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# Characterization of carotenoids (lyco-red) extracted from tomato peels and its uses as natural colorants and antioxidants of ice cream



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**Abstract** The nine carotenoid pigment compounds of tomato peels were identified by HPLC analysis. The main component of carotenoids (lyco-red) extracted from tomato peels was lycopene, phytoene, phytofluene,  $\beta$ -carotene, *cis*-lycopene and lutein. Consequently, the higher stability of carotenoids (lyco-red) extracted from tomato peels was observed in alkaline pH ranging from 7 to 10 and temperature ranging from 40 to 70 °C. Meanwhile, the degradation of carotenoids (lyco-red) extracted from tomato peel did not exceed than 16.20% of total pigments after 180 min incubation at 100 °C. On the other hand, the antioxidant activity of carotenoids (lyco-red) extracted from tomato peel was also studied by the Rancimat test at 110 °C on sunflower oil by adding 50–200 ppm of carotenoids (lyco-red) extracted from tomato peels. However, sunflower oil containing 50–200 ppm recorded higher induction period than 200 ppm BHT. Supplementing ice cream with carotenoids lyco-red extract increased the Radical Scavenging Activity RSA and Ferric Reducing Antioxidant Power (FRAP) in the ice cream by increasing the concentration of adding lyco-red extract. On the other hand, analysis of variance for sensory evaluation of prepared ice cream indicated that, ice cream containing 3% and 2% of carotenoids (lyco-red) extracted from tomato peels had the highest scores for flavor, body and texture, melting and color and the best mix compared with that prepared with 1%, 4% and 5% which recorded the lowest scores in all tested quality attributes.

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## Introduction

By-products derived from food processing are attractive source for their valuable bioactive components and color pig-

ments. These by-products are useful for development as functional foods, nutraceuticals, food ingredients, additives, and also as cosmetic products. Lycopene is a bioactive red colored pigment naturally occurring in plants. For instance Industrial by-products obtained from the plants are good sources of lycopene. (Kin et al., 2010). The main wastes of tomato processing industry are Seeds and peels. The peel can contain about 5 times more lycopene than tomato pulp (Sharma and Maguer, 1996).

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Lycopene is a red plant pigment found in tomatoes, guavas, watermelons, papayas and grapefruits. Mean while tomatoes being the largest contributor to the dietary intake of humans than others (Chalabi et al., 2004). Lycopene exhibits higher singlet oxygen ( $O_2$ ) quenching ability. Due to its strong color and non-toxicity, lycopene is a useful food coloring (registered as E160d).

Lycopene extract from tomato peel is intended for use as a food colorant. It provides the similar color shades, ranging from yellow to red, as do the natural and synthetic lycopenes. Lycopene extract from tomato is also used as a food/dietary supplement in products where the presence of lycopene provides a specific value (e.g., antioxidant or other claimed health benefits). The lycopene may also be used as an antioxidant in food supplements. Lycopene extract from tomato is intended for use in the following food categories: baked goods, breakfast cereals, dairy products including frozen dairy desserts, dairy product analogs, spreads, bottled water, carbonated beverages, fruit and vegetable drinks, soybean beverages, candy, soups, salad dressings, and other foods and beverages. (Lee and Chen 2002 and Yang et al., 2006).

Oleoresin is the material that remains after solvent extraction of a plant material followed by removal of the solvent. Tomato oleoresin is a semisolid mixture of a resin and essential oil that can be obtained from tomatoes and tomato pomace. Tomato pomace is a byproduct from the tomato processing industry, consisting of 5–10% of the fresh weight of tomatoes (Fondevila et al., 1994). Tomato oleoresin is a lycopene rich material that has potential for use in foods and supplements to enhance the nutritional value, functionality, color, and flavor.

Rao et al. (1998), reported that lycopene from tomato oleoresin was readily absorbed and may act as an in vivo antioxidant. Lipid extracts containing lycopene from tomatoes are available commercially for use in foods and nutritional supplements. Lyco-oleoresin extract from tomato is a lycopene-rich extract prepared from the ripe fruits of tomato (*Lycopersicon esculentum* L.). They also added that, the product is manufactured by crushing tomatoes, to produce crude tomato juice that is then separated into serum and pulp. The pulp is subsequently extracted using ethyl acetate as a solvent. The final extract consists of tomato oil in which lycopene together with a number of other constituents that occur naturally in tomato, are dissolved and dispersed. These constituents include fatty acids and acylglycerols, unsaponifiable matter, water soluble matter, phosphorus compounds, and phospholipids.

The intended use of Lyco-oleoresin (LycoRed) extract from tomato considered as a food colorant in dairy products, non-alcoholic flavored drinks, cereal and cereal products, bread and baked goods and spreads, to provide color shades from yellow to red. Also, Lycopene extract from tomato may be used in food supplements. EFSA, 2008).

The advantages of tomato lycopene used as an excellent natural food colorant and it is stable to heat and extreme pH values encountered in food processing, effective in low concentrations, has no off-flavors, and covers the full range of colors from yellow through orange to deep red. Addition of lycopene as a food colorant depends on the formulation, method of food preparation, and the manufacturing techniques involved. The nutraceuticals status of lycopene has accelerated research activities to improve processing factors

that lead to maintaining the nutritional as well as sensory quality of tomato product. Yildiz (2007).

The storage stability of butter, ice cream, and mayonnaise indicated that the addition of lycopene pigment from tomato waste peel did not have a detrimental effect on their quality during 4 months of storage. Sensory data of these products containing lycopene pigment had good consumer acceptability for fresh, as well as stored, products. Kaur et al. (2011).

The objective of the present study was to extract carotenoids (lyco-red) from tomato peel and identification of the most effective carotenoids by using HPLC. The stability at different pH values and temperature of extracted (lyco-red) was studied. Also, assessment of antioxidant activity of carotenoids (lyco-red) extracted from tomato peel on sunflower oil, physicochemical properties of functional ice cream mix and Sensory evaluation of prepared ice cream using various levels of carotenoid (lyco-red) extracted was also undertaken.

## Materials and methods

Tomato peel was obtained from Kaha Company for Preservative Foods Kaha, Kalyobia, Egypt.

Fresh buffalo's milk (6% fat) was obtained from a private farm. Skim milk powder, gelatin, fresh cream (25% fat) and sugar were purchased from the local market.

The solvents used for spectral and HPLC analysis were of HPLC grade and all other solvents used in this study were of ACS grade and obtained from Sigma Chemical Company, St. Louis, USA.

Refined sunflower free from antioxidants was obtained from Arma Food Industries, 10th of Ramadan Cairo, Egypt.

Synthetic antioxidant, namely butylated hydroxy toluene (BHT) and standard carotenoid were purchased from Sigma Chemical Co., St Lewis, USA.

### *Extraction of carotenoid (lyco-red) from tomato peel*

Lyco-red was extracted according to the method described by Hackett et al. (2004).

The obtained tomato peel was dried in oven dryer at 40 °C until the moisture content reached to 6% then ground and passed through 0.15 mm sieves.

Hundred grams of tomato peel powder were placed in 4-L beaker and 500 mL of ethanol was added, stirred for 20 min, and allowed to stabilize for 1.5 min. The mixture was then homogenized for 1 min. After that the mixture was filtered through Whatman filter papers (Whatman No 1 and cheesecloth). The filtrate was mixed with 250 mL of acetone/hexane solution (50:50, v/v) and homogenized for 1 min. A separatory funnel was used to separate the non-polar hexane layer containing lipid materials from the water-soluble fraction, and solvents were removed by reduced pressure at 40 °C. The oily of carotenoids (lyco-red) extracted from tomato peel was kept in a dark bottle and frozen stored until analysis and their uses.

### *Determination of total carotenoids*

Carotenoids content was determined by spectrophotometric method according to (Hornero and Minguéz 2001).

Carotenoids (lyco-red) extracted from tomato peel was dissolved in hexane and the absorbance was measured using a spectrophotometer at 472 and 508 nm.

#### *Determination of lycopene*

Lycopene was estimated according to the method described by (AOAC, 2007).

#### *Identification of the carotenoids: High Performance Liquid Chromatography (HPLC)*

The carotenoids (lyco-red) extracted from tomato peel were identified by Knauer HPLC pump 64 according to the method reported by (Gayle et al., 1987) using octadecyl silane C 18, 3.9 × 150 mm. For both HPLC columns, two solvents were used for elution: (1) methanol (2) ethyl acetate. The flow rate was 1.8 ml/min and absorbance was measured at 475 nm.

#### *Properties of carotenoid lyco-red extracted from tomato peel*

##### *Effect of pH*

A preliminary study was conducted to test the stability of carotenoids (lyco-red) extracted from tomato peel at different pH values within range of 2.0 to 10.0 for 30 min and then percentage of color loss was calculated.

##### *Effect of temperature*

A preliminary study was conducted to test the effect of heat for carotenoids (lyco-red) extracted from tomato peel at different temperature ranging from 40 °C to 100 °C for 30 min and then percentage of color loss was calculated.

##### *Thermal stability*

Holding of carotenoids (lyco-red) extracted from tomato peel at 90 °C and 100 °C was extended for 180 min through which they were removed each 30 min and cooled immediately in an ice bath followed by measuring absorption spectra of the solution at 472 nm.

##### *Evaluation of antioxidant activity*

Carotenoid (lyco-red) extracted from tomato peel was tested as antioxidant by using the Rancimat method as described by (Laubli and Bruttel 1986). Where 50, 100, 150, and 200 ppm of the carotenoids (lyco-red) extracted from tomato peel were mixed with 25 g of sunflower oil in a flask, against a sample 25 g of sunflower oil mixed with 200 ppm of synthetic BHT in a flask. On the other hand, the control was sunflower oil without any additives.

##### *Manufacture of ice cream mix*

According to the (Egyptian Standard, 2005), the ice cream mixture contained 0.5% gelatin, 8% fat and 10.5% milk solids non-fat (MSNF). The sugar content was adjusted at 16% by sucrose in the control mixture. The carotenoids (lyco-red) extracted from tomato peel were added to the ice cream mixture at six levels (0%, 1%, 2%, 3%, 4% and 5%) with keeping content of other ingredients without changes.

#### *Processing method*

The processing method was used as follows: the required amounts of skim milk powder were mixed with gelatin and sucrose, and then added slowly to the liquid ingredients (milk and cream) at 45 °C under vigorous agitation. The basic mixes were pasteurized at 80 °C for 10 min in water bath, and then cooled at 4 °C in ice bath. The carotenoids (lyco-red) extracted from tomato peel were added with different ratios (0%, 1%, 2%, 3%, 4% and 5%), were blended with the cooled mixes by using blender at full speed for 2 min. After that all mixes were aged for 24 h at 4 °C before frozen in an ice cream machine (Taylor-made, Model156, Italy). The produced ice cream was packaged in cups (100 cc) and placed in a freezing cabinet at -18 °C for 24 h at least before evaluation.

Specific gravity of resultant ice cream samples was determined as described by (Winton, 1958) at 20 °C. Specific gravity of ice creams was determined by means of filling a cool cup (with known weight and volume), with the resultant ice cream and then weighted.

$$\text{Specific gravity} = \frac{\text{Weight of ice cream}}{\text{Cup volume}} \times 100$$

The weight per gallon of ice cream in kilograms was determined according to (Burake, 1947), by multiplying the specific gravity of the frozen ice cream by the factor 4.5461. Overrun of ice cream (%) was calculated by applying the equation of (Arbuckle, 1986) as follows:

##### *%Overrun*

$$= \frac{\text{Weight of mix} - \text{Weight of the same volume of ice cream}}{\text{Weight of the same volume of ice cream}} \times 100$$

Total solids, protein and ash content of ice cream mix samples were determined as described by AOAC (2007), and fat content was determined as given by Ling (1963).

#### *The melting resistance*

The melting resistance was carried out according to the method of El-Nagar et al. (2002) with small modifications. Forty grams of cubic cut sample was placed on the screen, which was mounted on a beaker. The weight of the collected sample in the beaker was recorded at min 15, 30, and 45 of melting. The ratio of these values to the initial weight of frozen yogurt was calculated.

#### *Antioxidant capacity*

A – Radical Scavenging Activity (RSA%) assay Free radical Scavenging activity (RSA) of the samples was measured using the method of Brand-Williams et al. (1995) and expressed as percentage inhibition of the DPPH radical was determined by the following equation:

$$\text{RSA\%} = \frac{\text{Abs control} - \text{Abs sample}}{\text{Abs control}} \times 100$$

##### *B – Assay Ferric Reducing Antioxidant Power (FRAP)*

Antioxidant activity was measured using according to the method described by Benzie and Strain (1996) using the ferric antioxidant power (FRAP) assay.

### Sensory evaluation

Sensory evaluation was carried out by ten panelists to evaluate flavor, body and texture, melting and color of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel according to the method described by (Arbuckle, 1986).

### Statistical analysis

Means of data obtained for sensory evaluation of samples were evaluated using Duncan's multiple range test to identify significant differences at the 0.05 probability ( $p < 0.05$ ) using the statistical analysis system "SAS" (SAS Institute Inc., 1999).

## Results and discussion

### Total carotenoids

The total carotenoid in dry tomato peel was 128 mg/100 g. On the other hand, the oily of tomato peel extracts (lyco-red) contained 17.3 g/100 g from tomato peel. These results are agreement with (EFSA, 2008).

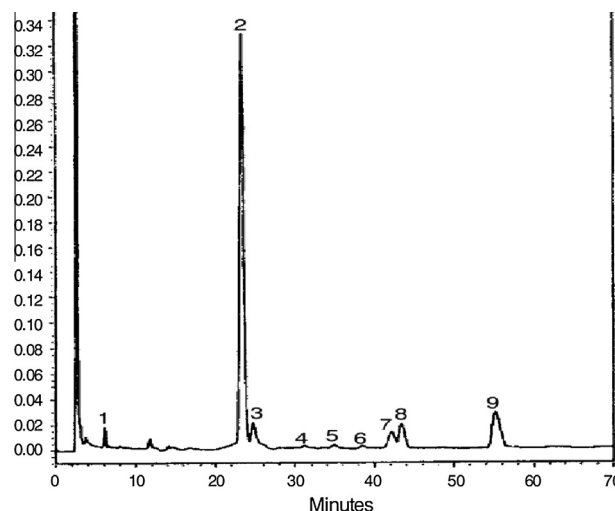
Lycopene extracted from tomatoes or tomato by product is similar with the EU as food coloring agent (E160d). The lycopene oleoresin from tomatoes can be used as a novel food ingredient contains 5–15% carotenoid (lycopene).

### Identification of carotenoids extracted from tomato peel (Lyco-Red) by using HPLC

Identification of carotenoids (lyco-red) extracted from tomato peel was done by HPLC are shown in Table 1 and Fig. 1. The carotenoids (lyco-red) extracted from tomato peel were separated based on their functional groups into thirteen fractions and identified nine compounds from them by HPLC. The carotenoids (lyco-red) extracted from tomato peel were identified namely (1) lutein, (2) lycopene, (3) *cis*-lycopene, (4)  $\gamma$ -carotene, (5) *cis*- $\zeta$ -carotene, (6)  $\zeta$ -carotene, (7)  $\beta$ -carotene, (8) phytofluene, and (9) phytoene respectively. The obtained results indicated that, the lycopene was the major carotenoids which represented with 86.12% of total carotenoids from tomatoes followed by 3.15% phytoene, 2.31% phytofluene, 2.11%  $\beta$ -carotene, 1.71% *cis*-lycopene, 1.51% lutein, 0.71% *cis*- $\zeta$ -carotene, 56%  $\zeta$ -carotene, and 52%  $\gamma$ -carotene respectively. These results are agreement with (Aghel et al., 2011).

**Table 1** Identification of carotenoids (lyco-red) extracted from tomato peel.

Peak	Retention time	Area %	Identified of carotenoid
1	5.86	1.50	Lutein
2	22.21	86.13	Lycopene
3	25.15	1.71	<i>cis</i> -Lycopene
4	31.64	0.52	$\gamma$ -Carotene
5	35.80	0.71	<i>cis</i> - $\zeta$ -Carotene
6	39.11	0.56	$\zeta$ -Carotene
7	41.90	2.11	$\beta$ -carotene
8	43.86	2.31	Phytofluene
9	54.85	3.15	Phytoene



**Fig. 1** HPLC separation of carotenoids (lyco-red) extracted from tomato peel.

Results also indicated that the lycopene was the predominated pigment in tomato peel, followed by phytoene, phytofluene,  $\beta$ -carotene and *cis*-lycopene respectively, while minor amounts of 9-*cis*-lutein, 13-*cis*- $\beta$ -carotene and 9-*cis*- $\beta$ -carotene were also detected. (Irin et al., 2012).

### Properties of carotenoids (lyco-red) extracted from tomato peel

#### Effect of pH

A preliminary study was conducted to test the stability of carotenoids (lyco-red) extracted from tomato peel at different pH values. The obtained results are illustrated in Table 2, from which the color changes were induced by pH variation. It could be observed that, the degradation% of carotenoid was increased gradually by lowering the pH. Therefore, the corresponding degradation was 9.6%, 14.7%, 22.4%, 36.3% and 49.2% at pH values of 6.0, 5.0, 4.0, 3.0 and 2.0 respectively, but there is no loss of carotenoid was observed at pH 9.0 and 10.0. On the other hand, the degradation of color did not exceed than 4.40% from pH 7.0 and 10.0. For instance, the highest stability and less degradation of carotenoids

**Table 2** Retention % of carotenoids (lyco-red) from tomato peel as a function of pH.

pH value	% Retained of carotenoid pigment	% Degradation of carotenoid pigment
2	50.80 <sup>f</sup>	49.20 <sup>a</sup>
3	63.70 <sup>c</sup>	36.30 <sup>b</sup>
4	77.60 <sup>d</sup>	22.40 <sup>c</sup>
5	85.30 <sup>c</sup>	14.70 <sup>d</sup>
6	90.40 <sup>b</sup>	9.60 <sup>e</sup>
7	95.60 <sup>a</sup>	4.40 <sup>f</sup>
8	97.20 <sup>a</sup>	2.70 <sup>f</sup>
9	100.00 <sup>a</sup>	0.00 <sup>f</sup>
10	100.00 <sup>a</sup>	0.00 <sup>f</sup>

Values with different letters in the same column are significant different at  $p < 0.05$ .



(lyco-red) extracted from tomato peel were noticed at alkaline media from pH 7.0 to 10.00.

Therefore, the carotenoids (lyco-red) extracted from tomato peel were more instable in the acid media and more fixed at alkaline media. These results may be due to the characteristic of conjugated double bond system of carotenoid produces the main problem associated with work and manipulation on carotenoids that is their particular instability, especially toward light, heat, oxygen and acids (Oliver and Palou, 2000).

*Effect of temperature*

The main cause of carotenoids degradation in foods is oxidation. In processed foods, the mechanism of oxidation is a complicated, process and dependent on many factors. The rate of pigments autoxidize by reaction with atmospheric oxygen depends on light, heat and presence of pro and antioxidants (Fennema, 1976). Moreover, isomerization is promoted by light, heat and acids (Rodriguez-Amaya, 2003).

Table 3 represents the rate of remained and degradation% of carotenoids (lyco-red) extracted from tomato peel. There is no degradation and also similar stability was observed as a result of exposing carotenoid (lyco-red) at moderate temperature between 40 °C and 70 °C, while at above 70 °C, the degradation of carotenoid (lyco-red) increased gradually by increasing the temperature. For instance, the degradation of carotenoid (lyco-red), caused by its exposing to higher temperature.

The highest degradation of carotenoids (lyco-red) extracted from tomato peel was observed at 100 °C followed by 90 and 80 °C, respectively. Therefore, the carotenoids (lyco-red) from tomato peel were more heat stable between 40 °C to 70 °C but the lower, degradation rate was noticed at 80 °C. These results

are confirmed with Shi et al. (2002). They dissolved extracted lycopene into canola oil and heated the samples at 25 °C, 100 °C and 180 °C. Also increasing the temperature from 100 °C to 180 °C or increasing thermal treatment time increased the degradation of lycopene compared with the treatment at 25 °C.

*Thermal stability*

The stability of carotenoids (lyco-red) extracted from tomato peel on duration time at temperatures, ranging between 90 °C and 100 °C is evident in Table 4.

The retention percentage of carotenoids (lyco-red) extracted from tomato peel was 90.70% after 90 min. at 100 °C. The destruction of carotenoids (lyco-red) extracted from tomato peel was 14.10% at 100 °C after 150 min. Lee and Chen, 2002 found that, higher temperature than 100 °C and longer incubation time lead to a large percentage of lycopene degradation Shi et al. (2002).

Observed that increasing temperature from 100 °C to 180 °C or increasing thermal treatment time caused to increase the degradation of lycopene compared with the treatment at 25 °C. These results may be due to its presence of carotene the form of complexes with protein or lipo-proteins, submicroscopic structure may be also a factor in their outstanding stability (Rizk and Tolba, 2002).

*Antioxidant activity of carotenoids (lyco-red) extracted from tomato peel*

Antioxidants are usually added to fats, oils and foods containing fats in order to inhibit the development of off-flavor arising from oxidation of unsaturated fatty acid. However, the use of commercial synthetic antioxidants is strictly controlled and increasing. Consumer awareness of food additives and safety has promoted increased interest to the use of natural antioxidants e.g., carotenoids, ascorbic acid and tocopherol (Laubli and Bruttel 1986).

Table 5 shows the induction period of sunflower oil containing different concentrations of carotenoids (lyco-red) extracted from tomato peel as natural antioxidant by the Rancimat test at 110 °C. Results indicated that, induction period of sunflower oil was increased by increasing the concentration of carotenoids (lyco-red) from tomato peel. The induction period was 3.25 and 7.20 h for sunflower oils without adding antioxidant and that contained 200 ppm BHT. However, our results showed that the induction period was increased gradually by adding and increasing the concentration of carotenoids (lyco-red) extracted from tomato peel as natural antioxidants. These values of induction periods increased to 9.40, 12.30,

**Table 3** Effect of temperature on the degradation rate of carotenoids (lyco-red) extracted from tomato peel.

Temperature (°C/30 min)	% Remained of lyco-red	% Degradation of lyco-red
40	100.00 <sup>a</sup>	0.00 <sup>c</sup>
50	100.00 <sup>a</sup>	0.00 <sup>c</sup>
60	100.00 <sup>a</sup>	0.00 <sup>c</sup>
70	100.00 <sup>a</sup>	0.00 <sup>c</sup>
80	98.60 <sup>ab</sup>	1.40 <sup>b</sup>
90	97.40 <sup>b</sup>	2.60 <sup>ab</sup>
100	95.30 <sup>b</sup>	4.70 <sup>a</sup>

Values with different letters in the same column are significant different at *P* < 0.05.

**Table 4** Thermal stability of carotenoids (lyco-red) extracted from tomato peel.

Pigment carotenoid (%)	Temperature (°C)	Duration time (min)					
		30	60	90	120	150	180
Remained	90	97.40 <sup>a</sup>	95.20 <sup>a</sup>	93.60 <sup>ab</sup>	91.80 <sup>b</sup>	90.60 <sup>b</sup>	90.00 <sup>b</sup>
Degradation	90	2.60 <sup>c</sup>	4.80 <sup>d</sup>	6.40 <sup>c</sup>	8.20 <sup>b</sup>	9.40 <sup>a</sup>	10.00 <sup>a</sup>
Remained	100	95.30 <sup>a</sup>	92.40 <sup>a</sup>	90.70 <sup>b</sup>	88.40 <sup>b</sup>	85.90 <sup>bc</sup>	83.80 <sup>c</sup>
Degradation	100	4.70 <sup>c</sup>	7.60 <sup>d</sup>	9.30 <sup>c</sup>	11.60 <sup>b</sup>	14.10 <sup>a</sup>	16.20 <sup>a</sup>

Values with different letters in the same row are significant different at *P* < 0.05.

**Table 5** Relation between induction periods of sunflower oil (SO) containing different ratios of carotenoids (lyco-red) extracted from tomato peel as natural antioxidant determined by the Rancimat at 110 °C.

Treatments	Induction period (h)
SO free from additives	3.25 <sup>c</sup>
SO containing 200 ppm BHT	7.20 <sup>de</sup>
SO containing 50 ppm lyco-red extract	9.40 <sup>d</sup>
SO containing 100 ppm lyco-red extract	12.30 <sup>c</sup>
SO containing 150 ppm lyco-red extract	16.22 <sup>b</sup>
SO containing 200 ppm lyco-red extract	20.70 <sup>a</sup>

Values with different letters in the same column are significant different at  $P < 0.05$ .

SO = sunflower oil.

16.22 and 20.70 h for sunflower oil that contained 50, 100, 150 and 200 ppm of carotenoids (lyco-red) extracted from tomato peel, respectively. These results are similar to those given by (Nilson et al., 1999) who proved that, the carotenoids act as antioxidants by destroying the free radicals. Also (Mubarak, 2003) reported that, carotenoids lyco-red as natural antioxidant extracts of 0.1% concentration increased the induction period of sunflower oil assessed by Rancimat method. The replacement of synthetic antioxidant by lyco-red natural antioxidant may have benefits due to health implication of functional parameter such as stability in both oil and water (Reglero et al., 1999). Lycopene, a C 40 poly isoprenoid compound containing 13 double bonds, is the most abundant carotenoid, accounting for approximately 80–90% of the total pigment contents in tomatoes. With its 11 conjugated and two non-conjugated double bonds, it was found to be a more efficient antioxidant (singlet oxygen quencher) than  $\beta$ -carotene,  $\alpha$ -carotene, and  $\alpha$ -tocopherol (Chun et al., 2009).

Lycopene as antioxidant has a singlet oxygen quenching ability twice as high that of  $\beta$ -carotene and 10 times higher than that  $\alpha$ -tocopherol (Weisburger, 2002).

#### Functional properties of ice cream mix

Physicochemical properties of functional ice cream mix prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels are given in Table 6. Results revealed that no significant differences in total solids, protein and ash

contents of ice cream mixes between the control and ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels. Addition of carotenoids (lyco-red) from tomato peels in ice cream mixes caused obvious and proportional increase in the fat content and gradual increase for specific gravity and weight per gallon (kg) by increasing the ratios of carotenoids (lyco-red) extracted from tomato peels was observed. On the other hand, the pH slightly decreases by increasing the ratio of carotenoids (lyco-red) extracted from tomato peel compared with that of the control mix.

#### Functional properties of ice cream resultant prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels

Functional properties of ice cream resultant prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels are illustrated in Table 7. The results indicated that, adding of carotenoids (lyco-red) extracted from tomato peels to ice cream mix increased the specific gravity and consequently weight per gallon (kg) in resulting ice cream compared with control. These results could be explained by the Hussein and Aumara (2006), the specific gravity and weight per gallon (kg) depend on the formula components in the resulting ice cream. On the other hand, overrun values of ice cream were decreased with increasing of carotenoids (lyco-red) level ranging from 46.32% to 34.62% for ice creams manufactured with different levels 0–5% of carotenoids (lyco-red) extracted from tomato peel, respectively. The decrement of overrun and increment of both specific gravity and weight per gallon of ice cream by increasing the substitution levels of carotenoids (lyco-red) extracted from tomato peel may be attributed to increase the mix's viscosity which extremely affects on whipping rate of mixes (Arbuckle, 1986).

#### Antioxidant capacity

##### Radical scavenging activity

Radical Scavenging Activity (RSA) of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel during storage period at  $-18$  °C for 30 days is illustrated in Table 8. Results revealed that, supplementing ice cream with carotenoids lyco-red extract increased the RSA in the ice cream by increasing the percentage of adding

**Table 6** Functional properties of ice cream mix prepared by adding different ratios of carotenoids (lyco-red) extracted from tomato peel.

Parameter	Control	Carotenoid (lyco-red) (%)				
		1%	2%	3%	4%	5%
Total solids%	32.93 <sup>a</sup>	32.92 <sup>a</sup>	32.91 <sup>a</sup>	32.91 <sup>a</sup>	32.91 <sup>a</sup>	32.90 <sup>a</sup>
Protein% (N $\times$ 6.38)	4.60 <sup>a</sup>	4.61 <sup>a</sup>	4.60 <sup>a</sup>	4.61 <sup>a</sup>	4.62 <sup>a</sup>	4.62 <sup>a</sup>
Fat%	8.0 <sup>d</sup>	8.13 <sup>c</sup>	8.25 <sup>bc</sup>	8.33 <sup>b</sup>	8.45 <sup>ab</sup>	8.58 <sup>a</sup>
Ash%	1.10 <sup>a</sup>	1.10 <sup>a</sup>	1.11 <sup>a</sup>	1.12 <sup>a</sup>	1.12 <sup>a</sup>	1.13 <sup>a</sup>
pH Values	6.22 <sup>a</sup>	6.20 <sup>ab</sup>	6.16 <sup>b</sup>	6.14 <sup>bc</sup>	6.10 <sup>c</sup>	6.07 <sup>d</sup>
Specific gravity	1.0921 <sup>c</sup>	1.1324 <sup>d</sup>	1.1510 <sup>c</sup>	1.1752 <sup>b</sup>	1.1911 <sup>ab</sup>	1.2122 <sup>a</sup>
Weight per gallon (kg)	3.62 <sup>d</sup>	3.80 <sup>c</sup>	3.93 <sup>b</sup>	4.04 <sup>b</sup>	4.13 <sup>a</sup>	4.25 <sup>a</sup>
Freezing point (°C)	-2.3 <sup>d</sup>	-2.5 <sup>c</sup>	-2.7 <sup>b</sup>	-2.9 <sup>b</sup>	-3.1 <sup>ab</sup>	-3.4 <sup>a</sup>

Values with different letters in the same row are significant different at  $P < 0.05$ .

**Table 7** Physical properties of functional ice cream resultant prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel.

Property	Control	% of adding Lyco Red				
		1%	2%	3%	4%	5%
Specific gravity	0.70 <sup>d</sup>	0.80 <sup>c</sup>	0.82 <sup>bc</sup>	0.84 <sup>b</sup>	0.86 <sup>a</sup>	0.89 <sup>a</sup>
Weigh per gallon (kg)	2.21 <sup>e</sup>	2.65 <sup>d</sup>	2.79 <sup>c</sup>	2.85 <sup>b</sup>	2.93 <sup>a</sup>	2.98 <sup>a</sup>
Overrun	46.32 <sup>a</sup>	42.24 <sup>b</sup>	40.13 <sup>c</sup>	39.32 <sup>cd</sup>	37.11 <sup>d</sup>	34.62 <sup>e</sup>
Melting resistance						
Loss% after 15 min min	12.60 <sup>c</sup>	13.80 <sup>d</sup>	14.10 <sup>cd</sup>	15.90 <sup>c</sup>	16.96 <sup>b</sup>	17.80 <sup>a</sup>
30 min	48.50 <sup>c</sup>	50.14 <sup>d</sup>	52.00 <sup>c</sup>	54.31 <sup>bc</sup>	56.43 <sup>b</sup>	58.62 <sup>a</sup>
45 min	85.32 <sup>c</sup>	88.41 <sup>d</sup>	89.67 <sup>cd</sup>	90.85 <sup>c</sup>	92.21 <sup>b</sup>	94.83 <sup>a</sup>

Values with different letters in the same row are significant different at  $P < 0.05$ .

**Table 8** Radical Scavenging Activity (RSA%) of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel during storage period.

Storage periods (days)	Control	Level of Lyco Red				
		1%	2%	3%	4%	5%
Zero time	37.12 <sup>a</sup>	50.60 <sup>a</sup>	56.13 <sup>a</sup>	61.55 <sup>a</sup>	67.30 <sup>a</sup>	72.40 <sup>a</sup>
7	35.15 <sup>b</sup>	58.40 <sup>b</sup>	54.80 <sup>b</sup>	60.20 <sup>b</sup>	66.10 <sup>b</sup>	70.60 <sup>b</sup>
14	33.14 <sup>c</sup>	46.30 <sup>c</sup>	52.33 <sup>c</sup>	58.30 <sup>c</sup>	64.80 <sup>c</sup>	68.70 <sup>c</sup>
21	31.70 <sup>d</sup>	44.90 <sup>d</sup>	50.50 <sup>d</sup>	56.78 <sup>d</sup>	63.10 <sup>d</sup>	66.90 <sup>d</sup>
30	29.80 <sup>e</sup>	43.12 <sup>e</sup>	58.31 <sup>e</sup>	54.45 <sup>e</sup>	61.70 <sup>e</sup>	64.85 <sup>e</sup>

Values with different letters in the same column are significant different at  $P < 0.05$ .

lyco-red extract. The RSA% of control supplemented with 1% and 5% of carotenoids (lyco-red) extracted from tomato peel increased by 36.31% and 95.04% respectively, while the corresponding rates after 30 days of storage were 44.70% and 117.62% in the same order. However, the percentage of RSA decreased gradually during cold storage for all treatments. Many investigators reported that milk and its components had Radical Scavenging Activity and different antioxidant properties (Chen et al., 2003; Kitts, 2005).

*Ferric Reducing Antioxidant Power (FRAP)*

The ability of the sample to reduce Fe<sup>3+</sup>-TPTZ to Fe<sup>2+</sup>-TPTZ was used as a criterion on antioxidant capacity. Ferric Reducing Antioxidant Power (FRAP) of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel during storage period at -18 °C for 30 days is illustrated in Table 9. Results indicated that, the supplementing of ice cream with carotenoids (lyco-red) extracted from tomato peel proportionally increased the FRAP values of the

ice cream by increasing the concentration. The increasing rate in FRAP values for ice cream samples supplemented with 1%, 5% of carotenoids (lyco-red) extracted from tomato peels is 76.0% and 204.0% respectively. Also, it is noteworthy that the reducing power of control samples was more effective by storage rather than the fortified samples. After 30 days of storage for ice cream mixes, the FRAP values of ice cream samples supplemented with 1% and 5% of carotenoids (lyco-red) extracted from tomato peels were more higher by 153.85% and 400.0% than the corresponding value of control.

*Sensory evaluations*

Sensory evaluations of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peel during storage at zero time after 30 days are shown in Table 10. The aforementioned data indicated that, the ice cream prepared with 3% of carotenoids (lyco-red) extracted from tomato peels recorded the highest total score for all tested parameters followed by 4%, 2%, 1% and 5% for ice cream

**Table 9** Ferric Reducing Antioxidant Power of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels during storage period.

Storage periods (days)	Control	Level of Lyco Red				
		1%	2%	3%	4%	5%
Zero time	25 <sup>a</sup>	44 <sup>a</sup>	54 <sup>a</sup>	60 <sup>a</sup>	68 <sup>a</sup>	76 <sup>a</sup>
7	22 <sup>b</sup>	39 <sup>b</sup>	51 <sup>b</sup>	56 <sup>b</sup>	65 <sup>b</sup>	73 <sup>b</sup>
14	18 <sup>c</sup>	37 <sup>c</sup>	47 <sup>c</sup>	53 <sup>c</sup>	62 <sup>c</sup>	70 <sup>c</sup>
21	16 <sup>d</sup>	35 <sup>d</sup>	46 <sup>d</sup>	51 <sup>d</sup>	60 <sup>d</sup>	67 <sup>d</sup>
30	13 <sup>e</sup>	33 <sup>e</sup>	42 <sup>e</sup>	49 <sup>e</sup>	57 <sup>e</sup>	65 <sup>e</sup>

Values with different letters in the same column are significant different at  $P < 0.05$ .

**Table 10** Sensory evaluation of ice cream prepared with different ratios of carotenoids (lyco-red) extracted from tomato peels.

Property	Storage periods	Control	Lyco Red added (%)				
			1%	2%	3%	4%	5%
Flavor (45)	0 Time	39 <sup>d</sup>	41 <sup>c</sup>	42 <sup>b</sup>	45 <sup>a</sup>	44 <sup>b</sup>	40 <sup>d</sup>
Body and Texture (30)		25 <sup>c</sup>	26 <sup>c</sup>	28 <sup>b</sup>	29 <sup>a</sup>	28 <sup>b</sup>	24 <sup>c</sup>
Melting quality (15)		14 <sup>a</sup>	13 <sup>a</sup>	13 <sup>a</sup>	13 <sup>a</sup>	12 <sup>b</sup>	11 <sup>c</sup>
Color (10)		6 <sup>d</sup>	7 <sup>c</sup>	9 <sup>ab</sup>	10 <sup>a</sup>	9 <sup>ab</sup>	7 <sup>c</sup>
Total score (100)		84 <sup>d</sup>	87 <sup>c</sup>	92 <sup>b</sup>	97 <sup>a</sup>	93 <sup>b</sup>	82 <sup>e</sup>
Flavor (45)	30 days	38 <sup>d</sup>	40 <sup>c</sup>	42 <sup>b</sup>	44 <sup>a</sup>	43 <sup>b</sup>	39 <sup>d</sup>
Body and Texture (30)		25 <sup>c</sup>	26 <sup>c</sup>	27 <sup>b</sup>	28 <sup>a</sup>	27 <sup>b</sup>	24 <sup>c</sup>
Melting quality (15)		14 <sup>a</sup>	13 <sup>a</sup>	13 <sup>a</sup>	13 <sup>a</sup>	12 <sup>b</sup>	11 <sup>c</sup>
Color (10)		6 <sup>d</sup>	7 <sup>c</sup>	8 <sup>b</sup>	9 <sup>a</sup>	9 <sup>a</sup>	7 <sup>c</sup>
Total score (100)		83 <sup>d</sup>	86 <sup>c</sup>	90 <sup>b</sup>	94 <sup>a</sup>	91 <sup>b</sup>	81 <sup>e</sup>

Values with different letters in the same column are significant different at  $P < 0.05$ .

with of carotenoids (lyco-red) extracted from tomato peels at zero time after 30 days of storage. This means that, adding 3% of carotenoids (lyco-red) extracted from tomato peel to ice cream mix improved the all parameter of sensory properties of ice cream at zero time after 30 days of storage, but addition of carotenoids (lyco-red) extracted from tomato peels at ratios higher than 4% caused to lowering the score for flavor, texture, melting quality and color at zero time after 30 days of storage. Finally, ice cream containing 3% of carotenoids (lyco-red) extracted from tomato peels was the best one for ice cream mix for all functional properties with high quality and acceptable sensory properties.

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