SciDoc Publishers
Infer, Interpret & Inspire Science

OPEN ACCESS

International Journal of Food Science, Nutrition and Dietetics (IJFS)
ISSN 2326-3350

Antioxidant Activity of Tomato (*Lycopersicon esculentum* L.) of Low Soluble Solids and Development of a Shelf Stable Spread

Review Article

Balaswamy K[1*], Prabhakara Rao PG[1], Pragati Yadav[2], Narsing Rao G[1], Sulochanamma G[1], Satyanarayana A[1]

[1] Council of Scientific and Industrial Research - Central Food Technological Research Institute (CSIR-CFTRI), Resource Centre, Habshiguda, Uppal Road, Hyderabad, India.
[2] Department of Biotechnology and Allied Sciences, Jayoti Vidyapeeth Women's University, Jaipur, India.

Abstract

Tomato (*Lycopersicon esculentum* L.) is known to be associated with a reduced risk of developing a certain chronic diseases and cancers due to the presence of lycopene, a bioactive carotenoid. Commercially, the vegetable is used in the preparation of tomato puree or ketchup, but the local varieties with lower total soluble solids was found to be not useful for the same and fetching not enough prices during glut and being wasted without processing. In the present study, the local tomato variety (*Heemsohna*) with lower °brix and higher acidity grown in India was analysed for antioxidant activity. Its suitability for preparation of a value added novel product, 'spread' was evaluated by mixing tomato juice with sugar in the ratio of 1:1, 2:1 and 3:1 followed by concentrating the pulp to 65 °brix. The spread was analysed for physicochemical parameters and sensory acceptability during storage for six months. The methanolic extracts of dehydrated tomato exhibited a 50% inhibition in 2,2-Diphenyl-1-picrylhydrazyl radical scavenging activity and 2,2'-Azino-bis (3-ethylbenzothiazoline-6- sulphonic acid) assay at a concentration of 5 and 2 mg/ml respectively. Variations in physicochemical properties of tomato spread such as °brix (64.5-65.0), pH (3.69-3.73), % acidity (0.69-0.74%), % reducing sugars (19.30-39.00%) % total sugars (56.95-60.21) and viscosity (2681-3255 cP) were measured. Significant changes were observed in sensory parameters such as colour, flavour and taste after 4 months however, the spread was well accepted by panelists with a maximum score of 6.9 for overall acceptability during the storage for six months. The study indicated that local varieties of tomato can be converted into a value added novel, highly acceptable and shelf stable spread which will help both farmers and consumers.

Keywords: Tomato; *Lycopersicon esculentum* L.; Dehydrated Powder; Antioxidant Activity; Spread; Physico-Chemical Analysis; Sensory Evaluation.

***Corresponding Author**:
K. Balaswamy,
CSIR-CFTRI, Resource Centre, Habshiguda, Uppal Road, Hyderabad 500 007, India.
Tel: +91-40-27151157
E-mail: kbswamy66@gmail.com

Recieved: July 10, 2015
Accepted: September 02, 2015
Published: September 03, 2015

Citation: Balaswamy K, at al., (2015) Antioxidant Activity of Tomato (*Lycopersicon esculentum* L.) of Low Soluble Solids and Development of a Shelf Stable Spread. *Int J Food Sci Nutr Diet.* 04(4), 202-207. **doi: http://dx.doi.org/10.19070/2326-3350-1500037**

Introduction

Tomato (*Solanum Lycopersicon*) has been widely called as *Lycopersicon esculentum* belongs to the family *Solanaceae*. Tomatoes have fleshy internal segments filled with slippery seeds surrounded by a watery matrix called serum. Lycopene is the natural carotenoid responsible for the dark red colour in many foods, most particularly in tomatoes. Epidemiological evidence indicated that lycopene is associated with a reduced risk of developing certain chronic diseases and cancers. Lycopene is a 40-carbon acyclic open-chain carotenoid containing 11 conjugated double bonds that handle energy transfer reactions and quenching of oxygen along with two unconjugated double bonds [1]. Lycopene lacks a β-ionone ring structure and hence does not have vitamin A activity but acts as an antioxidant [2]. Lycopene is used as colouring agent and an antioxidant in a broad range of food categories viz., bakery, bottled water, fruit and vegetable beverages, confectionery, dairy, oils and fats, soups, sauces. According to FAO/WHO (2009), the lycopene levels permitted for use in different food products range from 2 ppm in bottled water to 130 ppm in ready to eat cereals [3].

Fresh tomatoes are subjected to heat treatment for the production of different processed tomato products, such as tomato puree, tomato sauce and tomato paste [4]. Processing and cooking cause isomerization of naturally occurring all-trans lycopene to the cis-form that is more bio-available [5]. Lycopene from tomato paste has been reported to be more readily absorbed than lycopene from raw tomatoes [6]. Lycopene in fresh tomato, paste and boiled sauce were estimated to the extent of 12, 16 and 4mg/100 g [7]. Lycopene content of tomato remained unchanged during the production of juice or paste and remained stable for one year at room temperature. Lycopene's potent antioxidant actions are effective in maintaining the strength, thickness and fluidity of cell

membranes. It was found that serum lipid peroxidation and LDL oxidation were significantly reduced after the consumption of tomato products such as tomato juice, spaghetti sauce, and tomato oleoresin containing lycopene for a period of 1 week in human subjects [8].

India ranks first in the world in the production of fruits and second in vegetables, accounting roughly 10 and 15 percent, respectively, of total global production. Presently, a mere 2.2% of fruits and vegetables are processed [9]. India produced 18.28 million metric tonnes of tomato in 2013 [10]. Typical values for lycopene content of California-grown tomato varieties are ranged from 8.4 to 17.3 mg/100 g [11]. Tomato products such as tomato puree consists of lower concentrations (8-24 °brix) and tomato paste possesses higher level (24-40 °brix) [12]. Fruit spreads, low in sugar are made using fruit juice or pulp with the addition of low methoxyl pectins for the benefit of diabetic populations [13]. Earlier, honey based apple and mango spreads were prepared by replacing sugar at 25 or 35% at the end and raised the °brix to 68 [14]. In the present study, the local variety of tomato (*Heemsohna*) with lower total soluble solids and higher acidity were evaluated for lycopene content and antioxidant activity and standardize the process parameters for a novel spread for value addition.

Materials and Methods

Materials

Fresh and ripened tomatoes of local variety (*Heemsohna*) used in the present study were procured from the local vegetable market at Uppal, Hyderabad. Chemicals used in the study were of analytical grade and procured from M/s Sd. Fine Chemicals Ltd., Mumbai, India. DPPH (2, 2-diphenyl-1-picrylhydrazyl), ABTS (2, 2'-azino-bis (3- ethylbenzothiazoline-6-sulphonic acid) and potassium ferricyanide were purchased from M/s Sigma-Aldrich Fine Chemicals, Bangalore, India.

Extraction and Dehydration of Tomato Juice

Tomatoes were thoroughly washed in chlorine water (5 ppm) prepared using sodium hypochlorite. The tomatoes were cut into pieces and tomato juice after the hot break was extracted using a stainless steel (SS) fruit pulper (Sanitary type, Engineers Overseas Corporation, Kolkata, India). Tomato juice was analysed for °brix by using a hand refractometer (Erma, Japan), acidity by titration with standard alkali, pH using a digital pH meter (Control Dynamics, Bangalore, India). The reducing and total sugars were estimated by following Lane and Eynons method [15]. The juice also analysed for total polyphenol content (TPC) by measuring the colour developed by Folin-Ciocalteu reagent at 675 nm and expressed as gallic acid equivalents (GAE) (Sadasivam and Manickam, 1997) [16]. Lycopene from the sample was extracted using acetone and which was transferred into a hexane layer by liquid-liquid partitioning. The optical density (OD) of the hexane layer was read at 473 nm in a *UV-Visible* spectrophotometer, and the lycopene content was calculated using molar extinction coefficient (18.6×10^4) [15]. The colour of the juice was also assessed for lightness (L^*), redness (a^*) and yellowness (b^*) values using UltraScan VIS HunterLab colour measuring system. Further the colour values were used to compute chrome (c^*) for colour saturation using the expression $c^* = [(a^*)^2 + (b^*)^2]^{1/2}$ and hue angle (h^*) for colour range by using the formula $h^* = \tan^{-1} b^*/a^*$ [17]. Hue angle means how an individual perceives the colour of the object and the values are measured in the range of 0 to 360° for red to the magenta. The total colour difference (ΔE) is calculated using the the following formula.

$$\Delta E = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

Where L^*_2, a^*_2, and b^*_2 are values for brightness, redness and yellowness during storage and L^*_1, a^*_1, and b^*_1 are the initial values.

The juice was spread in aluminum trays and dehydrated in a tray dryer using the drying conditions: temperature 55-60°C, loading 2.5 kg per tray of 2.5 x 1.25 ft for 5 h. The juice flakes obtained were ground to fine powder (500 µm) and packed in metalized polyester polyethylene pouches. The juice powder was evaluated for its physico-chemical parameters viz., moisture by determining the loss on drying using an air oven, lycopene, total polyphenol content and HunterLab colour values as above.

Extract of the tomato juice powder (2 g) was prepared using methanol (100 ml) on a magnetic shaker for 2 h at room temperature. Further, the aliquots were diluted to obtain 1 mg/ml concentration and the extracts were centrifuged at 8000 rpm (Remi, Model C-30 BL, Mumbai, India). The supernatant was collected for analyzing antioxidant activity employing DPPH, ABTS and FRAPS assays [18-20].

Antioxidant Activity of Tomato Juice Powder

DPPH Radical Scavenging Activity: 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was measured following the method of Nanjo et al [18]. Methanol extracts with varying concentrations were taken in different test tubes, and the volume was made up to 1 ml. DPPH (0.004%) 4 ml was added to each test tubes and the contents were incubated at RT for 30 min. The absorbance of the solution was read at 517 nm. The OD of DPPH solution without sample was treated as control and calculated for percent inhibition. The DPPH activity of the extract was compared with butylated hydroxytoluene (BHT).

ABTS Assay: 2,2'-Azino-bis (3-ethylbenzothiazoline-6- sulphonic acid (ABTS) assay was carried out according to the method of Re et al [19]. The ABTS solution was prepared by mixing 7 mM ABTS and 2.45 mM potassium persulphate and then incubated in the dark at RT for 16 h. The mixture was diluted with 80% (v/v) methanol to obtain an absorbance of 0.700 at 734 nm. ABTS solution (3.9 ml) was mixed with 0.1 ml extract with varying concentrations and shaken thoroughly, and the absorbance was recorded at 734 nm after 10 min. The blank was prepared using methanol instead of samples. The ABTS (%) was calculated and compared with BHT.

Ferric Reducing Power: Methanol extract with varying concentrations in 1 ml was taken in different test tubes and added with 2.5 ml of phosphate buffer. The contents were mixed with potassium ferricyanide (2.5 ml) 1% solution and incubated for 20 min at 50 °C. Then, 2.5 ml of 10% trichloroacetic acid was added and centrifuged at 8000 rpm for 10 min. The supernatant of 2.5 ml was mixed with 2.5 ml distilled water and 0.5 ml 0.1% ferric chloride. The intensity of the colour was read at 700 nm. The reducing power activity was compared with those of BHT according to Yildrim et al [20].

Preparation of Tomato Spread

Trials were conducted for the development of tomato spread to varying the process parameters such as juice content and the inclusion of skin and serum portions. Tomato juice and sugar were mixed in the ratio of 1:1, 2:1 and 3:1. The required quantity of citric acid was added to maintain the final acidity of 0.7%, and °brix content of the juice was raised to 65 by concentration using minimum heat. The product was prepared without the addition of pectin and artificial food colours. Benzoic acid, 200 ppm was added as a preservative and stored in 200 ml sterilized glass bottles. The bottled product was stored at room temperature (30 ± 2°C) for six months during which, physicochemical analysis and sensory acceptability studies were conducted at bimonthly withdrawals.

The spread was analyzed initially and at bimonthly intervals for physicochemical parameters during six months of storage. Non-enzymatic browning (NEB) during storage was assessed by measuring the absorbance of the alcoholic extracts at 440 nm. The viscosity (cP) of spread was measured by using Brookfield viscometer (Model DV-II + Pro) at room temperature. The viscosity was noted using spindle S64 at maximum percent torque at different rotational speeds 10-200 rpm in a given period. The product was periodically evaluated for sensory attributes such as flavor, taste, texture and overall acceptability on a 9-point Hedonic scale [21].

Statistical Analysis

Experiments were carried out in triplicate, and the results are expressed as mean values with standard deviation. Sensory scores mentioned are mean values of 10 replicates and analysed by paired T test ANOVA and statistically considered by $P<0.05$ using IBM-SPSS 19.0 version.

Results and Discussion

The mean value for a total yield of the juice after removal of seed and skin was 78%. Values for °brix, pH and acidity were noted as 3.5, 3.66 and 0.41 for juice. Tomato juice showed lower amounts of lycopene (4.05 mg/100 g) and TPC (82 mg/100g). The colour measured by HunterLab for *L**, *a** and *b** values were 39.98, 17.2 and 15.78 respectively (Table 1). The present findings are comparable with the results of commercial and wild varieties of tomato grown in India [22]. The literature values are in the range of 4.38 to 7.64 for °brix, 4.31 to 29.99 mg/100 g for lycopene, 26.34 to 141.98 mg GAE/100 g for TPC and 28.63 to 36.32 for HunterLab red values (a*). It was observed that dehydration of tomato juice to yield dry flakes required a minimum period of 5 h. Tomato juice powder showed lycopene and TPC contents of 39.5 mg/100 g and 1720 mg/100g respectively. The HunterLab *L**, *a** and *b** values were recorded as 48.4, 18.78 and 18.16 respectively (Table 1). Since the data obtained from juice, the tomatoes of local variety were found to be not suitable for value addition with respect to °brix, colour and lycopene contents. However, the dehydrated tomato juice powder was found to be rich in lycopene, polyphenols and colour that can find applications in various food formulations.

Antioxidant Activity

The sample was evaluated for antioxidant activity applying different assays DPPH radical scavenging activity, ABTS and ferric reducing power. The antioxidant activity of a standard, BHT was also analysed by these methods and the data is presented in Table 2. The substances cause the change in colour of DPPH from violet to yellow upon reduction by electron donation can be considered as antioxidants or radical scavengers. The antioxidant activity of methanolic extracts of tomato juice powder that may contain more phenolic compounds assessed by DPPH and ABTS assays

Table 1. Physicochemical Characteristics of Tomato Juice and Tomato Juice Powder.

Parameter	Tomato juice	Tomato juice powder
Moisture (%)	-	9.97 ± 0.12
Lycopene (mg/100 g)	4.05 ± 0.28	39.50 ± 0.37
TPC (GAE) (mg/100)	82.0 ± 7.21	1724 ± 12.24
HunterLab colour values *L**	39.98 ± 0.03	48.4 ± 1.11
*a**	17.20 ± 0.03	18.78 ± 1.07
*b**	15.78 ± 0.38	18.16 ± 0.93
Chrome value (*c**)	23.34 ± 0.26	26.12 ± 0.44
Hue angle (*h**)	42.36± 0.19	44.0 ± 0.26

Values are of Mean ± SD (n = 3)

Table 2. Antioxidant Activity of BHT.

Concentration (µg/ml)	DPPH activity (% inhibition)	Concentration (µg/ml)	ABTS activity (% inhibition)	Concentration (µg/ml)	FRP (absorbance at 700 nm)
10	20.04 ± 1.67	1	26.60 ± 1.12	40	0.253 ± 0.014
20	37.03 ± 1.04	2	49.40 ± 1.09	80	0.387 ± 0.008
30	48.06 ± 0.51	3	70.90 ± 1.02	120	0.703 ± 0.017
40	60.06 ± 1.27	4	77.20 ± 3.02	160	0.851 ± 0.020
50	63.80 ± 1.91	5	75.56 ± 1.32	200	0.951 ± 0.003

Values are Mean ± SD (n = 3)

were presented in Figure 1. Tomato juice powder extract showed 50% inhibition with DPPH at 5 mg/ml, whereas, BHT showed off 20% inhibition at 10 µg and 63.8% at 50 µg/ml. Earlier, Vinha et al [23] demonstrated that 30% reduction in DPPH activity for tomato juice after removal of seed and skin in *Chucha* tomatoes due to losses of lycopene, β-carotene, ascorbic acid and polyphenols. Whole *Chucha* tomato juice possessed a 4.05 °brix, 79.3 mg/100g total polyphenols, 14.2 mg/100g lycopene and its methanolic extract exhibited antioxidant activity of 73.3% at 30 µg by DPPH assay. The higher polyphenol content in the methanolic extract might be affecting the % inhibition. It was observed that an inverse relationship between lyocpene content and antioxidant activity where as the correlation between total phenolics and antioxidant activity was positive (Kaur et al) [22]. Locally available tomatoes of Pakistan showed a lycopene content of 5.58 mg/100g and the dehydrated powder exhibited 37.68% DPPH inhibition at 1 mg/ml concentration (Shazad et al. 2014) [24]. Higher antioxidant activity (71.43% inhibition) was measured by ABTS assay at 2 mg/ml that is comparable with a concentration of 2 µg/ml of BHT (70.94%). The diluted ABTS solution (1:40) gave an absorbance of 0.70 which was treated as control. Reduction of Fe (III) to Fe (II) is often used as an indicator of the electron-donating antioxidant activity of phenolic compounds [20]. Ferric reducing power of tomato juice powder showed an absorbance of 0.9769 at 5 mg/ml concentration (Figure. 2) when compared an absorbance 0.9514 at 200 µg/ml of BHT.

Tomato Spread

The results from bench scale trials for the preparation of tomato spreads with varying concentrations of tomato juice are presented in Table 3. Tomato spreads prepared with tomato juice with or without serum and sugar at 2:1 ratio were found most suitable when consumed along with bread. All the spreads were bright red in colour and comparably better than other commercial tomato spreads. The chroma value (saturation of the colour) is much higher (15.75) in the product when compared to other products. Tomato spread with 1:1 ratio was found to be too loose and 3:1 ratio was too thick while applying on the bread. The red and yellow values are decreasing with increase in sugar ratio in spread preparation. Considering all the parameters, tomato spread was prepared in bulk using juice composed of serum, and sugar at 2:1 ratio, bottled and evaluated for shelf stability during storage for six months.

Table 4 shows the changes in physicochemical parameters of tomato spread prepared from optimised conditions during storage at room temperature. The spread possessed of °brix 64.5, pH 3.69, acidity 0.69%, reducing sugars 19.32%, total sugars 56.95% and an OD of 0.107 for NEB. Jams prepared by Ozdogan and Yilmaz [25] from cherry and commercial red tomato exhibited different values for physicochemical properties like °brix (68.25-68.79), pH (3.13-3.51) and total acidity (0.66-0.89%). During the study, the °brix, pH and acidity remained constant. pH values from 3.2 to 4.0 were ideal for the formation of gels in the presence of low methoxyl pectins to bind with covalent ions. The reducing and total sugars were increased significantly after storage of 6 months from 19.32 to 38.93% for reducing sugars and from 56.95 to 60.21% for total sugars were observed. Lycopene content was measured up to 5.4 mg/100 g in the spread on preparation day when processed using juice with serum, and the values were significantly decreased from 2 months onwards ($P<0.05$) that the values are almost constant for the next four months. Experimental studies conducted by Mayeaux et al on the thermal

Figure 1. Antioxidant activity of tomato juice powder by DPPH and ABTS assays.

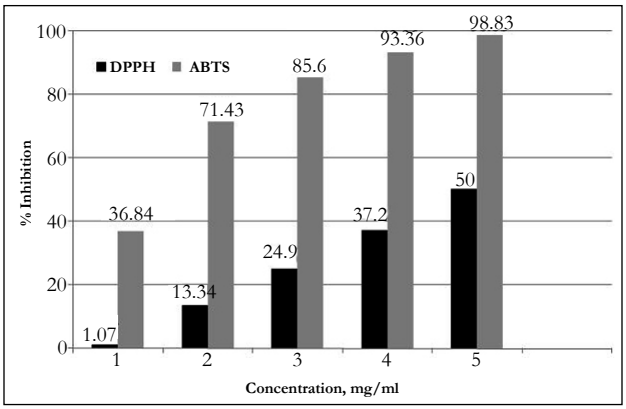
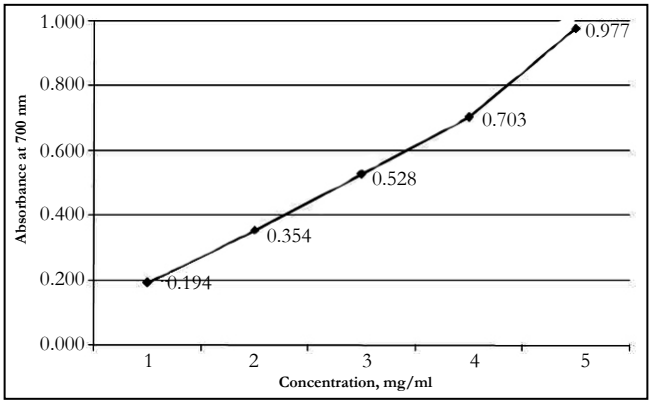


Figure 2. Antioxidant activity of tomato juice powder by FRP assay.



stability of pure lycopene standard showed a 50% reduction in lycopene at 100°C after 60 min exposure [26]. In contrast, tomato puree exposed to different light and temperature conditions showed no significant difference in lycopene content at the beginning and significantly decrease during six months [27]. Earlier, a study on production of tomato jam with a lycopene content of 7.6 mg/100 g was observed to exhibit DPPH activity of 0.12 mM Trolox equivalents per 100 g [28]. In their study lycopene content decreased and antioxidant activity increased during processing. The increase in polyphenol content in the spread from 127.23 to 178.5 mg/100 g and a marked increase in NEB values during storage up to OD of 0.35 was observed. NEB might be due to the interaction of free amino acids with simple sugars to form Maillard type compounds. The product was found in bright red in colour and shows mean values of *L*, a*, b*, c** and *h** values of 29.46, 11.16, 7.56, 13.48 and 34.11 respectively at zero-day of storage. During the storage, the variation in colour values was significantly decreased and noted as 27.12, 6.75, 4.24, 7.97 and 32.1 respectively. Decrease in Chroma (*c**), the saturation of colour is a natural phenomenon during storage of processed foods. The total colour differences (ΔE) were observed as 4.04, 5.5 and 5.99 during storage period of 2, 4 and 6 months compared to initial day. Tomato spread has shown a significant decrease in total colour after storage for 4 months ($P<0.05$). It was reported that lycopene isomerizes from trans-form to cis-form when heated or heat treated. The colour loss and development of off-flavours might be due to the breakdown of lycopene molecule after oxidation while reisomerization process that takes place during storage [29].

Table 5 shows the sensory data of spread that shows it is highly acceptable with scores of more than 8.0 for all parameters on the zero-day except for flavour that was not well perceived by panelists. Lycopene, the red colour pigment contributes for scoring the colour attribute. The scores indicate that spread retained all sensory characters till four months of storage. After six months, decrease in scores was observed for flavour, colour and overall acceptability. However, lycopene content reduced by 50% (from 5.4 to 2.7 mg/100 g) after first two months of storage that stabilized up to six months period. The score for texture parameter was poor due to thickening of spread during storage. The presence of low methoxyl pectin content (1.6-3.8%) in tomato juice might be a reason for thickening property [30]. The rheological study also supports the findings of a gradual increase in viscosity values from 2681 to 3255 cP during six months storage at room

Table 3. Physicochemical Analysis of Tomato Spreads Prepared Using Different Concentrations of Tomato Juice and Sugar.

Parameter	Ratio of tomato juice and sugar			
	1:1	2:1	3:1	2:1 (with serum)
°Brix	65.53 ± 0.12	70.00 ± 0.50	68.50 ± 0.87	64.03 ± 0.06
pH	4.16 ± 0.03	4.49 ± 0.15	4.66 ± 0.05	4.53 ± 0.05
Acidity (%)	0.79 ± 0.02	0.78 ± 0.03	0.82 ± 0.01	1.0 ± 0.02
Reducing sugars (%)	10.87 ± 0.29	10.55 ± 0.57	15.93 ± 0.58	16.34 ± 0.24
Total sugars (%)	61.31 ± 1.39	61.54 ± 0.14	57.73 ± 0.90	58.85 ± 1.02
Lycopene (mg/100g)	2.18 ± 0.16	3.76 ± 0.17	8.09 ± 0.32	4.55 ± 0.22
TPC (GAE) (mg/100g)	110.56 ± 10.23	553.67 ± 9.07	807.67 ± 11.59	583.65 ± 14.01
HunterLab values *L**	28.98 ± 0.17	29.73 ± 0.15	30.46 ± 0.17	32.07 ± 0.01
*a**	6.87 ± 0.02	12.89 ± 0.01	13.86 ± 0.03	12.34 ± 0.03
*b**	4.52 ± 0.02	8.50 ± 0.05	7.99 ± 0.01	9.42 ± 0.02
Chrome value (*c**)	8.22 ± 0.08	15.45 ± 0.29	16.00 ± 0.72	15.75 ± 0.78
Hue angle (*h**)	33.34± 1.38	33.46 ± 0.98	29.95 ± 1.97	37.35 ± 1.08

Values are of Mean ± SD (n = 3)

Table 4. Changes in Physicochemical Parameters in Tomato Based Spread Prepared from Optimized Conditions during Storage.

Parameter	Storage period (months)			
	0	2	4	6
°Brix	64.50 ± 0.30	65.00 ± 0.70	65.00 ± 0.87	65.00 ± 0.36
pH	3.69 ± 0.07	3.69 ± 0.06	3.57 ± 0.06	3.73 ± 0.11
Acidity (%)	0.69 ± 0.06	0.61 ± 0.04	0.71 ± 0.04	0.74 ± 0.04
Reducing sugars (%)	19.32 ± 0.78	30.58 ± 0.51*	32.66 ± 1.10*	39.00 ± 0.87*
Total sugars (%)	56.95 ± 0.60	58.29 ± 0.64	58.4 ± 0.46	60.21 ± 0.70*
TPC (GAE) (mg/100 g)	127.23 ± 1.33	176.20 ± 1.23*	174.20 ± 0.97*	178.50 ± 0.64*
Lycopene (mg/100 g)	5.40 ± 0.20	2.74 ± 0.10*	2.68 ± 0.10*	2.61 ± 0.14*
NEB	0.11 ± 0.01	0.26 ± 0.06*	0.35 ± 0.05*	0.35 ± 0.04*
HunterLab values *L**	29.46 ± 1.22	27.7 ± 0.93*	27.23 ± 0.31*	27.12 ± 0.73*
*a**	11.16 ± 0.26	8.02 ± 0.28*	6.76 ± 0.39*	6.75 ± 0.52*
*b**	7.56 ± 0.36	5.71 ± 0.22*	4.95 ± 0.08*	4.24 ± 0.21*
Chrome value (*c**)	13.48 ± 0.31	9.85 ± 0.26*	8.38 ± 0.33*	7.97 ± 0.25*
Hue angle (*h**)	34.11 ± 0.47	35.44 ± 1.12	36.21 ± 0.47*	32.13 ± 0.09*
Viscosity (*cP*)	2681 ± 108.28	2778 ± 18.68	2711 ± 19.05	3255 ± 30.41

Values are of Mean ± SD (n = 3), * indicates significant difference at $P<0.05$

Table 5. Changes in Sensory Parameters of Tomato Based Spread Prepared from Optimized Conditions during Storage.

Parameter	Storage period (months)			
	0	2	4	6
Appearance	8.44 ± 0.50	8.19 ± 0.37	8.06 ± 0.56	7.88 ± 0.35*
Colour	8.31 ± 0.46	8.06 ± 0.56	7.88 ± 0.64*	7.63 ± 0.52*
Flavour	7.38 ± 1.06	7.38 ± 0.52	7.38 ± 0.52	6.94 ± 0.42*
Taste	8.25 ± 0.38	8.19 ± 0.37	7.56 ± 0.62*	7.00 ± 0.76*
Texture	8.06 ± 0.56	7.81 ± 0.75	7.56 ± 0.82*	6.75 ± 0.71*
Overall quality	8.19 ± 0.65	7.94 ± 0.42	7.63 ± 0.52*	6.88 ± 0.64*

Values are of Mean ± SD (n = 10), * indicates significant decrease at P<0.05

temperature. Earlier, studies indicated that tomato pastes diluted with water to the initial °brix of fresh tomato showed Brookfield viscosity between of 5917 to 7358 kbn^{-1} [31].

Conclusions

The tomato juice powder possessed good quantities of lycopene and polyphenols, which exhibited antioxidant activity and hence can be utilised in food preparations for enhancing their functional properties. The study also favours for the production of a value added novel spread product from the local tomato with lower total soluble solids and higher acidity. The spread was also found to be rich in total polyphenols and lycopene content. The product is shelf-stable and was found to be acceptable even after six months of the storage period. Hence, the processing of local tomatoes will help to increase the economy of producers which in turn improve the health of consumers.

Acknowledgments

The authors thank Director, CSIR-CFTRI, Mysore, for his interest in the work carried out under the project Agropathy (BSC-105) and permission to publish the data.

References

[1]. Young AJ, Lowe GM (2001) Antioxidant and prooxidant properties of carotenoids. Arch Biochem Biophysics 385(1): 20-27.
[2]. Willcox JK, Catignani GL, Lazarus S (2003) Tomatoes and cardiovascular health. Crit Rev Food Sci Nutr 43(1): 1-18.
[3]. FAO/WHO, (2009) Food category system, In: General standards for food additives CODEX STAN 192-1995(Rev.10-2009), Annex B, 9-48.
[4]. Van het Hof KH, de Boer BC, Tijburg LB, Lucius BR, Zijp I, et al. (2000) Carotenoid bioavailability in humans from tomatoes processed in different ways determined from the carotenoids response in the triglyceride-rich-lipoprotein fraction of plasma after a single consumption and in plasma after four days of consumption. J Nutr 130(5): 1189-1196.
[5]. Omoni AO, Aluko RE (2005) The anti-carcinogenic and anti-atherogenic effects of lycopene, a review. Trends Food Sci Technol 16(8): 344-350.
[6]. Gartner C, Stahl W, Sies H (1997) Lycopene is more bioavailable from tomato paste than from fresh tomatoes. Am J Clin Nutr 66(1): 116-122.
[7]. Alda LM, Gogoasa I, Bordean DM, Gergen I, Alda S, et al. (2009) Lycopene content of tomatoes and tomato products. J Agroalimentary Proc Technol 15(4): 540-542.
[8]. Agarwal S, Rao AV (1998) Tomato lycopene and low density lipoprotein oxidation: a human dietary intervention study. Lipids 33(10): 981-984.
[9]. Ministry of Food Processing Industries, Annual Report 2005-06.
[10]. FAO (2015). http://www.faostat3.fao.org/download/Q/QC/E
[11]. Barrett DM, Anthon G (2001) Lycopene content of California-grown tomato varieties. Acta Hort 542: 165-173.
[12]. Hayes WA, Smith PG, Morris AE (1998) The production and quality of tomato concentrates. Crit Rev Food Sci Nutr 38(7): 537-564.
[13]. Anonymous (2014). http://extension.oregonstate.edu/fch/sites/default/files/documents/ sp_50_765_lowsugarfruits
[14]. Umesh Hebbar H, Rastogi NK, Subramanian R (2008) Properties of dried and intermediate moisture honey products: a review. Int J Food Prop 11(4): 804-819.
[15]. Ranganna S (1986) Handbook of analysis and quality control for fruits and vegetable products. (2nd edtn), Tata McGraw-Hill Publishing Company Limited, New Delhi.
[16]. Sadasivam S, Manickam A (1997) Biochemical Methods. (2nd edtn), New Age International Publishers, New Delhi, India. 193-194.
[17]. Barreiro JA, Milano M, Sandoval AJ (1997) Kinetics of colour change of double concentrated tomato paste during thermal treatment. J Food Eng 33(3): 359-371.
[18]. Nanjo F, Goto K, Seto R, Suzuki M, Sakai M, et al. (1996) Scavenging effects of tea catechins & their derivatives on 1, 1-diphenyl-2-picrylhydrazyl radical. Free Radic Biol Med 21(6): 895-902.
[19]. Re R, Pellegrini N, Proteggente A, Yang M, Rice-Evans C, et al. (1999) Antioxidant activity applying an improved ABTS radical cation decolourization assay. Free Radic Biol Med 26(9-10): 1231-1237.
[20]. Yildrim A, Mavi A, Kara AA (2001) Determination of antioxidant & antimicrobial activities of Rumex cripsus L. extracts. J Agric Food Chem 49(8): 4083-4089.
[21]. Amerine MA, Pangborn RM, Roessler EB (1965) Principles of sensory evaluation of food. Academic Press, New York.
[22]. Kaur C, Walia S, Nagal S, Walia S, Singh J, et al. (2013) Functional quality and antioxidant composition of selected tomato (Solanum lycopersicon L) cultivars grown in Northern India. LWT Food Sci Technol 50(1): 139-145.
[23]. Vinha AF, Alves RC, Barreira SV, Castro A, Costa AS, et al. (2014) Effect of peel and seed removal on the nutritional value and antioxidant activity of tomato (Lycopersicon esculentum L.) fruits. LWT Food Sci Technol 55(1): 197-202.
[24]. Shahzad T, Ahmad I, Choudhry S, Saeed MK, Khan MN (2014) DPPH Free radical scavenging activity of tomato, cherry tomato and watermelon: lycopene extraction, purification and quantification. Int J Pharmacy Pharm Sci 6(2): 223-228.
[25]. Ozdogan F, Yilmaz E (2008) Production and evaluation of tomato jam products. Akademik-Gida 6(6): 11-17.
[26]. Mayeaux M, Xu Z, King JM, Prinyawiwatkul W (2006) Effects of cooking conditions on the lycopene content in tomatoes. J Food Sci 71(8): C461–C464.
[27]. Markovic K, Hruskar M, Vahcic N (2007) Stability of lycopene in tomato puree during storage. Acta Alimentaria 36(1): 89-98.
[28]. Veljovic M, Davidovic S, Pecic S, Despotovic S, Leskosek –Cukalovic I, et al. (2012) Lycopene content and antioxidant capacity of tomato jam. Proceedings of the 6th Central European Congress on Food, CE Food. 138-143.
[29]. Xianquan S, Shi J, Kakuda Y, Yueming J (2005) Stability of lycopene during food processing and storage. J Med Food 8(4): 413-422.
[30]. Anthon GE, Diaz JV, Barrett DM (2008) Changes in pectins and product consistency during the concentration of tomato juice to paste. J Agric Food Chem 56(16): 7100-7105.
[31]. Chong HH, Simsek S, Reuhs BL (2014) Chemical properties of pectin from industry hot and cold break tomato products. Food Nutr Sci 5: 1162-1167.