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# INFLUENCE OF PRE-DRYING TREATMENTS ON THE QUALITY ATTRIBUTES AND STORAGE STABILITY OF TOMATOES

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## ABSTRACT

Oven drying process for tomato quarters was carried out at 55ºC ± 5ºC until a constant weight was reached. Different pre-drying treatments (250, 500 and 1000ppm ascorbic acid solution, 0.5, 2 and 4% $CaCl_2$ solution, freezing at –18ºC for 15 days, freezing with 500ppm ascorbic acid solution and freezing with 2% $CaCl_2$ solution) were used to improve the quality attributes and storage stability of dried tomatoes. Untreated samples were served as control. Changes in moisture content, ascorbic acid, lycopene, total phenols, pH, acidity, colour, non-enzymatic browning and rehydration ratio were estimated during storage at ambient conditions for 6 months. The obtained results showed an effectiveness of all pre-treatments on quality attributes and storage stability of dried tomatoes as compared to the control. Significant differences were found in mostly quality attributes after pre-drying treatments, storage and interaction between pre-drying treatments and storage.

**Keywords:** Tomato, Drying, lycopene, Colour, Quality.

## INTRODUCTION

Tomato (*Lycopersicon esculantum* L.), belongs to the family of Solanaceae, is one of the most widely consumed fresh vegetables in the world. Tomatoes contain a number of health functional constituents such as red-coloured carotenoid lycopene and other flavonoids, phenolic acids (especially chlorogenic acids) and ascorbic acid in addition to basic nutritional compounds (Charanjeet *et al*., 2004; Slimestad and Verheul, 2009; Veillet *et al*., 2009).

Among all vegetable crops in Egypt, tomatoes enjoy the highest cropping intensity ratio in land use (Alboghdady, 2014). According to the statistics of Food and Agriculture

Organization (FAO, 2012), the tomato cultivated area and productivity in Egypt were estimated to be 8625219 tons from a total area of 265200 hectares.

Tomato has a limited shelf life at ambient conditions and is highly perishable. It creates glut production season and becomes scanty during off-season. Short shelf life coupled with inadequate processing facilities lead to heavy revenue loss to the country. The demand for dried tomato is increasing rapidly both in domestic and international market with major portion being used for preparation of convenience food. Thus, there exist a need to develop suitable technology for processing and preservation of this valuable product in a way that will not only check losses but also generate additional revenue for the country (Ahmed and Shivhare, 2001; Purseglove *et al*., 2001; Akanbi *et al*., 2006 and Davoodi *et al*. 2007).

It is assumed that food processes might accelerate more bound phenolic compounds releasing from the breakdown of cellular constituents . Although, disruption of cell walls may also trigger the release of oxidative and hydrolytic enzymes that would destroy the antioxidants in fruits, however,high temperature of air-dried processing would deactivate these enzymes and avoid the loss of phenolic acids and, therefore,lead to the increase of total phenolic compounds (Chism and Haard 1996).

Little considerations and attention are however, given to preservation aspect of this important agricultural product in Egypt. Therefore, the main objective of this investigation was to evaluate the use of various pre-drying treatments for improving the storage stability and keeping quality of dried tomatoes during storage at ambient conditions for 6 months.

## MATERIALS AND METHODS

### Materials:

Freshly harvested and ready to be eaten tomatoes (Super Jackall) about 50 kg with an average weight of 90-100 gm. were purchased from a local market (Minia, Egypt) and were dried on the day of purchase using an oven drying method.

### Methods:

#### Preparation of fresh tomatoes for drying process:

Tomato samples were subjected to some successive steps of washing, sorting and trimming. Then, were cut into equal quarters and treated with different pre-drying treatments as follows:

- Untreated samples which served as control ($T_0$).
- Dipping in 250, 500 and 1000 ppm ascorbic acid solution for 10 min at (22ºC ) ambient temperature ($T_1$, $T_2$ and $T_3$, respectively).
- Dipping in 0.5, 2 and 4% $CaCl_2$ solution for 10 min at (22ºC) ambient temperature ($T_4$, $T_5$ and $T_6$, respectively).
- Freezing at –18ºC for 15 days ($T_7$).
- Dipping in 500 ppm ascorbic acid solution for 10 min then freezing at –18ºC for 15 days ($T_8$).

- Dipping in 2% $CaCl_2$ solution for 10 min then freezing at –18ºC for 15 days ($T_9$).

Pre-treated tomato samples were drained and spread in a single layer on the drying trays then oven dried at 55ºC ± 5ºC until a constant weight was reached. The dried samples were packed in polyethylene bags and stored in airtight containers till analysis.

**Physico-chemical and quality attributes of dried tomatoes:**

**Moisture content** of dried tomato samples were determined according to the methods of the AOAC (2000).

**Ascorbic acid** was determined by the 2,6-dichlorophenol-indophenol method according to Ranganna (1977).

**Lycopene pigment** was measured following the method described by Ranganna (1977).

**Total phenols** was carried out according to the method of Musa *et al*.(2011) using Folin-Ciocalteu reagent and the result was expressed as mg of gallic acid equivalents/100g sample.

**pH values** of dried tomato samples were determined according to the methods of the AOAC (2000). **Titratable acidity** was determined according to Adekunte *et al*. (2010).

**Colour characteristics** of samples were measured by a colour difference meter (model colour Tec-PCM, USA) using different colour parameters ($L^*$, $a^*$ and $b^*$) according to Francis (1983).

**Non-enzymatic browning (NEB)** was determined by measuring the absorbance of the alcoholic extract at 420 nm. Five grams of the samples were soaked in 100 ml of 60% ethanol for overnight. The soaked samples were homogenized and the extract was filtered through Whatman No. 1 filter paper. The optical density of the filtrate was measured at 420 nm in 1 cm quartz cuvette by using a Labomed, inc. Spectro UV-Vis R.S. spectrophotometerand expressed as an index for NEB (Ranganna, 1986).

**Rehydration ratio** was used to express ability of the dried samples to absorb water. It was obtained by dividing the rehydrated weight by the initial weight (Prakash *et al*., 2004 and Lee *et al*., 2006).

**Statistical analysis:**

Data collected were subjected to two-way analysis of variance (ANOVA) to determine the overall effect of treatments, storage and their interaction on physico-chemical and quality attributes of samples. The differences were separated using the least significance difference (LSD). (Snedecor&Cochran, 1982).

## RESULTS AND DISCUSSION

**Physico-chemical and quality attributes of dried tomatoes:**

Changes in moisture content, ascorbic acid, lycopene, total phenols, pH, acidity, colour, non-enzymatic browning and rehydration ratio were estimated after storage of dried tomatoes at ambient room temperature for 6 months. The results are shown in Tables (1 – 5).

**Moisture content of dried tomatoes:**

Table (1) shows that the effect of pre-drying treatments and storage periods on the moisture content of dried tomatoes . The moisture content ranged between 6.09 (T8)and 7.26% (T0) at zero time of storage. The moisture contents of dried tomatoes were increased during storage period and reached between 11.68(T7) and 13.35% (T6) at the end of the storage period of (6 months). The results also showed that, the highest value of increament was found in samples treated with 4% $CaCl_2$ solution ($T_6$), whereas, the lowest value was found in frozen samples ($T_7$).

**Ascorbic acid content of dried tomatoes:**

The data in Table (1) shows that the effect of pre-drying treatments and storage periods on ascorbic acid content of dried tomatoes. Ascorbic acid content decreased steadily during storage for all treatments. Gallali *et al*. (2000); Uddin *et al*. (2002); Nindo *et al*. (2003) and Orikasa *et al*. (2008) reported that ascorbic acid is an important nutrient in fresh fruits and vegetables. It is water-soluble vitamin and more sensitive to heat, oxygen, light and considered to be highly subjected to losses during processing and storage. Consequently, the retention of ascorbic acid is used as an indicator of the potential preservation of all other nutrients.

**Lycopene content of dried tomatoes:**

Table (2) shows the effect of pre-drying treatments and storage periods on lycopene contents of dried tomatoes. A significant loss in lycopene content was observed during storage for all treatments .In case of untreated sample (T0), lycopene content decreased from 18.88 to 5.24 mg/100g after storage period of six months.

Decrease in lycopene content in the dried tomato could be attributed to the oxidation of the lycopene pigment during the drying process. Shi and Maguer (2000) observed that carotenoids are susceptible to oxidation in the presence of light, oxygen and low pH. Lycopene constitutes approximately 83% of tomato pigments, so its degradation may have an important effect on the final product colour as well as nutritional and functional value (Shi *et al*. 1999).

**Total phenolic content (TPC) of dried tomatoes:**

The data given in Table (2) showed that a significant differences in total phenol content of dried tomato were found among the pre-drying treatments, storage and interaction between pre-drying treatments and storage period.The initial concentration of total phenols in dried tomato samples varied from 105.6 (T5) to 457.6 (T9) mg /100 g (Table 2). These results were inagreement with those reported by Giovanelli

&Paradiso, (2002), Lavelli & Giovanelli, (2003) and Patras *et al*., 2009.

Regarding to Table (2), it was noted that pre-drying treatments (Dipping in dieffrent levels of ascorbic acid solution ) had higher levels of total phenol content (from 542 to 584mg/100g) after storage period of six months.

Lavelli and Giovanelli (2003) suggested that the increament of total phenol concentrations of processing tomato products may be due to hydrolysis processes. Lavelli *et al*. (1999) explained that there could be two reasons for this phenomenon: (1) the release of free hydroxyl groups through hydrolysis of flavonoid glycosides, and (2) the release of phenols by cell walls. The degradation of the cell-wall polysaccharide structures favour the phenol release from skins, notably those phenols that are linked to the cell wall (Pinelo *et al*., 2006).

**pH and titratable acidity of dried tomatoes:**

The pH and titratable acidity values are presented in Tables (3). The results showed that a little decrease in pH values was observed in all treatments during storage .Titratable acidity was increased from 5.32 to 6.97% after six months of storage.

These results are in agreement with those obtained by Aworth *et al.* (1983), Giordano *et al.* (2000); Okanlawon, *et* al. (2002) and Ramandeep and Geoffrey (2006).They indicated higher acidity in dried samples which may be related to the partial fermentation occurred in some trials, due to longer time consumption and pectic enzyme activity in first hours of the process.

**Colour characteristics of dried tomatoes:**

The Hunter colour parameters $L^*$, $a^*$ and $b^*$ are widely used to describe colour changes during drying and storage of fruits and vegetables (McGuire,1992; Lau *et al*., 2000, Ergunes and Tarhan, 2006, Rodrigo *et al*., 2007 and Shih *et al*., 2009).

Results pertaining to colour are presented in Table (4). There was a significant difference in the lightness ($L^*$) of the pre-drying treatment samples and storage periods. Treatments caused the appearance of brown pigments which is due to the chemical interaction between reductive sugars and amino acids. Similar results reported by Arsalan and Özcan (2011). Another reason for decolouration and the regression of lightness can be directly because of moisture loss.

The high value of the ($a^*$) parameter shows the greatest degree of the tomatoes' redness prior to drying. This colour declined in its density, however, when the pre-drying treatment samples were exposed to the oven . This declining is similar to the declining of the anthocyanin content. With regard to redness, there was significant difference between the pre-drying treatments samples and storage periods. However, natural redness was less prominent in those samples that had been dried in the oven because the longer duration of exposure to heat caused more severe degradations in the red pigments and their transformation into unnatural pigments. The occurrence of non-enzymatic reactions is further reasons. (Guiné and Barroca 2012).

The results presented in Table (4) showed that the pre-drying treatments and storage periods had a significant effect on yellowness parameter ($b^*$). The ($b^*$) parameter indicates the yellowness of the samples. The yellowest of all the dried samples ranged from 21.52 in ($T_2$) to 27.94 in ($T_6$) before storage and ranged from 25.26 ($T_8$) to 32.14($T_4$) after 6 months of storage period.

**Non-enzymatic browning (NEB) of dried tomatoes:**

Non-enzymatic browning (NEB) of dried tomatoes as affected by pre-drying treatments and storage periods was determined by measuring the absorbance (optical density) of the alcoholic extract at 420 nm and expressed as an index for NEB. The obtained results are presented in Table (5). The NEB values increased during storage period for all treatments. Similar results were obtained by Krokida *et al*. (2001), Davoodi *et al*. (2007) and Koca *et al*. (2007). They reported that most of the browning was occurred in food during drying is due to Maillard reactions. Browning can also appear during long storage, and was generally dependent upon product characteristics and storage conditions.

**Rehydration ratio of dried tomatoes:**

The rehydration ratio is used to express ability of the dried materials to absorb water. It was obtained by dividing the rehydrated weight by the initial weight (Prakash *et al*., 2004 and Lee *et al*., 2006). The results presented in the Table (5) showed that pre-drying treatments and storage periods had significant decrease on the rehydration ratio of dried tomatoes. It could also be seen that ($T_6$) had the highest rehydration ratio (5.69) followed by $T_5$ (5.57) before storage, however ($T_9$) had the lowest rehydration ratio (3.46) followed by ($T_8$).

It is inferred that shrinkage of tomato tissue pre-treated with $CaCl_2$ was not as large as that of raw tomato during drying. Hence, open structure promoted water diffusion and resulted in faster drying and subsequently formation of open structure due to calcium pre-treatment concluded to better rehydration property and reconstitution of the product (Lewicki and Lazuka, 2002). Similar results were obtained by Ayub Hossain and Gottschalk (2009) who indcated that the rehydration ratios of all samples decreased with the storage time but their reduction rates were small.

Table (1): Moisture (%) and Ascorbic acid contents (mg/100g) of dried tomatoes as affected by pre-drying treatments and storage periods.

| Treatments | Storage period (month) | | | | | |
|---|---|---|---|---|---|---|
| | Moisture (%) | | | Ascorbic acid (mg/100g) | | |
| | 0 | 3 | 6 | 0 | 3 | 6 |
| $T_0$ | 7.26 | 11.23 | 11.79 | 176.0 | 132.0 | 90.5 |
| $T_1$ | 6.58 | 12.67 | 11.92 | 234.0 | 188.7 | 84.9 |
| $T_2$ | 6.11 | 11.86 | 11.77 | 243.3 | 155.3 | 76.9 |
| $T_3$ | 6.48 | 11.55 | 11.76 | 311.3 | 194.1 | 86.0 |
| $T_4$ | 7.09 | 13.18 | 12.97 | 182.8 | 100.2 | 63.8 |
| $T_5$ | 6.89 | 13.53 | 11.80 | 154.4 | 104.0 | 54.9 |
| $T_6$ | 7.12 | 13.29 | 13.35 | 109.7 | 63.5 | 65.3 |
| $T_7$ | 6.52 | 6.50 | 11.68 | 145.8 | 145.8 | 94.0 |
| $T_8$ | 6.09 | 11.25 | 12.23 | 227.6 | 187.6 | 89.6 |
| $T_9$ | 6.60 | 11.48 | 12.18 | 193.7 | 180.5 | 75.8 |
| F value | ** | ** | ** | ** | ** | ** |
| LSD 0.05 | A=0.069 | B=0.030 | AB=0.104 | A=8.07 | B=7.93 | AB=13.24 |

All mean scores, bearing different superscripts in columns differ significantly ($P < 0.05$).

Table (2): Lycopene (mg/100g) and Total phenol (mg/100g) of dried tomatoes as affected by pre-drying treatments and storage periods.

| Treatments | Storage period (month) | | | | | |
|---|---|---|---|---|---|---|
| | Lycopene (mg/100g) | | | Total phenol (mg/100g) | | |
| | 0 | 3 | 6 | 0 | 3 | 6 |
| $T_0$ | 18.88 | 14.63 | 5.24 | 315.9 | 424.9 | 367.9 |
| $T_1$ | 12.09 | 7.85 | 5.97 | 197.2 | 363.2 | 480.2 |
| $T_2$ | 18.23 | 13.28 | 5.29 | 378.3 | 463.6 | 542.9 |
| $T_3$ | 17.35 | 16.70 | 15.05 | 306.0 | 435.2 | 582.6 |
| $T_4$ | 12.30 | 11.42 | 11.29 | 154.2 | 137.1 | 584.1 |
| $T_5$ | 13.65 | 12.31 | 10.49 | 105.6 | 158.1 | 278.1 |
| $T_6$ | 12.19 | 11.06 | 10.7 | 171.4 | 126.9 | 244.5 |
| $T_7$ | 10.14 | 10.04 | 9.90 | 154.6 | 154.6 | 239.5 |
| $T_8$ | 13.88 | 12.95 | 11.33 | 311.4 | 435.9 | 547.5 |
| $T_9$ | 7.54 | 6.81 | 5.35 | 457.6 | 154.9 | 227.6 |
| F value | ** | ** | ** | ** | ** | * |
| LSD 0.05 | A=0.64 | B=0.40 | AB=1.38 | A=1.12 | B=1.51 | AB=2.53 |

All mean scores, bearing different superscripts in columns differ significantly ($P < 0.05$).

Table (3): pH values and Titratable acidity (%) of dried tomatoes as affected by pre-drying treatments and storage periods.

| Treatments | Storage period (month) | | | | | |
|---|---|---|---|---|---|---|
| | pH values | | | Titratable acidity (%) | | |
| | 0 | 3 | 6 | 0 | 3 | 6 |
| $T_0$ | 4.03 | 4.26 | 4.06 | 5.37 | 5.69 | 5.81 |
| $T_1$ | 4.34 | 4.20 | 4.15 | 5.32 | 5.69 | 5.79 |
| $T_2$ | 4.32 | 4.26 | 4.16 | 5.41 | 5.70 | 5.83 |
| $T_3$ | 4.26 | 4.23 | 4.05 | 5.45 | 5.48 | 5.54 |
| $T_4$ | 4.26 | 4.23 | 4.15 | 5.39 | 5.41 | 5.60 |
| $T_5$ | 4.25 | 4.22 | 4.14 | 5.41 | 5.46 | 5.49 |
| $T_6$ | 4.21 | 4.20 | 4.12 | 5.47 | 6.42 | 6.50 |
| $T_7$ | 4.26 | 4.16 | 4.05 | 5.83 | 6.06 | 6.20 |
| $T_8$ | 4.25 | 4.15 | 4.10 | 5.97 | 6.25 | 6.97 |
| $T_9$ | 4.26 | 4.23 | 4.14 | 5. 69 | 6.07 | 6.24 |
| F value | * | ** | * | * | * | * |
| LSD 0.05 | A=0.107 | B=0.260 | AB=0.040 | A=1.55 | B=0.32 | AB=0.35 |

All mean scores, bearing different superscripts in columns differ significantly (P < 0.05).

Table (4): Colour characteristics of dried tomatoes as affected by pre-drying treatments and storage periods.

| Treatments | Colour characteristics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | L (Lightness) | | | a (redness/greenness) | | | b (yellowness/blueness) | | |
| | Storage periods (month) | | | | | | | | |
| | 0 | 3 | 6 | 0 | 3 | 6 | 0 | 3 | 6 |
| $T_0$ | 38.74 | 42.59 | 47.37 | 24.1 | 31.67 | 34.53 | 24.75 | 25.7 | 28.18 |
| $T_1$ | 43.49 | 44.49 | 45.08 | 23.45 | 24.45 | 26.25 | 24.44 | 26.36 | 30.42 |
| $T_2$ | 38.23 | 42.43 | 43.56 | 16.82 | 18.97 | 25.01 | 21.52 | 25.64 | 25.76 |
| $T_3$ | 38.35 | 40.12 | 46.06 | 19.03 | 21.05 | 23.26 | 22.58 | 25.21 | 30.86 |
| $T_4$ | 40.25 | 46.55 | 48 | 18.74 | 21.25 | 28.47 | 25.78 | 31.78 | 32.14 |
| $T_5$ | 40.78 | 47.23 | 51.84 | 21.41 | 26.07 | 25.42 | 27.54 | 28.42 | 31.22 |
| $T_6$ | 44.97 | 47.2 | 50.52 | 21.2 | 22.07 | 27.82 | 27.92 | 28.13 | 28.88 |
| $T_7$ | 43.72 | 49.79 | 48.06 | 22.34 | 22.57 | 22.56 | 24.46 | 26.69 | 26.77 |
| $T_8$ | 41.69 | 42.41 | 43.07 | 19.32 | 21.8 | 23.49 | 22.98 | 24.65 | 25.28 |
| $T_9$ | 46.6 | 51.89 | 55.3 | 16.07 | 20.86 | 21.54 | 21.65 | 25.83 | 28.42 |
| F value | ** | ** | ** | * | ** | * | ** | ** | ** |
| LSD 0.05 | A=3.32 | B=1.71 | AB=5.9 | A=3.84 | B=1.71 | AB=5.9 | A=2.40 | B=1.07 | AB=3.8 |

All mean scores, bearing different superscripts in columns differ significantly (P < 0.05).

Table (5): Non-enzymatic browning ($OD_{at\ 420\ nm}$) and Rehydration ratio of dried tomatoes as affected by pre-drying treatments and storage periods.

| Treatments | Storage period (month) | | | | | |
|---|---|---|---|---|---|---|
| | Non-enzymatic browning | | | Rehydration ratio | | |
| | 0 | 3 | 6 | 0 | 3 | 6 |
| $T_0$ | 1.024 | 1.837 | 2.613 | 5.01 | 4.58 | 4.27 |
| $T_1$ | 1.343 | 2.227 | 2.653 | 5.07 | 4.56 | 4.30 |
| $T_2$ | 1.660 | 2.127 | 2.963 | 4.92 | 4.85 | 4.42 |
| $T_3$ | 1.720 | 2.343 | 2.783 | 5.12 | 4.68 | 4.13 |
| $T_4$ | 1.063 | 1.137 | 1.487 | 5.53 | 5.15 | 3.84 |
| $T_5$ | 0.9233 | 1.383 | 2.543 | 5.57 | 5.43 | 4.48 |
| $T_6$ | 0.8733 | 1.163 | 1.673 | 5.69 | 4.64 | 4.28 |
| $T_7$ | 1.277 | 1.377 | 2.377 | 4.18 | 3.92 | 3.78 |
| $T_8$ | 2.047 | 2.197 | 2.883 | 3.85 | 3.84 | 3.63 |
| $T_9$ | 1.243 | 1.397 | 2.283 | 4.46 | 3.54 | 3.46 |
| F value | ** | ** | ** | ** | ** | ** |
| LSD 0.05 | A=0.081 | B=0.042 | AB=0.052 | A=0.81 | B=0.42 | AB=0.15 |

All mean scores, bearing different superscripts in columns differ significantly ($P < 0.05$).

**CONCLUSION**

The obtained results showed an effectiveness of all pre drying-treatments on quality attributes and storage stability of dried tomatoes as compared to the control. Significant differences were found in mostly quality attributes after pre-drying treatments, storage and interaction between pre-drying treatments and storage period. Pre-drying treatments with $CaCl_2$ and ascorbic acid gave the best results in respect to lycopene, total phenol contents and ascorbic acid retention, colour parameters and rehydration ratio of dried tomatoes. Therefore, they can be recommended as pre-drying treatments before tomato drying to preserve colour properties, lycopene and total phenol contents.

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**الملخص العربي**

**دراسة تأثير معاملات ما قبل التجفيف للطماطم على صفات الجوده والثبات أثناء التخزين**

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أجريت عملية تجفيف بالفرن لأرباع الطماطم على درجة حرارة 55 م ° ±5 م ° حتى تم الوصول إلى وزن ثابت. واستخدمت معاملات مختلفة قبل التجفيف كالنقع فى (250 و 500 و 1000جزء فى المليون محلول حمض الاسكوربيك، 0.5، 2 و 4٪ محلول كلوريد الكالسيوم، وتجميد على -18م° لمدة 15 يوما،معاملة ب 500جزء فى المليون من محلول حمض الاسكوربيك اومحلول كلوريد الكالسيوم 2% ثم التجميد وعينة بدون معامله قبل التجفيف(كنترول) لتحسين صفات الجودة والتخزين للطماطم المجففة. قدرت التغييرات في محتوى الرطوبة، وحمض الأسكوربيك، الليكوبين،الفينولات الكليه، الحموضة، التلون غير الانزيمي والتشرب وذلك أثناء التخزين على درجه حرار الغرفه لمدة 6 أشهر. وأظهرت النتائج التي تم التوصل اليها تاثير معاملات ما قبل التجفيف على صفات الجودة والثبات أثناء تخزين الطماطم المجففة بالمقارنة مع الكنترول. سجلت فروق معنوية في معظم صفات الجودة والتخزين للطماطم المجففة بعد معاملات ما قبل التجفيف والتخزين والتداخل بين معاملات ما قبل التجفيف والتخزين على جودة الطماطم المجففة.