



Study of Chemical Properties of Lycopene Containing Tomato Purees

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors designed the study and wrote the protocols, performed the statistical analysis, managed the analysis of the study, literature searches and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

A study on chemical properties of different treatments prepared using dried tomato (*Lycopersicon esculentum*), tomato pulp & water was carried out at School of Home Science, B.B.A.U, LUCKNOW during July 2020 to May 2021 to find out most appropriate treatment/puree having high content of lycopene and Vitamin-C, which can be used during off season for consumption, as a substitute to fresh tomatoes. Apart from lycopene & Vitamin-C; total soluble solids, acidity, ascorbic acid content, ash, moisture and pH of the samples drawn from different treatments were also studied during the investigation. Five different types of treatments viz. Dried tomato powder without food additives (T₁), Mixture of tomato powder and water (ratio 1:10) without heating (T₂), Mixture of tomato powder and water (ratio 1:10) heating at 60-70⁰C for 5 minutes (T₃), Fresh tomato pulp (T₄) & Tomato pulp cooked at 60-70⁰C for 35 minutes (T₅) were used in the investigation. The effect of these treatments was discernible, as reflected on content of lycopene & Vitamin-C. The highest Lycopene content of 90.34±4.18 mg per 100 g was obtained from tomato pulp cooked at 60-70⁰C for 35 minutes followed by dried tomato powder without food additives (66.47±2.02 mg per 100 g). Similarly, highest content of Vitamin-C i.e. 109.03±6.68 mg per 100 g was obtained from dried

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tomato powder without food additives and lowest 19.43 ± 0.95 mg per 100 g from mixture of tomato powder and water (ratio 1:10) heating at $60-70^{\circ}\text{C}$ for 5 minutes. These results appeared highly promising considering the nature of powder & pulp.

Keywords: *Lycopene; vitamin-C; tomato puree; Lycopersicum esculentum.*

1. INTRODUCTION

1.1 Tomatoes (*Lycopersicum esculentum*) are one of the most widely grown and consumed vegetable and they come in various sizes, shapes and colors.

1.2 On the global scale, tomatoes are the most important vegetable crop with about 182.2 million tons of production [1].

1.3 Tomato is grown in India in abundance both in summer and winters. Some of the Indian tomato varieties are Sankranti, Pusa-ruby, Arka-alok, Arka abha and Vaibhav [2].

1.4 Tomato though botanically a fruit is generally considered as vegetable because of the way in which it is consumed.

1.5 Red tomato contains about 94% moisture, but, it is an excellent source of minerals and vitamins. Tomato contains large amounts of Vitamin-C, and A, providing 40% and 15% of the daily intake value, respectively.

1.6 As per Jayathunge et al., [3], lycopene found in tomatoes act as an antioxidant and neutralizes free radicals which can damage cells in the body, inhibit the lungs, breast, and endometrial cells and also cuts down the risk of developing prostate cancer by 45%.

1.7 Traditionally, fresh tomato and tomato based product such as sauce, puree, juice, and paste are the major dietary sources of lycopene.

1.8 Though, tomatoes have got a lot of benefits, but some shortcomings also lie in it. As, tomato is a highly perishable in the fresh state, due to high moisture content leading to wastages and losses during harvesting and storage. Losses in tomato productions are also accrued to poor post harvest handling practices. Therefore, prevention of these losses and wastage is of paramount importance.

1.9 It is also important to emphasize the demand of dehydrated tomato products in domestic and in international markets, which is increasing

rapidly and major portion of it being used for preparation of convenient foods [4].

1.10 Conversion of tomato into other forms such as tomato powder, souse, etc can be done on large scale to prevent losses occurring during harvesting and post harvest handling.

1.11 Investigations of better technologies that can be used to reduce losses of antioxidant & Vitamins during processing; and technologies for reducing cost of processing, packaging, handling, and transportation of the products must also be done at faster pace by the research community.

1.12 The need of tomato processing usually arises to preserve the product for consumption during off season.

1.13 In thermal stability study using a pure lycopene standard, Mayeaux, et al., [5] have reported that, 50% of lycopene was degraded at 100°C after 60 min, at 125°C after 20 min and 150°C after less than 10 min. Only 64.1% and 51.5% lycopene was retained when the tomato slurry was baked at 177°C and 218°C for 15 min, respectively. At these temperatures, only 37.3% and 25.1% of lycopene was retained after baking for 45 min. In 1 min of the high power of microwave heating, 64.4% of lycopene still remained. However, more degradation of lycopene in the slurry was found in the frying study. Only 36.6% and 35.5% of lycopene was retained after frying at 145 and 165°C for 1 min, respectively.

1.14 Hence, this experiment was carried out at School of Home Science, Department of Food Science & Nutrition, B.B.A.U, LUCKNOW to find out most appropriate treatment/puree having high content of lycopene and Vitamin-C after processing, which can be used for consumption during off season, when the fresh tomatoes are not available in the markets of Lucknow, (U.P.), India and elsewhere. Apart from lycopene & Vitamin-C; total soluble solids, acidity, ascorbic acid content, ash, moisture and pH of the samples drawn from different treatments were also studied during the investigation.

2. MATERIALS AND METHODS

2.1 The investigation was carried out at Food Science Analysis Laboratory, School of Home Science, Department of Food Science & Nutrition, B.B.A.U, Lucknow, Uttar Pradesh, India, during July 2020 to May 2021 in randomized design with three replications & five treatments viz. Dried tomato powder without food additives (T₁), Mixture of tomato powder and water (ratio 1:10) without heating (T₂), Mixture of tomato powder and water (ratio 1:10) heating at 60-70°C for 5 minutes (T₃), Fresh tomato pulp (T₄) & Tomato pulp cooked at 60-70°C for 35 minutes (T₅).

2.2 Technique Used for Preparation of Raw and Cooked Tomato Puree

The amount of tomato (7.00 kg.) used to prepare tomato powder & pulp under the experimental work was purchased from the local markets of Lucknow at the rate of Rs.10/- per Kg., considering its basic quality attributes like freshness, redness, shape and size, as the redness of the tomato is indicator of rich lycopene content. To prepare tomato pulp & powder, tomatoes were first thoroughly washed in water to remove all dirt or dust and foreign matter attached to their surfaces, then soaked all the excess water on tomato surface with the help of soaking paper. Then, all the tomatoes were divided into two parts, i.e. 1st part (5.00 kg) to make tomato powder & 2nd part (2.00 Kg) to make tomato pulp under the experiment.

2.3 Technique Used for Preparation of Pulp

Tomato pulp was obtained by passing the fresh fully red tomatoes through the fine pulping machine and seed & skin were separated following the protocols described by Dauthy [6]. The extracted pulp used as basic material from which other treatments were made. The recovery of pulp was 50% of tomatoes on weight basis. Pulp was concentrated in open kettle to evaporate the extra moisture present in it. Then pulp was filled into cans (temperature of filling 82°C to 88°C) and processed in boiling water for 20 minutes. The processed cans were cooled immediately by dipping them in cold water and stored in dry and cool place.

2.4 Technique used for Preparation of Tomato Powder

Tomato was cut into slices of uniform thickness to dry it quickly & placed on the tray of dehydrator in a single layer so that they can't stick with each other. The temperature of the dehydrator was kept at 50-60°C to dehydrate it. Tomato slices took 27 hours to dry in the dehydrator. Then, dehydrated slices used for pulverizing into powder, in a high powered blender.

2.5 Sampling Technique

Any experimental work has defined sampling procedure to conduct it, which has been followed in the present investigation. Sampling was done by selecting random samples from the treatments/purees prepared. Step by step procedure was followed to find out sample from the whole material of treatment/puree. As already cited above, that five treatments were prepared using pulp, powder & water as planned under the experiment to substantiate the hypothesis and find out the best treatment having significantly higher amount of lycopene & Vitamin-C. Apart from lycopene & Vitamin-C; total soluble solids, acidity, ascorbic acid content, ash, moisture and pH of the samples drawn from different treatments were also studied during the investigation. To minimize the error/ bias three samples from each treatment were taken randomly from the treatment/puree prepared under this experiment and analyzed for chemical attributes.

The data collected during the investigation were compiled in tabular form and analyzed on the statistical method to find out means, standard deviation among the treatments, as per Gomez and Gomez [7] and to check the significance of the same, help of ANOVA table were taken.

2.6 Estimation of Chemical Properties

2.6.1 Lycopene content

To estimate the lycopene content, 5 g sample from each treatment was drawn in triplicate and organic solvent was used to extract and solubilize lycopene contained in the samples, followed by chromatographic absorbance measurement at 504 nm of each sample, as per the method of Adsule et al. (1979).

2.6.2 Total soluble solids

To estimate the total soluble solids, 5 g sample from each treatment was drawn in triplicate & TSS content of each sample was determined by using hand refracto-meter of different ranges and value was expressed as percent of TSS [8].

2.6.3 Total acidity

To estimate the total acidity, 5 g sample from each treatment was drawn in triplicate, then the each sample was diluted with distilled water and the content was titrated against 0.1 N NaOH using phenolphthalein as indicator, separately. The total acidity was calculated in percentage of anhydrous citric acid present in the sample [8].

2.6.4 Ascorbic acid and vitamin C

To estimate the Ascorbic acid, 5 g sample from each treatment was drawn in triplicate & Ascorbic acid was determined by use of titration method, in which 2,6-dichloro-phenol & indo-phenol solutions were used as described by Ranganna [8]. Estimation of vitamin C content in the samples was also determined by titration method, 2,6-dichloro-phenol & indo-phenol reagents were used for the purpose.

The method is based on colour change of the reagent, oxidation or reduction. The ionized form of 2,6-dichloro-phenol & indo-phenol gives red colour in acid and blue in basic medium. Dehydro-ascorbic acid is obtained through reaction with vitamin C, after reducing the identification reactive, 4-(hydroxi-phenol-amino acid)-2,6-dichloro-phenol. This method is commonly used, due to the fact that it is easy to use and due to the reagent sensitivity.

2.6.5 Ash

To estimate the ash content, 5g sample from each treatment was drawn in triplicate & weighed accurately in separate dry crucible. The sample in the crucible was ignited with the flame of a suitable burner for about one hour. The ignition was done by keeping it in a muffle furnace at 250°C until a grayish black ash was formed. The dish was cooled in the desiccators and weighed [9]. The ash content was calculated as per the following formula:

$$\text{Ash content (\%)} \text{ of the sample} = \frac{M2 - M}{M1 - M} \times 100$$

Where, M: Mass of the empty crucible (g)

M1: Mass of the crucible with the sample before ignition (g)

M2: Mass of the crucible with the sample after ignition (g)

2.6.6 Moisture

To estimate the moisture content, 5g sample from each treatment was drawn in triplicate & weighed accurately in separate moisture dish. These Dishes were transferred into an oven maintaining temperature at 55 ± 2°C for 1 hour and dried samples were weighed again. Moisture content was calculated by subtracting the dried weight from fresh weight and was expressed as percentage on the basis of treatment [10]. Percentage of Moisture content of the samples was calculated using following formula:

$$\text{Moisture content} = \frac{\text{Sample's weight} - \text{Sample's dry weight}}{\text{Sample's weight}} \times 100$$

2.6.7 pH

To estimate the pH, 5g sample from each treatment was drawn in triplicate & weighed, separately. Then each of the said samples were blended appropriately in 15 ml distilled water, then, blended material was poured into boiling distilled water to make it up to 100ml of slurry, separately. The slurries were permitted to cool. After that the pH of the slurry, obtained so, was estimated utilizing a digital pH meter [11].

3. RESULTS AND DISCUSSION

3.1 Chemical attributes such as lycopene (mg/ 100 g), vitamin C (mg/ 100 g), total soluble solids (%), acidity (%), ascorbic acid (mg/ 100 g), ash (%), moisture (%) and pH of the samples drawn from different treatments were studied during the investigation. The salient findings of the present study and brief discussions derived there are summarized hereunder:

3.1.1 Lycopene content of different treatments (mg/100 g)

It is pertinent from the data presented in Table 1 that the highest mean score of lycopene 90.34±4.18 mg/ 100 g was recorded in T₅ (Tomato pulp cooked at 60-70°C for 35 minutes) & lowest 4.05±0.16 mg/ 100 g in T₃ (Mixture of tomato powder and water in ratio 1:10, heating at 60-70°C for 5 minutes).

Lycopene content of different treatments varied due to mixing with water in different ratios, factors affecting their concentrations and its thermal stability. Mayeaux, et al., [5] have reported that in thermal stability study using a pure lycopene standard it was found that 50% of lycopene was degraded at 100°C after 60 min., hence, T₃ which resulted in lowest lycopene content i.e. 4.05±0.16 mg/100 g., was prepared from the mixture of tomato powder and water in ratio 1:10, heating at 60-70°C for 5 minutes, as the powder used for was obtained from tomato dried in oven at 50-60°C for 27 hours. Whereas, T₅, was made of tomato pulp cooked at 60-70°C

for 35 minutes resulted in very high mean score of lycopene content i.e. 90.34±4.18 mg per 100 g. due to very less thermal loss of the same. T₁ had followed the T₅ in mean lycopene content.

The data collected on lycopene content and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value in ascending order was 4.05±0.16, 4.98±0.94, 5.35±0.15, 66.47±2.02 & 90.34±4.18 mg per 100 g in different treatments viz.T₃, T₂, T₄, T₁, T₅, respectively. The statistical method used for analysis of the said data is summarized below:

Statistical analysis of data on Lycopene Content (As per Randomized Design)

	T 1		T 2		T 3		T 4		T 5	
Sample	X ₁	X ₁ ²	X ₂	X ₂ ²	X ₃	X ₃ ²	X ₄	X ₄ ²	X ₅	X ₅ ²
1	68.58	4703.21	5.85	34.22	4.21	17.72	5.49	30.14	94.03	8,841.64
2	64.56	4167.99	4.08	16.64	4.05	16.40	5.20	27.04	85.80	7,361.64
3	66.29	4394.36	4.42	19.53	3.89	15.13	5.38	28.94	91.21	8,319.26
Total	199.43	13265.56	14.35	70.39	12.15	49.25	16.07	86.12	271.04	24,522.54

$$T = \sum X_1 + \sum X_2 + \sum X_3 + \sum X_4 + \sum X_5 = 199.43 + 14.35 + 12.15 + 16.07 + 271.04 = 513.04$$

$$CF = \frac{T^2}{N} = \frac{263210.04}{15} = 17547.33$$

$$\text{Total Sum of Squire (SST)} = \sum X_1^2 + \sum X_2^2 + \sum X_3^2 + \sum X_4^2 + \sum X_5^2 - CF$$

$$= 13265.56 + 70.39 + 49.25 + 86.12 + 24522.54 - 17547.33$$

$$= 37993.86 - 17547.33 = 20449.53$$

$$SSB = \left[\frac{(\sum X_1)^2}{n_1} + \frac{(\sum X_2)^2}{n_2} + \frac{(\sum X_3)^2}{n_3} + \frac{(\sum X_4)^2}{n_4} + \frac{(\sum X_5)^2}{n_5} \right] - CF$$

$$= \left[\frac{(199.43)^2}{3} + \frac{(14.35)^2}{3} + \frac{(12.15)^2}{3} + \frac{(16.07)^2}{3} + \frac{(271.04)^2}{3} \right] - 17547.33$$

$$= 13257.44 + 68.64 + 49.20 + 86.08 + 24487.56 - 17547.33 = 37948.92 - 17547.33 = 20401.59$$

$$\text{Within Samples Sum of Squire (SSW)} = SST - SSB = 20449.53 - 20401.59 = 47.94$$

$$MSW = SSW \div (n_1 - 1) = (n_2 - 1) + (n_3 - 1) + (n_4 - 1) + (N_5 - 1) \\ = 47.94 \div (3 - 1) + (3 - 1) + (3 - 1) + (3 - 1) + (3 - 1) = 47.94 \div 10 = 4.79$$

ANOVA Table for Lycopene content in different treatments

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	20401.59 (SSB)	2	10200.78	10200.78 ÷ 4.00 = 2550.19
ii) Within samples	47.94 (SSW)	12	4.00	
Total	20449.53	14		

Result: Calculated value of $F = 2550.19$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference in lycopene content was significant among the treatments.

Table 1. Lycopene content of different treatments (mg/100 g)

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	68.58	5.85	4.21	5.49	94.03
2.	64.56	4.08	4.05	5.20	85.80
3.	66.29	4.42	3.89	5.38	91.21
Total	199.43	14.95	12.15	16.07	271.04
Mean	66.47	4.98	4.05	5.35	90.34
Standard deviation	2.02	0.94	0.16	0.15	4.18

3.1.2 Vitamin C in different treatments (mg/100 g)

It is evident from the data presented in Table 2 that the highest mean score of Vitamin C content (mg/100g) recorded was 109.03 ± 6.68 and lowest 19.43 ± 0.95 in T₁ (Dried tomato powder without food additives) and T₃ (Mixture of tomato powder and water (ratio 1:10) heating at 60-70°C for 5 minutes) respectively.

Chemical properties of different purees and powder prepared under the treatments varied due to mixing with water in different ratios, factors affecting chemical changes while processing/heating and their concentrations. As,

T₁ (Dried tomato powder without food additives) had resulted in very high mean score of Vitamin C i.e. 109.03 (mg/100 g) compared to other treatments, which may be due to high concentration of powder which consisted Vitamin C. T₅ had followed the T₁ in mean value of Vitamin-C.

The data collected on Vitamin C content and analyzed during the investigation, conspicuously indicates that it has very high significance among different treatments, as, mean value of the same in descending order was 109.03 ± 6.68 , 60.74 ± 1.26 , 22.70 ± 1.96 , 20.18 ± 0.59 & 19.43 ± 0.95 mg/100 g in treatment T₁, T₅, T₄, T₂, T₃, respectively.

ANOVA Table for Vitamin-C

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	18312.02	2	9156.01	$9156.01 \div 8.55 = 1070.88$
	(SSB)			
ii) Within samples	102.65 (SSW)	12	8.55	
Total	18414.67	14		

Result: Calculated value of $F = 1070.88$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 2. Vitamin C content (mg/100 g):

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	115.07	20.83	20.12	21.05	62.19
2.	101.86	20.05	19.82	24.87	60.15
3.	110.15	19.67	18.35	22.19	59.89
Total	327.08	60.55	58.29	68.11	182.23
Mean	109.03	20.18	19.43	22.70	60.74
Standard deviation	6.68	0.59	0.95	1.96	1.26

3.1.3 Total Soluble Solids content of different treatments (%)

It is pertinent from the data presented in Table 3 that the highest mean score of total soluble solids (%) recorded was 12.23 ± 1.13 and lowest 1.17 ± 0.74 in T₅ and T₃, respectively.

Chemical properties of different treatments varied due to mixing with water in different ratios and factors affecting their concentrations. As, T₅ had very high mean of total soluble solid i.e.

$12.23 \pm 1.13\%$ compared to other treatments, it was actually due to high concentration of puree which consisted more TSS in the treatment. T₁ had followed the T₅ in mean TSS content.

The data collected on total soluble solids and analyzed during the investigation, conspicuously indicates that it had very high significance in different treatments, as, mean value in ascending order was 1.17 ± 0.74 , 2.04 ± 0.57 , 2.99 ± 0.45 , 8.79 ± 2.64 & $12.23 \pm 1.13\%$ in treatments T₃, T₂, T₄, T₁, T₅, respectively.

ANOVA Table for total soluble solids in different treatments

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	287.77 (SSB)	2	143.89	$143.89 \div 1.55 = 92.83$
ii) Within samples	18.59(SSW)	12	1.55	
Total	306.36	14		

Result: Calculated value of $F = 92.83$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 3. Total soluble solids content of different treatments (%)

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	6.5	2.68	0.05	3.51	13.5
2.	11.67	1.85	1	2.65	11.87
3.	8.20	1.59	1.5	2.82	11.32
Total	26.37	6.12	3.5	8.98	36.69
Mean	8.79	2.04	1.17	2.99	12.23
Standard deviation	2.64	0.57	0.74	0.45	1.13

3.1.4 Acidity of different treatments

It is evident from the data presented in Table 4 that the highest mean score of acidity content (%) recorded was 4.20 ± 0.04 and lowest 0.06 ± 0.03 in T₁ (Dried tomato powder without food additives) and T₃ (Mixture of tomato powder and water ratio 1:10 heating at 60-70°C for 5 minutes), respectively.

As the chemical properties of different treatments varied due to difference in water content vis-a-vis factors affecting their concentrations, T₁ had resulted in very high mean value of acidity i.e. $4.20 \pm 0.04\%$ compared to other treatments, it was due to high concentration of powder & chemical changes took place in processing. T₁ had followed the T₅ in mean total acidity content.

The, data collected on acidity and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value in ascending order was 0.06 ± 0.03 , 0.21 ± 0.17 , 0.27 ± 0.14 , 0.86 ± 0.11 & $4.20 \pm 0.04\%$ in treatments T₃, T₄, T₂, T₅, T₁, respectively.

ANOVA Table for acidity of different treatments

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	36.78 (SSB)	2	18.39	18.39÷0.08 = 229.88
ii) Within samples	0.96 (SSW)	12	0.08	
Total	37.74 (SST)	14		

Result: Calculated value of $F = 229.88$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 4. Acidity of different treatments

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	4.17	0.41	0.03	0.39	0.95
2.	4.20	0.28	0.09	0.21	0.88
3.	4.25	0.12	0.07	0.04	0.74
Total	12.62	0.81	0.19	0.64	2.57
Mean	4.20	0.27	0.06	0.21	0.86
Standard deviation	0.04	0.14	0.03	0.17	0.11

3.1.5 Ascorbic Acid in different treatments (mg/100 g)

It is evident from the data presented in Table 5 that the highest mean score of ascorbic acid content (mg/100 g) recorded was 13.45 ± 0.47 and lowest 2.04 ± 0.21 in T₄ (Fresh tomato pulp) and T₃ (Mixture of tomato powder and water (ratio 1:10) heating at 60-70°C for 5 minutes) respectively.

Chemical properties of different purees and powder prepared under the treatments varied due to mixing with water in different ratios, factors affecting chemical changes while processing/heating and their concentrations. As,

T₄ (Fresh tomato pulp) had resulted in very high mean of ascorbic acid content i.e. 13.45 (mg/100 g) compared to other treatments, which was due to high concentration of pulp which consisted it. T₅ had followed the T₄ in mean total ascorbic acid content.

The data collected on ascorbic acid content and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value in descending order was 13.45 ± 0.47 , 10.70 ± 0.58 , 6.54 ± 1.31 , 2.99 ± 0.42 & 2.04 ± 0.21 in treatments T₄, T₅, T₁, T₂, T₃, respectively.

ANOVA Table for ascorbic acid content

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	288.44 (SSB)	2	144.22	144.22÷0.41 = 703.51
ii) Within samples	5 (SSW)	12	0.41	
Total	293.44	14		

Result: Calculated value of $F = 703.51$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 5. Ascorbic Acid content of different treatments (mg/100 g)

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	5.12	2.96	2.10	13.12	11.08
2.	6.82	2.58	2.22	13.25	11.00
3.	7.70	3.43	1.81	14.00	10.03
Total	19.64	8.97	6.13	40.37	32.11
Mean	6.54	2.99	2.04	13.45	10.70
Standard deviation	1.31	0.42	0.21	0.47	0.58

3.1.6 Total Ash content of different treatments (%)

It is evident from the data presented in Table 6 that the highest mean score of ash content (%) recorded was 10.55 ± 0.27 and lowest 4.43 ± 0.54 in T₄ (Fresh tomato pulp) and T₅ (Tomato pulp cooked at 60-70 °C for 35 minutes.) respectively.

Chemical properties of different purees and powder prepared under the treatments varied due to mixing with water in different ratios, factors affecting chemical changes while processing/heating and their concentrations.

Hence, T₄ (Fresh tomato pulp) had resulted in very high mean of ash content i.e. 10.55 (%) compared to other treatments, it was due to high concentration of pulp which consisted ash. T₁ had followed the T₄ in mean ash content.

The data collected on ash content and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value in descending order was 10.55 ± 0.27 , 10.54 ± 0.24 , 8.88 ± 0.79 , 8.52 ± 0.44 & $4.43 \pm 0.54\%$ in treatments T₄, T₁, T₂, T₃, T₅, respectively.

ANOVA Table for total ash

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	75.03 (SSB)	2	37.515	$37.515 \div 0.206 = 182.11$
ii) Within samples	2.47 (SSW)	12	0.206	
Total	77.50	14		

Result: Calculated value of $F = 182.11$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 6. Total Ash content of different treatments (%)

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	10.35	9.58	9.02	10.78	5.05
2.	10.48	9.05	8.19	10.62	4.05
3.	10.81	8.02	8.36	10.25	4.21
Total	31.64	26.65	25.57	31.65	13.31
Mean	10.54	8.88	8.52	10.55	4.43
Standard deviation	0.24	0.79	0.44	0.27	0.54

3.1.7 Moisture content of different treatments (%)

It is pertinent from the data presented in Table 7 that the highest mean score of moisture content (%) recorded 93.05 ± 0.46 was and lowest 4.55 ± 0.83 in T₄ (Fresh tomato pulp) and T₁ (Dried tomato powder without food additives) respectively.

Chemical properties of different purees and powder prepared under the treatments varied due to mixing with water in different ratios, factors affecting chemical changes while processing/heating and their concentrations. As, T₄ (Fresh tomato pulp) had contained very high mean value of moisture i.e. 93.04 (%) compared to other treatments. T₅ had followed the T₄ in mean moisture content.

However, data collected on moisture content and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value in descending order was 93.05 ± 0.46 , 70.07 ± 0.76 , 61.22 ± 0.79 , 56 ± 0.09 , & $4.55 \pm 0.83\%$ in treatments T₄, T₅, T₂, T₃, T₁, respectively.

ANOVA Table for moisture content

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	12720.58 (SSB)	2	6360.29	$6360.29 \div 0.52 = 12231.33$
ii) Within samples	6.20 (SSW)	12	0.52	
Total	12726.78	14		

Result: Calculated value of $F = 12231.33$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 7. Moisture content of different treatments (%)

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	5.51	60.42	56.09	92.54	70.58
2.	4.11	62.00	56.02	93.45	69.20
3.	4.03	61.25	55.90	93.15	70.45
Total	13.65	183.67	168.01	279.14	210.23
Mean	4.55	61.22	56.00	93.05	70.07
Standard deviation	0.83	0.79	0.09	0.46	0.76

3.1.8 pH of all treatments

It is pertinent from the data presented in Table 8 that the highest mean score of pH content (%) recorded 4.47 ± 0.08 was and lowest 3.03 ± 0.06 in T₅ (Tomato pulp cooked at 60-70°C for 35 minutes) and T₃ (Mixture of tomato powder and water (ratio 1:10) heating at 60-70°C for 5 minutes) respectively.

Chemical properties of different purees and powder prepared under the treatments varied due to mixing with water in different ratios, factors affecting chemical changes while processing/heating and their concentrations.

Hence, T₅ (Tomato pulp cooked at 60-70°C for 35 minutes) had resulted in very high mean of pH content i.e. 4.47 (%) compared to other treatments, which was due to high concentration of acid which affects pH. T₁ had followed the T₅ in mean value of pH.

The data collected on pH value and analyzed during the investigation, conspicuously indicates that it has very high significance in different treatments, as, mean value of pH in descending order was 4.47 ± 0.08 , 4.13 ± 0.08 , 3.21 ± 0.04 , 3.04 ± 0.03 & 3.03 ± 0.06 in treatments T₅, T₁, T₄, T₂, T₃, respectively.

ANOVA Table for pH value

Source of variance	S.S.	d.f	M.S.	Variance ratio F
i) Between samples	5.47 (SSB)	2	2.74	$2.74 \div 0.001 = 2740$
ii) Within samples	0.01 (SSW)	12	0.001	
Total	5.48	14		

Result: Calculated value of $F = 2740$; variance one (v_1) = 2; variance two (v_2) = 12 and $F_{.05}$ value as per table = 3.89.

As F value > Table value of $F_{.05}$, hence, difference of Total soluble solids was significant among the treatments.

Table 8. pH value of all treatments

Sample	T ₁	T ₂	T ₃	T ₄	T ₅
1.	4.05	3.05	3.08	3.25	4.46
2.	4.21	3.07	3.06	3.18	4.40
3.	4.14	3.01	2.96	3.20	4.56
Total	12.4	9.13	9.1	9.63	13.42
Mean	4.13	3.04	3.03	3.21	4.47
Standard deviation	0.08	0.03	0.06	0.04	0.08

4. CONCLUSION

4.1 It was found during the investigation that chemical properties of different treatments varied due to mixing with water in different ratios, heating, chemical changes and difference in concentrations. For example mixture of tomato powder and water (ratio 1:10) heating at 60-70 °C for 5 minutes (T₃) had lowest Lycopene, Vitamin C, TSS, Acidity, Ascorbic acid and pH whereas tomato pulp cooked at 60-70°C for 35 minutes (T₅) had the highest amount of Lycopene, TSS, Ascorbic acid, pH due to less moisture content, which resulted in very good chemical properties of the same.

4.2 In conclusion, tomato pulp cooked at 60-70°C for 35 minutes i.e.T₅ and dry tomato powder without food additives i.e. T₁ was found to be the best treatment in overall chemical properties. Though, T₅ had got only 55% vitamin-C if compared with T₁, but, it had significantly higher value of the same in comparison to all other treatments.

4.3 Hence, tomato pulp cooked at 60-70°C for 35 minutes & dried tomato powder without food additives can be adopted for processing, packing & storage, for supply during off season. But, looking on the keeping quality and lowest moisture content, dried tomato powder without food additives is recommended for the purpose. However, if benefits of antioxidant and Vitamin-C, etc. are desired T₅ (tomato pulp cooked at 60-70°C for 35 minutes) would be recommended for the purpose.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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