this process is not performed, the grapes reach to the safe moisture content that was informed as 18% for seeded grapes and between 15–18% for seedless grapes by dry grape standard in 2 or 3 weeks and this long drying period causes to obtain low quality final product [12, 17, 18]. It takes about 10 days to reach safe moisture content, if turned 2 or 3 times during this period. After drying period, the fruit sized, destemmed, screened, washed in potable water, aspirated and static picked to remove defects and foreign materials [i].

Dried grape must be stored after drying until the following season to consume. But occurred losses in stored products due to especially from animal origin organisms (such as raisin moth) and molds (ochratoxin A) are considered to be 10% per year [19]. Widely used method is fumigation for the prevention of losses occurred due to pests in the stored products also in Turkey. On the other hand consumer demand for products in developed countries changed drastically by increasing living standards. Consumers prefer the products that are produced environment-friendly production techniques and grown in natural or near natural environments instead of classical production techniques that use extensively chemicals.

Onar and Aktas [20] performed a research on ozone application as pretreatment before drying of grape to extend storage life and reduce product quality losses occurred due to some pests such as dried grape moth (*Ephestia figuliella* Greg.). For this aim dried grape samples were stored 1 year, controlled and analyzed quarterly. For comparison, conventional method applied in Turkey namely soaking process using mixture of potassium carbonate (K<sub>2</sub>CO<sub>3</sub>) and olive oil was performed also. Besides to these ozone, soaking to the mixture; ozone-plus-soaking pre-treatments were also tested for grape samples. According to research results, ozone treatment before drying process of grape was found as quite advantageous application in terms of drying time and the final product quality and effective to reduce mold and yeast growth especially in long-term storage of dried

grape. During storage *Aspergillus niger*, *Penicillium sp* and *Fusarium sp* were determined on the dried grape samples. Pre-treatments could decrease especially growing of *Penicillium sp* and *Fusarium sp*. It was found that ozone application before drying process of grape is an very effective method to prevent growth of yeast and mold on dried grape. No fungi growth was determined on ozone pre-treated samples during storage. While the cleanest samples in respect of fungus were found as ozone pre-treated samples, the higher fungus growth was determined for no-treated and BOU samples at the end of 1 year storage as seen in Fig. 2. Pre-treatment of BOU could decrease the fungus growth for 6 months storage period with effect of ozone but then negative effect of dipping process could not be eliminated in respect of growing of *Aspergillus niger*, *Penicillium sp* after 1 year storage.

### 3.3 Fig

Turkey is the biggest dried fig producer and exporter in the world. 60–70% of world's dried fig production and 75% of world's fig export [ii].

Figs should be dried after the harvesting ripeness is completed, generally known when the fruits fall down from the trees at 30–50% of moisture content. All damaged fruits must be separated before drying to prevent infestation of mold growth [3]. They were dried on racks, concrete, plastic sheet or cot-like wooden bedstead to the safe moisture content of 24–30% and takes about 8 to 10 days under natural solar drying or shadow drying [15].

The main problems of conventional dried fig production are decreases in food quality and safety because of the hazardous microorganisms, aflatoxin B1, and some storage pests such as *Ephestia* or *Plodia* [21]. Insect and microbial count of sun dried figs could be higher than

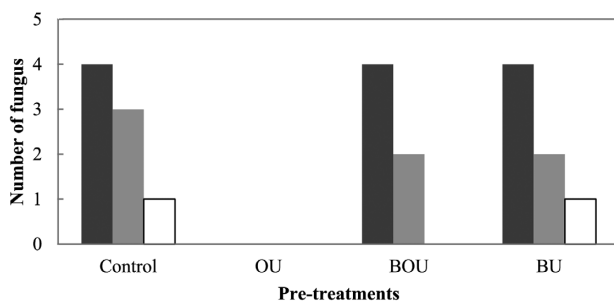


Fig. 2 Effect of treatments on fungi growth (OU: samples pre-treated with ozone gas for 30 minutes; BU: dipping into 5%  $K_2CO_3$  + 1% olive oil solution (10 times); BOU: pre-treatment with both ozone and solution of  $K_2CO_3$  and olive oil (firstly dipping then ozone application)). ■, *Aspergillus niger*; ▣, *Penicillium sp.*; □, *Fusarium sp.*

permitted levels due to natural growing conditions and poor agricultural practices in growing areas. For this reason, after drying process completed, atmospheric fumigation applied for 24 hours if necessary. Then aflatoxin control done under UV light treatment and contaminated fruit removed. The figs subjected to vacuum fumigation with  $CO_2$ , UV light treatment and washing [3].

Some researches using ozone gas or ozonated water had been started to perform in Turkey for reduction of aflatoxin B1, whereas ozonated water was affected for decreasing microbial counts. A research was performed to keep quality and extend shelf life of dry fig using ozone by Öztekin *et al.* [21] and Zorlugenç *et al.* [22]. In the research performed by Zorlugenç *et al.* [22] the effectiveness of gaseous ozone and ozonated water on microbial flora and aflatoxin B1 content of dried figs were investigated. After dried figs were exposed to 13.8 mg/L ozone gas and 1.7 mg/L ozonated water for 7.5, 15 and 30 min, variation of aerobic mesophilic bacteria (AMB), *E. coli*, coliform, yeast and mold counts were determined. In dried figs, 30 g of dried figs were artificially contaminated with aflatoxin B1 (50 milliliter) at a level of 21 mg /kg using a standard of aflatoxin B1. Aflatoxin contaminated figs were treated with gaseous ozone (13.8 mg milliliter ozone gas concentration) and ozonated water ( $1.7 \pm 0.17$  mg/L of average dissolved ozone concentration) for 30, 60 and 180 minutes.

During the ozonated water process, *E. coli*, coliform, yeast and molds were completely inactivated. In gaseous ozone treatment, *E. coli* and molds population were exactly destroyed. However, substantial reduction in aerobic mesophilic bacteria, coliform and yeast counts were determined. *A. flavus* and *A. parasiticus* which cause aflatoxin formation were isolated from non-ozonated dried figs. Due to inactivation of all molds in dried figs, aflatoxin formation potential was decreased after ozonation process [22]. In Fig. 3, effects of gaseous ozone and ozonated water on degradation of aflatoxin B1 in artificially contaminated dried figs were given.

### 3.4 Tomato

Tomato) is most commonly commercially produced vegetable in the world. Its production reached 159,023,383 metric tons in the world, and about 11,003,400 metric tons in Turkey in 2011 [iv]. Depend on the high production amount of tomato, 92% of the total vegetable exporting of Turkey is dried tomato [23]. Natural sun drying is practiced widely in most tropical and subtropical countries and generally this method has been using

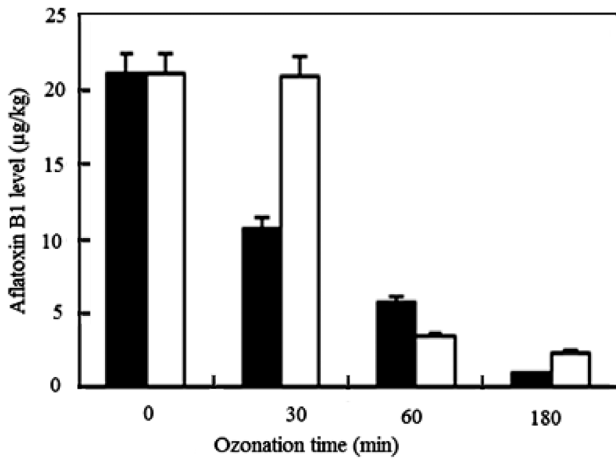


Fig. 3 Effects of gaseous ozone and ozonated water on degradation of aflatoxin B1 in artificially contaminated dried figs. ■, gaseous ozone; □, ozonated water. In practical applications in Turkey, ozone gas with 5 ppm concentration are being used for inactivation of all of coliform bacteria in dried figs for at least 3 hours [iii].

in Turkey to obtain dried tomato. To improve the quality of dried tomato products, industrial drying methods such as hot-air and solar drying are suggested [24, 25] but general preferred method is natural sun drying for many dried tomato producer companies in Turkey.

In practice, salt or sulphur ( $\text{SO}_2$ ) pretreatments as a preservative are being used before drying of tomato and drying process needs between 5–7 days. Salt treatment with 6–8% ratio for wet weight is applied as pretreatment and  $\text{SO}_2$  treatment to obtain maximum 2500–3000 ppm sulphur in the dried tomato is applied. Both salted and sulphured sun dried tomatoes are prepared from fresh tomatoes harvested at the peak of their ripeness. Drying process of tomato is finished when final moisture content of tomato is 18–23%. To prevent quality losses, sodium metabisulfite solution is also used widely as pretreatment. But its concentration must be limited due to sulfur limitation for exported products as 200 ppm. Tomatoes are prepared in the shape of halves, strips (julienne cut), diced and ready-to-eat before drying. Dried tomatoes that have optimum moisture levels are collected into small mounds and then passed through a rotating sieve to remove any foreign bodies and packed into jute bags. Finally the tomatoes are fumigated under plastic sheeting, weighed, and moved into cold-storage [ii].

Many research had been performing to improve in dried foods quality by applying various pretreatments before tomato drying process in Turkey. Using of methyl and ethyl ester emulsions or alkali pretreatment in aqueous solutions of  $\text{NaOH}$  and  $\text{K}_2\text{CO}_3$  increases water per-

meability of waxy layer of tomato namely improves the drying rate [26]. Hasturk Sahin *et al.* [27] studied that the effects of pretreatments using different pretreatments on lycopene retention and colour properties of dried tomato slices that were dried using different drying methods such as hot-air drying (coded as HA) at 65, 75 and 85°C drying temperatures, sun drying (coded as SD), vacuum drying and freeze drying and compared to no-pretreated samples (coded as NPT). Pretreatment 1 coded as AA+CA is dipping into 2% ethyl oleate +4% potassium carbonate solution for one minute, and then dipping into solution of 1% ascorbic acid +1% citric acid to sliced tomato samples for 2 minutes. Pretreatment 2 coded as NMBS is dipping into 2% ethyl oleate +4% potassium carbonate solution for one minute and then dipping into solution of 2% sodium metabisulfite for 2 minutes.

According to natural sun drying results; sun drying decreased the brightness but pretreatments increased it. Highest lycopene content was found for sun dried samples compared to those results obtained for hot air drying. Pretreatments especially increased highly lycopene content of sun dried samples as seen in Fig. 4. It was concluded that for sun drying process of tomato, quality parameters of sun dried samples were found higher generally when the process was performed under hygienic conditions and at higher place than ground.

#### 4. Conclusions

Drying is one of the most important process among post-harvest processes. It causes some decrease in the quality of the final products. Some pretreatments per-

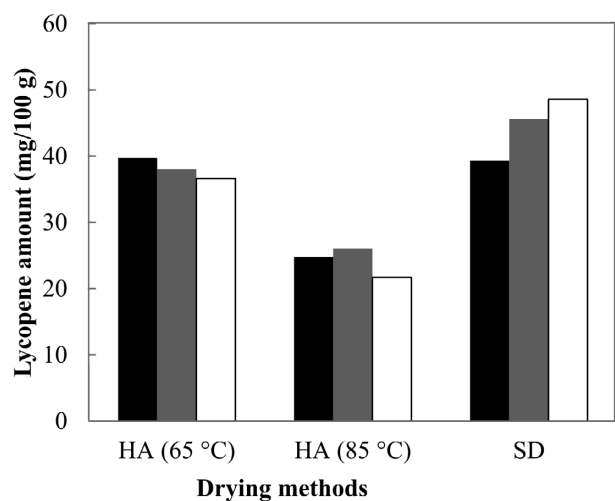


Fig. 4 Lycopene content changes in dried tomato samples in respect of pretreatments. ■, No-treated; ■, AA+CA; □, NMBS.

formed before, during or after drying process in Turkey are used to produce commercial products of dried fruits and vegetables in order to reduce losses. Reduction of losses in dried fruits and vegetables and expanding markets of them without any problem in respect of consumer request and exporting regulations for Turkey and another countries which are important dried fruits and vegetables exporting countries increase income and decrease economic losses. Number of researches should be increased on the investigation of alternative methods especially non-chemical applications and these applications must be assessed individually for each fruits and vegetables more detailed.

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