Effect of thermal processing and chemical preservatives on the physicochemical and phytochemical parameters of carrot juice

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Abstract

Carrot is an excellent source of β-carotene and antioxidants. Carrot is a cool season crop and during the harvesting season, large quantities get spoiled due to excess production. So a long term preservation method is required that could be useful to prevent spoilage of carrot such that it could be consumed in off seasons as well. Keeping in view the nutritional and therapeutic value of carrots carrot, juice was processed and treated with different chemical additives and tested for various physichochemical, phytochemical characteristics and antioxidant activity. At the end of storage period of six months, KMS treated samples were found to retain the maximum nutritional quality. There was significant (p ≤ 0.05) increase in the shelf stability of the chemically preserved juices than the thermally treated samples.

Key words: Antioxidant activity, Carrot, Phenolics, Phytochemicals, Storage.

INTRODUCTION

Carrot (Daucus carota Sativus) is one of the most important seasonal root vegetable of Apiaceae (Umbelliferae) family, grown extensively in India during winter season. It is an excellent source of β-carotene, a precursor of vitamin A, which protects cells from free radicals which may damage the basic cell structure of healthy cells (Demir et al., 2004; Yoon et al., 2005). Carrot is rich in antioxidants like α-carotene, β-carotene, phytochemicals, glutathion, calcium, phosphorus and consumed as versatile vegetable with excellent source of calcium pectate, an extraordinary pectin fiber that has the cholesterol lowering properties (Kaur et al., 2012). Carrot juice has the therapeutic properties which improves the boosting of immunity, helps to heal minor wounds, injuries, reduce the risk of heart disease and blood pressure. It cleans the liver by excreting fats and bile, helps to fight anaemia, improves eye health, reduces the risk of high blood pressure, stroke, heart disease and some types of cancer (Wrolstad, 2004; Bahkru, 1993). Because of all these properties, it is considered as health drink. Several studies have been conducted to quantify the physicochemical, phytochemical and antioxidant activity of Carrot so far, there has not been a systematic study on the effect of various chemical additives or preservatives on the shelf life of carrot juice. Keeping in view the nutritional and therapeutic value of carrots and to make them available throughout the year, carrot juice can be prepared, treated, stored and tested for various characteristics. Hence, the present investigation has been carried out with the objective to study the effect of processing and storage on bioactive compounds and antioxidant activity of carrot juice.

MATERIALS AND METHODS

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

Extraction process of carrot juice: Fresh carrots were washed thoroughly and cut off from the top and were peeled. The Carrot 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.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Chemical additives</th>
<th>Dose(ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₂</td>
<td>Na-benzoate</td>
<td>3000</td>
</tr>
<tr>
<td>T₃</td>
<td>KMS</td>
<td>3000</td>
</tr>
<tr>
<td>T₄</td>
<td>Na-benzoate + KMS</td>
<td>1500+1500</td>
</tr>
</tbody>
</table>

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The pre-sterilized glass bottles were filled with the hot juice and corked. T, sample was given the pasteurization treatment followed by processing at 100°C for 20 min in boiling water bath and gradually cooled to the room 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 standardised 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). 5 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 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 carotenoids and β-carotene:** Total carotenoids and β-carotene 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 separating 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.

For separation of β-carotene, a glass column filled with aluminium oxide was taken. Prior to use, it was activated by drying in oven for 2 h at 100°C to be free from moisture. 1 cm layer of Na₂SO₄ was added over the top of the column. The column was washed with acetone in petroleum ether ether. 5 ml of the extract was loaded on to the column carefully. α-carotene moved off the column prior to all other pigments. Column was washed with eluent till the desired pigments have moved off the column and the eluent is colorless. The extract was collected in the 10 ml volumetric flask and the volume was made up with 3 per cent acetone in petroleum ether ether. The intensity of the color was then read at 452nm in spectrophotometer using 3 per cent acetone in petroleum ether ether as blank. A standard curve was prepared taking 25 mg of α-carotene dissolved in 2.5 ml of chloroform and made upto volume (250ml) with petroleum ether ether. The absorbance was plotted against concentration for the standard curve.

mg of carotene per 100 g =

\[\text{Conc. of } \beta\text{-carotene from std. curve x final vol. x dilution factor} \times 100\]

Weight of sample

**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).

**Effect on Total solids and TSS:** TS increased non-significantly (p≤0.05) in all the end of 6 months of storage. On the day of preparation, the amount of %TS in the samples

\[\% \text{ AA} = \frac{\text{Control OD}(0 \text{ min}) - \text{Sample OD}(30 \text{ min}) \times 100}{\text{Control OD}(0 \text{ min})}\]
The treatments had no significant effect (p ≤ 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 ≤ 0.05) on acidity of the carrot juice. The titratable acidity of samples T₁ to T₄ on day first was 8.3 for each sample (Table 1) which gradually increased non-significantly (p ≤ 0.05) after 6 months of storage. 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 ≤ 0.05) on Total solids as well as TSS.

**Effect on color (L, a, b values):** Color is one of the most important visual attributes for juices. The L value varied significantly (p ≤ 0.05), both for storage as well as chemical treatments. On the day of preparation, the lightest sample T₁ followed by T₃, T₂, and T₄ (Table 1). The lightness of sample T₃ 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, T₁ remained the lightest and T₃ was found dull than the other samples. The ‘a’ and ‘b’ values changed non-significantly (p ≤ 0.05) (Table 1).

**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 ≤ 0.05) on vitamin C content. Also the Vitamin C content decreased significantly (p ≤ 0.05) during the storage. On the day of preparation, Vitamin C content in samples (mg/100g) is given in Table 2. The values came out to be lower in T₂, as heat treatment destroys vitamin C. At the end of 6 months, the vitamin C content reduced significantly (p ≤ 0.05). 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).

**Effect on total phenols:** The total Phenolic content in samples T₁ to T₄ on the first day is given in Table 2. The added chemicals preserved the phenolic content more than thermally treated sample (T₀). But both the treatments and 6 months storage decreased the Total phenols significantly (p ≤ 0.05). According to the findings, a decrease in total polyphenol content of tomato juices after 3, 6 and 9 months of storage were reported (Valverdu-Queralt et al., 2011). The decrease was found to be least in sample T₁, followed by T₄ and T₃.

**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, percent Antioxidant activity for samples T\textsubscript{1} to T\textsubscript{4}, given in Table 2, on the first day of preparation was found to found to decrease significantly (p≤0.05) during storage for 6 months. However, the decrease was found to be least in sample T\textsubscript{4}. 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 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 β-carotene:** Effect of storage on Total carotenoids and β-carotene of carrot juice is shown in Table 2. Both Total carotenoids and β-carotene decreased non-significantly (p≥0.05) with treatments and 6 months of the storage. Dhaliwal and Hira (2001) also observed the decreasing trend in β-carotene content during six month storage of carrot: beetroot (95:5) beverage. The slight decrease in total carotenoids and β-carotene content may be due to oxidation of highly unsaturated carotenoid structure (Kidmose et al., 2002). Chen et al. (1996) observed the stability of carotenoids during storage of carrot juice by subjecting the carrot juice to storage at different temperatures and in light and dark for 3 months.

**CONCLUSION**

The experiment was to compare the effect of different chemical additives on the storage stability of Carrot juice. In this study, it is evident that potassium metabisulphite proved to be a better preservative than Na-benzoate, the combination (KMS+Na-Benzate) and thermal treatment for the stability of physicochemical and phytochemical parameters and maintaining the antioxidant activity of the carrot 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.

**REFERENCES**


