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# Development of technology for preparation of fortified tomato (*Solanum lycopersicum* L.) beverage

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**Abstract**
The present investigation entitled "Development of technology for preparation of fortified tomato (*Solanum lycopersicum* L.) beverage" was aimed to evaluate the sensory as well as nutritive quality of developed product during storage. For preparation of tomato beverage using different levels of calcium chloride ($C_1$- control, $C_2$ - 0.5%, $C_3$ - 1.0% and $C_4$- 1.5%) and xanthan gum ($X_1$- control, $X_2$- 0.25%, $X_3$- 0.50%, $X_4$- 0.75% and $X_3$- 1.00%). The experiment was laid out using completely randomized design with factorial concepts. Overall findings of investigation revealed that tomato beverage can be prepared using 1.0 per cent calcium chloride with 0.5 per cent xanthan gum ($C_3X_3$) was found better. The tomato beverage can be successfully stored for a period of 6 months in glass bottle without much changes in physico-chemical, sensory and microbial quality.

**Keywords:** Technology, preparation, fortified tomato, *Solanum lycopersicum*

## Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important edible and nutritional vegetable crops in the world. It is most adaptable and productive crop in poly house as well as open field condition. Tomato is a native to Peruvian and Mexican region and a member of the 'Solanaceae' family (Willcox *et al.*, 2003) [14]. In India, it is being cultivated in Madhya Pradesh, Karnataka, Andhra Pradesh, Telangana, Gujarat, Odisha and West Bengal. Among all states, Madhya Pradesh is leading in tomato production with annual production of 31.02 lakh metric tons. In Gujarat, it is grown over an area of 46.40 thousand hectares with an average annual production of 13.19 lakh metric tons (Anon., 2017) [1].

Tomato is highly nutritious and delicious fruit vegetable. It contains 94.7 per cent water, 1.0 per cent protein, 0.1 per cent fat, 1.6 per cent fiber, 1.9 per cent carbohydrates and 0.51 per cent organic acids (Mc Glasson, 1993; Rai *et al.*, 2002) [6]. Beverage prepared from fruit or vegetable can be one of the refreshing drinks having zero carbonation, relatively low or zero preservative which are excellent source of several important vitamins and minerals. The beverage can be prepared in various forms *viz.*, RTS, nectar, squash, crush and syrup (Bhagwan and Awadhesh, 2014).

According to WHO (2003) [13], the process whereby nutrients are added to foods (in relatively small quantities) to maintain or improve the quality of the diet for such a community or a population is known as food fortification. Calcium is one of the most important nutrient for bone health. It is essential for the normal development and maintenance of the skeleton and the proper functioning of neuromuscular and cardiac systems (Mccarron and Heaney, 2004) [5]. Xanthan gum is an extracellular polysaccharide secreted by *Xanthomonas campestris*. It is used in the food industries for improving texture, enhancing viscosity, creating gel structures and control crystallization in many food products (Pongsawatmanit *et al*., 2011) [9].

## Materials and methods
**Raw material:** The experiment was conducted at the Laboratory of Centre of Excellence on Post Harvest Technology, ASPEE college of Horticulture and Forestry, N.A.U., Navsari. Fully ripened tomatoes were procured from Regional Horticulture Research Station, Navsari Agricultural University, Navsari.

The tomatoes were weighed, sorted and washed thoroughly in clean water and cut into pieces by using knife.

**Methodology adopted for product preparation:** The tomato pieces were boiled for 10 min. Then pulp was extracted by removing peel and seeds by using pulper. A total number of 20 treatments were studied for preparation of fortified tomato beverages using four levels of calcium chloride (Factor 1) along with five levels of xanthan gum (Factor 2). The acidity of the fortified beverage was adjusted to 0.3 per cent in all the treatments. The black salt was added to the beverage at 0.1 per cent concentration in all treatments.

**Experimental details:** There were 20 treatment combinations used for preparation of tomato beverage with four different levels ofcalcium chloride (factor 1) and five different levels of xanthan gum (factor 2) and processed into tomato beverage and their details are as follows:

**Factor 1:** Calcium chloride levels (C)

| Calcium chloride levels (C) | *Concentrations (%) |
|---|---|
| $C_1$ | 0 |
| $C_2$ | 0.5 |
| $C_3$ | 1.0 |
| $C_4$ | 1.5 |

**Factor 2:** Xanthan gum levels (X)

| Xanthan gum levels (X) | *Concentrations (%) |
|---|---|
| $X_1$ | 0 |
| $X_2$ | 0.25 |
| $X_3$ | 0.50 |
| $X_4$ | 0.75 |
| $X_5$ | 1.00 |

Treatment combinations

| | | | |
|---|---|---|---|
| 1 = $C_1X_1$ | 6 = $C_2X_1$ | 11 = $C_3X_1$ | 16 = $C_4X_1$ |
| 2 = $C_1X_2$ | 7 = $C_2X_2$ | 12 = $C_3X_2$ | 17 = $C_4X_2$ |
| 3 = $C_1X_3$ | 8 = $C_2X_3$ | 13 = $C_3X_3$ | 18 = $C_4X_3$ |
| 4 = $C_1X_4$ | 9 = $C_2X_4$ | 14 = $C_3X_4$ | 19 = $C_4X_4$ |
| 5= $C_1X_5$ | 10 = $C_2X_5$ | 15 = $C_3X_5$ | 20 = $C_4X_5$ |

**Physical-chemical and sensory analysis of tomato beverage**

The total soluble solids (TSS) of beverage were determined by Abbe refractometer, acidity, ascorbic acid, total sugars, reducing sugars and lycopene were determined by the methods described by Rangana, 1997. Calcium was determined by versnate method as detailed by Jackson, 1973. The samples of tomato beverage analysed on the basis of colour, texture, taste, flavour and overall acceptability using 9 point Hedonic scale according to the method of Amerine *et al.* (1965) [2]. Sensory panelists (7-9 members) comprised of trained faculty members and PG students of ASPEE College of Horticulture and Forestry, NAU, Navsari (Gujarat) were employed for sensory evaluation throughout the entire period of storage.

**Results and Discussion**

**Physico-chemical parameters:** The effect of different treatments on physic-chemical parameters of tomato beverage during six months of storage has been presented in following heads.

**Total soluble solids (TSS)**

**Effect of calcium chloride:** The data pertaining to TSS of tomato beveragehas been presented in Table 1. It was observed that grand mean TSS of beverage (C) varied from 12.81°Brix to 14.24°Brix when beverage contain different concentrations of calcium chloride. The minimum TSS was found in beverage prepared without using calcium chloride ($C_1$) and maximum TSS in beverage prepared by using 1.5 per cent calcium chloride ($C_4$). The effect of calcium chloride was found significant and higher in TSS was due to addition of calcium chloride, which contain about 99 per cent solids. Similar results have been reported by Kumar and Parimita (2016) [4] for fortified tomato leather.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean TSS of beverage (X) varied from 13.10°Brix to 13.42°Brix, with minimum TSS (13.10°B) in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) while, maximum TSS (13.42°B) in beverage prepared by using 0.75 per cent xanthan gum ($X_4$) and the effect of xanthan gum was found significant. It might be due to hydrocolloids control crystallization in beverage (Norhayati *et al.*, 2019) [7].

**Effect of storage period:** Data depict that storage of beverage resulted increase in mean TSS (P) from initial value of 13.13°Brix to 13.53°Brix after six months of storage and the effect of storage period was found significant. The increase in TSS during storage might be attributed to conversion of polysaccharides to simple sugars (Kumar and Parimita, 2016) [4].

**Effect of interaction:** The interaction of calcium chloride, xanthan gum and storage period (C×X×P) has showed significant difference for TSS. Further, increase in TSS of tomato beverage during six months storage was found minimum (13.50°B to 13.67°B, 13.00°B to 13.17°B and 13.75°B to 13.92°B) in beverage prepared by using 0.5 per cent calcium chloride with 0.25 per cent xanthan gum ($C_2X_2$), 1.0 per cent calcium chloride along with 0.25 per cent xanthan gum ($C_3X_2$) and 1.0 per cent calcium chloride along with 0.75 per cent xanthan gum ($C_3X_4$), respectively. Whereas, increase in TSS was found maximum (12.83°B to 13.58°B and 12.17°B to 12.92°B) in beverage prepared by using 0.5 per cent calcium chloride with control level of xanthan gum ($C_2X_1$) and 0.25 per cent xanthan gum with control level of calcium chloride ($C_1X_2$). However, non-significant difference was observed in TSS among interaction of calcium chloride and storage period (C×P).

**Acidity**

**Effect of calcium chloride:** The data pertaining to acidity of tomato beverage has been presented in Table 2. It was observed that grand mean acidity (C) of beverage varied from 0.34 per cent to 0.36 per cent, with minimum acidity in beverage prepared by using 0.5 per cent calcium chloride ($C_2$) and maximum acidity in beverage prepared by using 1.5 per cent calcium chloride ($C_4$). However, the effect of calcium chloride was found non-significant.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean acidity (X) of beverage contain different concentrations of xanthan gum varied from 0.33 per cent to 0.36 per cent with minimum acidity in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) while, maximum acidity in beverage prepared without using of xanthan gum ($X_1$) and the effect of xanthan gum was found significant.

**Effect of storage period:** Data depict that storage of beverage resulted increase in mean acidity (P) from initial value of 0.33 per cent to 0.37 per cent after six months of storage and the effect of storage period was found significant. Similar results was reported by Sree and Vanajalata (2015) [11] for orange and pomegranate blended RTS which might be due to release of acids from pulp or juice particles due to autolysis of cells.

**Effect of interaction:** Further, increase in acidity of tomato beverage during six months storage was found maximum (0.32% to 0.41%) in beverage prepared without using calcium chloride and xanthan gum ($C_1X_1$). Whereas, acidity was remain stable in beverage prepared by using 1.0 per cent calcium chloride along with 0.25, 0.5 and 1.0 per cent xanthan gum ($C_3X_2$, $C_3X_3$ and $C_3X_5$) as well as 1.5 per cent calcium chloride along with 0.25 per cent xanthan gum ($C_4X_2$) after six months of storage that were 0.34, 0.36, 0.34 and 0.36 percent, respectively. However, non-significant difference was observed in acidity among interaction of calcium chloride, xanthan gum and storage period (C×X×P). Furthermore, significant difference was observed in acidity among interaction of calcium chloride and storage period (C×P). It might be due to hydration of the added calcium compound with acid during storage (Szajnar *et al.*, 2017) [12].

**Ascorbic acid**

**Effect of calcium chloride:** The data pertaining to ascorbic acid of tomato beverage has been presented in Table 3. It was observed that grand mean ascorbic acid (C) of beverage varied from 4.82 to 5.01 mg/100 ml, with maximum ascorbic acid in beverage prepared by using 1.0 per cent calcium chloride ($C_3$) and minimum ascorbic acid in beverage prepared without using of calcium chloride ($C_1$). However, the effect of calcium chloride was found non-significant.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean ascorbic acid of beverage contains different concentrations of xanthan gum (X) varied from 4.70 to 5.14 mg/100 ml, with minimum ascorbic acid (4.70 mg/100 ml) in beverage prepared without using of xanthan gum ($X_1$) and using of 0.25 per cent xanthan gum ($X_2$) while, maximum ascorbic acid (5.14 mg/100 ml) in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) and the effect of xanthan gum was found significant. It might be due to hydrocolloids help to prevent oxidation of vitamin C in beverage (Nwaokoro and Akanbi, 2015) [18].

**Effect of storage period:** Data depict that storage of beverage resulted decrease in mean ascorbic acid (P) from initial value of 5.03 to 4.73 mg/100 ml after six months storage and the effect of storage period was found significant. Ascorbic acid content decreased with the advancement of storage period which might be due to oxidation by trapped oxygen in glass bottles and formation of dehydro-ascorbic acid (Sree and Vanajalata, 2015) [11].

**Effect of interaction:** Further, decrease in ascorbic acid of tomato beverage during six months storage was found maximum (4.85 mg/100 ml to 3.81 mg/100 ml) in beverage prepared by using 0.5 per cent calcium chloride with control level of xanthan gum ($C_2X_1$) and 0.25 per cent xanthan gum with control level of calcium chloride ($C_1X_2$). While, no changes were found in beverage prepared by using 0.5 per cent calcium chloride along with 0.25 per cent, 0.75 per cent and 1.0 per cent xanthan gum ($C_2X_2$, $C_2X_4$ and $C_2X_5$) as well as 1.0 per cent calcium chloride along with 0.50 per cent and 0.75 per cent xanthan gum ($C_3X_3$ and $C_3X_4$) up to six months storage that were 4.85, 5.20, 5.20, 5.20 and 4.85 mg/100 ml, respectively. However, non-significant difference was observed in ascorbic acid among interaction of calcium chloride, xanthan gum and storage period (C×X×P).

**Reducing sugars**

**Effect of calcium chloride:** The data pertaining to reducing sugars of tomato beverage has been presented in Table 4. It was observed that grand mean reducing sugars (C) of beverage varied from 10.10 per cent to 10.43 per cent in beverage contain different concentrations of calcium chloride, with minimum reducing sugars in beverage prepared by using 1.5 per cent calcium chloride ($C_4$) and maximum in beverage prepared by using 0.5 per cent calcium chloride ($C_2$). Furthermore, the effect of calcium chloride was found significant.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean reducing sugars (X) of beverage contain different concentrations of xanthan gum varied from 10.19 per cent to 10.42 per cent with minimum reducing sugars in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) while, maximum in beverage prepared by using 0.5 per cent xanthan gum ($X_3$) and the effect of xanthan gum was found significant.

**Effect of storage period:** Data depict that storage of beverage resulted increase in mean reducing sugars (P) from initial value of 10.21 per cent to 10.36 per cent after six months of storage. Further, slightly decrease in reducing sugar in tomato beverage was observed at four months storage and the effect of storage period was found significant. It might be due to inversion of non reducing sugars to reducing sugars by acids present in the product.

**Effect of interaction:** The interaction of calcium chloride, xanthan gum and storage period (C×X×P) has showed significant difference for reducing sugars. Further, increase in reducing sugars of tomato beverage during six months storage was found maximum (10.11% to 10.72%) in beverage prepared by using 0.5 per cent calcium chloride along with 0.5 per cent xanthan gum ($C_2X_3$). Whereas, minimum increase (9.95% to 10.05%) was found in beverage prepared by using 1.0 per cent calcium chloride along with 1.0 per cent xanthan gum ($C_3X_5$).

**Total sugars**

**Effect of calcium chloride:** The data pertaining to total sugars of tomato beverage has been presented in Table 5. It was observed that grand mean total sugars (C) of beverage varied from 16.37 per cent to 16.64 per cent, with minimum total sugars in beverage prepared using 1.0 per cent calcium chloride ($C_3$) while, maximum in beverage prepared without using of calcium chloride ($C_1$) and the effect of calcium chloride was found significant.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean total sugars (X) of beverage contains different concentrations of xanthan gum varied from 16.05 per cent to 17.22 per cent with minimum total sugars in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) while, maximum in beverage prepared by using 0.25 per cent

xanthan gum ($X_2$) and the effect of xanthan gum was found significant. It is probably due to thickners are polysaccharides in nature (Nwaokoro and Akanbi, 2015) [18].

**Effect of storage period:** Data depict that storage of beverage resulted increase in mean total sugars (P) from initial value of 16.18 per cent to 16.93 per cent after six months storage and the effect of storage period was found significant. Similar trend of increasing in total sugars was reported by Sree and Vanajalata (2015) [11] for orange and pomegranate blended RTS which might be due to hydrolysis of starch/sucrose into sugar.

**Effect of interaction:** The interaction of calcium chloride, xanthan gum storage period (C×X×P) has showed significant difference for total sugars. Further, increase in total sugars of tomato beverage during six months storage was found maximum (14.89% to 19.90%) in beverage prepared by using 0.5 per cent calcium chloride along with 0.50 per cent xanthan gum ($C_2X_3$). Whereas, minimum (17.57% to 17.73%) increase was found in beverage prepared without using calcium chloride with 0.25 per cent xanthan gum ($C_1X_2$).

**Lycopene**

**Effect of calcium chloride:** The data pertaining to lycopene content of tomato beverage has been presented in Table 6. It was observed that grand mean lycopene content (C) of beverage having different concentrations of calcium chloride varied from 0.989 to 0.990 mg/100 ml, with minimum lycopene (0.989 mg/100 ml) in beverage prepared by using 1.0 and 1.5 per cent calcium chloride ($C_3$ and $C_4$) while, maximum (0.990 mg/100 ml) in beverage prepared without or with 0.5 per cent calcium chloride ($C_1$ and $C_2$). However, the effect of calcium chloride was found non-significant.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean lycopene content (X) of beverage having different concentrations of xanthan gum varied from 0.988 mg/100 ml to 0.992 mg/100 ml with minimum lycopene content (0.988 mg/100 ml) in beverage prepared by using of 0.5 per cent xanthan gum ($X_3$) while, maximum lycopene content (0.992 mg/100 ml) in beverage prepared by using 1.0 per cent xanthan gum ($X_5$) and the effect of xanthan gum was found significant. It might be due to hydrocolloids prevents oxidation of lycopene in beverage (Nwaokoro and Akanbi, 2015) [18].

**Effect of storage period:** Data depict that storage of beverage resulted decrease in mean lycopene content (P) from initial value of 0.993 to 0.986 mg/100 ml after six months storage and the effect of storage period was found significant. The gradual decrease in lycopene content also reported by Nwaokoro and Akanbi (2015) [8] for tomato-carrot bended juice that might be due to degradation of lycopene due to oxidation and isomerization.

**Effect of interaction:** Further, decrease in lycopene content of tomato beverage during six months storage was found maximum (0.994 to 0.983 mg/100 ml) in beverage prepared by using 0.5 per cent xanthan gum ($C_1X_3$). While, minimum (0.994 to 0.991 mg/100 ml) change was found in beverage prepared by using 1.0 per cent calcium chloride along with 1.0 per cent xanthan gum ($C_3X_5$) which was followed by beverage prepared by using 1.0 per cent calcium chloride along with 0.50 per cent xanthan gum ($C_3X_3$) that was 0.990 to 0.986 mg/100 ml. However, non-significant difference was observed in lycopene among interaction of calcium chloride, xanthan gum and storage period (C×X×P). Furthermore, significant difference was observed in lycopene among interaction of xanthan gum and storage period (X×P).

**Calcium**

**Effect of calcium chloride:** The data pertaining to calcium content of tomato beverage has been presented in Table 7. It was observed that grand mean calcium content (C) of beverage having different concentrations of calcium chloride varied from 1.63 to 2.40 mg/100 ml, with minimum (1.63mg/100 ml) in beverage prepared without using calcium chloride ($C_1$) while, maximum (2.40mg/100 ml) in beverage prepared by using 1.5 per cent calcium chloride ($C_4$) and the effect of calcium chloride was found significant. It might be due to increasing level of calcium chloride increase calcium content in beverage.

**Effect of xanthan gum:** Data showed that among different treatments the grand mean calcium content (X) of beverage having different concentrations of xanthan gum (X) ranged from 1.94 to 2.06 mg/100 ml with minimum calcium (1.94 mg/100 ml) in beverage prepared without using xanthan gum ($X_1$) while, maximum calcium (2.06 mg/100 ml) in beverage prepared by using 1.0 per cent xanthan gum ($X_5$). However, the effect of xanthan gum was found non-significant.

**Effect of storage period:** Data depict that storage of beverage resulted decrease in mean calcium content (P) from initial value of 2.08 to 1.96 mg/100 ml after six months storage. However, the effect of storage period was found non-significant. Similar trend of decreasing calcium content with increasing storage period was reported by Szajnar *et al.* (2016) for calcium fortified yoghurt which might be due to hydration of the added calcium compound.

**Effect of interaction:** Further, decrease in calcium content of tomato beverage during six months storage was found maximum (2.0 to 1.73 mg/100 ml) in beverage prepared by using 1.0 per cent calcium chloride without xanthan gum ($C_3X_1$) while, no changes were found in beverage prepared by using 0.5 per cent calcium chloride along with 0.5 and 0.75 per cent xanthan gum($C_2X_3$ and $C_2X_4$) and 1.5 per cent calcium chloride along with 0.5 and 0.75 per cent xanthan gum ($C_4X_3$ and $C_4X_4$), respectively. Furthermore, calcium content was remain stable in beverage prepared by using 1.0 per cent calcium chloride along with 0.5 per cent xanthan gum ($C_3X_3$) upto four months storage. However, non-significant difference was observed for calcium content among interaction of calcium chloride, xanthan gum and storage period (C×X×P).

**Table 1:** Effect of different treatments on TSS (°B) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | TSS (°Brix) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 12.50 | 12.17 | 12.92 | 12.50 | 12.67 | 12.65 | 12.81 |
| | $C_2$ - 0.5 | 12.83 | 13.50 | 13.00 | 12.50 | 12.75 | 12.92 | 13.12 |
| | $C_3$ - 1.0 | 12.75 | 13.00 | 12.75 | 13.75 | 12.25 | 12.90 | 13.05 |
| | $C_4$ - 1.5 | 13.75 | 14.25 | 14.25 | 14.00 | 14.00 | 14.05 | 14.24 |
| | mean | 12.96 | 13.23 | 13.23 | 13.31 | 12.92 | 13.13 | |
| 2 month ($P_2$) | $C_1$ - 0 | 12.50 | 12.33 | 12.92 | 13.08 | 12.67 | 12.70 | |
| | $C_2$ - 0.5 | 12.83 | 13.58 | 13.17 | 12.50 | 12.75 | 12.97 | |
| | $C_3$ - 1.0 | 12.75 | 12.92 | 12.83 | 13.75 | 12.25 | 12.90 | |
| | $C_4$ - 1.5 | 13.75 | 14.25 | 14.25 | 14.00 | 14.00 | 14.05 | |
| | mean | 12.96 | 13.27 | 13.29 | 13.33 | 12.92 | 13.15 | |
| 4 month ($P_3$) | $C_1$ - 0 | 12.92 | 12.67 | 13.00 | 12.92 | 12.83 | 12.87 | |
| | $C_2$ - 0.5 | 13.17 | 13.75 | 13.33 | 12.75 | 13.08 | 13.22 | |
| | $C_3$ - 1.0 | 13.17 | 13.17 | 13.00 | 13.92 | 12.58 | 13.17 | |
| | $C_4$ - 1.5 | 14.42 | 14.42 | 14.42 | 14.42 | 14.33 | 14.40 | |
| | mean | 13.42 | 13.50 | 13.44 | 13.50 | 12.21 | 13.41 | |
| 6 month ($P_4$) | $C_1$ - 0 | 13.08 | 12.92 | 13.25 | 12.92 | 13.00 | 13.03 | |
| | $C_2$ - 0.5 | 13.58 | 13.67 | 13.42 | 12.92 | 13.25 | 13.37 | |
| | $C_3$ - 1.0 | 13.25 | 13.17 | 13.08 | 13.92 | 12.83 | 13.25 | |
| | $C_4$ - 1.5 | 14.42 | 14.50 | 14.50 | 14.42 | 14.42 | 14.45 | |
| | mean | 13.58 | 13.56 | 13.56 | 13.54 | 13.38 | 13.53 | |
| | Grand mean (X) | 13.23 | 13.39 | 13.38 | 13.42 | 13.10 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.015 | 0.017 | 0.034 | 0.015 | 0.030 | 0.034 | 0.067 |
| | CD at 5% | 0.043 | 0.048 | 0.097 | 0.042 | NS | 0.095 | 0.188 |
| | CV% | 0.87 | | | 0.87 | | | |

**Table 2:** Effect of different treatments on acidity (%) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Acidity (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 0.32 | 0.32 | 0.32 | 0.32 | 0.34 | 0.32 | 0.35 |
| | $C_2$ - 0.5 | 0.32 | 0.34 | 0.32 | 0.32 | 0.32 | 0.32 | 0.34 |
| | $C_3$ - 1.0 | 0.36 | 0.34 | 0.36 | 0.32 | 0.34 | 0.35 | 0.35 |
| | $C_4$ - 1.5 | 0.34 | 0.36 | 0.34 | 0.34 | 0.32 | 0.34 | 0.36 |
| | mean | 0.34 | 0.34 | 0.34 | 0.33 | 0.33 | 0.33 | |
| 2 month ($P_2$) | $C_1$ - 0 | 0.34 | 0.32 | 0.34 | 0.32 | 0.34 | 0.33 | |
| | $C_2$ - 0.5 | 0.32 | 0.34 | 0.32 | 0.32 | 0.32 | 0.32 | |
| | $C_3$ - 1.0 | 0.36 | 0.34 | 0.36 | 0.32 | 0.34 | 0.35 | |
| | $C_4$ - 1.5 | 0.34 | 0.36 | 0.34 | 0.34 | 0.32 | 0.34 | |
| | mean | 0.34 | 0.34 | 0.34 | 0.33 | 0.33 | 0.34 | |
| 4 month ($P_3$) | $C_1$ - 0 | 0.36 | 0.34 | 0.34 | 0.34 | 0.32 | 0.34 | |
| | $C_2$ - 0.5 | 0.34 | 0.36 | 0.34 | 0.34 | 0.32 | 0.34 | |
| | $C_3$ - 1.0 | 0.38 | 0.36 | 0.38 | 0.32 | 0.32 | 0.35 | |
| | $C_4$ - 1.5 | 0.36 | 0.36 | 0.38 | 0.38 | 0.34 | 0.37 | |
| | mean | 0.36 | 0.36 | 0.36 | 0.35 | 0.33 | 0.35 | |
| 6 month ($P_4$) | $C_1$ - 0 | 0.41 | 0.36 | 0.38 | 0.38 | 0.36 | 0.38 | |
| | $C_2$ - 0.5 | 0.38 | 0.38 | 0.34 | 0.34 | 0.34 | 0.36 | |
| | $C_3$ - 1.0 | 0.38 | 0.34 | 0.36 | 0.34 | 0.34 | 0.35 | |
| | $C_4$ - 1.5 | 0.38 | 0.36 | 0.38 | 0.38 | 0.34 | 0.37 | |
| | mean | 0.39 | 0.36 | 0.37 | 0.36 | 0.35 | 0.37 | |
| | Grand mean (X) | 0.36 | 0.35 | 0.35 | 0.34 | 0.33 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.005 | 0.006 | 0.012 | 0.003 | 0.006 | 0.006 | 0.013 |
| | CD at 5% | NS | 0.017 | NS | 0.008 | 0.016 | NS | NS |
| | CV% | 12.89 | | | 6.38 | | | |

**Table 3:** Effect of different treatments on ascorbic acid (mg/100 ml) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Ascorbic acid (mg/100 ml) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 4.85 | 4.85 | 5.20 | 5.20 | 5.20 | 5.06 | 4.82 |
| | $C_2$ - 0.5 | 4.85 | 4.85 | 5.20 | 5.20 | 5.20 | 5.06 | 4.92 |
| | $C_3$ - 1.0 | 4.85 | 5.20 | 5.20 | 4.85 | 5.20 | 5.06 | 5.01 |
| | $C_4$ - 1.5 | 5.20 | 4.51 | 5.20 | 4.51 | 5.20 | 4.92 | 4.87 |
| | mean | 4.94 | 4.85 | 5.20 | 4.94 | 5.20 | 5.03 | |
| 2 month ($P_2$) | $C_1$ - 0 | 4.51 | 4.51 | 5.20 | 5.20 | 5.20 | 4.92 | |
| | $C_2$ - 0.5 | 4.51 | 4.85 | 5.20 | 5.20 | 5.20 | 4.99 | |
| | $C_3$ - 1.0 | 4.85 | 5.20 | 5.20 | 4.85 | 5.20 | 5.06 | |
| | $C_4$ - 1.5 | 5.20 | 4.51 | 5.20 | 4.51 | 5.20 | 4.92 | |
| | mean | 4.77 | 4.77 | 5.20 | 4.94 | 5.20 | 4.98 | |
| 4 month ($P_3$) | $C_1$ - 0 | 4.51 | 4.16 | 4.85 | 4.85 | 5.20 | 4.72 | |
| | $C_2$ - 0.5 | 4.16 | 4.85 | 4.85 | 5.20 | 5.20 | 4.85 | |
| | $C_3$ - 1.0 | 4.85 | 5.20 | 5.20 | 4.85 | 5.20 | 5.06 | |
| | $C_4$ - 1.5 | 5.20 | 4.51 | 5.20 | 4.51 | 5.20 | 4.92 | |
| | mean | 4.68 | 4.68 | 5.03 | 4.85 | 5.20 | 4.89 | |
| 6 month ($P_4$) | $C_1$ - 0 | 4.51 | 3.81 | 4.85 | 4.85 | 4.85 | 4.58 | |
| | $C_2$ - 0.5 | 3.81 | 4.85 | 4.85 | 5.20 | 5.20 | 4.78 | |
| | $C_3$ - 1.0 | 4.51 | 4.85 | 5.20 | 4.85 | 4.85 | 4.85 | |
| | $C_4$ - 1.5 | 4.85 | 4.51 | 4.85 | 4.51 | 4.85 | 4.72 | |
| | mean | 4.42 | 4.51 | 4.94 | 4.85 | 4.94 | 4.73 | |
| | Grand mean (X) | 4.70 | 4.70 | 5.09 | 4.90 | 5.14 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.086 | 0.096 | 0.192 | 0.042 | 0.084 | 0.094 | 0.187 |
| | CD at 5% | NS | 0.274 | NS | 0.118 | NS | NS | NS |
| | CV% | 13.55 | | | 6.61 | | | |

**Table 4:** Effect of different treatments on reducing sugar (%) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Reducing sugar (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 10.06 | 10.60 | 10.43 | 10.32 | 10.00 | 10.28 | 10.39 |
| | $C_2$ - 0.5 | 9.85 | 10.07 | 10.11 | 12.05 | 9.70 | 10.36 | 10.43 |
| | $C_3$ - 1.0 | 10.37 | 10.00 | 10.00 | 10.43 | 9.95 | 10.15 | 10.24 |
| | $C_4$ - 1.5 | 10.43 | 9.75 | 10.01 | 9.85 | 10.16 | 10.04 | 10.10 |
| | mean | 10.18 | 10.11 | 10.14 | 10.66 | 9.96 | 10.21 | |
| 2 month ($P_2$) | $C_1$ - 0 | 9.95 | 10.66 | 10.54 | 10.43 | 10.16 | 10.35 | |
| | $C_2$ - 0.5 | 9.90 | 10.27 | 12.03 | 9.90 | 10.60 | 10.54 | |
| | $C_3$ - 1.0 | 10.48 | 10.06 | 10.06 | 10.60 | 10.05 | 10.25 | |
| | $C_4$ - 1.5 | 10.60 | 9.85 | 10.11 | 10.16 | 10.32 | 10.21 | |
| | mean | 10.23 | 10.21 | 10.68 | 10.27 | 10.28 | 10.34 | |
| 4 month ($P_3$) | $C_1$ - 0 | 10.00 | 10.77 | 10.60 | 10.43 | 10.27 | 10.41 | |
| | $C_2$ - 0.5 | 9.95 | 10.32 | 11.12 | 9.95 | 10.66 | 10.40 | |
| | $C_3$ - 1.0 | 10.60 | 10.00 | 10.05 | 10.48 | 10.00 | 10.23 | |
| | $C_4$ - 1.5 | 10.32 | 9.70 | 9.90 | 9.85 | 9.90 | 9.93 | |
| | mean | 10.22 | 10.20 | 10.42 | 10.18 | 10.21 | 10.24 | |
| 6 month ($P_4$) | $C_1$ - 0 | 10.11 | 10.83 | 10.66 | 10.54 | 10.37 | 10.50 | |
| | $C_2$ - 0.5 | 10.11 | 10.43 | 10.72 | 10.00 | 10.77 | 10.41 | |
| | $C_3$ - 1.0 | 10.66 | 10.11 | 10.27 | 10.60 | 10.05 | 10.34 | |
| | $C_4$ - 1.5 | 10.54 | 9.80 | 10.11 | 10.43 | 10.11 | 10.20 | |
| | mean | 10.35 | 10.29 | 10.44 | 10.39 | 10.33 | 10.36 | |
| | Grand mean (X) | 10.25 | 10.20 | 10.42 | 10.38 | 10.19 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.023 | 0.026 | 0.051 | 0.024 | 0.048 | 0.054 | 0.108 |
| | CD at 5% | 0.066 | 0.074 | 0.146 | 0.067 | 0.134 | 0.151 | 0.302 |
| | CV% | 1.71 | | | 1.82 | | | |

**Table 5:** Effect of different treatments on total sugar (%) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Total sugar (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 16.82 | 17.57 | 15.76 | 16.13 | 15.85 | 16.43 | 16.64 |
| | $C_2$ - 0.5 | 16.96 | 16.18 | 14.89 | 15.62 | 16.82 | 16.10 | 16.57 |
| | $C_3$ - 1.0 | 15.60 | 17.11 | 15.76 | 16.39 | 15.36 | 16.04 | 16.37 |
| | $C_4$ - 1.5 | 17.42 | 16.96 | 15.76 | 15.36 | 15.24 | 16.15 | 16.48 |
| | mean | 16.70 | 16.96 | 15.54 | 15.88 | 15.82 | 16.18 | |
| 2 month ($P_2$) | $C_1$ - 0 | 17.11 | 17.42 | 16.02 | 16.25 | 15.88 | 16.53 | |
| | $C_2$ - 0.5 | 17.11 | 16.53 | 15.12 | 15.76 | 16.82 | 16.27 | |
| | $C_3$ - 1.0 | 15.74 | 17.42 | 15.90 | 16.53 | 15.48 | 16.21 | |
| | $C_4$ - 1.5 | 17.73 | 17.11 | 16.02 | 15.62 | 15.48 | 16.39 | |
| | mean | 16.92 | 17.12 | 15.76 | 16.04 | 15.91 | 16.35 | |
| 4 month ($P_3$) | $C_1$ - 0 | 17.42 | 17.57 | 16.13 | 16.53 | 15.90 | 16.71 | |
| | $C_2$ - 0.5 | 17.42 | 16.67 | 15.60 | 15.90 | 16.96 | 16.51 | |
| | $C_3$ - 1.0 | 15.85 | 17.73 | 16.02 | 16.96 | 16.25 | 16.56 | |
| | $C_4$ - 1.5 | 17.89 | 17.42 | 16.25 | 15.90 | 15.62 | 16.62 | |
| | mean | 17.14 | 17.35 | 16.00 | 16.32 | 16.18 | 16.60 | |
| 6 month ($P_4$) | $C_1$ - 0 | 17.57 | 17.73 | 16.39 | 16.67 | 16.02 | 16.88 | |
| | $C_2$ - 0.5 | 17.27 | 16.67 | 19.90 | 16.13 | 17.11 | 16.42 | |
| | $C_3$ - 1.0 | 15.88 | 17.89 | 16.13 | 17.11 | 16.25 | 16.65 | |
| | $C_4$ - 1.5 | 18.05 | 17.57 | 16.39 | 16.02 | 15.76 | 16.76 | |
| | mean | 17.19 | 17.47 | 17.20 | 16.48 | 16.28 | 16.93 | |
| | Grand mean (X) | 16.99 | 17.22 | 16.13 | 16.18 | 16.05 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.034 | 0.037 | 0.075 | 0.033 | 0.065 | 0.072 | 0.144 |
| | CD at 5% | 0.097 | 0.106 | 0.214 | 0.092 | 0.182 | 0.202 | 0.403 |
| | CV% | 1.57 | | | 1.51 | | | |

**Table 6:** Effect of different treatments on lycopene (mg/100 ml) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Lycopene (mg/100 ml) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 0.996 | 0.990 | 0.994 | 0.994 | 0.997 | 0.994 | 0.990 |
| | $C_2$ - 0.5 | 0.990 | 0.996 | 0.991 | 0.995 | 0.992 | 0.993 | 0.990 |
| | $C_3$ - 1.0 | 0.992 | 0.990 | 0.990 | 0.990 | 0.994 | 0.991 | 0.989 |
| | $C_4$ - 1.5 | 0.993 | 0.994 | 0.990 | 0.993 | 0.996 | 0.993 | 0.989 |
| | mean | 0.993 | 0.992 | 0.991 | 0.993 | 0.995 | 0.993 | |
| 2 month ($P_2$) | $C_1$ - 0 | 0.993 | 0.990 | 0.991 | 0.991 | 0.996 | 0.993 | |
| | $C_2$ - 0.5 | 0.990 | 0.993 | 0.991 | 0.995 | 0.992 | 0.992 | |
| | $C_3$ - 1.0 | 0.992 | 0.990 | 0.988 | 0.988 | 0.993 | 0.990 | |
| | $C_4$ - 1.5 | 0.993 | 0.994 | 0.988 | 0.989 | 0.996 | 0.992 | |
| | mean | 0.992 | 0.992 | 0.989 | 0.991 | 0.994 | 0.992 | |
| 4 month ($P_3$) | $C_1$ - 0 | 0.989 | 0.985 | 0.983 | 0.989 | 0.992 | 0.987 | |
| | $C_2$ - 0.5 | 0.984 | 0.987 | 0.986 | 0.990 | 0.987 | 0.987 | |
| | $C_3$ - 1.0 | 0.985 | 0.986 | 0.986 | 0.986 | 0.993 | 0.987 | |
| | $C_4$ - 1.5 | 0.984 | 0.985 | 0.985 | 0.989 | 0.990 | 0.987 | |
| | mean | 0.985 | 0.985 | 0.985 | 0.988 | 0.990 | 0.987 | |
| 6 month ($P_4$) | $C_1$ - 0 | 0.987 | 0.984 | 0.983 | 0.987 | 0.992 | 0.986 | |
| | $C_2$ - 0.5 | 0.984 | 0.985 | 0.985 | 0.990 | 0.987 | 0.986 | |
| | $C_3$ - 1.0 | 0.985 | 0.985 | 0.986 | 0.986 | 0.991 | 0.987 | |
| | $C_4$ - 1.5 | 0.984 | 0.985 | 0.984 | 0.989 | 0.990 | 0.986 | |
| | mean | 0.985 | 0.985 | 0.984 | 0.988 | 0.990 | 0.986 | |
| | Grand mean (X) | 0.989 | 0.989 | 0.988 | 0.990 | 0.992 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.0007 | 0.0008 | 0.0015 | 0.0003 | 0.0006 | 0.0007 | 0.0014 |
| | CD at 5% | NS | 0.0023 | NS | 0.0008 | NS | 0.0020 | NS |
| | CV% | 0.51 | | | 0.25 | | | |

**Table 7:** Effect of different treatments on calcium (mg/100 ml) of tomato beverage during storage period of 6 months

| Storage period (P) | Calcium chloride concentration (C) (%) | Calcium (mg/100 ml) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Xanthan gum concentration (X) (%) | | | | | mean (C) | Grand mean (C) |
| | | $X_1$ - 0 | $X_2$- 0.25 | $X_3$ - 0.50 | $X_4$- 0.75 | $X_5$- 1.0 | mean (P) | |
| 0 month ($P_1$) | $C_1$ - 0 | 1.73 | 1.73 | 1.60 | 1.60 | 1.73 | 1.68 | 1.63 |
| | $C_2$ - 0.5 | 2.00 | 2.40 | 2.00 | 2.13 | 2.13 | 2.13 | 2.05 |
| | $C_3$ - 1.0 | 2.00 | 2.00 | 2.13 | 2.00 | 2.13 | 2.05 | 2.03 |
| | $C_4$ - 1.5 | 2.40 | 2.53 | 2.40 | 2.40 | 2.53 | 2.45 | 2.40 |
| | mean | 2.03 | 2.17 | 2.03 | 2.03 | 2.13 | 2.08 | |
| 2 month ($P_2$) | $C_1$ - 0 | 1.60 | 1.60 | 1.73 | 1.60 | 1.73 | 1.65 | |
| | $C_2$ - 0.5 | 2.00 | 2.13 | 2.00 | 2.13 | 2.13 | 2.08 | |
| | $C_3$ - 1.0 | 2.00 | 2.00 | 2.13 | 2.13 | 2.13 | 2.08 | |
| | $C_4$ - 1.5 | 2.40 | 2.40 | 2.40 | 2.40 | 2.53 | 2.43 | |
| | mean | 2.00 | 2.03 | 2.07 | 2.07 | 2.13 | 2.06 | |
| 4 month ($P_3$) | $C_1$ - 0 | 1.60 | 1.60 | 1.73 | 1.60 | 1.60 | 1.63 | |
| | $C_2$ - 0.5 | 1.87 | 2.13 | 2.00 | 2.13 | 1.87 | 2.00 | |
| | $C_3$ - 1.0 | 1.73 | 2.00 | 2.13 | 2.13 | 2.13 | 2.03 | |
| | $C_4$ - 1.5 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 | |
| | mean | 1.90 | 2.03 | 2.07 | 2.07 | 2.00 | 2.01 | |
| 6 month ($P_4$) | $C_1$ - 0 | 1.47 | 1.60 | 1.60 | 1.47 | 1.60 | 1.55 | |
| | $C_2$ - 0.5 | 1.87 | 2.13 | 2.00 | 2.13 | 1.87 | 2.00 | |
| | $C_3$ - 1.0 | 1.73 | 1.87 | 2.00 | 2.13 | 2.13 | 1.97 | |
| | $C_4$ - 1.5 | 2.27 | 2.27 | 2.40 | 2.40 | 2.27 | 2.32 | |
| | mean | 1.83 | 1.97 | 2.00 | 2.03 | 1.97 | 1.96 | |
| | Grand mean (X) | 1.94 | 2.05 | 2.04 | 2.05 | 2.06 | | |
| | | C | X | C×X | P | C×P | X×P | C×X×P |
| | S.Em± | 0.030 | 0.034 | 0.068 | 0.017 | 0.034 | 0.038 | 0.076 |
| | CD at 5% | 0.087 | NS | NS | 0.047 | NS | NS | NS |
| | CV% | 11.56 | | | 6.45 | | | |

**Sensory parameters:** The organoleptic characteristics such as colour, texture, taste, flavour and overall acceptability decreased slightly with advancement of storage period. The tomato beverage prepared by using 1.0 per cent calcium chloride with 0.5 per cent xanthan gum ($C_3X_3$) was found superior based on nutritional as well as sensory quality and found more shelf stable during storage compared to other treatments.

## Conclusion

From the foregoing discussion, it can be concluded that tomato beverage prepared by using 25 per cent tomato pulp, 1.0 per cent calcium chloride and 0.5 per cent xanthan gum possess better quality on the basis of nutritional and sensory characteristics during storage. The concentration of calcium chloride and xanthan gum can be assize on 25 per cent pulp basis. The tomato beverage can be successfully stored for a period of 6 months in glass bottles without much changes in physico-chemical, sensory and microbial quality. Thus, the developed technology can commercially be adopted by food processing industry for the production tomato beverage.

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