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Effect of chemical preservation over thermal processing on storage stability of tomato juice

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ABSTRACT

The present investigation was carried out to study the effect of chemical treatments and storage on physicochemical, phytochemical compounds and antioxidant activity of tomato juice. Potassium metabisulfite, Sodium benzoate and their combination was used as chemical additives. Thermal treatment lead to the destruction of phytochemical nutrients and antioxidant activity. Non-significant ($p \leq 0.05$) decrease was found for physicochemical parameters and antioxidant activity. Out of chemical additives, Potassium Metabisulfite treated samples were found to retain the maximum nutritional quality and antioxidant activity at the end of storage period of six months. There was significant increase in the shelf stability of the chemically preserved juices than the thermally treated samples.

Key words: Antioxidant activity, Chemical additives, Phytochemicals, Storage, Tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum)* is the world's most commercially produced vegetable (Ensminger *et al.,* 1994). Present world production is about 100 million tons fresh fruit produced on 3.7 million hectares (www.growtomatoes.com). Tomato has an excellent nutritional profile owing largely to its balanced mixture of vitamins such as A, B_1, B_2, K, E, Biotin, folic acid, nicotinic and pantothenic acids, Vitamin C, minerals like potassium, phosphorus, calcium, iron and zinc, lycopene and phenolic acids (Berry, 2000). Phytonutrients are the naturally occurring substances in plants that are responsible for their color, hue, chroma, flavor and natural resistance to disease. Lycopene, the principal pigment conferring red color to tomatoes, contribute 87 percent of total carotenoids in ripe and red tomatoes (Kaur *et al.,* 2004; Singh and Rai, 2006). It is not only the most abundant but the most efficient singlet oxygen quencher (free radical scavenger) (Mascio *et al.,* 1989). Antioxidant function of lycopene is associated with immune-stimulatory properties, lowering DNA damage, malignant transformation and reducing biological oxidative damage of proteins, lipids and other cell components (Krajcovicova-Kudlackova and Dusinska, 2004). Because of all these properties, it is considered as nutritionally important. Several researchers have worked on the extraction of tomato juice and studied their storage stability. Tomatoes are eaten all over the world in the form of salads, in burgers and sandwiches, sauces, ketchups, pastes, soups, powder, canned whole. One more convenient way to consume tomato is in the form of juice. Several researchers have worked on the preservation of tomato juice by heat treatment but high temperature reduces the nutrional quality. Therefore, tomatoes can be chemically preserved in the order to increase its shelf stability. Hence, the present investigation has been carried out with the objective to study the effect of chemical treatments and storage on physicochemical, phytochemical compounds and antioxidant activity of tomato juice.

MATERIALS AND METHODS

Raw materials: The study was conducted in the Department of Food Science and Technology, Punjab Agricultural University, Ludhiana. Tomatoes were procured from the local market.

Extraction process of tomato juice: Fresh tomatoes were washed thoroughly. The tomato juice was extracted in a juicer extractor (Kalsi: 9001-2008). The juice was pasteurized at 83°C for 3 min and citric acid @ 0.15% was added, followed by chemical preservatives.

Dose distribution of chemical additives

Sample	Chemical additives	Dose(ppm)
T_2	Na-benzoate	3000
T_3	KMS	3000
T_4	Na-benzoate+ KMS	1500+1500

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The pre-sterilized glass bottles were filled with the hot juice and corked. T_1 sample was given the pasteurization treatment followed by processing at 100°C for 20 min in boiling water bath and gradually cooled to a low temperature under running tap water. These processed juices were kept for storage at room temperature for six months.

Analytical evaluation

Physico-chemical analysis: Carrot juices were analysed at regular interval of one month for the parameters like Total solids**,** Titratable acidity using AOAC methods (AOAC, 2000). TSS was taken using hand refractometer (ERMA, Japan), Color (Lab) using Minolta Hunter colorimeter.

Determination of vitamin C: Ascorbic acid was extracted from the sample with 0.4 per cent oxalic acid and determined by titrimetric method using 2, 6-dichlorophenol indophenol dye solution (0.04 per cent) which was standardized against standard L-ascorbic acid (0.1 mg/ml of 0.4 per cent oxalic acid). 5g sample was taken for estimation and volume was made to 100 ml with 0.4 per cent oxalic acid solution. It was filtered and 10 ml aliquot was titrated with standardized dye. The end point was recorded as pink color, which persisted for atleast 15sec. The results were expressed as ascorbic acid mg percent of sample (Ranganna, 1997).

Determination of total phenolic content: The total phenolic content of blended juice was determined with the Folin–Ciocalteu method (Singleton *et al.*, 1999). Five gram of RTS juice was taken and refluxed with 80% methanol for two hours in a round bottom flask and residue was then further refluxed for an hour. After filtration of the extract volume was made to 100 mL with 80% methanol. Filtrate (0.5 ml) was taken into a test tube containing 0.5 ml water. The Folin- Ciocalteau reagent (5 ml) then kept for 5 min, and saturated solution of sodium carbonate (1 ml) was mixed. A standard curve was plotted by taking known amount of Gallic acid as reference standard and concentration was calculated from the standard curve.

Determination of % anti oxidant activity: Free radical scavenging activity was determined by DPPH (2,2- di phenyl picryl-1- hydrazyl) method. A method according to Brand-Williams *et al.* (1995) was followed with some modifications. Five gram of blended RTS juice was taken and refluxed with 80% methanol for two hours in a round bottom flask and residue was then further refluxed for one hour. After filtration of the extract volume was made to 100 ml with 80% methanol. To 1ml of methanolic extract of sample, 2ml of 1mM freshly prepared DPPH and 1ml of 50 mM tris buffer was added and absorbance was determined at 517 nm (blank as 80 per cent methanol and tris buffer) after 30 minutes. The free radical scavenging activity was evaluated by comparing the absorbance of the sample solution with control solution to which distilled water was added instead of sample. BHT was taken as a standard at a fixed concentration of 5mg/ml.

$$\% AA = \frac{\text{Control OD(0 min)} - \text{Sample OD(30 min)} \times 100}{\text{Control OD (0 min)}}$$

Determination of total carotenoids and lycopene: Total carotenoids and lycopene were also estimated using Ranganna, (1997) methods Sample was extracted with acetone in a pestle and mortar using sodium sulphate until the residue was colorless. This extract was transferred to separatory funnel and 10-15 ml of petroleum ether was added. Pigments were transferred to the petroleum ether phase by diluting the acetone by water. Extraction of acetone phase with small volume of petroleum ether was repeated till colorless. Petroleum ether extract was filtered and transferred to 25 ml volumetric flask and volume was made up to the mark with petroleum ether. The total carotenoids were estimated by measuring the O.D of the extract at 452 nm using petroleum ether as blank.

The total lycopene content was estimated by measuring the O.D of the above extract at 503 nm using petroleum ether as blank.

$$\text{Lycopene mg/100g} = \frac{3.1206 \times \text{O.D} \times \text{volume made} \times \text{dilution factor} \times 100}{\text{Weight of sample} \times 1000}$$

Statistical analysis: The results were evaluated by Analysis of Variance (ANOVA) and Tukey's post hoc tests using Systat statistical program version 16 (SPSS Inc., USA).

RESULTS AND DISCUSSION

The samples were studied for the effect of different chemical additives on Physicochemical [TS, TSS, Acidity, Color (L, a, b)], Phytochemical (Ascorbic acid, Total Carotenoids, Lycopene and Total phenols) and % antioxidant activity for the storage period of 6 months.

Effect on total solids and TSS: TS increased non-significantly ($p \leq 0.05$) in all the juices during the storage. On the day of preparation, the amount of TS in sample T1, T2, T3, T4 were 7.17, 7.22, 7.37 and 7.31 per cent respectively. At the end of 6 months, the TS in the samples increased to 9.33, 8.43, 8.05 and 8.17 per cent respectively. The TSS values of samples T_1 to T_4 on day first were 4.1 for each sample which gradually increased to 4.3 for T1 and 4.2 for T2 to T4 after 6 months of storage. Although TSS increased for all the samples but the changes were non-significant ($p \leq 0.05$). An increase in soluble content of apple pulp was reported during storage when preserved with chemical

preservatives (Kinh *et al.*, 2001). The treatments had no significant effect ($p \leq 0.05$) on Total solids as well as TSS.

Effect on acidity: According to the results, chemical additives as well as storage has a non-significant effect ($p \leq 0.05$) on acidity of the Tomato juice. The titratable acidity of sample T_1 on day first was found to be 0.438 and 0.441 percent for the three chemically treated samples (T_2 to T_3) that gradually increased to 0.503, 0.488, 0.482 and 0.485 percent respectively (Fig 1). A slight increase in titratable acidity was also found during storage of papaya products (Kulwal *et al.*, 1985). The acidity of the thermally treated sample (T_1) increased more as compared to other chemically treated samples and the change was least in T3 sample.

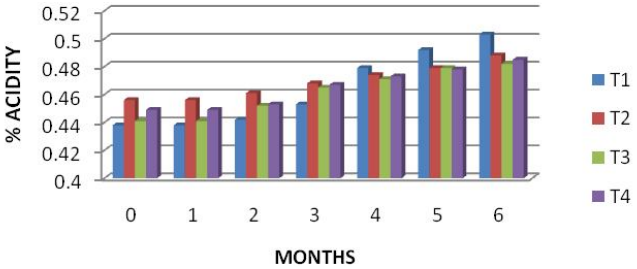


FIG 1: Effect of storage period and treatments on Titratable acidity (%) of Tomato juice*

Effect on color (L a b values): Color is one of the most important visual attributes for juices. The L, a, b value varied non-significantly ($p \leq 0.05$), both for storage as well as chemical treatments. On the day of preparation, the lightest sample was T_3 followed by T_4, T_2 and T_1. The lightness of sample T_3 containing KMS is attributed to the bleaching action of KMS that helped to maintain the bright red color of the juice. At the end of 6 months, T_3 remained the lightest and T_1 was found dull than the other samples.

Effect on vitamin C content: Vitamin C is light and heat sensitive, the concentration of vitamin C follows first order kinetics and thus storage time affects vitamin C content (Heldman and Singh, 1981). According to the results, chemical additives have significant effect ($p \leq 0.05$) on vitamin C content. Also the vitamin C content decreased significantly ($p \leq 0.05$) during the storage. On the day of preparation, vitamin C content in samples T_1 was 12.66 and 13.11 mg/100g for the three chemically treated samples. The values came out to be lower in T_1 as heat treatment destroys vitamin C. At the end of 6 months, the vitamin C content reduced to 6.39, 7.36, 8.82 and 7.91mg/100g for samples T1 to T3 respectively (Fig 2). Out of the chemically treated samples, potassium metabisulphite retained the maximum Vitamin C. The application of KMS reduces the loss of ascorbic acid during the storage of leafy vegetables (Negi and Roy, 2000).

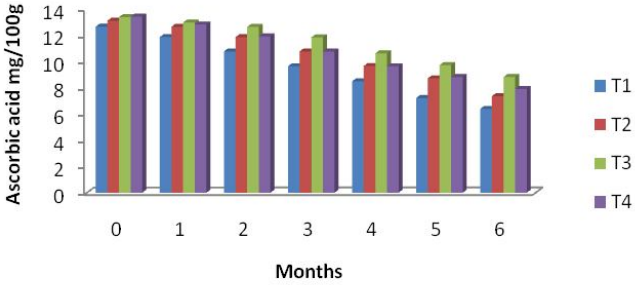


FIG 2: Effect of storage period and treatments on Ascorbic acid content (mg/100g) of Tomato juice

Effect on total phenols: The total phenolic content in samples T_1 to T_4 on the first day was 47.39, 48.11, 48.57 and 47.87mg/100g respectively. The added chemicals preserved the phenolic content more than thermally treated sample (T_1). But both the treatments and storage affected the Total phenols non-significantly ($p \leq 0.05$). At the end of 6 months, the Total phenolic content came out to be 40.81, 42.89, 43.92 and 42.16 mg/100g respectively (Fig 3). According to the findings, a decrease in total polyphenol content of tomato juices after 3, 6 and 9 months of storage were reported (Vallverdu-Queralt *et al.*, 2011). The decrease was found to be least in sample T_3, followed by T_4 and T_2.

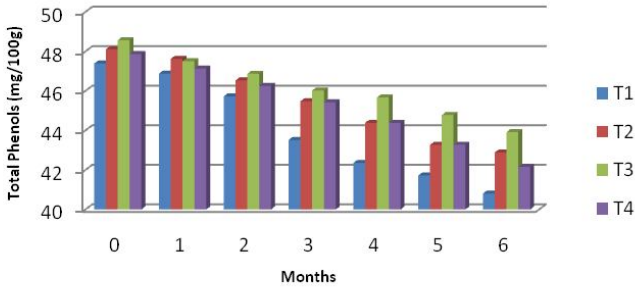


FIG 3: Effect of storage period and treatments on total phenols (mg/100g) of tomato juice

Effect on antioxidant activity: Antioxidants delay the oxidation process, inhibiting the polymerization chain initiated by free radicals and other subsequent oxidizing reactions (Halliwell and Aruoma, 1991). According to the results, on the day of preparation, percent antioxidant activity for samples T_1 to T_4 was found to be 45.77, 47.33, 49.48 and 48.73 percent respectively (Fig 4). Non-Significant ($p \leq 0.05$) decrease in antioxidant activity was found during storage for 6 months.

At the end of 6 months, the percent antioxidant activity slightly decreased to 41.92, 42.77, 45.88 and 44.73 percent respectively. However, the decrease was found to be least in sample T_3. It has been reported that the decrease in antioxidant activity may be linked to a decrease in total phenolic content and vitamin C during storage (Klimczak *et*

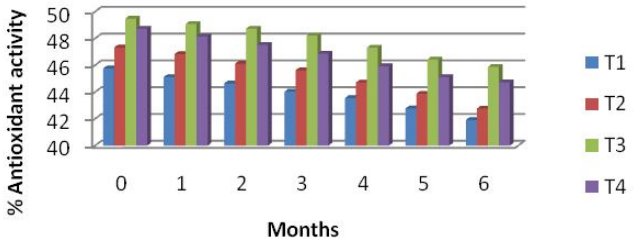
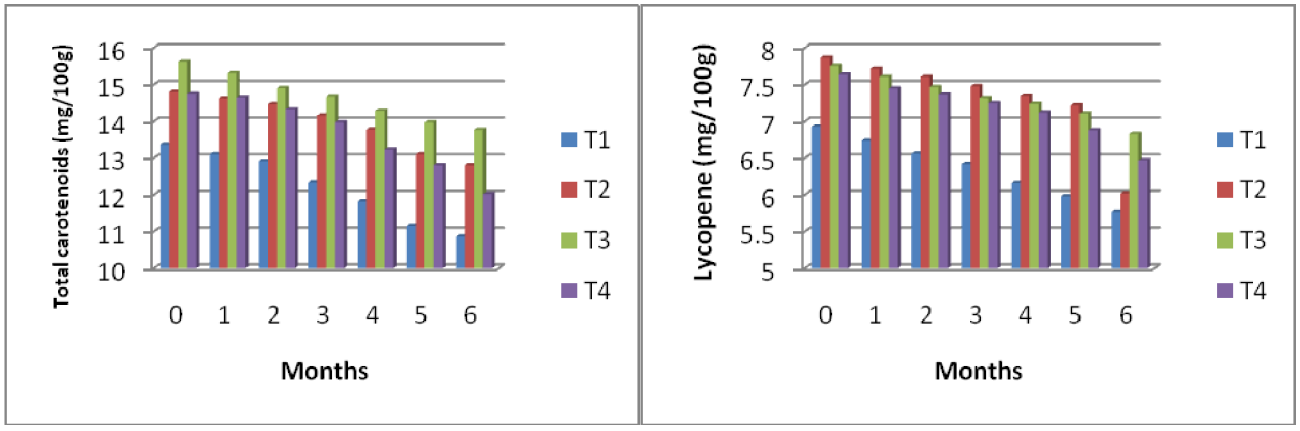


FIG 4: Effect of storage period and treatments on % antioxidant activity of tomato juice

al., 2007). According to them, antioxidant activity of orange juices decreased by 45 percent after 6 months of storage at 28°C.

Effect on Total carotenoids and lycopene: Effect of storage on total carotenoids and β-carotene of tomato juice is shown in Figure 5(a) and 5(b) respectively. Total carotenoids decreased non-significantly ($p \leq 0.05$) from 13.37 to 10.87, 14.81 to 12.81, 15.63 to 13.77 and 14.75 to 12.02 mg/100g for the samples T1, T2, T3 and T4 respectively after 6 months of the storage. The decrease in total carotenoids and β -carotene content may be due to oxidation of highly unsaturated carotenoid structure (Kidmose *et al.*, 2002). Lycopene content also showed non-significant ($p \leq 0.05$) reduction during storage of 6 months. The reduction in Lycopene was found to be from 6.93 to 5.77, 7.87 to 6.02, 7.76 to 6.83 and 7.64 to 6.47mg/100g respectively. These findings were in agreement with Lin and Chen (2005) who reported decrease in the lycopene and its isomers during storage due to oxidative degradation. For both total carotenoids and lycopene, the maximum retention was of the KMS treated sample. Beneficial action of sulfite as an antioxidant in stabilizing carotenoids in dehydrated vegetables has been reported (Nutting *et al.*, 1970).



(a) **(b)**

FIG 5: Effect of storage period and treatments on (a) total carotenoids (mg/100g) (b) lycopene (mg/100g) of tomato juice

CONCLUSION

The experiment was to compare the effect of different chemical additives on the storage stability of tomato juice. In this study, it is evident that potassium metabisulphite proved to be a better preservative than Na-benzoate, the combination (KMS+Na-Benzoate) and thermal treatment for the stability of physicochemical and phytochemical parameters and maintaining the antioxidant activity of the tomato juice. At the end of storage period of six months, non-significant change was found in all the parameters except 'L' value and vitamin C. KMS samples were found to retain the maximum nutritional quality and antioxidant activity. There was significant increase in the shelf stability of the chemically preserved juices than the thermally treated samples.

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