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Technological and Chemical Studies on Canned Tomato Product

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ABSRACT

In this study the effects of pre-treatments additives (citric acid 2%, NaCl 2%, and $CaCl_2$ 1%), during processing and storage periods on chemical composition, phytochemical compounds, antioxidant activity, total counts (bacteria, yeast and molds) and sensory evaluation of fresh canning tomatoes was investigated. The fresh tomatoes had moisture content (94.1%), pH (4.54), total acidity (0.48%), ash (23.1%), fibers (22.5%), total and reducing sugars were 53.7 and 7,8%, respectively. Fresh tomatoes were rich in antioxidant compounds (Lycopene, total carotenoids, ascorbic acid and total phenols) which represent 109,162.1, 433.4 and 836.3 mg/100 g dry weight basis, respectively, meanwhile antioxidant activity for fresh 39.4% (FW). Moisture content of tomatoes after canning process is no more change compared to fresh tomatoes, since it was about 94% of control sample at zero time. Even, after storage expected at 4 and 8 months which reached about 93.98% and 93.97%, respectively. The average of pH and titratable acidity at zero time 4.44 and 0.53% of control sample, were slightly decreased after 4 and 8 months. The ash and fibers content of canned tomatoes were reduced compared with fresh tomatoes, while total and reducing sugar content increased after canning process compared to fresh tomatoes and was decreased after 4 and 8 months of storage. On the other hand, non-enzymatic browning in canned tomatoes was increased when compared to fresh tomatoes. Although, canned tomatoes product was high acceptability and safety for consumer as a result of removal of seeds and peel. However, it had low nutritional values when compared with fresh tomatoes. Because of reduction of antioxidants active compounds such as lycopene, total carotenoid, ascorbic acid, and total phenols. Canned tomatoes had reduction in antioxidant activities compared with fresh tomatoes, since reached to 34.2% after canning process. In the same time, antioxidant activities were reduced from 33.7% to 33.1% after 4 and 8 months of storage. In addition, most of antioxidant compounds were stabled during storage especially total phenols and lycopene. Canning of tomatoes and pre-treatments can extend their shelf life and improved acceptability and safety of this product. $CaCl_2$ pre-treated (T4) had the best results compared with control (T1) and the other treatments. The total count of bacteria, yeast and molds for control and treatments less than permissible limits (10^3/g and 10^4/g) and the values of sensory evaluation of canned tomato product were high. It can be recommended that the canning process uses to increase the shelf life of tomatoes because the excess of Egyptian total production is very high after using as fresh fruit.

Keywords: tomatoes canning, chemical composition, phytochemical compounds, antioxidant activity.

INTRODUCTION

Tomatoes (*lycopersicon escolentum*) are one of the most ubiquitous crops in the world and are grown in Asia, Africa, North America, Europe, and South America (FAO 2014). The worldwide production of tomatoes is about 170.8 million tones. China is the first producer of tomatoes, accounted for 31% of the total production. The first country for tomatoes production is China which followed by India then USA and Turkey, as for Egypt is the fifth producer of tomatoes fruit (FAO, 2018).The moisture content of tomatoes slices was 94.95% for fresh tomato, therefore, total solids and total soluble solids contents were 5.05% and 4.1%, respectively. Acidity of tomatoes fresh (% citric acid) was 0.23%, while values of lycopene and carotenoids are 5.181 mg/100 g (DW) and 5.181 5.181 mg/100 g (DW) (Abou-Zaid and Ibraheem 2015). The pulp has the highest moisture content and soluble fibers content, but it has low fat, protein, and ash content. While the peel exhibited high levels of carbohydrates and total fibers and the seeds presented high content of fat, protein, and insoluble fibers. Potassium is the main mineral found in fresh tomatoes fruits (Peteria *et al.,* 2018). Vitamin C content of the fresh tomatoes was reached to be 1856.65 mg of ascorbic acid per 100 g of dry sample. While total phenolic content of the fresh samples was 735 mg / 100 g of DW, and antioxidant activity of fresh tomatoes samples was 83.65 ± 1.12 mg/ g of dry sample (Sajid *et al.,* 2015). Rutin was the main phenolic compound (79% of total phenolic compounds present) in fresh cherry tomatoes (Valeria *et al.,* 2015).

Consumption of tomatoes and its products continuously has been correlated with a reduction in susceptibility to various types of cancers and cardiovascular diseases. These positive effects are attributed to the antioxidant compounds present in tomatoes such as vitamin C and E, carotenoids, polyphenols, which play a key role in the health protection mechanisms by scavenging free radicals (Ray *et al.,* 2011). In terms of, lycopene is the main phytochemical compound in tomatoes and because of their having antioxidants properties, it might neutralize free radicals and prevent from diseases such as cancer, premature aging, cardiovascular problem, osteoporosis, diabetes and many other diseases (Basiri, 2010). Tomatoes are characterized with trace elements, such as selenium, copper, manganese and zinc, since are co-factors of antioxidant enzymes (Martinez-Valverde *et al*., 2002). In addition, consumption of tomatoes juice in type 2 diabetic subjects caused a significant elevation of plasma lycopene as well as increased resistance of low-density lipoprotein (LDL) to oxidation (Gianetti *et al.,* 2002).

Canning processes extend the shelf life of the products and make it safe for human consumption by destroying the pathogenic microorganisms. The sterilization of the canned food is usually carried out by steam heating to a temperature sufficient to kill the microorganisms. On the positive side, heat destroys microbial pathogenic, spoilage organisms and endogenous and introduced enzymes that would otherwise render the food inedible or unsafe. At the same time, concentrations of heat-labile vitamins, particularly thiamine, vitamin C and folate are reduced by the heat of the sterilization process (Ahmed *et al.,* 2012). Both physical and chemical changes occur during processing and, to a lesser extent, during storage, and it is these that determine the product quality in terms of its sensory properties and nutrient content. These physical and chemical changes are influenced by the time and temperature of the process, the composition and properties of the food, the canned medium, and the conditions of storage (Patras *et al.,* 2009). Peels and seeds removal, two commonly practiced procedures either at home or by the processing manufacture, affected on the physicochemical properties, bioactive compounds contents and antioxidant capacity of tomatoes fruits. In general, peeling was more detrimental, since it caused a higher decrease in lycopene, β-carotene, ascorbic acid and phenolics contents (averages of 71%, 50%, 14%, and 32%, respectively) and significantly

lowered the antioxidant capacity of the fruits. Although seeds removal favored the increase of both color and sweetness, some bioactive compounds (11% of carotenoids and 24% of phenolics) as well as antioxidant capacity (5%) were loss (Vinha *et al.,* 2014). In general, the variety type and brine composition had the greatest effect on canned unpeeled tomatoes halves. Since, the tomatoes halves canned in 0.1% NaCl brine had lower titratable acidity (0.26 and 100 g) and ascorbic acid values (5.36 mg/100 g) than the corresponding values (91.8%, 5.25 g/100, 0.31 and 100 g and 8.93 mg/100 g, respectively) obtained from tomatoes halves processed in combined brine solution of 0.1% NaCl and 1% $CaCl_2$ brine (Makanjuola *et al.,* 2012).

The objective of this research is determined the acceptability and safety of these products to people and protected phytochemical of tomatoes throughout canning by employment some modifications on these methods.

MATERIALS AND METHODS

Materials:

Fully ripe, red color tomatoes (*Lycopersicon escolentum*) cv. Alisa was procured from local vegetable market of Mansoura city-El Dakahlia Governorate (Egypt).

Chemicals and reagents:

All chemicals were of reagent grade without any further purification. Folin-Ciocalteau reagent, 1,1-diphyenyl-picrylhdrazyl (DPPH), sodium chloride 2%, citric acid 2%, calcium chloride "salt" 1% , lead acetate, sodium oxalate, meta-phosphoric acid, petroleum ether, total plate count and rose Bengal chloramphenicol agar were purchased from El-Gomhoria company for chemicals Mansoura, Egypt.

Methods:

Tomatoes were washed with tap water to remove any dust and undesirable materials, removed the place that connect fruit with plant stock, then tomatoes were divided into two parts:

Part 1: control (without any treatment).

Part 2: canning process:

Fresh tomatoes was put in boiling water for 2 min then put in cold water to facilitate removing the peel. After that, it was cut into equal pieces (4 quarters), then separate the seeds from the pieces and separate liquid from tomatoes during removal of seeds used in the preparation of various treatments (citric acid 2%, sodium chloride 2% and calcium chloride 1%) which added again to tomatoes parts in the glass jars.

The parts of the tomatoes were put regularly in jars and solution covers all pieces of tomatoes with leave about 10% above solution empty. Jars were sterilized in boiling water for 20 minutes. This product was preserved at ambient temperature for eight months and analyses carried out each four months.

Analytical methods:

Chemical analysis:

Fresh tomatoes and canning treatments were subjected to the following determinations as follows: Moisture content, pH value, total acidity, ash, fiber and minerals contents were determined according to the AOAC (2005). Total and reducing sugars were estimated according to Somogyi (1952). Total polyphenols was determined according to Singleton and Rossi 1965). Phenolic compounds were determined by HPLC according to Goupy *et al*., (1999). Non-enzymatic browning was estimated according to Ranganna (1979). Carotenoids were determined by using the method of Riso and Porrini (1997). Ascorbic acid was estimated by method described by Pearson (1973). Lycopene was determined by using the method of Gould and Gould, (1988). While the antioxidant activity of samples, an extract was studied through the evaluation of the free radical-scavenging effect on the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical was performed according to Hsu *et al*., (2003).

Microbiological analysis (Total bacteria, yeast and molds):

Total plate count (TPC) agar was prepared for determination of total bacterial, yeast and mold counts according to ISO-4833 (2003). Tomatoes sample (10 g) was blended and homogenized, then was mixed with 90 mL of sterilized water and serial dilutions was made. Aliquots (0.1mL) of each dilution were inoculated on the TPC agar at 37°C for 2 days and resulting growth was enumerated as long colony forming units (CFU) g^{-1}. Yeast and mold (Y&M) were determined according to NP-3277 (1987), using Rose Bengal Chloramphenicol Agar, surface inoculation and incubated at 25 °C for 5 days. A total of three independent measurements were taken per sample and results were expressed as Log_{10} cfu g^{-1}.

Sensory evaluation:

Panel of trained judges were asked to evaluate the tomatoes products for color, taste, odor, texture and general appearance using a score scale from 1 to 10. Where 1 indicates dislike extremely and 10 like extremely according to Larmond, (1970).

Statistical Analysis:

Experimental data were analyzed statistically using the analysis of variance and the means were further tasted using least significant difference test (LSD) as outlined by Steel and Torie (1980). Least significant difference tests at $p < 0.05$ were performed to compare treatment means. Results are presented as mean ± standard error. All determinations were repeated three times.

RESULTS AND DISCUSSION

Chemical composition of canned tomatoes product:

The chemical composition of canned-tomatoes treatments were presented in Table (1), it was showed that moisture content of fresh tomatoes (94.1%) is not far from control of canned tomatoes (94%) at zero time, also, results appeared that moisture contents of canned- tomatoes treatments T3 were less than T2, T4 and control (93.79, 93.90, 93.97and 94%, respectively) at zero time, while during storage periods, showed slightly decrees in moisture content in all treatments. These results are in agreement with (Karakaya and Yilmez 2007) they observed that the moisture contents of canned, fresh, and sun-dried tomatoes were 94.24%, 93.76%, and 23.39%, respectively.

Data in Table (1) showed that the average content of pH for T1 (control), T2, T3 and T4 were 4.44, 4.51, 4.42 and 4.38, respectively, at zero time, while it was decreased during storage which reached to 4.24, 4.31, 4.30 and 4.29, respectively, after storage for 8 months. In contrast, total acidity for T1, T2, T3 and T4 was ranged from 0.52 to 0.55 % (as citric acid) at zero time, while it ranged from 0.53 to 0.56 after 8 months of storage period. In addition, results appeared that $CaCl_2$ pretreated samples (T4) had lower acidity compared to others, while NaCl pre-treated samples (T3) and citric acid pre-treated samples (T2) had high acidity. Those results were in harmony with (Makanjoula *et al.,* 2012) reveal that the drained weight, pH and titratable acidity of canned Roma VF halves were 91.71% , 4.82, and 0.26 respectively.

Data in Table (1) showed the non-enzymatic browning (NEB) in canned tomato, results appeared that T1 (con-

trol) content the highest value of NEB followed by T3, T2 and T4 which were 0.591, 0.561, 0.541 and 0.511 Absorbance Unit, respectively, at zero time. In addition, it was observed a slight increase in control and other treatments after 4 and 8 months of storage period.

Results in Table (1) appeared that ash and fibers contents of canned-tomatoes were reduced compared with fresh tomatoes, which may be related to processing, removed peel and seeds during preparing of tomatoes fruits these results were in agreement with (Abdel-Hamid 1982) who observed that tomatoes juice is lower in crude fibers and higher in carbohydrates in comparison with fresh tomatoes; the difference is due to processing, where tomatoes juice is heated and treated to remove peel, seeds and fibers. The content of ash in canned-tomatoes treatments were ranged from 9.7 to 9.8% at zero time, whereas, it found slight increase after storage period. Meanwhile, T1 (control) content the highest value of fibers (10.7%), while T3 had the lowest value (10.3 %).

The same Table (1) appeared that total sugars content of canned tomatoes was increased after canning process compared to fresh tomatoes, which were 78.8% and 53.7% DW, respectively. Increase in total sugar after canning process can be attributed to analyzed effect of canning process on carbohydrate components. Results showed that, T3 had the highest content of total sugars (80.7 %) followed by T4 (80.2 %) and T2 (80 %), at zero time. However, total sugars were reduced after 4 and 8 months of storage periods. On the other hand, reducing sugars content in canned tomatoes showed an increasing trend (18.6%) with the increase in canning temperature compared with fresh tomatoes (7.8 %). This trend might be as a resulted from the hydrolysis of polysaccharides in all samples, these results are in agreement with (Manashi *et al.,* 2013) who reported that such increase in reducing sugars level can be ascribed to rapid hydrolysis of polysaccharides and their subsequent conversion to reducing sugars, that includes glucose and fructose content, at higher temperature. These results are in agreement with (De Sio *Jose et al.,* 2019) they reported that the sum of glucose and fructose accounted for 80% of sugars. Meanwhile, reducing sugar was increased after 4 and 8 months of storage period which ranged from 20.2 to 20.5 % (DW), respectively.

Table 1. The effect of canning process and storage period on chemical composition of tomatoes product (on dry weight)

Treatments	Fresh tomatoes	Canned tomatoes product											
		T1 control			T2			T3			T4		
Component		Storage periods			Storage periods			Storage periods			Storage periods		
		0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months
*Moisture%	94.1± 0.39	94± 0.4	93.98 ±0.4	93.97 ±0.41	93.90 ±0.41	93.91 ±0.39	93.90 ±0.4	93.79 ±0.4	93.80 ±0.39	93.78 ±0.4	93.97 ±0.41	93.94 ±0.39	93.89 ±0.4
*pH value	4.54 ±0.3	4.44 ±0.3	4.33 ±0.31	4.24 ±0.3	4.51 ±0.29	4.43 ±0.31	4.31 ±0.3	4.42 ±0.3	4.39 ±0.31	4.30 ±0.3	4.38 ±0.3	4.32 ±0.31	4.29 ±0.3
*Total acidity%	0.48 ±0.28	0.53 ±0.28	0.53 ±0.29	0.54 ±0.28	0.54 ±0.29	0.55 ±0.28	0.55 ±0.29	0.55 ±0.27	0.55 ±0.29	0.56 ±0.28	0.52 ±0.28	0.53 ±0.29	0.53 ±0.27
*Non-enzymatic browning(absorbance unit)	0.164 ±0.26	0.591 ±0.25	0.611 ±0.26	0.631 ±0.25	0.541 ±0.26	0.591 ±0.26	0.601 ±0.25	0.561 ±0.26	0.592 ±0.25	0.602 ±0.24	0.511 ±0.25	0.541 ±0.25	0.571 ±0.26
Ash %	23.1 ±0.3	9.8 ±0.28	9.7 ±0.29	9.8 ±0.3	9.7 ±0.28	9.8 ±0.29	9.7 ±0.28	9.8 ±0.29	9.8 ±0.29	9.7 ±0.3	9.7 ±0.3	9.7 ±0.3	9.8 ±0.28
Fibers %	22.5 ±0.33	10.7 ±0.34	10.5 ±0.33	10.3 ±0.32	10.5 ±0.34	10.5 ±0.32	10.3 ±0.33	10.3 ±0.33	10.2 ±0.34	10.3 ±0.32	10.5 ±0.33	10.3 ±0.34	10.2 ±0.33
Total sugar%	53.7 ±0.24	78.8 ±0.23	76.9 ±0.24	75.3 ±0.24	80 ±0.23	78.6 ±0.24	76.6 ±0.25	80.7 ±0.24	79.3 ±0.24	77.6 ±0.25	80.2 ±0.25	78.8 ±0.24	77.3 ±0.24
Reduce sugar%	7.8 ±0.33	18.6 ±0.34	20.2 ±0.33	20.5 ±0.33	20.5 ±0.34	21 ±0.32	21.7 ±0.35	21 ±0.34	21.7 ±0.33	22 ±0.34	20.8 ±0.35	21.5 ±0.33	21.9 ±0.34

Mean (±SD) *** On fresh weight.**
T1: Control (canned-tomatoes without treatment). **T2: Canned-tomatoes + citric acid + food oil.**
T3: Canned-tomatoes + sodium chloride + food oil. **T4: Canned-tomatoes + calcium chloride + food oil.**

Phytochemical Compounds and Antioxidant Activity of canned tomatoes product:

Although, canned tomatoes product was high acceptability for consumer as a result of removal of seeds and peel. However, it had low nutritional values when compared with fresh tomato, oven-dried tomatoes, and sun-dried tomatoes. Results in Table (2) showed a significant reduced of lycopene and total carotenoids between fresh tomatoes and control (T1) after canning process (109 and 71.69 mg/100g DW) and (162.1 and 93.56 mg/100g DW) respectively. This result is in harmony with (Rozzi *et al.,* 2002) who stated that the tomato peel contains 72% - 92% of the lycopene that is found in the water insoluble fraction and in conventional hot-break processing the majority of the outer tissues are discarded as waste. Whoever, (Karakaya and Yilmaz 2007) reported that the values of lycopene content (use whole tomatoes) of canned, fresh, and sun-dried tomatoes were 3.55 mg/100g, 5.51 mg/100g, and 1.77 mg/100g, respectively. The lowest lycopene content of sun-dried tomatoes could be due to the drying conditions they were exposed to light and oxygen. While (De Sio Jose *et al.,* 2019) reported that, no significant differences between raw and diced tomatoes were recorded for lycopene on a fresh weight basis. On the other hand, control (T1) had the lowest contents of lycopene and total carotenoids compared with T2, T3 and T4, which may be due to the protective effect for pre-treatment for samples. Data in Table (2) appeared that T4 had the highest contents of lycopene and total carotenoids (80 and 96.78 mg/100g DW) respectively, while T3 content the lowest value (78.47 and 93.90 mg/100g DW) respectively, at zero time. No significant change in lycopene and total carotenoids during storage, a decrement was observed for lycopene and total carotenoids for all treatments after 4 and 8 months of storage periods. This outcome, was in agreement with (Ordóñez-Santos *et al.,* 2009) they stated that lycopene content showed no significant change during storage. (Lin and Chen 2005) observed that the

stability of carotenoids in canned tomato juice during storage, and they found that the amounts of β-carotene and lycopene decreased with increasing storage periods. In addition, D'Evoli *et al.,* (2013) found that heating caused both pigment degradation and an extractability increase due to the breaking of protein-carotenoid complexes.

Data in Table (2) showed that all canned tomato treatments are decreased in ascorbic acid compared to tomato fresh, which may be due to effect heat of canned process, the average content of ascorbic acid in fresh and control after canning process was about 433.4 and 199.3mg/100g DW, respectively. Samples which pre-treatments before processing had highest content of ascorbic acid compared to control (T1), the results revealed that T4 had the highest contents of ascorbic acid followed by T2 and T3 (211.53, 211.19 and 206.61 mg/100g (DW), respectively) at zero time. These contents of ascorbic acid were reduced after 4 and 8 months of storage, this reduction of ascorbic acid due to high oxidation during storage, this outcome was in harmony with (Ahmed *et al.,* 2012) who explained the possible reason for reduction of ascorbic acid could be autoxidation or oxidation by pro-oxidants generated from other compounds during storage. In addition, (Vashista *et al.,* 2003) reported that there was a continuous decrease in ascorbic acid content of soup as increased storage.

Canned tomatoes had reduction antioxidant activities compared with fresh tomatoes. The contents of antioxidant activity for T1 (control), T2, T3 and T4 were 34.2, 34.3, 34.3 and 34.2 % (FW), respectively. These values were reduced after 4 and 8 months of storage periods. These result was in agreement with (Ahmed *et al.,* 2012) who reported that antioxidant activity of canned tomatoes decreased with storage periods irrespective of the treatments, since the average reduction of antioxidant activity of the canned tomatoes was 18% during 6 months of storage. (Pavlovic *et al.,* 2017) who found that, the antioxidant content in tomatoes fruits decreased upon thermal treatment, but the significance and amplitude of the differences were genotype dependent.

Table (2) appeared that total phenols content of canned tomatoes are decreased compared which fresh tomatoes. The average content of total phenols in fresh and control (T1) were 836.3 and 579.7 mg/100g (DW), respectively, at zero time. These result are in agreement with (De Sio *et al.,* 2019) who reported that compared to fresh fruit , diced tomatoes showed significantly reduced concentrations of polyphenols in terms of total solids (-8%). Pre-treated samples showed high maintained of total phenols during storage compared to control. T4 had the highest amounts of total phenols (589.8 mg/100g DW) followed by T3 (588.1 mg/100g DW) and T2 (581.8 mg/100g DW) compared to T1 (579.7 mg/100g DW). Meanwhile, total phenols were slightly increased after 4 and 8 months of storage.

Table 2. Effect of canning process and storage period on phytochemical compounds and antioxidant activity of canned-tomatoes product (on dry weight):

Treatment	Fresh tomatoes	Canned tomatoes product											
		T1 control			T2			T3			T4		
Components		Storage periods			Storage periods			Storage periods			Storage periods		
		0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months	0 time	After 4 months	After 8 months
Lycopene (mg/100g)	109 ±0.3	93.56 ±0.32	93.39 ±0.32	93.05 ±0.32	96.1 ±0.33	95.76 ±0.32	95.59 ±0.33	93.90±0. 32	93.56 ±0.32	93.39 ±0.33	96.78 ±0.33	96.44 ±0.32	96.10 ±0.33
Total carotenoids (mg/100g)	162.1 ±0.30	71.69 ±0.30	71.36 ±0.29	71.02 ±0.29	79.15 ±0.29	78.81 ±0.30	78.47 ±0.29	78.47 ±0.30	78.14 ±0.30	77.97 ±0.29	80 ±0.30	79.83 ±0.29	79.49 ±0.29
Ascorbic acid (mg/100g)	433.4 ±0.20	199.3 ±0.19	181.7 ±0.20	171.4 ±0.21	211.19 ±0.20	192.54 ±0.21	173.22 ±0.20	206.61 ±0.20	190 ±0.19	171.69 ±0.20	211.53 ±0.20	192.71 ±0.21	172.71± 0.20
Total phenols (mg/100g)	836.3 ±0.22	579.7 ±23	584.6 ±0.22	589.7 ±0.22	581.8 ±0.22	585.7 ±0.22	589.6 ±0.23	588.1 ±0.22	592.4 ±0.22	595.5 ±0.22	589.8 ±0.23	593.9 ±0.22	596.8 ±0.22
*Antioxidant activity %	39.4 ±0.54	34.2 ±0.53	33.7 ±0.54	33.1 ±0.53	34.3 ±0.53	33.6 ±0.53	33.2 ±0.54	34.3 ±0.54	33.5 ±0.53	33.1 ±0.54	34.2 ±0.35	33.5 ±0.53	33.2 ±0.54

Mean (±SD) *** On fresh weight.**
T1: Control (canned-tomatoes without treatment). **T2: Canned-tomatoes + citric acid + food oil.**
T3: Canned-tomatoes + sodium chloride + food oil. **T4: Canned-tomatoes + calcium chloride + food oil.**

Total counts (bacterial, yeast and molds) of canned tomatoes product:

The total count of bacteria, yeast and molds at zero time and after storage for 8 months at room temperature for canned tomato are showed in Table (3). Results indicated that the total bacteria and molds were very few and not detected for all treatments at zero time, but not found any yeast at zero time for all treatments. Meanwhile, there were a few numbers of total bacteria, yeast and molds after storage period for 8 months, which were ranged from 3 to 3.2 log CFU/g of total bacteria, 1.6 to 1.9 log CFU/g of yeast and 1.6 to 2 log CFU/g of molds for control, T1, T2 and T3. In addiction the total count of bacteria, yeast and molds for T1, T2 and T3 are less than control. The decrease of microbial counts related to the severity of thermal treatment during processing and the preservative effect used like citric acid, sodium chloride and calcium chloride has been demonstrated to be able to inhibit the growth of bacteria, yeasts and molds. De Sáo José *et al.* (2018) showed that the mesophilic aerobic bacteria count after sanitization treatments was reduced between 0.27 and 2.33 log CFU/g compared to cherry tomatoes that were not sanitized. While, Latapi and Barrett, (2006b) stated that yeast growth was reduced significantly to an average of 3.5 log CFU/g when tomatoes were dipped in a 10% salt solution for 5 min before sun drying and there was additional decrease to 2.2 log CFU/g when was increased of salt concentration to 15% or 20%.

Data in Table (3) appeared that the total count of bacteria, yeast and molds for control and all treatments less than permissible limits (103/g and 104/g) set by (Codex, 2003b and FDA, 2013) and the International Commission for Microbial Specifications for foods (ICMSF). Previous results are proved all samples in this study high safety when consumed without any infection or risks for consumers. Therefore, canned tomatoes product has completely safe when consumption.

(Figures:1, 2): Effect of canning process and storage periods (at ambient temperature) on total counts at zero time and 8 months of storage:

Table 3. Effect of canning process and storage periods (at ambient temperature) on microbial counts (Log10 CFU/g) of canned tomatoes products:

Treatment No.	Bacterial counts Log10 CFU/g		Yeast counts Log10 CFU/g		Molds counts Log10 CFU/g	
	Storage periods		Storage periods		Storage periods	
	Zero time	After 8months	Zero time	After 8months	Zero time	After 8months
T1 control	0.52±0.39^{a}	3.2±0.29^{a}	0±0.00	1.9±0.24^{a}	0.43±0.52^{a}	2±0.54^{a}
T2	0.49±0.38^{ab}	3.1±0.28^{ab}	0±0.00	1.8±0.23^{b}	0.42±0.52^{ab}	1.8±0.53^{ab}
T3	0.48±0.39^{ad}	3.0±0.28^{ac}	0±0.00	1.6±0.23^{ad}	0.41±0.53^{ad}	1.6±0.53^{d}
T4	0.49±0.38^{ac}	3.0±0.29^{ad}	0±0.00	1.7±0.24^{ac}	0.42±0.52^{ac}	1.7±0.54^{ac}
$LSD_{0.05}$	0.496	0.489	0.000	0.301	0.386	0.361

CFU/g = Cell forming unit/g.
All values are means of three replicates ± stander deviation (SD), Values in the same column with different letters are significantly different (P =0.5)
T1: Control (canned-tomatoes without treatment). T2: Canned-tomatoes + citric acid + food oil.
T3: Canned-tomatoes + sodium chloride + food oil. T4: Canned-tomatoes + calcium chloride + food oi

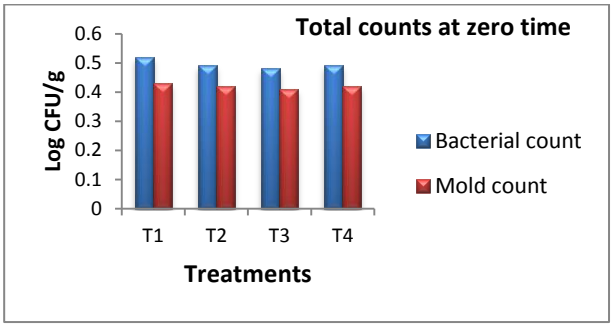

Figure 1.

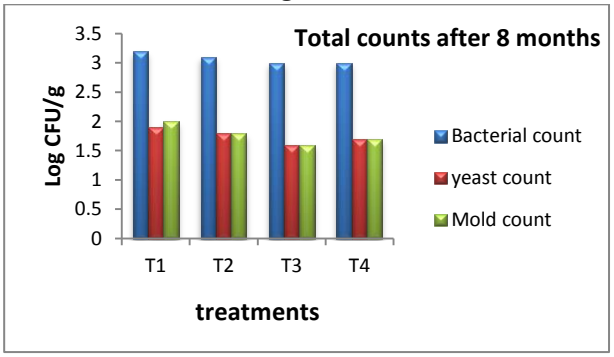

Figure 2.

*** The values of yeast count are zero (yeast do not found at zero time).**
T1: Control (canned-tomato without treatment).
T2: Canned-tomatoes + citric acid + food oil.
T3: Canned-tomatoes + sodium chloride + food oil.
T4: Canned-tomatoes + calcium chloride + food oil.

Sensory evaluation of canned tomatoes product:

The values of sensory evaluation of canned tomatoes product was higher than oven and sun-dried tomatoes products, that it was may be due to use of its solution preservatives which protecting quality attributes, such as color, taste, odor, texture, and appearance. Table (4) showed that there are significant differences between canned tomato treatments for sensory evaluation. Results indicated that the control (T1) of canned tomato had lowest scores for all sensory properties color, taste, odor, texture, and appearance that were about 8.23, 8, 7.91, 7.93, and 8, respectively at zero time of storage. Meanwhile (T4) had the best scores for color (8.52), texture (8.14), and general appearance (8.44), while (T3) had the best scores for odor (8.22) and taste (8.19). However, pre-treated with citric acid for canned tomato had good scores of color, taste, texture, and appearance that were about 8.48, 8.13, 8, and 8.22, respectively, compared to control at zero time of storage. Therefore, all pre-treated process was given the best values in each attributes compared to control. There were no significant differences between T2, T3, and T4 for texture. These result are in agreement with (Ahmed *et al.*, 2012) who reported that application of chemical preservatives maintained firmness of canned tomatoes through the storage, so the texture was significantly ($p < 0.05$) higher in pre-treated samples than the control samples during storage. This outcome was in agreement with (Luna-Guzmán and Barrett, 2000) firming and resistance of softening resulting from calcium addition can be attributed to the formation of calcium pectates, which increased the rigidity of the middle lamella. There were no significant differences between T1, T2, T3, and T4 for odor. Therefore, salt-dipped canned tomatoes are a good option to consumers.

Data in Table (5) indicated that there were significant differences between canned tomatoes treatments for sensory evaluation after 8 months of storage. T1 had the lowest scores for color, taste, odor, texture and appearance that were 6, 5.13, 5, 5 and 5 respectively. In addition, T4 had the highest scores for color, texture, appearance that were about 6.63, 5.29, and 5.24, respectively. On the other hand, T3 had the best values of taste, odor and appearance that were 5.43, 5.57 and 5.24, respectively, and T2 had good scores in all sensory properties compared to control. The sensory evaluation was indicated that the canned tomatoes pre-treated with sodium chloride and calcium chloride had the highest mean scores. Generally, results are in agreement with (Ahmed *et al.*, 2012) reported that chemical preservatives maintained quality characteristics of canned tomatoes thus extending the shelf life of this product. Notable, citric acid pre-treated sample had a tart-sourness taste compared with another samples, it may be because of increased acids when used to citric acid treatment, thereby this result in harmony with (Baldwin *et al.*, 2008) who showed that the balanced ratio between sugars and organic acids is important to overall flavor intensity in tomatoes, sweetness, and sourness since high acids and low sugars contents will produce a tart tomato, while high sugars and low acids contents will result in a tasteless tomato.

Table 4. Sensory evaluation of canned tomatoes product at zero time:

Treatments No.	Organolyptic characteristics score				
	Color	Taste	Odor	Texture	Appearance
T1 control	8.23±0.73^{a}	8.00±0.89^{a}	7.91±0.92^{a}	7.93±0.87^{a}	8.00±0.92^{a}
T2	8.48±0.77^{ac}	8.13±0.93^{ab}	8.00±0.91^{ab}	8.00±0.98^{ab}	8.22±0.99^{ab}
T3	8.33±0.73^{ab}	8.19±1.00^{ad}	8.22±0.92^{ad}	8.00±1.13^{ac}	8.31±0.97^{ac}
T4	8.52±0.71^{ad}	8.14±0.91^{ac}	8.13±0.89^{ac}	8.14±0.99^{ad}	8.44±0.89^{ad}
$LSD_{0.05}$	0.624	0.661	0.594	0.597	0.612

Table 5. Sensory evaluation of canned tomatoes product after 8 months of storage:

Treatments No.	Organolyptic characteristics score				
	Color	Taste	Odor	Texture	Appearance
T1 control	6.00±0.86[a]	5.13±0.99[a]	5.00±0.98[a]	5.00±1.01[a]	5.00±0.98[a]
T2	6.32±0.89[ab]	5.41±0.97[ab]	5.23±0.86[ab]	5.14±0.99[ab]	5.12±0.97[ab]
T3	6.52±0.79[ac]	5.57±1.00[ac]	5.43±0.92[ad]	5.23±1.18[ac]	5.24±0.95[ac]
T4	6.63±0.78[d]	5.51±0.95[ad]	5.33±0.89[ac]	5.29±0.99[ad]	5.24±0.89[d]
$LSD_{0.05}$	0.586	0.685	0.599	0.619	0.655

Mean ± SD

All values are means of three replicates ± stander deviation (SD), Values in the same column with different letters are significantly different (P =0.5)

T1: Control (canned-tomato without treatment). **T2: tomato powder + citric acid + food oil.**

T3: tomato powder + sodium chloride + food oil. **T4: tomato powder + calcium chloride + food oil**

CONCLUSION

Canning of tomatoes and pre-treatments can extend their shelf life and improved acceptability and safety of this product. $CaCl_2$ pre-treated T4 had the best results compared with control T1 and the other treatments. And most of antioxidant compounds were stabled during storage especially total phenols and lycopene.

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دراسات تكنولوجيه وكيميائية على منتج الطماطم المعلبة

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تناولت تلك الدراسة تأثير استخدام معاملات قبل التصنيع وهى (حمض الستريك 2% , كلوريد الصوديوم2% و كلوريد الكالسيوم 1%) وايضا تأثير اختلاف فترات التخزين على التركيب الكيميائى والنشاط المضاد للأكسدة والعد الميكروبى والتقييم الحسى لمنتج الطماطم المعلب. ووجد ان الطماطم الطازجة تحتوى على نسبة رطوبة (94.1%) و pH (4.54) وحموضة كلية (0.48%) و نسبة الرماد (23.1%) و الالياف (22.5%) ونسبة السكريات الكلية والمختزلة 53.7 و 7.8% على التوالى وان الطماطم الطازجة غنية بمركبات عديدة مضادة للاكسدة مثل الليكوبين والكاروتينات الكلية وحمض الاسكورربيك و الفينولات كانت نسبها على الترتيب 109مجم/100 جم , 162.1مجم/100 جم , 433.4مجم/100 جم , 836.3مجم/100 جم على اساس الوزن الجاف ، بينما كان نشاط المضاد للاكسدة للطماطم الطازجة 39.4% على اساس الوزن الرطب. ولقد بينت النتائج المتحصل عليها ان نسبة الرطوبه للمنتج المعلب لم يختلف كثيرا عن الطماطم الطازجة 94% حتى بعد التخزين لم تختلف الرطوبة فى المنتج المعلب سواء بعد 4 اشهر او بعد 8 اشهر (93.98% , 93.97 على الترتيب). اما pH و الحموضه الكلية كانت 4.44 و 0.53 والتى انخفض كل منهما بعد التخزين عن هذه القيم. ومع عملية ازالة القشرة الخارجية والبذور حدث انخفاض معنوى فى نسبة الرماد والالياف المقدرة على الوزن الجاف مقارنة بالطماطم الطازجه. والسكريات الكليه تزيد قيمتها بعد التعليب بينما تنخفض بعد التخزين لمدة 4 اشهر و 8اشهر , أما السكريات المختزله تميل الى الزياده بعد التعليب وبعد التخزين لمدة 4 اشهر و 8اشهر. اما بالنسبة للتلون البنى الغير انزيمى فيزيد بعد التعليب مقارنة بالطماطم الطازجة ، مع استمرار الزيادة بعد التخزين عند 4 ، 8 اشهر. وكنتيجة للمعاملة المستخدمه عند التعليب وازالة القشرة الخارجية فان القابلية ودرجة الامان عند استهلاك المنتج المعلب تكون مرتفعة فى حين ان المكونات الهامة فى الطماطم تقل عن الطازجة. ولوحظ من النتائج انخفاض النشاط المضاد للاكسدة ليصل الى 34.2% بعد التعليب مباشرة حتى بعد التخزين عند 4 و 8 اشهر ينخفض الى 33.7% و 33.1% بالترتيب. واتضح من الدراسة ان المعاملات المستخدمة فى تعليب الطماطم قد اطالت عمر المنتج وحسنت درجة القابلية والأمان للمنتج , وخصوصا المعاملة بكلوريد الكالسيوم 1% مقارنة بالكنترول والمعاملات الاخرى , ولم يحدث تغيرات كبيره لمضادات الاكسده الموجوده فى الطماطم وخصوصا الفينولات الكليه والليكوبين اثناء التخزين. كما ان العد الميكروبى كان عند الحدود المسموح بها سواء للكنترول والعينات المعاملة (10^3/ جم , 10^4/ جم) كما ان للقيم المتحصل عليها للصفات الحسية كانت عالية. وتوصى الدراسة بأن تعليب الطماطم طريقة ناجحة حيث تساهم فى زيادة مدة حفظ الطماطم , قابلية المنتج المعلب للاستهلاك وبالتالى تقليل كمية الفاقد من محصول الطماطم والتى تنتج بكميات كبيرة فى مصر.