Evaluation of Natural Pigments Extracted from Tomato Wastes and the Possibility of their Encapsulation.

ABSTRACT

This study aimed to evaluate the best methods from extracting natural pigments from tomato fruit wastes by four techniques used to extract lycopene and β-carotene each of them consisting of three solvents: ethanol, acetone and hexane in the following ratios (1:1:1), (2:1:1), (1:2:1) and (1:1:2) ml respectively. We studied too the possibility of encapsulation by freeze drying with a mixture of gelatin and gum Arabic as a carrier in nine microcapsules differing with respect to the total encapsulant (E) (2.5, 5.0, and 7.5%) and core (C) concentrations, the latter varying in relation to the total weight of encapsulant (25, 50, and 75%). The nine microcapsules were coded as follows: (1) E2.5/C25; (2) E2.5/C50; (3) E2.5/C75; (4) E5.0/C25; (5) E5.0/C50; (6) E5.0/C75; (7) E7.5/C25; (8) E7.5/C50; and (9) E7.5/C75. We found that the best solvent mixture for the extraction process was 1:1:2, and the most efficient microcapsules were E5.0/C75, E5.0/C50 and E2.5/C25. By studying the stability of the best three microcapsules when exposed to different values of heat, light, oxygen and pH, it was found that the most stable of them was E5.0/C75, followed by E5.0/C50 and then E2.5/C25. It was therefore recommended that further future studies are needed to evaluate the potential of this microcapsule as a natural additive in food, pharmaceuticals and cosmetics.

Keywords: *natural pigments; extracted; evaluation; tomato wastes; encapsulation*

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most widely cultivated vegetable crops. Millions of tomato tons are processed every year to produce products such as ketchup and sauce, resulting in large amounts of by-products, such as peel, pulp, and seeds that represent a 10–40% of total processed tomatoes. Around 70% of wet pomace consists of the skin and pulp that are lycopene-rich components of waste originate from tomato paste manufacturing **[1].** Over 130 million tons are processed every year, and approximately eight million tons represent the waste generated as estimated by the **[2].** In fact, a considerable number of produced tomatoes are not suitable for fresh consumption due to unacceptable color, maturity, or shape, thus representing an economic loss for producers and a negative environmental impact **[3]**. Although tomatoes are commonly consumed fresh, over 80% of the tomato consumption comes from processed tomato pro-ducts such as tomato juice, paste, puree, ketchup and sauce **[4**]. During commercial processing of tomato, a large quantity of waste at different stages is generated. The major part of the tomato waste is the tomato pomace that comes from the pulper **[1].** The wet pomace contains 33% seed, 27% skin and 40% pulp, while the dried pomace contains 44% seed and 56% pulp and skin **[5].** On average, tomato pomace accounts for approximately 3-5% (w/w) of the raw material applied for processing **[6]**. Additionally, large quantities of tomato peel residues are generated from the processing industry. Therefore, the recycling of tomato waste is currently among the top environmental stakes, and alternative uses need to be proposed. The solid residue remaining after the industrial processing of tomatoes, i.e., tomato pomace, consists of large amounts of tomato peels and seeds that currently find use as animal feed and fertilizers or are sent to landfill **[7&8].** However, it is still rich in highly beneficial

phytochemicals such as carotenoids, phenolic compounds, and vitamins, among which lycopene is the most important antioxidant present in the ripened tomato, representing 80–90% of the total pigments **[9&10]**. Many epidemiological data support a correlation between carotenoids, especially lycopene intake, and several nutritional and health benefits, including the prevention of carcinogenesis and cardiovascular diseases **[11&12]**. In addition, phenolics are recognized for their antimicrobial and antioxidant activity and for their contribution in preventing various oxidative stress-associated diseases **[13&14]**. In this line, given their antioxidant or nutritional properties, numerous approaches have been proposed for the valorization of the unused parts of tomato in various sectors, including the recovery and isolation of carotenoid compounds to be used for the micro-capsulation of functional foods, as well as for pharmaceutical and cosmetic products, instead of chemically synthesized molecules **[15&16].**

Common colors from plant items have drawn a fair amount of consideration around the world. These pigments show different colors and are comprised of distinctive colors, for example, orange (β-carotene), yellowish-green (lutein), green (chlorophyll), and blue-purple (anthocyanin) **[17]**. Lycopene is the red color found in red colors products of the soil, for example, tomato, papaya, pink grapefruit, pink guava and watermelon. Lycopene is a carotenoid hydrocarbon (additionally called carotene). The amplified conjugated double bond arrangement of these compounds is a critical component in the carotenoids in charge of their alluring colors that it frames the light retaining chromospheres **[18]**. The presence of visible colors in these compounds have conjugated double bonds. The more noteworthy the quantity of conjugated double bonds, the higher a wavelength esteem for most extreme assimilation **[19]**. Lycopene is one of the mainstream colors most important in nourishment industry as nutritional substance for its medical advantages **[20]**. The compound has given more importance because of their broad utilization in food, makeup and pharmaceuticals. In the interim, the costs of crude materials are expanding also their accessibility is diminishing **[21]**.

The extraction of carotenoids from vegetable sources is usually carried out by using organic solvents (e.g., hexane, acetone, chloroform, ethanol, etc.) because they are soluble in fat. A mixture of hexane with acetone and ethanol is often employed **[22&23]**. Also, supercritical fluids using non-organic solvents are suitable for the extraction of compounds that can easily become degraded by light, oxygen, and high temperatures like lycopene, but the solubility of these substances is still relatively low compared to their solubility in organic solvents. High pressures must be applied to obtain reasonable extraction from dried vegetable material, making it a costlier process **[24]**. Consequently, from an industrial point of view, solvent extraction is the first option because of its simplicity and low costs. However, the process is very time consuming and requires large amounts of solvents according to the mass of the final products.

In food processing field, microencapsulation technique has been widely used to protect food ingredients against deterioration, volatile losses, or premature interaction with other ingredients. The protective mechanism therein is to form a membrane (wall system) to enclose droplets or particles of the encapsulated material (core). So far, various kinds of microencapsulation techniques such as solvent dispersion/evaporation, phase separation (coacervation), co-crystallization, interfacial polymerization etc., have been developed, among which, spray-drying is the most commonly used one in the food industry due to its continuous production and easiness of industrialization **[25; 26; 27;**

28]. However, microencapsulation of lycopene by spray-drying has not been reported, to my knowledge.

For microencapsulation by spray-drying, gelatin is a good choice as wall material due to its good properties of emulsification, film-formation, water-solubility, edibility and biodegradation, etc. **[29]**. In addition, hydrocarbon compounds are also used as one significant component of wall materials [**30**], which can act as plasticizer, or some others, promoting the formation of spherical and smooth-surfaced microcapsules, enhancing adhesion force between wall and core materials, **[29]**. It has been reported that mixture of gelatin and sucrose has been successfully used in microencapsulation of beta-carotene **[31]**.

The aim of this study is to evaluation of natural pigments extracted from tomato wastes and the possibility of their encapsulation.

MATERIALS AND METHODS

Materials:

Plant material and dried tomato waste were prepared from fresh tomato waste material obtained after pressing the pulp as by-product from the fruit and vegetable processing industry (Al Habib Food Industries, Gamasa Industrial Zone, Dakahlia, Egypt). Tomato waste was dried in freeze dryer at -40 °C for 48h. Dried tomato waste material was ground, packed in vacuumed plastic bags and stored at -20 °C until further analysis.

Chemicals were analytical grade and purchased from Algomhourya Company, Tanta city, Egypt.

Methods:

Extraction of pigments:

Four techniques were prepared for extraction of lycopene and β-carotene from tomato wastes, each was consisting of three solvents: ethanol, acetone and hexane in the following ratios (1:1:1), (2:1:1), (1:2:1) and (1:1:2) ml respectively.1g of liquidized pulp was added to the solvent's mixture. The mixture was placed in a tube covered with silver foil and a lid, and stored in a refrigerator at 3 °C, where it remained until full depigmentation. Then another 10 ml of ethanol, 10 ml of acetone and 20 ml of hexane were added; this was later filtered in Whatman filter paper number 8, whereby 50 ml of distilled water was added for phase separation, and then the whole mixture was poured into a 150 mL test tube, discarding the previous fraction. The reading was carried out in the supernatant at 503 nm for the lycopene and 450 nm for the β-carotene. In both techniques, the equations to measure the level of β-carotene and lycopene were developed by (**32**), and the result was given in µg g-1 (Equations 1 and 2, respectively). The analysis of the pigments was determined in triplicate.

$$C_{\beta\text{-arotene}} = 4.624\ XA_{450} - 3.091\ XA_{503} \quad (1)$$

$$C_{Lycopene} = 3.956\ XA_{450} - 0.806\ XA_{503} \quad (2)$$

In which: $C_{\beta\text{-caroteno}}$ $C_{Lycopene}$ = Lycopene and β-carotene concentration in µg g^{-1}.

A_{450} and A_{503} = absorbance in the respective wavelengths.

Encapsulation process:

The methodology for obtaining microcapsules by complex coacervation was adapted from procedures described in **[33]**. Gelatin and gum Arabic solutions were prepared by dissolution in water at 50◦C. The gelatin solution (2.5, 5, and 7.5%) and oil dispersed lycopene (20% lycopene) were mixed in an Ultra Turrax shaker (IKA T18 Basic, Rio de Janeiro, Brazil) at 10.000 rpm for 3 minutes in order to obtain an emulsion. The emulsion was then mixed with the gum Arabic solution (2.5, 5, and 7.5%) by mechanical stirring. The pH was then adjusted to 4.0 ± 0.01 by adding hydrochloric acid (0.5 M) with a dropper. Up to this point in the process, the temperature was monitored and maintained at 50 ± 3◦C. The system was then cooled to 10◦C in an ice bath and finally placed in a refrigerator at 3◦C for 24 hours to complete particle precipitation.

After obtaining the coacervated microcapsules, they were concentrated by using a sieve (Mesh of 25 μm). The samples were concentrated in plexiglass plates covered with aluminum foil containing small holes and submitted to slow freezing in a freezer at −20◦C for 24 hours. The frozen samples were then freeze-dried (Edwards Pirani 501 Freeze Dryer, West Sussex, UK) for about three consecutive days under the following operational conditions: condenser temperature of −60 ◦C, 10^{-1} mbar pressure, and a final temperature of 25◦C.

Nine microcapsules were studied, differing with respect to the total encapsulant (E) (2.5, 5.0, and 7.5%) and core investigated (C) concentrations, the latter varying in relation to the total weight of encapsulant (25, 50, and 75%). The nine microcapsules were coded as follows: (1) E2.5/C25; (2) E2.5/C50; (3) E2.5/C75; (4) E5.0/C25; (5) E5.0/C50; (6) E5.0/C75 ;(7) E7.5/C25; (8) E7.5/C50; and (9) E7.5/C75. The encapsulant rational maintained at 1:1 for all microcapsules, since this was the best ratio according to **[34]** who studied the microencapsulation of vetiver oil by complex coacervation using gelatin and gum Arabic as the encapsulating agents.

Determination of lycopene:

The extracted solution of lycopene samples was analyzed in an HPLC system consisting of a Shimadzu HPLC pump LC-20AD×2 units, Shimadzu 996 photodiode array detector (PDA- UV/VIS detector) and Rheodyne 7725i manual sample injector with a 20-µL sample loop (**35**). The system was controlled with Chromatography software (Shimad zu HPLC shimadzu 996 photodiode array detector (PDA-UVVIS) Rheodyne 7725i.

Determination of carotenoids:

The carotenoids (lyco-red) separated from tomato peel were determined by Knauer HPLC pump 64 as indicated by the technique reported by **[35]** utilizing octadecyl silane C 18, 3.9 x 150mm. For both HPLC columns, two solvents were used for elution: (1) methanol (2) ethyl acetic acid derivation. The flow rate was 1.8ml/min and absorbance were measured at 475 nm. A mixture of methanol and ethyl acetic acid (54:46) as mobile phase, (sample amount: 20µL, flow, 1.8mL/ min) and identified at 475nm.

Encapsulation efficiency:

The method described in **[36]** to calculate encapsulation efficiency was adapted: about 10 mg of the sample were dissolved in 0.5 mL of water in order to break the microcapsules. Ten mL of acetone were then added. After mixing, the tubes remained at rest in the dark for about 2 h for decantation of the encapsulation material. Absorption was read in a spectrophotometer (Beckman DU70–CA, United States) in the visible

wavelength 470 nm and using a previously elaborated standard curve it was possible to calculate the concentration of lycopene present in the microcapsules. Encapsulation efficiency was calculated as the quantity of lycopene present in the capsules compared to the lycopene initially used to produce them.

Stability of the lycopene:

The lycopene stability in the microcapsules was studded as affected by heat, light, pH and oxygen was observed according to **[37]** with some modifications; in our study, the samples were tested directly in order to measure the changes in the concentration of lycopene, 1 gram of sample was weighed. The heat effect was evaluated with exposure of the samples between 25-90 °C for 10 min in a controlled thermostatic water bath (Julabo, Germany). The measurement of the experiment time started immediately when the sample temperature reached the temperature set in the equipment. After each treatment, the samples were cooled to 10°C to stop the effect of the temperature. In evaluating the stability in light, the samples were placed in Petri dishes and stored in a refrigerator at 4 °C with a relative humidity of 85%. The refrigerator was fitted with a 25 W lamp 20 cm above the samples. The effect of the pH change on the retention of carotenoids was evaluated at pH 3, 4, 5, 6, 7, 8, 9, 10 and 11, preparing a 1N NaOH solution for the alkaline pH and a solution of 1N H_2SO_4 for the acid pH regulated with a buffer solution. Each solution was used on the samples for 1 hour at room temperature and protected from light. For the oxygen stability tests, the samples were exposed in an oxygen atmosphere for 0, 2, 4, 6, 8 and 10 h. So, a hermetically sealed capsule was used, coupled to a vacuum pump and saturated with an injection of oxygen gas with a purity of 95%.

Statistical analysis:

All experiments were run in triplicate and results were represented as means ± standard deviation. Statistical analyses were carried out using Origin 7.0 software package and Microsoft Office Excel 2010.

RESULTS AND DISCUSSION

Pigment extraction methods:

The effect of solvent mixtures on the yield of β-carotene and lycopene produced from tomato wastes as in Table (1), where significant differences were observed between the effect of the solvent mixtures on the yield of β-carotene, which ranged between 24.5-27.2 µg/g and the best of these mixtures was (1:1:2) and the least effective is (1:1:1). Also, the results showed the same effect of the solvent mixture on the yield of lycopene, which ranged between 24.5-27.2 µg/g of tomato wastes, where the highest yield was obtained from the solvent mixture (1:1:2), and the lowest yield was the mixture (10:10:10). These results are due to the polar strength of the hexane solvent by increasing its concentration in the mixture.

According to **[38]**, when combining the solvents for the extraction of carotenoids pigments, the efficiency was superior in comparison to the usage of solvents individually. Since, the polar solvents, such as ethanol and acetone, are able to enter phospholipidic substances which compose the cell lipoprotein membranes, whilst a polar solvent, such as hexane, are more efficient in solubilizing carotenoids. Lycopene and β-carotene are considered to be a polar substance.

Table (1): Effect of extraction techniques on the yield contents of β-carotene and lycopene pigments.

Solvent mixture*	β-carotene (µg/g)	Lycopene (µg/g)
(1:1:1)	24.5[d]	44.3[d]
(2:1:1)	26.8[b]	46.7[b]
(1:2:1)	25.6[c]	45.2[c]
(1:1:2)	27.2[a]	47.7[a]

*= *(ethanol: acetone: hexane)*

Therefore, the effect of polar and a polar solvent mixture in extracting pigments is higher than the effect of one single polar or a polar solvent, which leads to obtaining a better performance in extracting pigments, which also was observed in this study.

Encapsulation efficiency:

Encapsulation efficiency of lycopene was evaluated for nine microcapsules as shown in Table (2) where, it was found that the highest efficiency was with microcapsules 6: E5.0/C75, 1: E2.5/C25 and 5: E5.0/C50, which were 99.77%, 99.56% and 97.28%, respectively. The lowest efficiency in microcapsules 2: E2.5/C25; 3: E2.5/C75 and 8: E7.5/C50 which were 90.86%, 92.73% and 92.73%, respectively. High values are normally found in the literature for the encapsulation efficiency of coacervated capsules **[39]** when gelatin and gum Arabic are used as the encapsulating agents. However, when pectin and soy protein isolate were used as the encapsulating agents to encapsulate propolis and casein hydrolysate, the encapsulation efficiencies were in the range from 66–72% **[40]** to 78–91% **[41]**. These results confirmed that gelatin and gum Arabic were more efficient encapsulating agents than pectin and soy protein isolate. When lycopene was encapsulated by spray drying, the encapsulation efficiencies were in the range from 21.01 to 29.73% using modified starch **[42]**, from 12.1 to 82.2% using gelatin and sucrose **[43]** and from 25.6 to87.5% **[27]** using gum Arabic, gellan gum, and maltodextrin as the encapsulation material.

Table (2): Efficiency of the lycopene microcapsules.

Microcapsuletion	Encapsulation efficiency (%)
1	99.56[a]
2	90.86[c]
3	92.05[c]
4	96.34[b]
5	97.28[ab]
6	99.77[a]
7	95. 87[b]
8	92.73[bc]
9	95.07[bc]

Different letters in the same column indicate that there was significant difference between samples ($P < 0.05$). Microcapsules 1: E2.5/C25; 2: E2.5/C25; 3: E2.5/C75; 4: E5.0/C25; 5: E5.0/C50; 6: E5.0/C75; 7: E7.5/C25; 8: E7.5/C50; and 9: E7.5/C75.

In view of these results, it is possible to affirm that complex coacervation is a more efficient method to encapsulate lycopene than spray drying. This can be explained by the milder temperatures used in complex coacervation, an important factor for the encapsulation of a highly sensitive compound such as lycopene.

Lycopene microcapsules stability when it was exposed to heat:

Table (3) shows the effect of different temperatures from 20 to 90 ℃ on the stability of lycopene microcapsule for the three best microcapsules its E5.0/C75, E2.5/C25 and E5.0/C50. It was noted that there were no significant differences between the three

Table (3): Microcapsule stability at different temperature.

Temperature (°C)	Retention rate of lycopene (%)		
	E5.0/C75	E2.5/C25	E5.0/C50
20	100^{Aa}	100^{Aa}	100^{Aa}
30	98^{Aa}	97^{Aa}	98^{Aa}
40	97^{Aab}	95^{Ab}	96^{Ab}
50	95^{Ab}	88^{Cc}	91^{Bc}
60	90^{Ac}	80^{Cd}	85^{Bd}
70	85^{Ad}	72^{Ce}	77^{Be}
80	81^{Ae}	66^{Cf}	72^{Bf}
90	75^{Af}	60^{Cg}	66^{Bg}

Different small letters in the same column indicate that there was significant difference between temperatures and different capital letter in the same row between samples ($P < 0.05$).

microcapsules when they were exposed to temperatures up to 40 ◦C, but significant differences appeared between them with increasing temperature, and the most stable microcapsule was E5.0/C75, followed by E5.0/C50, and the least stable was E2.5/ C25. It was also observed that the stability of lycopene microencapsulation decreased with increasing temperature in all mixtures.

These results may be due to the increase in the proportion of gel and gum Arabic coated with lycopene particles', which makes it less susceptible to the effect of heat. These results are in agreement with those of **[37]** they found r that retention rate is higher in gelatin, sugar and lecithin with increasing temperature; At 90°C, the retention level of gelatin, sugar and lecithin reached 90.11%, mixture of maltodextrin: gum Arabic reached 83.18% and β-carotene extracted from sunflower oil reached 75.23% reported values greater than 95% in lutein microencapsulated with gelatin and starch as wall material when evaluated at temperatures of 90°C.

Lycopene microcapsules stability when exposed to light:

Table (4) shows the effect of illumination time on light stability of lycopene microcapsule for the three best microcapsules its E5.0/C75, E2.5/C25 and E5.0/C50. The data shown in the table indicate that there are significant differences between the microcapsules for their ability to be stable by increasing the time of exposure to light. The microcapsule E5.0/C75 was the most stable, which decrease to 53%, after 30 days, followed by E5.0/C50 by 51%, and the least stable of them was E2.5/C25 by 47. % . The results also showed that increasing the exposure time of microcapsules to light had a significant effect on the extent of lycopene stability in them.

Table (4): Effect of Illumination time on light stability of lycopene microcapsule.

Illumination time (day)	Retention rate of lycopene (%)		
	E5.0/C75	E2.5/C25	E5.0/C50
0	100^{Aa}	100^{Aa}	100^{Aa}
5	94^{Ab}	87^{Bb}	92^{Ab}
10	85^{Ac}	78^{Bc}	83^{Ac}
15	74^{Ad}	65^{Cd}	70^{Bd}
20	65^{Ae}	57^{Ce}	61^{Be}
25	60^{Af}	50^{Cf}	53^{Bf}
30	53^{Ag}	47^{Bf}	51^{Af}

Different small letters in the same column indicate that there was significant difference between temperatures and different capital letter in the same row between samples ($P < 0.05$).

[44] have studied that light could trigger oxidation and isomerization processes in carotenoids, reducing the concentration; the wall materials in gelatin, sugar and lecithin encapsulation, because they are good emulsifying agents, reduced the action of light in the core of the microparticles, thereby decreasing the processes of oxidation and isomerization in the carotenoids. **[37]** microencapsulated lutein with porous starch and gelatin as wall materials, and reported retention levels of 90% in microencapsulated lutein exposed to light for 30 days.

Lycopene microcapsules stability to pH changes:

The effect of pH variation on the stability of lycopene microcapsule in E5.0/C75, E2.5/C25 and E5.0/C50 can be seen in Table 5. There were insignificant differences between the three microcapsules up to 8 pH and then significant differences after that up to 10 pH, and it was noted that the microcapsules E5.0/C75 was more tolerant of high pH, followed by E5.0/C50 and then E2.5/C25. It was also found that there were no significant differences between the pH numbers for all microcapsules up to pH 8, then significant differences after that by increasing the pH number in all mixtures. There were insignificant differences between the three microcapsules up to 8 pH and then significant differences after that up to 10 pH, and it was noted that the mixture E5.0/C75

was more tolerant of high pH, followed by E5.0/C50 and then E2.5/C25. There was also a significant increase in the percentage of lycopene by microencapsulation in all microcapsules up to pH 8 and then a significant decrease in the increase of pH after that in all microcapsules, and the most decrease was in the microcapsule E2.5/C25, followed by E5.0/C50 and then E5.0/C75 where it was 71, 85 and 89%, respectively.

Table (5): Effect of pH variation on stability of lycopene microcapsule.

pH	Retention rate of lycopene (%)		
	E5.0/C75	E2.5/C25	E5.0/C50
4	87^{Ae}	70^{Bd}	85^{Ad}
5	88^{Ade}	71^{Bcd}	87^{Ac}
6	90^{Ac}	73^{Bb}	89^{Ab}
7	92^{Ab}	74^{Bab}	90^{Aab}
8	94^{Aa}	75^{Ca}	91^{Ba}
9	92^{Ab}	73^{Cb}	88^{Bbc}
10	89^{Ad}	71^{Ccd}	85^{d}

Different small letters in the same column indicate that there was significant difference between temperatures and different capital letter in the same row between samples ($P < 0.05$).

[37] reported a similar behavior in microencapsulated lutein with gelatin and starch as the wall material when exposed to a pH between 1.00 and 11. The retention level in the evaluated pH range presented significant differences ($p < 0.05$) between the three tested samples: gelatin, sugar and lecithin, with 84.21%, had a statistically higher retention rate than maltodextrin: gum Arabic (79.23%) and β-carotene extracted from sunflower oil (65.23%).

Lycopene microcapsules stability when exposed to oxygen:

In Table 6 effect of oxygen on the retention level in E5.0/C75, E2.5/C25 and E5.0/C50 can be seen. With an increase in the hours of exposure of lycopene microcapsules to oxygen, significant differences were observed between the three microcapsules. It was also noted that the most stable of them was E5.0/C75, followed by E5.0/C50, then E2.5/C25. It was also found that the increase in the number of days of exposure of the microcapsules to oxygen led to a significant decrease in the content of the three microcapsules of lycopene, as it was 74, 60, and 51% for E5.0/C75, E5.0/C50 and E2.5/C25, respectively after 10 days. Comparing β-carotene extracted from sunflower oil with gelatin, sugar and lecithin and maltodextrin: gum Arabic showed that the wall materials provided an oxygen barrier, reducing the degradation of the carotenoids present in the core of the microparticles because this environmental factor is responsible for degradation by the oxidation and isomerization of carotenoids, as previously reported by **[44 and 45]**.

Table (6): Effect of oxygen on stability of lycopene microcapsules.

Oxygen exposure time (h)	Retention rate of lycopene (%)		
	E5.0/C75	E2.5/C25	E5.0/C50
0	100^{Aa}	100^{Aa}	100^{Aa}
2	96^{Ab}	93^{Bb}	95^{Ab}
4	90^{Ac}	80^{Cc}	86^{Bc}
6	83^{Ad}	69^{Cd}	79^{Bd}
8	79^{Ae}	60^{Ce}	73^{Ae}
10	74^{Af}	51^{Cf}	60^{Bf}

Different small letters in the same column indicate that there was significant difference between temperatures and different capital letter in the same row between samples ($P < 0.05$).

CONCULOSION

In this paper, we evaluate some methods of extracting pigments from tomato fruit residues and encapsulation using a mixture of gelatin and gum Arabic as a carrier in nine microcapsules differing with respect to the total encapsulant (E) (2.5, 5.0, and 7.5%) and core (C). concentrations, the latter varying in relation to the total weight of encapsulant (25, 50, and 75%). The nine microcapsules were coded as follows: (1) E2.5/C25; (2) E2.5/C50; (3) E2.5/C75; (4) E5.0/C25; (5) E5.0/C50; (6) E5.0/C75; (7) E7.5/C25; (8) E7.5/C50; and (9) E7.5/C75. We evaluated them all and chose the best three of them were E5.0/C75, E5.0/C50 and E2.5/C25. We studied their stability to heat, light, oxygen and pH. We studied their stability to heat, light, oxygen and pH, and it was found that the most stable of them was E5.0/C75, followed by E5.0/C50. Future studies are needed to evaluate the potential of this microcapsule as a natural additive in food, pharmaceuticals and cosmetics. Finally, it could be clearly concluded through this study that it is possible to follow successful technique in extracting lycopene and β-carotene.

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