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Formulation and quality assessment of tomato (*Lycopersicon esculentum*) cordial with xanthan stabilizer

M.R. Roshana*, Musthapha Mufeeth and U.L. Abdul Majeed

Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka

*Correspondence: mrroshana30@gmail.com; ORCID: https://orcid.org/0000-0002-8634-6699

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Abstract Tomato fruit is a nutritious part of the human diet providing a variety of health benefits. Searching for other means of utilization than direct consumption of tomatoes seems a timely need to reduce post-harvest losses caused by the rapid perishability of ripened tomatoes. In the present study, three tomato cordial formulations with xanthan gum as a stabilizer were tested for sensory properties, and the best formula was tested for its physico-chemical properties and stability over one month period. Well-ripened and healthy fruits were chosen to prepare the cordial. According to the Sri Lankan Standards (SLS 730), three different cordial samples were prepared only changing the concentration of xanthan gum stabilizer as 0.3%, 0.4% and 0.5% (w/v). Using 30 semi-trained panellists, prepared samples were subjected to sensory testing on a 5-point Hedonic scale, and 0.5% of xanthan gum containing cordial was selected as the best formula. The shelf-life evaluation of the best sample was conducted weekly for one month through physicochemical and microbiological analysis. Significant changes ($p<0.05$) were observed only in vitamin C content and total soluble solids (TSS) during the shelf-life evaluation. At end of the storage period, the cordial with 0.5% xanthan gum possessed pH 3.26, titratable acidity 1.35%, vitamin C 31.9 mg/100ml, TSS 44.9 °Brix, total sugar 19.8% and polyphenol content 0.0021 mg/ml GAE. Changes in the total plate counts during the one month of storage are within the acceptable limit (less than 50 per ml) according to the Sri Lankan Standards (SLS 516). It can be concluded that tomato cordial can be formulated by using 5% of xanthan gum stabilizer and that was found to be stable for one month without any deterioration.

Keywords: Preservation, physiochemical analysis, shelf-life, stabilizer, value addition.

1 Introduction

Tomato (*Lycopersicon esculentum* L.) belongs to the family Solanaceae. It originated in Peru and was considered a weed due to its spreadable nature in South and Central

America (Dhaliwal 2017). At present, it is cultivated on large scale all over the world to maintain the availability of tomatoes for indigenous consumption or as an export commodity. It is an annual plant; therefore, it is considered to be a warm-season crop. In 2014, with a production of 171 million tons, the global tomato-cultivated area was 5 million ha, with China and India being the significant tomato-producing countries (FAOSTAT 2017). Tomato can be filled in an assortment of geological zones in open fields or nurseries, and the organic product can be gathered by manual or mechanical methods. In the past, the tomato was not perceived as an important natural product, yet its acceptability is currently all around the world acknowledged as a nutritious food product. Because of its high vitamin, malic acid, and citric acid content (Serio *et al*. 2006), it is often referred to as the poor man's orange. In several ways, tomatoes are eaten, such as raw in salads, fried in soups, jams, ketchup, pickled sauces, and other ways.

Tomato is a nutrient-dense and super-food which is consumed by most people. Rich with beneficial phytochemicals such as lycopene (Agarwal and Rao 2000), tomatoes play a vital role in preventing chronic diseases and delivering other health benefits (Nasir *et al*. 2015). Consumption of tomatoes can decrease the risk of diabetes and cancer, especially prostate cancer in men (Shahar *et al*. 2011). Increasing consumption of fruits and vegetables significantly reduces the risk of obesity and overall mortality (Dias 2012). Lycopene is an important antioxidant that helps to combat the development of cancerous cells and other forms of health problems and diseases. The presence of lycopene accumulation in the human body flushes out free radicals in the body (Basu and Imrhan 2007). Among the carotenoids, lycopene is the most effective antioxidant (Mortensen and Skibsted 1997). From the perspective of consumers, the colour of the fruits is a significant feature. Lycopene is the pigment that gives ripe tomatoes their rich red colour. The generation of lycopene is prevented when the temperature of the fruits reach 30°C. When the temperature is between 12 and 21°C, lycopene develops optimally. Low light intensity reduces lycopene accumulation, resulting in inconsistent fruit colour (Brandt *et al*. 2006).

Tomato fruit quality is determined by the skin colour of the fruits when the redness increases on the skin that will resemble the good flavour attributes on the skin (Tigist *et al*. 2013). In tomato fruits, when the sugar content is at its highest, a linear relationship has been observed between the sugar content and taste, at which point the skin acquires its richest colour (Samaila *et al.* 2011). The satisfactory texture of tomato results only when adequate pectinase, calcium and pectin are available in tomatoes. Based on the maturity of tomato pectin concentration noticed that initial increment and subsequent declined (Freeman and Reimers 2010). Tomato fruit can be divided into five portions such as; outer and inner wall, inner locule tissue, gelatinous pulp, skin, and seed. Tomato’s outer and inner wall regions assume a significant function in the tomato quality because the highest contents of dry matter, insoluble solids, and decreasing sugar exist in those locales of the tomato (Bhowmik *et al*. 2012).

Tomatoes are considered a healthy source of ascorbic acid (Vitamin C), with about 25 mg/100 g. In tomato-based products, acidity plays an essential role in taste. The presence of acids in tomatoes helps the food processor because pH below 4.3 can control the anaerobic microorganisms in the food while pH over 5 makes it difficult to control the spores of microorganisms (Nasir *et al*. 2015). Soluble solids of tomato mainly come from sugar which is an important contributor to the flavour. More than 60% of solids in tomatoes are free sugars such as D-glucose and D-fructose and a lower amount of sucrose, ketoheptose and raffinose (Abdu 2016). Starch content in tomatoes depends on the fruit maturity, cultivar, and ripening conditions. Overripe fruits have low starch content than matured fruits.

Adding value to a product increases the shelf-life of most perishable fruits and is a way of mitigating post-harvest loss. Tomatoes are well known as quickly perishable fruits, and the post-harvest loss is 54% in Sri Lanka (Institute of Post-Harvest Technology 2016). Being a nutritionally rich commodity, tomatoes are used in different forms of food preparations which will improve human nutritional status by supplying micronutrients and bioactive phytochemicals. Cordials are concentrated fruit beverages. Making juice from fruits is the key stage in cordial preparation, which is then purified through a fine cloth or special juice filters to make it pure. A filtered 50-60% sugar syrup solution is heated to 90°C and the right proportion is combined with the fruit juice. The addition of hot sugar syrup to the juice decreases the boiling time and retains the colour and taste of the juice (Helali *et al*. 2008). Several hydrocolloids have been widely utilized in the food industry to produce gel structure, to improve viscosity, to function as an encapsulating agent in the coating process, to regulate crystallization, to prevent syneresis, and to improve product physical stability (Dickson 2003). Therefore, they can have a direct impact on food characteristics including appearance and texture. Xanthan gum is a commonly used stabilizer to provide a satisfying texture, odour and taste in citrus and fruit-flavoured beverages. These beverages include xanthan gum in the range of 0.001-0.5% and facilitate the suspension of insoluble components by dissolving fast and fully at low pH. Xanthan gum has branching hydrocolloid with more and lengthier branches than other forms of gum, allowing it to create more hydrogen bonds and enhance viscosity significantly (Akkarachaneeyakorn and Tinrat 2015). Godoy (1997) used 0.175% xanthan to study the stability of guava nectar over 180 days of storage and found 99% stability. Garruti (1989) reported 100% stability in passion fruit juice after adding 0.2 % xanthan gum, while Souza (2009) discovered that adding 0.2% xanthan gum was one of the best treatments for stabilizing peach nectar (94.7%).

Commercial production of tomato-based cordial in Sri Lanka is not available, and this is the first attempt of research to produce and introduce it into the market. In addition, no attempt has been made to study the effect of xanthan gum in the formulation of tomato-based cordial as a stabilizer. Therefore, this study was conducted with two objectives; firstly, to find the best formula for a cordial from tomato (*Lycopersicon esculentum*) by changing the amount of xanthan gum and testing for sensory properties, and secondly, to analyze the best formula for its physico-chemical properties and stability over one month period.

2 Material and Methods

2.1 Tomato pulp extraction

Well ripened and healthy tomato fruits (variety: Thilina) were procured locally from the home garden of a villager from Kaluthawali, Batticaloa after harvesting. Heat treatment was conducted at 60°C in a 500 ppm sodium meta-bisulphite (SMS) (BDH Chemicals, UK) for 2 min to inactivate the enzymatic activity that decreases the browning and increases the shelf-life of the fruits (Abeywickrama and Jayasooriya 2010). The fruit's outer skin was stripped off and the fruits were placed in the juice extractor (Model: KN-SB056, Japan) to extract the pulp. To remove the seeds, the pulp was purified through a 750 μm sieve. Finally, the extracted dense pulp was stored in a glass bottle and kept in a refrigerator at 4°C until further use.

2.2 Preparation of tomato cordial

The tomato cordial was prepared according to the method described by Abeywickrama and Jayasooriya (2010) with some modifications.

Table 1: Different formulations of tomato cordial developed.

Ingredients	Treatments with different amounts of ingredients		
	Treatment 1	Treatment 2	Treatment 3
Water (ml)	49.17	49.07	48.97
Tomato pulp (g)	25	25	25
Sugar (g)	25	25	25
Xanthan gum (g)	0.3	0.4	0.5
SMS (g)	0.035	0.035	0.035
Citric acid (g)	0.5	0.5	0.5

The cordial was prepared as shown in Table 1 according to the Sri Lanka Standards (SLS 730) guidelines. Three cordial formulations were established with three concentrations of xanthan gum, i.e., 0.3%, 0.4%, and 0.5%. First, sugar was blended with water and heated to 70°C for 10 min. While stirring, xanthan gum (Sigma-Aldrich, USA) was added to the mixture. After dissolving the xanthan gum correctly, the tomato pulp was added to the sugar mixture and then heated using a gas burner up to 85°C for 20 min to change the Brix value. The cordial was allowed to cool and sodium meta-bisulphite (SMBS) (BDH Chemicals, UK) was applied as a preservative. The cordial was eventually filled into bottles that were pre-sterilized using a hot air oven at 160°C for 45 min and immediately sealed.

2.3 Sensory evaluation

To find the best formula among the cordials produced, a sensory evaluation was carried out. It was conducted using a 5-point hedonic scale. Thirty semi-trained panellists were served with 1:4 (cordial: water) diluted samples of cordial. Therefore, thirty replications were prepared per each treatment. Only one questionnaire per person was provided to mention their responses for colour, odour, taste, mouthfeel, and overall acceptability of three cordials. Friedman Rank test was done to analyze sensory data using Minitab 19.2 version.

2.4 Shelf-life evaluation of the final product

The shelf-life evaluation was carried out for one month by determining the organoleptic properties and physicochemical changes of the final product (Treatment 3). A microbiological test also was carried out. All experiments were done weekly for a month.

2.5 Analysis of physico-chemical properties of the final product

Only the best sample chosen from the sensory assessment was tested for physico-chemical properties. Three replications were prepared per each treatment for the analysis. By using a digital pH meter (Starter 3100, OHAUS, USA), the pH was measured. By titrating juices with standard NaOH using an auto titrator, the titratable acidity was calculated as a percentage of citric acid. The vitamin C content was measured using 2,6-dichlorophenol indophenol dye process. Using recommended AOAC (2019) techniques, the total soluble solids (TSS) was calculated. Total sugar was measured according to the Lane-Eynon equation. Total phenol content was spectrophotometrically calculated (Siddiqui *et al*. 2017) based on the Folin-Ciocalteu process.

2.6 Microbiological analysis of the product

Microbial analysis (total plate count) of the final product was carried out to determine the safety of the product. Nutrient agar media and dilution series were prepared as follows. Sterilized peptone water (9 ml) was filled into three test tubes. One milliliter of tomato cordial was added to the Tube-1 and mixed (10^{-1} dilution). One milliliter from the Tube-1 mixture was pipetted into the Tube-2 and mixed (10^{-2} dilution). One milliliter from the Tube-2 mixture was added to the Tube-3 and mixed (10^{-3} dilution). One milliliter from each dilution sample was pipetted out and introduced aseptically into sterilized petri dishes in two replicates. Then 15 ml of media was poured into petri dishes and kept in the incubator for 24 hours. After an incubation period, colony counts were taken.

2.7 Data analysis

The experiment was carried out in a complete randomized design. The significance of the treatment effects on measured parameters was analyzed by Analysis of Variance (ANOVA) ($\alpha = 0.05$). The difference between means of nutritional parameters was determined by Duncan's Multiple Range Test (DMRT). Nutritional data were analyzed using Statistical Analysis System (SAS) software. Friedman test was done to analyze the sensory data using MINITAB 19.2 version software package.

3 Results and Discussion

3.1 Selection of the best recipe from the sensory evaluation

The findings of the sensory assessment of the cordial with three levels of xanthan gum are given in Table 2.

Table 2: Sensory evaluation of freshly prepared tomato cordial with three different xanthan gum levels.

Treatment (% xanthan gum)	Colour	Taste	Odour	Appearance	Mouthfeel	Overall acceptability
T_1 (0.3%)	3.65±0.09^c	3.33±0.15^b	3.19±0.05^a	3.75±0.04^a	4.05±0.02^a	3.45±0.09^b
T_2 (0.4%)	4.05±0.12^b	3.05±0.02^c	3.38±0.06^a	3.45±0.02^a	4.25±0.04^a	3.15±0.03^c
T_3 (0.5%)	4.48±0.05^a	4.25±0.08^a	3.48±0.04^a	3.93±0.03^a	4.35±0.03^a	4.45±0.12^a

The values are means of 30 replicates ± standard error, the means with the same letters for a given parameter are not significantly different from each other at 5% significant level based on Friedman's Rank test. (T_1: Cordial having 0.3% Xanthan gum; T_2: Cordial having 0.4% Xanthan gum; T_3: Cordial having 0.5% Xanthan gum)

Three tomato cordial samples had significant differences ($p<0.05$) in colour, flavour, and overall acceptability, but not ($p>0.05$) in the odour, appearance, and mouthfeel. Treatment 3 received the maximum volume of rank for colour, taste, odour, appearance, mouth sensation, and overall acceptability with 0.5% xanthan gum. Therefore, treatment 3 was selected as the best sample for the shelf-life evaluation. Dogan *et al.* (2013) has reported that 0.5% xanthan gum as the stabilizer was the most accepted one for cloudy mulberry juice among panellists (average acceptance was 6.90 ± 1.37 points).

3.2 Evaluation of the shelf-life of tomato cordial with 0.5% xanthan gum by physicochemical properties

Changes in the pH of the cordial during one month of storage are shown in Figure 1. The initial pH of the product was 3.43 which indicated microbial stability of the product, but it decreased within one month. Between the initial and end of the 4th week, there were no significant differences ($p>0.05$) of the pH of tomato cordial having 0.5% xanthan gum. Titrable acidity and pH are inversely proportional to each other (Hirdyani 2015). Therefore, the product is safe for consumption within a month. The addition of sugar to the mixture increases the efficiency of the fermentation reaction of microorganisms. Therefore, release of organic acid in the final product is the reason for declining the pH with time (Koh *et al*. 2010).

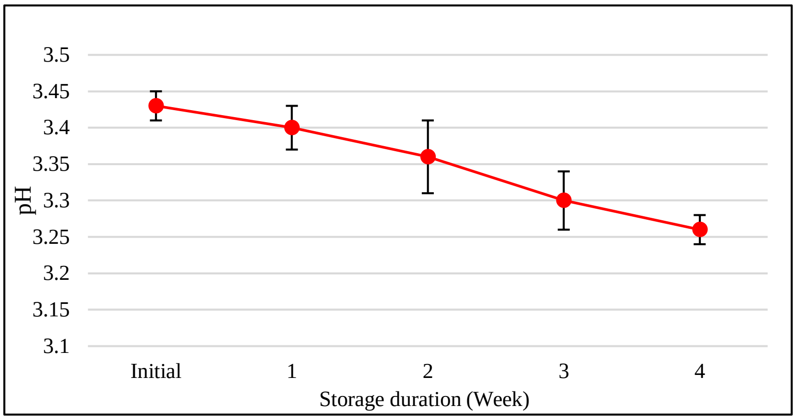

Fig 1. Changes in the pH of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean.

The titratable acidity of cordial having 0.5% xanthan gum increased during the storage period as shown in Figure 2. There were no significant differences ($p>0.05$) among titratable acidity between the initial and end of the 4th week. Acidity increased with time due to the slow rate of diffusion of organic acids in the product by the fermentation reaction of lactic acid bacteria (You *et al*. 2017). There is a positive relationship between pH and titratable acidity (Islam *et al*. 2013). Normally tomatoes are a good source of citric acid, but a small amount of malic acid and glutamic acid are responsible for the titratable acidity (Anthon *et al*. 2011). These findings were consistent with the results of Kesavanath *et al*. (2015) for the star fruit and sweet orange juices blend fruit cordial.

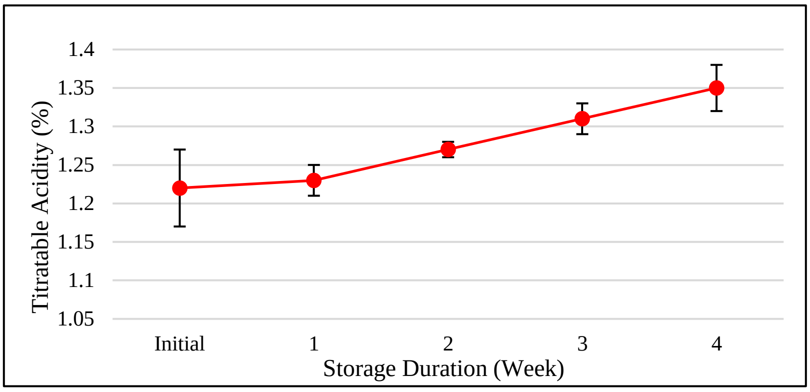

Fig 2. Changes in the titratable acidity of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean.

The changes in vitamin C content of the cordial having 0.5% xanthan gum was slightly decreasing along with the storage period (Figure 3). There was a significant difference ($p<0.05$) of vitamin C between the initial and end of the 4th week.

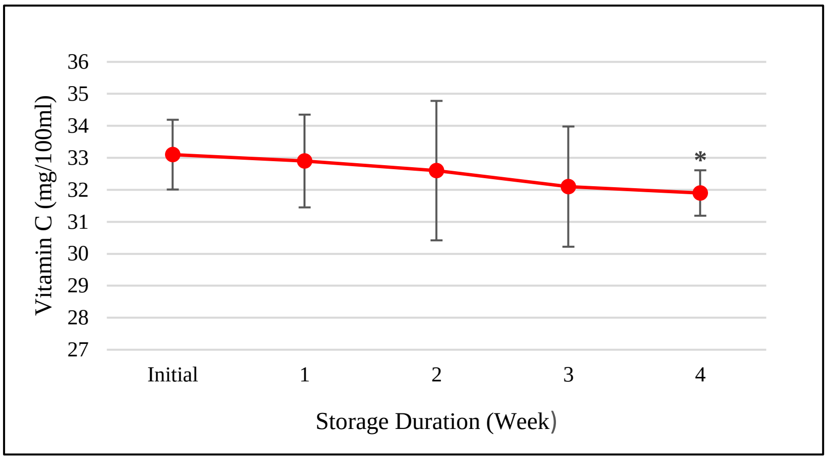

Fig 3. Changes in the Vitamin C of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean. The symbol (*) indicates significant differences between the initial and corresponding week of the cordial ($p< 0.05$).

Breakdown of vitamin C into dehydro-ascorbic acid may be attributed to it (Hamid *et al*. 2017). Due to the presence of oxygen, ascorbic acid is particularly susceptible in its present state. Higher storage temperature causes a more rapid loss of ascorbic acid (El-ishaq and Obirinakem 2016), and thus ascorbic acid of tomato-based products may also be heavily affected by temperature variation.

Total Soluble Solid (TSS) was increasing throughout the storage period (Figure 4). During the storage time, there was a significant difference ($p<0.05$) in the total soluble solid between the initial and end of the 4th week. But, the final product after one month can be considered as in acceptable range, as the TSS value was above 40 Brix as per the Cordial specification of Sri Lankan Standards (SLS 730). The slower rate of hydrolysis of carbohydrates into soluble sugar, excessive moisture losses from the final product can be the reasons for increasing the Brix value of the final product (Tigist *et al*. 2013).

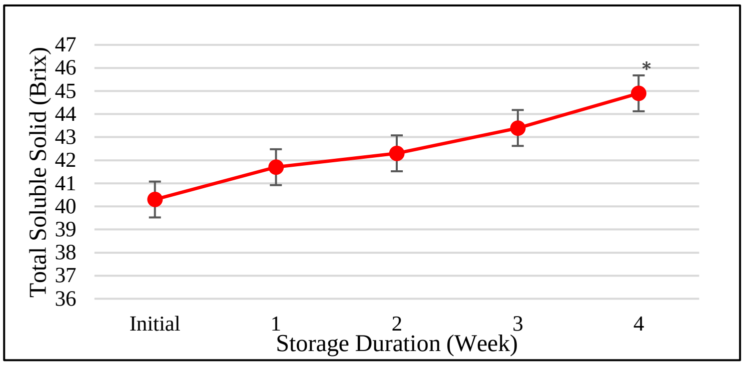

Fig 4. Changes in the total soluble solid of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean. The symbol (*) indicates significant differences between the initial and corresponding week of the cordial (p-value < 0.05)

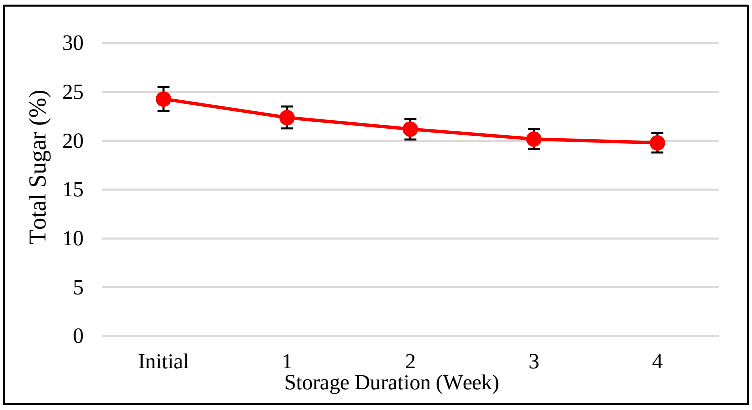

Fig 5. Changes in total sugar content of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean.

Total sugar indicated a diminishing pattern with the storage time due to polysaccharide hydrolysis and sugar oxidation (Figure 5). However, no significant change was observed ($p>0.05$) in the total sugar content of the finished product between the beginning and last week of the tested shelf life. Kesavanath *et al*. (2015) found that star fruit and sweet orange fruit blended cordial had a substantial reduction in total sugar over the entire storage cycle at ambient temperature.

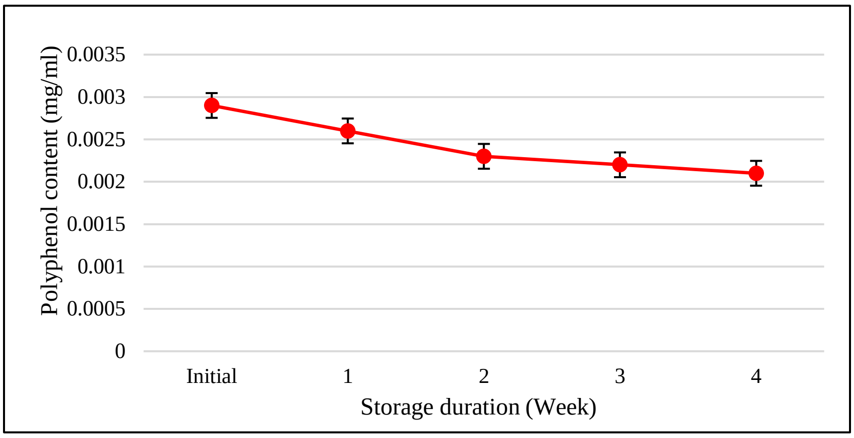

Fig 6. Changes in polyphenol content of the cordial having 0.5% xanthan gum during the one month of storage. Values represent the means of triplicate readings (n=3). Error bars represent the standard error (SE) of the mean.

The polyphenol content of the final product decreased during the storage period (Figure 6). There were no significant differences ($p>0.05$) among the polyphenol content between the initial and end of the 4th week. Thermal treatment of tomato-based products will result in a loss of the total phenol content (Abushita *et al*. 2000). In the breakdown of cellular constituents, thermal treatment such as conventional pasteurization applied to tomato related products such as ketchup and tomato juices could release more bound phenolic compounds (Dewanto *et al*. 2002). Cellular destruction, though, can unleash oxidative enzymes that could demolish phenolic compounds, therefore, continuous loss of polyphenol content was observed (Vallverdú-Queralt *et al*. 2016).

3.3 Evaluation of the shelf-life of tomato cordial having 0.5% xanthan gum by microbiological tests

There were no total plate counts observed in the freshly prepared cordial having 5% xanthan gum. Carter *et al*. (2007) stated that numerous products with the addition of sodium metabisulphite alone could securely be kept sterile *via* the pasteurization process.

Table 3: Changes of the total plate count test for the final product of tomato cordial with 0.5% xanthan gum over four weeks.

Days	Mean plate count in CFU/ml
7	18
14	25
21	32
28	38

Changes in the total plate counts (Table 3) during the one month of storage are within the acceptable limit (less than 50 per ml) according to the Sri Lankan Standards (SLS 516). From the results, the final product had met the requirement for the shelf-life evaluation. Therefore, the product is acceptable for human consumption for one month and the cost of one bottle (100 ml) of cordial was Rs. 24.84 based on the raw material cost at the market.

4 Conclusions

The present study was conducted to formulate the tomato cordial by changing the concentration of the xanthan gum stabilizer. According to the sensory evaluation, cordial having 0.5% xanthan gum was selected as the best sample among the panelists. There were no significant changes ($p>0.05$) in the physicochemical properties of the 0.5% xanthan gum cordial during one month of storage period. But, vitamin C content significantly ($p<0.05$) decreased throughout the month where the TSS was rising significantly. After a month of storage, the selected cordial sample (0.5% xanthan gum) had pH 3.26, titratable acidity 1.35%, vitamin C 31.9 mg/100ml, total soluble solids 44.9 °Brix, total sugar content 19.8% and polyphenol content 0.0021 mg/ml GAE. The product was found to be stable for one month, and suitable for human consumption.

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