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Nutritional and Sensory Quality of Prepared *Tomato* (*Solanum lycopersicum*) Leather

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Abstract: *Tomato* has a limited shelf life and is highly perishable due to its high moisture content. As fruit leather, is a traditional food of Nepal, it can be beneficial to move towards value addition and diversification of the traditional product. The main aim was to analyze the nutritional values and phytochemicals of the *tomato* pulp and prepared leather, and sensory evaluation of prepared *tomato* leather. Five samples A, B, C, D and E were prepared with 80:20, 72.5:27.5, 95:5, 87.5:12.5 and 65:35 fruit pulp: sugar ratio respectively. Analysis of raw *tomato* pulp and all the five samples was performed. Sensory quality of the product sample A was found superior to that of other samples but chemical and phytochemical properties of product sample C was found superior than that of other prepared samples. Therefore, we had two best products, in terms of sensory properties and in terms of nutritional properties. The best product on the basis of nutrients (sample C) had acidity (%), TSS (°Bx), pH, total ash content (%), crude protein (%), crude fat (%), crude fiber (%), carbohydrate (%), vitamin C (mg/100 g), total energy (Kcal/100 g), TPC (mg GAE/g of dry extract), TFC (mg QE/g of dry extract), DPPH scavenging activity (% of inhibition) and lycopene content (mg/100 g) was found to be 3.70.1, 20 ± 0.02, 3 ± 0.1, 2.30 ± 0.05, 2.69 ± 0.04, 0.87 ± 0.02, 5.46 ± 0.01, 69.68 ± 0.02, 25.17 ± 1.25, 297.31 ± 0.01, 85.35 ± 0.02, 65.39 ± 0.02, 59.23 ± 0.03 and 98.57 ± 0.02 respectively. A tasty and nutritious product of *tomato*, leather can be prepared which can be more appealing to the consumer.

Key words: *Tomato* leather, nutritional composition, anti-oxidant, sensory evaluation

1. Introduction

Tomato (*Solanum lycopersicum*), a fruit from the nightshade family is native to South America. It's commonly eaten and prepared like a vegetable, despite botanically being a fruit. Tomatoes are the major dietary source of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart disease and cancer. They are also a great source of vitamin C, potassium, folate, and vitamin K. Usually red when mature; tomatoes can also come in a variety of colours, including yellow, orange,

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green, and purple. Many subspecies of tomatoes exist with different shapes and flavor.[1]

Fruit leathers are dehydrated fruit-based products that are eaten as desserts or snacks, and presented as flexible stripes or sheets. They receive this name because of the final product aspect (it is shiny and has the texture of leather).[2] They are flexible sheets that have a concentrated fruit flavor and nutritional aspects. Fruit pulp-based fruit leathers are nutritious and organoleptically acceptable to customers. They contain substantial quantities of dietary fibers, carbohydrates, minerals, vitamins, and antioxidants, which remain constituents of the finished product.[3] Drying inhibits the growth of bacteria, yeasts, and mold through the removal of water. Dehydration has been used widely for this purpose since ancient times; the earliest known practice is 12,000 B.C. by inhabitants of the modern Middle East and Asia regions. Dehydration, one of the oldest food preservation methods can be defined as the process of removing water from an object. Dehydration involves the reduction of water activity, which avoids or delays food spoilage induced by microbial or enzymatic reactions, as well as other degradative reactions, such as lipid oxidation, non-enzymatic browning, and hydrolysis.[4]

In Nepalese society, fruit leather which is called *mada*, is specially preferred by kids and young girls. It is prepared by mixing fruit pulp and sugar. As it doesn't require huge capital, it is more famous among home scale production in Nepal and can provide with good profit.[5] Sun drying was not considered good in comparison to solar and cabinet drying as it took long time as well as produced inferior quality product, which may have been due to environmental contamination. Microbial growth was also highly probable.[6] *Tomato* leather can be prepared from cabinet drying which can solve the problem of farmers and can be of low microbial growth compared to that of traditional sun drying method. As fruit leather, is a traditional food of Nepal, it can be beneficial to move towards scientific advancement towards value addition and diversification of the traditional product. Hence, this dissertation work may contribute to enhancing or maintaining the uniformity in quality of *tomato* during its product development and to minimize the loss for farmers caused due to underutilization of *tomato*, by introducing *tomato* products development. This work may also contribute to the preservation of tomato and can be made available during its off-season in the form of fruit leather and other delicious products.

2. Experimental Section

2.1. Collection of raw materials

Tomato of "*pusa ruby*" variety, sugar and salt were bought from the local market of Itahari (26°40′N 87°17′E). The fruits were fresh and sound and of almost uniform size and maturity. They were stored under refrigeration until preparation started. Ripe *tomato* was used for the preparation of the product.

2.2. Chemical reagents and equipments

All the chemical reagents and equipments used for the analytical purpose was obtained from the laboratory of Nilgiri College, Itahari, Nepal. The chemicals used were petroleum ether (boiling point: 60-80 °C, specific density: 0.68, Himedia laboratories Pvt. Ltd, India), catalyst mixture (potassium sulphate and copper sulphate pentahydrate), hydrochloric acid (HCl) (Thermofisher scientific India Pvt. Ltd, assay 35-37 % LR grade), sulphuric acid (H_2SO_4) (Thermofisher scientific India Pvt. Ltd, assay 90-91 % LR grade), ethanol (Sisco, assay 99.9 %), phenolphthalein indicators, methanol (Sisco, assay 99.9 %), sodium carbonate (Na_2CO_3) (Qualigens, assay 99 %), sodium hydroxide (NaOH) (Qualigens fine chemicals, assay 97 %), 2,6-dichloroindophenol and Quercetin (from Himedia laboratories Pvt. Ltd, India), ferric chloride ($FeCl_3$) (Thermo Fischer scientific India, Pvt. Ltd, assay 96 %, anhydrous), Folin-Ciocalteu's reagent (Thermo Fischer scientific India, Pvt. Ltd) and Gallic acid (Lobachemie, India, assay 99.5 %). All the glassware apparatus like a beaker, volumetric flask, etc. used were of borosilicate from the manufacturer 'JSGW'. The equipment used in the experiment were electric weighing balance (Samsung), hot air oven (Kshitij), cabinet dryer, Kjeldahl digestion set, muffle furnace (Y. P. scientific), buchner's filter

assembly, beakers, spectrophotometer (Labtronics, India), conical flask, volumetric flasks, burette, pipettes, test tubes, tripod stands, test tube stand, Whatman filter paper, the crucible, petri plate, petri dish, soxhlet apparatus, heating mantle, measuring cylinder, spatula and glass rod.

2.3. Preparation of *tomato* leather

Tomato leather was prepared with slight modification as shown in *Fig.* 1.[7] Five samples were prepared and coded with variation in *tomato* pulp and sugar by parts while keeping the salt constant to 2 % for every formulation as shown in *Table* 1.

Table 1. Experimental design for the preparation of *tomato* leather (per 100 g)

Sample	*Tomato* pulp (parts)	Sugar (parts)
A	80	20
B	72.5	27.5
C	95	5
D	87.5	12.5
E	65	35

While keeping salt constant in every formulation (i.e., 2 %)

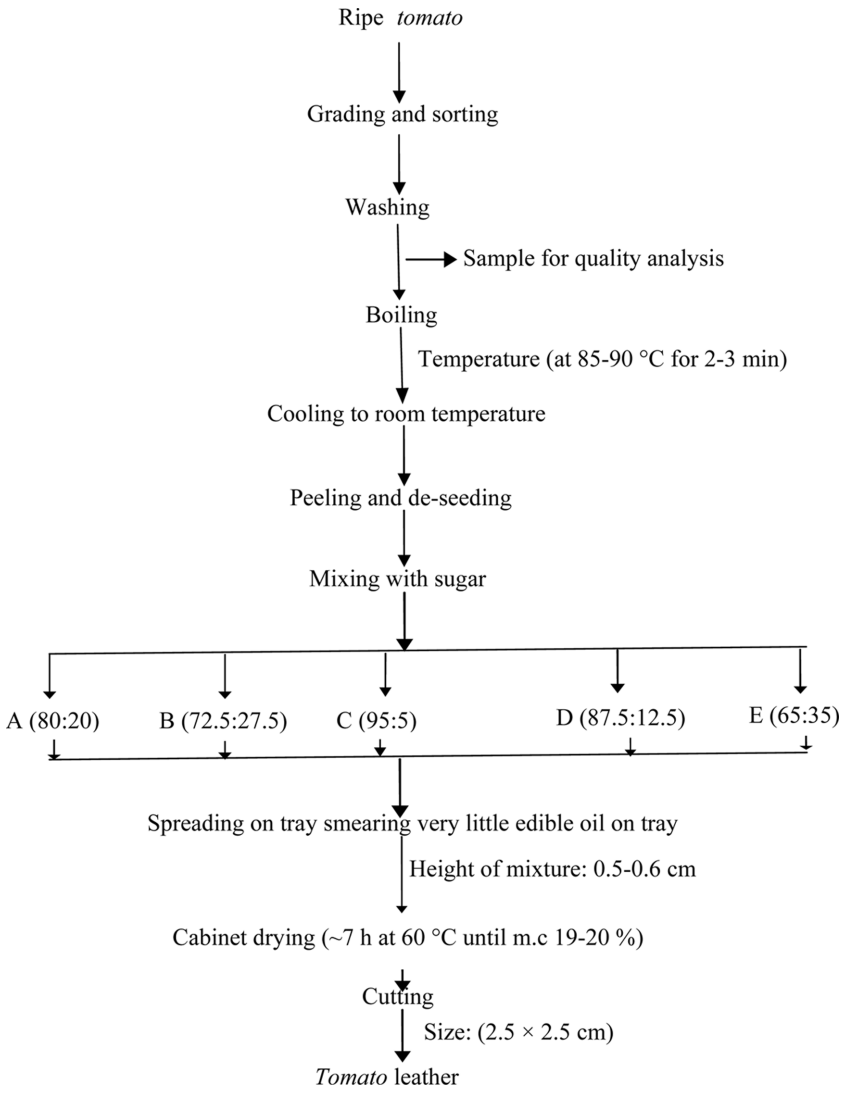

Fig. 1. Preparation of *tomato* leather.

2.4. Analytical methods

2.4.1. Determination of acidity

Ten grams of sample was taken and fine grinding was done by adding water making final volume of 100 ml. 10 ml of prepared sample was used for acidity determination was taken in conical flask and NaOH solution was taken as titre in burette. Phenolphthalein was taken as indicator. The volume consumed for neutralization was noted and acidity was calculated by using formula, as presented in Eq. (1).[4]

$$\%\ \text{Acid (as citric acid)} = \frac{\text{Titre} \times \text{Normality of NaOH} \times \text{Volume made up (ml)} \times 64}{\text{Aliquot (ml)} \times \text{weight of sample taken} \times 1000} \times 100 \quad (1)$$

2.4.2. Determination of TSS

TSS of the tomato pulp and prepared leather was determined by using hand refractometer of range 0 to 32 °Bx. The values are expressed in °Bx. Two grams of sample was taken and crushed. It was dissolved in 10 ml of water. The TSS was then observed in the refractometer after calibrating it to zero with water. The observed value was multiplied by 5 to get the final TSS of the sample.[4]

2.4.3. Determination of crude fat content

Crude fat content of the samples was determined by solvent extraction method using Soxhlet apparatus and solvent petroleum ether.[4]

2.4.4. Determination of crude protein content

Crude protein content of the samples was determined indirectly by measuring total nitrogen content by macro Kjeldahl method. Factor 6.25 was used to convert the nitrogen content to crude protein.[4]

2.4.5. Determination of total ash

Total ash content of the samples was determined by using Muffle furnace.[4]

2.4.6. Determination of crude fiber content

Crude fiber content of the samples was determined by acid-base method.[4]

2.4.7. Determination of pH

For the determination of pH, digital pH meter was used.[4]

2.3.8. Determination of ascorbic acid

Ascorbic acid (Vitamin C) was determined by 2, 6 – dichlorophenol indophenol visual dye method. To measure vitamin C, the leather was ground and extracted by 3 % meta-phosphoric acid (HPO_3). Dye factor was calculated by using the formula, as presented in Eq. (2).[4]

$$\text{Dye factor} = \frac{\text{mg of ascorbic acid}}{\text{Weight of sample}} \quad (2)$$

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titer value} \times \text{dye factor} \times \text{volume made up}}{\text{Weight of sample}} \quad (3)$$

2.4.9. Determination of reducing sugar

The reducing sugar % was determined as described in (FSSAI, 2015) by using the formula as presented in Eq. (4).

$$\text{Reducing Sugars \%} = \frac{\text{Dilution} \times \text{Fehling factor} \times 100}{\text{Weight of sample} \times \text{Titre value}} \quad (4)$$

2.4.10. Total carbohydrate

Total carbohydrate was determined by difference method, as presented in Eq. (5).

$$\text{Total carbohydrate (\%)} = 100 - (\text{moisture} + \text{protein} + \text{fat} + \text{crude fiber} + \text{ash})\ \% \quad (5)$$

2.4.11. Total energy

The energy values were calculated by multiplying the values of crude proteins, lipids, and carbohydrates by recommended factors (4, 9, and 4, respectively). The energy values were expressed as Kcal/100 g.[10]

2.4.12. Yield calculation

Yield of *leather* prepared was determined by using formula, as presented in Eq. (6).[11]

$$\text{Yield \%} = \frac{\text{Product weight}}{\text{Raw material weight (Except added water)}} \times 100 \quad (6)$$

2.5. Preparation of extract

The fresh *tomato* pulp and *tomato* fruit leather were subjected for phytochemicals extraction using methanol. Briefly, 10 g of samples were steeped in 100 mL of 80 % ethanol for 12 h at room temperature. Then, these samples were filtered using Whatman filter paper (No. 41). After filtration, all the extracts were stored in screw capped bottles at 2-4 °C until further analysis. The concentration of the extract was determined by evaporating 10 mL of extract to dryness (at 80 °C) and measuring the weight of the residue.[12]

2.6. Determination of total phenolic content

Total phenolic content (TPC) was determined using spectrophotometric method with some modifications. The reaction mixture was prepared by mixing 0.5 ml of plant extract solution, 2.5 ml of 10 % Folin-Ciocalteu's reagent dissolved in water and 2.5 ml of 7.5 % of Na_2CO_3 aqueous solution. The samples were thereafter incubated in a thermostat at 45 ºC for 45 min. The absorbance was determined using spectrophotometer at wave length = 765 nm. The samples were prepared in quadruple for each analysis and the mean value of absorbance was obtained. The same procedure was repeated for the standard solution of galic acid and the calibration line was constructed. Based on the measured absorbance, the concentration of galic acid equivalent expressed in terms of (mg of GAE/g of dry extract).[13]

2.7. Determination of DPPH radical scavenging activity

DPPH free radical scavenging activities (antioxidant activities) of extracts were determined with slight variation. Different dilutions of the extracts were made using 80 % ethanol (4 mg of DPPH in 100 ml ethanol to give asolution of 100 μM). Then 1 ml of the extract was mixed with 2 ml of 0.1 mM DPPH solution. The absorbance was read at 517 nm after 30 min incubation in the dark. Finally, percentage scavenging activity was determined using Eq. (7).[14]

$$\% \text{ Scavenging activity} = (Ac\text{-}As) \times 100/Ac \quad (7)$$

Where, Ac = Absorbance of control

As = Absorbance of test sample

% Scavenging activity = the total capacity of antioxidants for eliminating free radicals

2.8. Determination of total flavonoid content

Total flavonoid content was determined using a modified aluminium chloride assay method. 2 ml of solution was pipette out in a test tube in which 0.2 ml of 5 % sodium nitrate ($NaNO_3$) was mixed and stand for 5 min. 0.2 ml Aluminium Chloride ($AlCl_3$) was pipetted out, mixed in the tube and allowed to stand for 5 min. Add 2 ml of 1N sodium hydroxide (NaOH) in the tube and finally volume was made up to 5 ml. The absorbance was measured after 15 min at 510 nm against a reagent blank. The test result was correlated with standard curve of Quercetin (20, 40, 60, 80, 100 μg/ml) and the total flavonoid content is expressed as mg quercetin equivalents (QE).[15]

2.9. Determination of lycopene

Lycopene content was determined by extracting tomato with the help of acetone in a separating funnel containing 10 to 15 ml of petroleum ether. An aliquot was diluted to 30 ml with petroleum ether and the color was measured at 1cm cell at 503 nm in a spectrophotometer using petroleum ether as blank and was calculated by using formula as presented in Eq. (8).[4]

$$\text{Lycopene content (mg/100 g)} = \frac{3.1206 \times \text{O.D} \times \text{volume made up to} \times 100}{1 \times \text{sample weight} \times 100} \quad (8)$$

2.10. Sensory evaluation

The panelist members consisted of research students and teachers of Nilgiri College who had previous experience in the sensory evaluation. Nine panelists of sound health were trained before evaluating the samples of tomato leather by using 9-point hedonic rating test system.[4] The panelists were provided with the uniform quantity of prepared five different samples of tomatoleather in stainless steel plate to analyze appearance, texture, taste, flavor and overall acceptability. Each panelist was provided with 5 samples

and an evaluation card. They were provided with potable water for rinsing between the samples.

2.11. Statistical analysis

The data of each experimental analysis that were performed in triplicate was analyzed in one-way and two-way analysis of variance (ANOVA), no blocking at 5 % level of significance by using software GenStat Release 12.1 (Copyright 2009, VSN International Ltd.). MS-Excel 2019 was used for charts and curves. Means were separated using Tukey's LSD post hoc test ($P < 0.05$).

3. Results and Discussion

3.1. Analysis of fresh *tomato* pulp

The fresh *tomato* pulp was analyzed and results were obtained as shown in *Table* 2. The moisture content was found to be 91.48 % which was less than 93.5 %[16] and 93.9 %.[17] TSS was found to be 5.65 °Bx which was greater than the range given by 4 % but was more than the range 4.0-4.5 °Bx.[18] TSS of fresh *tomatoes* was 4.9±3 °Bx.[19,20] The minimum value of soluble solid around 4.5 % is considered low for industrial *tomatoes*.[21] The pH was found to be 2.8 which was significantly lower than the range of 4.38-4. 45.[18,22] The pH value for industrial *tomato* varies was ranged between 4.3-4.4.[21] The crude protein was found to be 2.50 % which was greater than 0.8 % [17] and 1.3 %.[16] The crude fat was found to be 0.89 % which was higher than of 0.1 %.[16] The crude fiber was found to be 0.13 % which was lower than 1.82 % and 0.5 %.[16,17] The vitamin C content was found to be 39.2 mg/100 g which was more than the value 23 mg/100 g.[16] The total ash content was found to be 2.5 % which was significantly greater than the value 0.62 % and 0.7 %.[16,17] The carbohydrate was found to be 2.5 % which was less than 3.9 %.[16] Total energy was found to be 28.01 Kcal which was higher than 21 Kcal.[16]

These variations seen may be caused due to variation in the geographical production area, variety of *tomato*, maturity period and time of study performed.

Table 2. Quantitative analysis of physico-chemical and phytochemical in *tomato* pulp

Parameters	Results (wb)
Moisture content (%)	91.48±0.55
Acidity (as citric acid) (%)	4.10±0.02
TSS (°Bx)	5.65±0.78
pH	2.8±0.09
Vitamin C content (mg/100 g)	39.2±2.64
Crude protein (%)	2.50±0.26
Crude fat (%)	0.89±0.21
Crude fiber (%)	0.13±0.67
Total ash content (%)	2.50±0.01
Total carbohydrate (%)	2.5±0.46
Total energy (Kcal/100 g)	28.01±4.75
DPPH radical scavenging activity (% of inhibition)	76.88±2.5
Total phenolic content (mg GAE/g of dry extract)	116.73±1.08
Total flavonoid content (mg QE/g of dry extract)	111.87±0.25
Total lycopene content (mg/100 g)	55.50±0.32

*Values are mean of triplicate. Numbers in the parentheses are the standard deviations of the data.

3.2. Analysis of *tomato* leather

All the product samples of the tomato leather were analyzed. The results obtained are presented in *Table* 3 and in *Fig.* 2 respectively.

The mean crude fat of the sample A, B, C, D and E were found to be 0.79 %, 0.73 %, 0.87 %, 0.80 % and 0.62 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the crude fat of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The crude fat of the

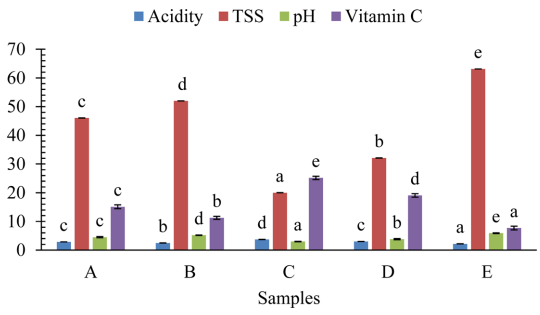

Fig. 2. Nutritional analysis of *tomato* leather.

Table 3. Quantitative analysis of physico-chemical composition and phytochemicals of *tomato* leather

Samples	Crude fat (db%)	Crude protein (db%)	Crude fiber (db%)
A	0.79±0.036^{bc}	2.11±0.01^{bc}	4.17±0.02^{c}
B	0.73±0.01^{b}	1.94±0.01^{b}	3.79±0.02^{b}
C	0.87±0.02^{d}	2.69±0.04^{d}	5.46±0.01^{e}
D	0.80±0.02^{c}	2.3±0.2^{c}	4.85±0.02^{d}
E	0.62±0.02^{a}	1.45±0.05^{a}	2.59±0.02^{a}

Samples	Total ash content (db%)	Carbohydrate (db %)	Energy (Kcal/100 g)
A	1.75±0.01^{c}	72.18±0.02^{c}	304.27±0.02^{c}
B	1.39±0.04^{b}	73.15±0.02^{d}	306.93±0.02^{d}
C	2.30±0.05^{e}	69.68±0.02^{a}	297.31±0.01^{a}
D	1.97±0.02^{d}	71.08±0.01^{b}	300.72±0.02^{b}
E	1.17±0.02^{a}	75.17±0.02^{e}	312.06±0.02^{e}

Samples	DPPH (% of inhibition)	Total phenolic content (mg GAE/g of dry extract)	Total flavonoid content (mg QE/g of dry extract)	Lycopene (mg/100 g)
A	45.11±0.01^{c}	69.33±0.02^{c}	51.56±0.01^{ab}	89.11±0.01^{c}
B	40.90±0.02^{b}	60.25±0.01^{b}	45.37±0.02^{ab}	85.3±0.20^{b}
C	59.23±0.03^{e}	85.35±0.02^{e}	65.39±0.02^{b}	98.57±0.02^{e}
D	50.83±0.01^{d}	78.90±0.02^{d}	56.06±0.02^{b}	93.66±0.02^{d}
E	29.17±0.02^{a}	54.18±0.02^{a}	39.67±2.07^{a}	78.26±0.02^{a}

*Values are mean of triplicate. Numbers in the parentheses are the standard deviations of the data.

product sample A was found to be 0.790.036 %. Increase in pulp content resulted in increased crude fat of the product samples.[12,23]

The mean crude protein of the sample A, B, C, D and E were found to be 2.11 %, 1.94 %, 2.69 %, 2.3 % and 1.45 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the crude protein content of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples B, C, and E to each other but there was no significant difference between the samples A and C. The crude protein in the product sample A was found to be 2.110.01 %. Increase in pulp content resulted in increased crude protein of the product samples.[12,23]

The mean crude fiber of the sample A, B, C, D and E were found to be 4.17 %, 3.79 %, 5.46 %, 4.85 % and 2.59 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on crude fiber of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other to each other. The crude fiber in the product sample A was found to be 4.170.02 %. Increase in pulp content resulted in increased crude fiber of the product samples.[12,23]

The mean total ash content of the sample A, B, C, D and E were found to be 1.75 %, 1.39 %, 2.30 %, 1.97 % and 1.17 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the total ash content of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The total ash content of the product sample A was found to be 1.750.01 %. Increase in pulp content resulted in increased total ash content of the product samples.[12,23]

The mean carbohydrate of the sample A, B, C, D and E were found to be 72.18 %, 73.15 %, 69.68 %, 71.08 % and 75.17 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p <$

0.05) of sugar on the carbohydrate of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The carbohydrate in the product sample A was found to be 72.180.02 %. Increase in sugar proportion resulted in increased carbohydrate of the product samples.[12,23]

The mean energy value of the sample A, B, C, D and E were found to be 304.27 Kcal/100 g, 306.93 Kcal/100 g, 297.31 Kcal/100 g, 300.72 Kcal/100 g and 312.06 Kcal/100 g respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the energy value of the sample at 5 % level of significance. The statistical analysis shows that there was no significant difference between the samples A, B and C, D to each other but there was significant difference between samples C and E. The total energy in the product sample A was found to be 304.270.02 Kcal/100 g. Increase in sugar proportion resulted in increased energy values of product samples.[12,23,24]

The mean DPPH of the sample A, B, C, D and E were found to be 45.11 %, 40.90 %, 59.23 %, 50.83 % and 29.17 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the DPPH radical scavenging activity of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The DPPH radical scavenging activity of the product sample A was found to be 45.110.01 % of inhibition. Increase in pulp content resulted in increased DPPH radical scavenging activity of the product samples.[12,23]

The mean total flavonoid content of the sample A, B, C, D and E were found to be 51.56, 45.37, 65.39, 56.06 and 39.67 mg QE/g of dry extract respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the total flavonoid content of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The total flavonoid content of the product sample A was found to be 51.560.01 mg QE/g of dry extract. Increase in pulp content resulted in increased total flavonoid content of the product samples.[12,23]

The mean total phenolic content (TPC) of the sample A, B, C, D and E were found to be 69.33, 60.25, 85.35, 78.90 and 54.18 mg GAE/g of dry extract respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the TPC of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The TPC of the product sample A was found to be 69.330.02 mg GAE/g of dry extract. Increase in pulp content resulted in increased TPC of the product samples.[12,23]

The mean lycopene of the sample A, B, C, D and E were found to be 89.11 %, 85.3 %, 98.57 %, 93.66 % and 78.26 % respectively (*Table* 3). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the lycopene of the sample at 5 % level of significance. The statistical analysis shows that there was significant difference between the samples A, B, C, D and E to each other. The lycopene of the product sample A was found to be 89.110.01 % of inhibition. Lycopene is more bioavailable in *tomato* processed products than in raw *tomatoes*, since formation of lycopene cis-isomers during food processing and storage may increase its biological activity. Notably, cooked lycopene or consumed in oil media, such as *tomato* paste, *tomato* sauce, or pizza, appear to be optimal for the efficient absorption of lycopene.[25]

The mean acidity of the sample A, B, C, D and E were found to be 2.87 %, 2.49 %, 3.7 %, 3 % and 2.2 % respectively (*Fig.* 2). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the acidity of the sample at 5 % level of significance. Increase in pulp content resulted in increased acidity of product samples.[12,23]

The mean TSS content of the sample A, B, C, D and E were found to be 46.05°Bx, 52°Bx, 20 °Bx, 32.10 °Bx, and 63.11 °Bx respectively (*Fig.* 2). Statistical analysis showed that there is significance effect ($p < 0.05$) of sugar on the total soluble solid (TSS) of the sample at 5 % level of significance. Increase in sugar amount resulted in increased TSS.[7,12,23,26-28]

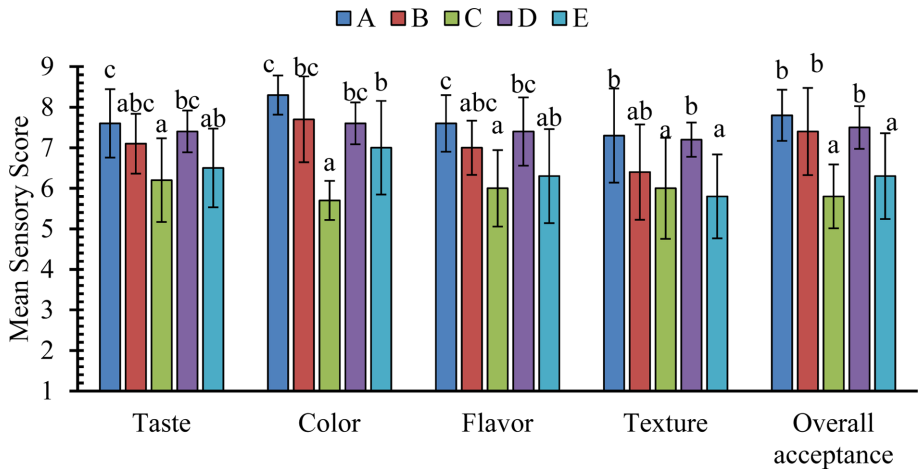

Fig. 3. Mean sensory score of prepared *tomato* leather.

The mean pH of the sample A, B, C, D and E were found to be 4.5, 5.2, 3, 3.8 and 5.9 units respectively (*Fig.* 2). Statistical analysis showed that there is significance effect ($p < 0.05$) of sugar on the total soluble solid (TSS) of the sample at 5 % level of significance. The pH of the product sample A was found to be 4.50.2 unit. The decrease in pulp content resulted in increased pH of the product samples.[12,23]

The mean vitamin C content of the sample A, B, C, D and E were found to be 15.11 mg/100 g, 11.25 mg/100 g, 25.17 mg/100 g, 19.05 mg/100 g and 7.69 mg/100 g respectively (*Fig.* 2). Statistical analysis showed that there is significance effect ($p < 0.05$) of pulp on the vitamin C content of the sample at 5 % level of significance. Vitamin C content of the product sample A was found to be 15.110.67 mg/100 g. Vitamin C content was varied in the tomato leather samples as per the amount of *tomato* pulp addition, in respect to other fruits.[12,23] Various factors such as heat processing, oxidation, light etc. plays role in the loss of vitamin C. The vitamin C loss can amount to 10 – 60 % of original in fruits and vegetables.[29]

3.3. Effect of variation of sugar and pulp on sensory attributes of *tomato* leather

The prepared *tomato* leather samples were analyzed as per the sensory preferences of the panelists (*Fig.* 3). The relation of the prepared samples with respect to their sensory attributes was displayed as PCA plot in *Fig.* 4(a) on the basis of variance-covariance matrix and *Fig.* 4(b) on the basis of correlation matrix.

3.3.1. Color

The mean sensory score for color of the sample products A, B, C, D, and E were found to be 8.3, 7.7, 5.7, 7.6 and 7 respectively. The data were subjected for LSD at 5 % level of significance. The color can be faded during sun drying due to direct contact with atmosphere but the appearance in cabinet drying may be affected by browning and caramelization of sugar at high temperature.[30]

3.3.2. Texture

The mean sensory score for texture of the three products A, B, C, D and E were found to be 7.3, 6.4, 6, 7.2 and 5.8 respectively. Statistical analysis showed that there is significant effect ($p < 0.05$) on the texture of the samples at 5 % level of significance. The texture of the leather is dependent upon length of drying, humidity of air, sugar content etc. Drying at low temperature produces rubbery leather whereas drying at high temperature produces hardened leather.

3.3.3. Taste

The mean sensory score for taste of the three products A, B, C, D and E were found to be 7.6, 7.1,

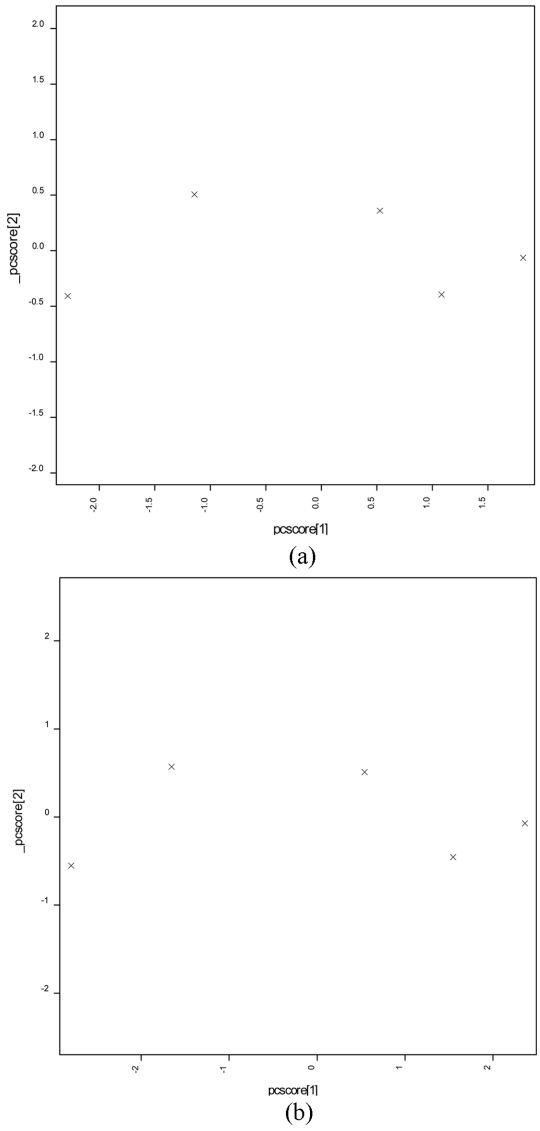

Fig. 4. Principle component analysis (PCA) plot for sensory attributes of prepared leather a) on the basis of variance-covariance matrix and b) on the basis of correlation matrix.

6.2, 7.4 and 6.5 respectively. Statistical analysis showed that there is significant effect ($p < 0.05$) on the taste of the samples at 5 % level of significance. The amount of sugar directly affects the taste of leather.

3.3.4. Flavor

The mean sensory score for flavor of the three products A, B, C, D and E were found to be 7.6, 7, 6, 7.4 and 6.3 respectively. Statistical analysis showed that there is significant effect ($p < 0.05$) on the flavor of the samples at 5 % level of significance. Flavor is the perception one gets after tasting food which includes both the taste and aroma of the food.[31]

3.3.5. Overall acceptance

The mean sensory score for the overall quality of the three products A, B, C, D and E were found to be 7.8, 7.4, 5.8, 7.5 and 6.3 respectively. Statistical analysis showed that there is significant effect ($p < 0.05$) on the overall acceptance of the samples at 5 % level of significance.

3.4. Selection of the best product

The selection of best product was on the basis of sensory score, phytochemicals and nutritional characteristics. Percentage DPPH inhibition was higher in sample C followed by D, A, B and E. Similar pattern was observed for TPC and TFC which suggest sample C to be the best among the samples. Among all the samples, crude fiber was higher in sample C followed by D, A, B and E. Sample C possessed the highest vitamin C among all the samples. Though, the result of chemical and phytochemicals content was higher in sample C, sensory parameters: taste, texture, flavor and overall acceptance comparatively suggest sample A to be the best. Regarding to our study sample C was selected as the best sample with desirable sensory properties and significantly higher vitamin C, phytochemicals content and antioxidant activities

3.5. Yield of *tomato* leather

Each kg of *tomato* contained 800 g pulp and 200 g seed. Pulp loss could be minimized by careful deseeding of the fruit. The yield of the dried leather was found to be 35 %, which can be increased by proper handling and minimizing the loss after drying during scraping of the product from the tray.

3.6. Correlation between chemical and sensory parameters

The correlation coefficient is a measure of strength of the relationship between two variables. A correlation

Table 4. Correlation table between chemical and sensory properties

	Color	*Texture*	*Taste*	*Flavor*	*O.A*	*Acidity*	*TSS*	*pH*	*Vitamin C*	*TPC*	*DPPH*	*Flavanoid*	*Lycopene*
Color	1												
Texture	0.736507	1											
Taste	0.930788	0.927537	1										
Flavor	0.917185	0.939799	0.999337	1									
O.A	0.9503	0.868266	0.987051	0.982468	1								
Acidity	-0.55341	0.119731	-0.23538	-0.20418	-0.31451	1							
TSS	0.511166	-0.18595	0.165495	0.131605	0.241063	-0.97247	1						
pH	0.455323	-0.25221	0.105669	0.071757	0.189983	-0.9797	0.994542	1					
Vitamin C	-0.52604	0.171816	-0.18794	-0.1546	-0.27037	0.99017	-0.99447	-0.99633	1				
TPC	-0.43006	0.288733	-0.07426	-0.03932	-0.16737	0.962636	-0.98924	-0.9959	0.988601	1			
DPPH	-0.40173	0.277912	-0.05516	-0.02311	-0.11945	0.967468	-0.98301	-0.98679	0.979684	0.972494	1		
Flavanoid	-0.50428	0.190937	-0.16713	-0.13426	-0.24896	0.993681	-0.99028	-0.99598	0.998791	0.985902	0.983433	1	
Lycopene	-0.39288	0.30315	-0.03946	-0.00632	-0.11298	0.967088	-0.98826	-0.99398	0.984914	0.98589	0.997427	0.98709	1

of -1 shows a perfect negative correlation and correlation of +1 shows a perfect positive correlation. From the *Table* 4, nearness to +1 show positive correlation indicated by green color, -1 show negative correlation indicated by red color and values around 0 is indicated by yellow color respectively.

4. Conclusions

Sample A prepared with 80:20 *tomato* pulp: sugar ratio was considered to be the best in sensory attributes with highest mean score among all the prepared samples as per the sensory score provided by the panelists and sample C prepared from 95:5 fruit pulp: sugar ratio was found to be higher in nutritional attributes like vitamin C, fiber, protein, phytochemicals etc. Nutritional characteristics were significantly different ($p < 0.05$) among all the samples. *Tomato* can be preserved for the off-season availability. A tasty and nutritious product of *tomato*, leather can be prepared which can be more appealing to the consumer.

Conflicts of Interest

The authors declare no conflicts of interest.

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