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Nutritional values and acceptability of syrups produced after blending carrots, sweet potatoes, and tomatoes

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Abstract

Background: The artificial syrups on the market are known with many harmful health effects for using unnatural colors and flavors. This study evaluated the effect of different compositions of syrups and storage on the quality and nutritional value of syrups produced from three types of high nutritional vegetables such as carrot, sweet potato, and tomato, at weighting ratios T1 (6:2:2), T2 (5:3:2), T3 (4:4:2), T4 (3:5:2), and T5 (2:6:2). Pasteurization was performed at 85 °C/25 s for concentrated syrup at 65°Brix. Physicochemical analyses were applied to the recovered drink at 14°Brix every 2 months for 6 months.

Results: Ascorbic acid, carotenoids, lycopene, color values, total phenols, and antioxidant activity gradually decreased in all treatments during storage, while acidity and browning increased. Increasing sweet potatoes about 4% or decreasing under 3% harmed the overall acceptability of the syrups.

Conclusion: Finally, the findings revealed that T2 and T3 were the most suitable samples on storage. Therefore, our data recommended producing syrups from carrot, sweet potato, and tomato with the same composition of T2 and T3, which give a more attractive taste and flavor similar to apricot juice.

Keywords: Carrots, Sweet potatoes, Tomatoes, Synthetic, Natural syrups

Background

Artificial or synthetic syrups use artificial coloring and flavoring since they are inexpensive and stable. However, unnecessary intake will lead to serious health problems (Kus and Eroglu 2015). Excessive intake of synthetic pigments and flavors led to burp, migraine headache, allergic and poisonous symptoms (Goodman 2013). A mutating activity that contributes to cancer has also been noticed (Sarıkaya et al. 2012). The level of synthetic pigments in foods should be restricted. Synthetic syrups have no therapeutic benefit and nutritional, due to the absence of dietary fiber, minerals, vitamins, and artificial sweeteners sometimes are added as an alternative to sugar. Using of natural materials in a different industrial product

becomes a universal trend. Vegetables have important content of bioactive compounds, dietary fiber, attractive color, and flavors (Kongkachuichai et al. 2015), enhanced nutritional value, health properties, and reduced risk of degenerative diseases (Girones-Vilaplana et al. 2016; Hussein et al. 2017). Developing a new product by mixing two or more types of fruit or vegetables can improve market popularity and achieve excellent color and flavor as well as economical manufacturing (De Carvalho et al. 2017). Carrot (*Daucus carota* L.) has a higher level of carotenoids, phenols, and flavonoids in addition to vitamins and minerals (Da Silva et al. 2007; Sharma et al. 2012).

Sweet potatoes include vital antioxidants like ascorbic acid, β -carotene, phenolics, tocopherols, folates, and flavonoids as well as dietary fiber (Fernandez-Orozco et al. 2013). Carotenoids in carrots as well as sweet potatoes

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have demonstrated various biological activities (Dhiman et al. 2017; Olagunju and Sandewa 2018).

Tomatoes have several antioxidants like β -carotene, ascorbic acid, lycopene, tocopherols, and total phenols (Perago et al. 2009). Lycopene is one of the antioxidants that have an activity that exceeds both α - and β -carotene and prevents many diseases due to the inhibitory effect of cell breakdown and strengthening it (George et al. 2004; Sharoni and Levi 2006). Vitamin E in tomatoes displayed a higher activity against LDL oxidation and caused atherosclerotic and carcinogenic (Brigelius-Flohe et al. 2002). This study developed new natural syrups from different kinds of vegetables that enhance flavor and color characteristics in addition to improve nutritional value and health benefits.

Methods

Fresh carrots (*Daucus carota* L.), sweet potatoes (*Ipomoea batatas* L.), and tomatoes (*Lycopersicon esculentum*) fruit are obtained from a local market in Ismailia, Egypt. The carrots and sweet potatoes have an orange pulp color while the tomato is selected in terms of ripeness and shape. DPPH (2, 2-diphenyl-1-picrylhydrazyl) and Folin–Ciocalteu gained from Sigma-Aldrich (St. Louis, USA). Both analytical grade solvents and chemicals bought from Sigma Chemical Corporation, Egypt.

Preparing carrot, sweet potato, and tomato pulps

The running tap water was used to wash and remove dirt and impurities of carrot as well as sweet potato, then the outer shell and the thrones were removed, and the carrot was washed by the water well. The carrot put in a pot with immersion in water and boiled for 20 min to soften each tissue with applied the same procedures on sweet potato. The hand mixer was used for carrots to get the pulp. Sweet potatoes were peeled by hand and then manually mashed. The tap water was used to wash fresh tomatoes then dried in the air and pulped with a Moulinex juice extractor (type, 753, Moulinex, Spain). Tomato pulp was obtained by filtration through stainless steel strainers.

Preparing carrot, sweet potato, and tomato syrups

Carrot, sweet potato, and tomato pulps were combined at a weighting ratio of 6:2:2 (T1), 5:3:2 (T2), 4:4:2 (T3), 3:5:2 (T4), and 2:6:2 (T5); the sugar was used to concentrate the blends to 65°Brix. Sodium benzoate was used to syrups by 1 g/kg, while the concentration solution of citric acid was used to change the pH to 4. The syrup was pasteurized at 85 °C/25 s, hot filled in glass bottles, capped, and placed in a water bath at 85 °C for 15 min to kill spoiling microorganisms. The cold water was used to cool glass bottles to room temperature, and samples were

taken for analysis after processing and every 2 months after that.

Assessment of Brix, pH, total acidity, and vitamin C

The Abbe refractometer was used to determine the degree of °Brix at 20 °C. Jenway 3510 pH meter (UK) was used to detect the pH value. Total acidity (TA) was measured by titrating of diluted syrup at 14°Brix with sodium hydroxide at concentration 0.1 N for pH 8.1 (the findings expressed as % citric acid) (AOAC 2000). Vitamin C was measured using the 2,6-dichlorophenolindophenol dye solution by titration method (AOAC 2000).

Assessment of total phenols (TP), antioxidant activity (AA), beta-carotene, lycopene, and browning

Folin–Ciocalteu was used to determine total phenolic compounds as described by Osorio-Esquivel et al. (2011). DPPH was employed to assess antioxidant activity, identical to the way Ravichandran et al. (2013). β -Carotene content was measured as described by Barros et al. (2011) using a mixture of hexane: acetone (6:4, v/v). The method of Barrett and Anthon (2001) was utilized to estimate lycopene. The method of Ranganna (2010) was used to measure the browning.

Assessment of color

Color reader CR-10 (Konika Minolta, Inc., Osaka, Japan) was utilized to measure color parameters L^* (transparency), a^* (red to green), and b^* (yellow to blue).

Sensory attributes

All sensory evaluations of different tested diluted syrups achieved using the method of Howard and Dewi (1995) by ten staff members (semi-trained panelists) for taste (10), odor (10), color (10), mouth feel (10), and appearance (10). Overall acceptability calculates as the average of total scores.

Statistical analysis

The data obtained were subjected to variance analysis (ANOVA) using COSTAT (CoHort software version 6.303) at $P=0.05$. The mean of different treatments was compared by Duncan's test at $P=0.05$.

Results

pH and acidity

Figure 1 shows the influence of storage and treatments on the pH and acidity of dilution syrup at 14 Brix. pH decreased up to 4 or less was an essential factor in preserving syrups against microbial spoilage. The pH value varied from 3.91 to 3.98 at zero time. The existing data showed that T2 and T3 had higher pH values. Throughout storing for 6 months, the pH value decreased, and the

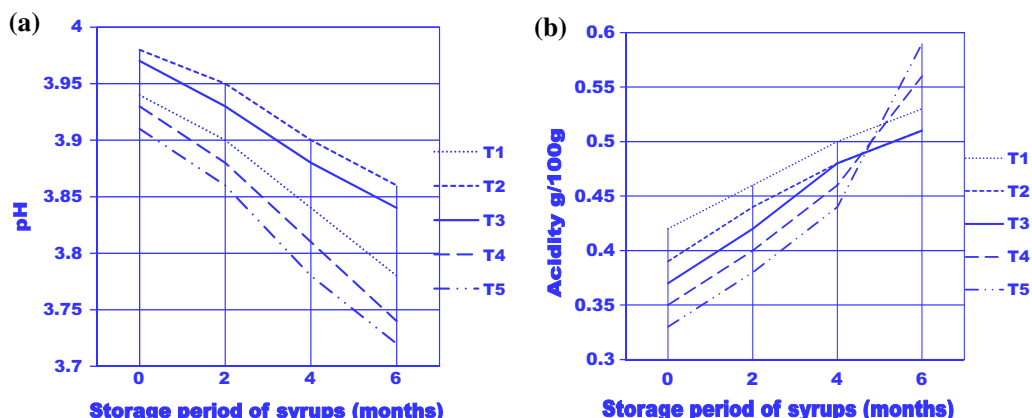


Fig. 1 Change in pH and acidity in different syrups during the storage period

acidity increased in all treatments. T2 and T3 recorded the maximum pH value while T5 and T4 registered the minimum level compared with the other treatments.

Ascorbic acid

Changing in ascorbic acid content is shown in Fig. 2a. The thermal process during pasteurization effected on ascorbic acid retention in addition to storage periods. T1 recorded maximum ascorbic acid retention after preparation syrups and pasteurized. T1 was the highest ascorbic acid retention (98%) at zero time against 90% for the lowest one (T3). There was a gradual decrease in the level of ascorbic acid detected during storage. By storage ending, T1 and T2 had the maximum of vitamin C retention (71 and 60%) of the original amount at zero times.

Browning (non-enzymatic browning)

Figure 2b shows the development of polymerized color and browning. The browning varied from 0.025 to 0.045 at zero time for all treatments. The increasing amount of

carrots had a positive relation with browning increasing. T5 has the lowest browning compared to the rest treatments at zero time. Browning increased gradually in syrups by increasing the time of storage progressively. T2 and T3 (0.113 and 0.120) had the lowest browning after the storage period, while the increase in browning of T5, T4, and T1 was more noticeable.

Total phenolics content (TP)

The differences between TP for different treatments were insignificant at zero time, as shown in Fig. 3a. During storage, the TP content dropped in all treatments. T2 and T3 recorded higher retention of TP with value (76% and 74%). The retention rate of the TP value of T5 was 55% compared to T4 and T1 (68% and 69%), respectively.

Carotenoids

The data regarding the influence of storage on carotenoid retention in diluted syrups are shown in Fig. 3b. The findings exhibit that the retention rate for all treatments

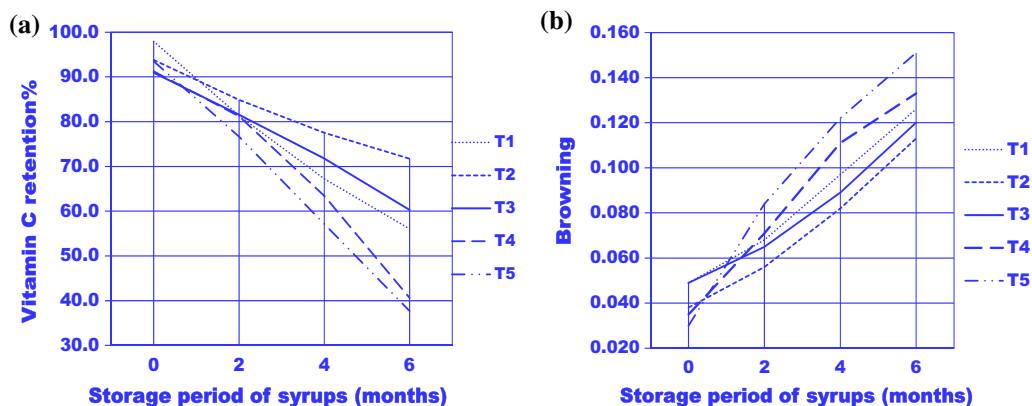


Fig. 2 Change in vitamin C and browning in different syrups during the storage period

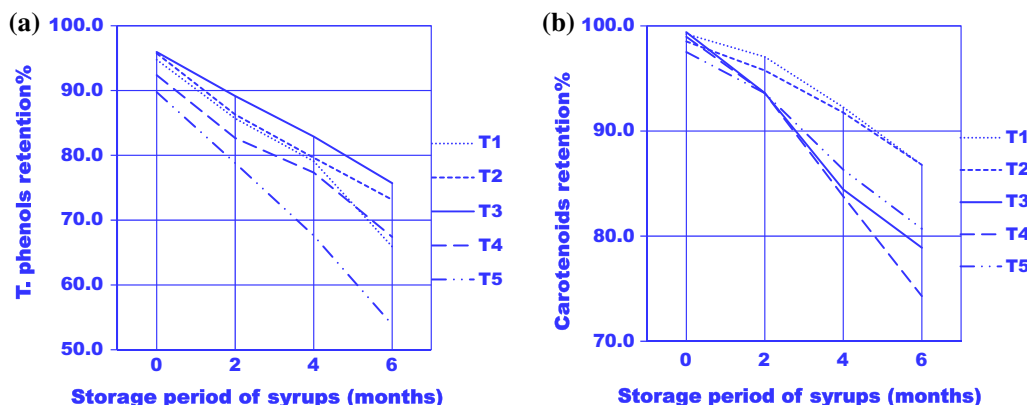


Fig. 3 Retention of total phenols and carotenoids in different syrups during the storage period

varied from (98–99%) at zero time immediately after processing. All syrups had the same decreasing pattern in carotenoids through 6 months of the store. T1 and T2 recorded the highest β -carotene retention (88%) compared to T5 and T3 (82% and 79%) after 6 months of storage. T4 was the lowest retention rate of β -carotene after 180 days of an ambient store with a retention rate of 75%. By storage ending, samples containing 5 and 4% carrots were the most carotenoids maintained relative to sample comprising 6, 3, and 2% carrots in their composition.

Lycopene

The changes in lycopene syrups are presented in Fig. 4a. The lycopene retention in syrup samples had small changes at zero time, due to the constant percentage of the tomato pulp applied to the syrup composition of the five samples. The T2 lycopene retention rate equaled T5, and they recorded the maximum lycopene retention rate compared to the rest samples. The retention rate of lycopene decreased during storage to

65–88% compared to 96–98% at zero time, with losses varying from 10 to 31%, where T2 had the maximum rate of lycopene retention (88%) and T5 had the lowest retention rate (65%).

Antioxidant activity (AA)

Figure 4b shows the decrease in total antioxidant activity in different treatments during the storage period. The AA was ranged between 87 and 99% for the various treatments at zero time. T3 was the best treatment at zero time, which recorded the highest retention with total antioxidant activity, while T4 was the worst. As storage continued, the AA rate was reduced in different samples. The retention rate of AA ranged from 65–88% against 87–99% at zero time, with a loss rate of between 11 and 22%. T3 still recorded the maximum retention rate with AA (88%) compared with other treatments throughout storage.

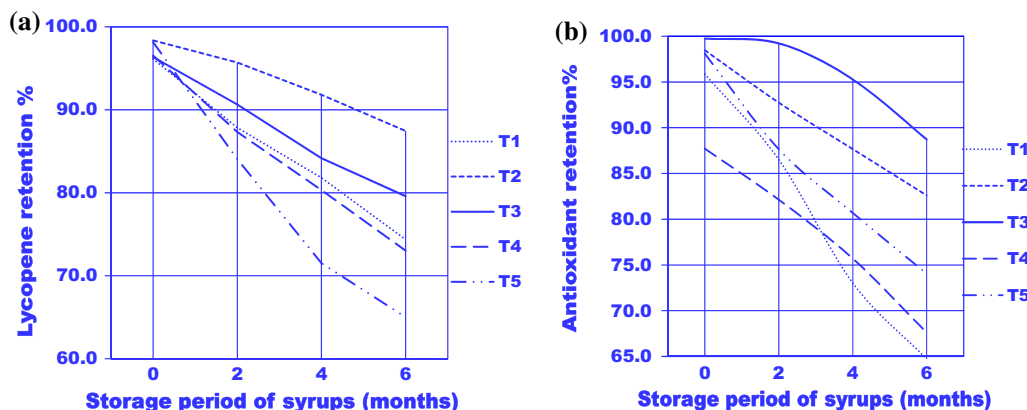


Fig. 4 Retention of lycopene and antioxidants activity in different syrups during the storage period

Color evaluation

The surface color, L* or transparency (brightness to darkening), a* (redness), and b* (yellowness) values of diluted syrups were measured and are pointed in Fig. 5. The level of transparency, redness, and yellowness are linking to visual panel effects and shelf life dependent on color shifts. L* (transparency) values ranged from 42.2 to 45.9 at zero time. Transparency value increased (increase brightness) with increases in the content of sweet potatoes in the sample, while the transparency decreased (increase darkening) with an increase in the carrots percent.

The ratio of 2:6:2, T5 recorded the maximum transparency at zero time. Differences at a* (red color) were detected between different treatments at zero time. The value of b* (yellow color) is proportional to carotenoids so that more carotenoids responsible for yellow and orange contributed to an increase in yellowness or b*, which is a measurement of the color from yellow (100) to blue (-100). The findings reveal that with a rise in carrots in syrups, the color rises to the orange color at zero time. The value of yellowness decreased from T1 to T5. During storage for 6 months, the values of transparency, redness, and yellowness of all diluted syrups decreased dramatically. Slightly darkening developed in the syrup as a result of a Millard reaction between sugars and amino acids. Higher carotenoids, lycopene, and brightness were reported (5:3:2, T2 and 4:4:2, T3). The findings showed that T2 and T3 syrups were a more suitable color compared with the rest syrups.

Sensory evaluation

Figure 6 illustrates the organoleptic features of various syrups at the start and end of the storage. Color, taste, odor, mouthfeel, and appearance are the most sensory

attributes that influence the acceptability of syrups and customer approval or rejection. The highest overall acceptability score (9.1) was given by T1, which the panelists chose as more acceptable at zero time. T2 and T3 came out with scores after T1 (9.0 and 8.9). T4 and T5 (8.6) registered the lowest scores.

The mean score for color, odor, taste, mouthfeel, appearance, and total acceptance of various syrups continuously decreased significantly during storage under ambient storage, because of the production of the browning, the color score reduced, making the appearance of the product less desirable to the panelists. All syrups had a higher acceptance score even after the storage period. Finally, the most favorable sample by the panelists was the T2 followed by T3. Therefore, it is highly recommended using them for commercial production due to their attractive color and flavor. Further relationships between all analyses parameters confirmed the superiority of these two treatments, as shown in Fig. 7. These links are explained in discussion section. It is also clear from the influence of different treatments and storage period on the final quality of syrups.

Discussion

Acidity has a positive relationship with taste, as seen by the findings after 6 months; the best tasting treatments (T1, T2) had the lowest acidity at zero time. Increasing acidity and pH decrement during storage are due to pectin degradation to pectic acid or sugar degradation (Supraditareporn and Pinthong 2007; Ayub et al. 2010). Ahmed et al. (2019) have reported the same pattern of findings in peach juices stored for 90 days.

The level of ascorbic acid has a good indicator of the quality and nutritional value of syrups after the thermal process and storage. The lack of ascorbic acid during

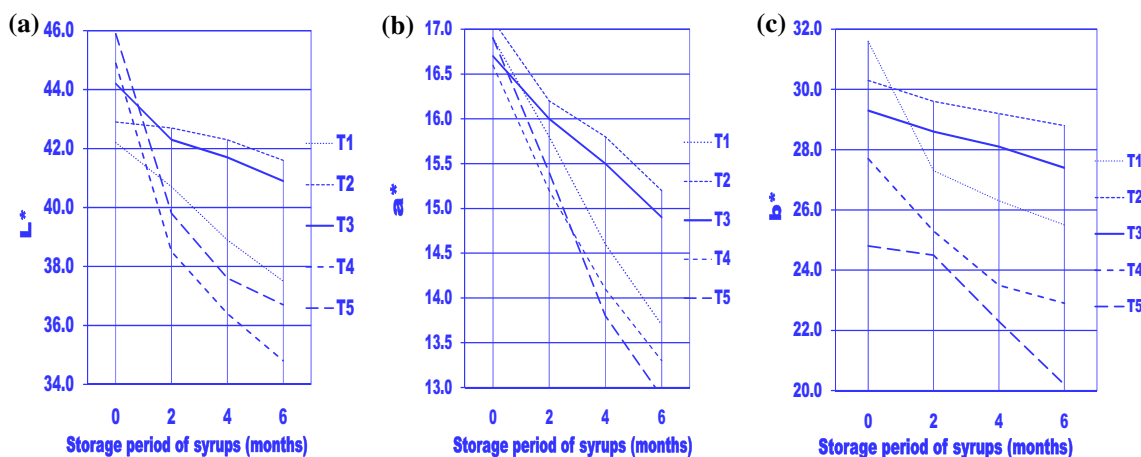


Fig. 5 Hunter's values (L*, a*, b*) in different syrups during the storage period

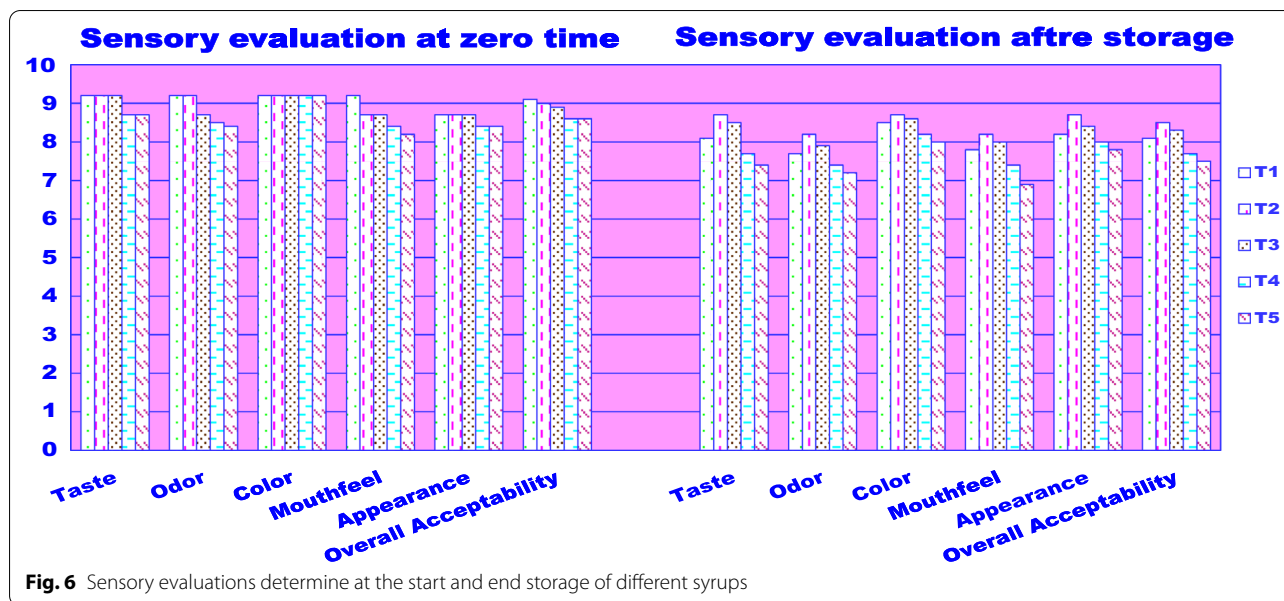


Fig. 6 Sensory evaluations determine at the start and end storage of different syrups

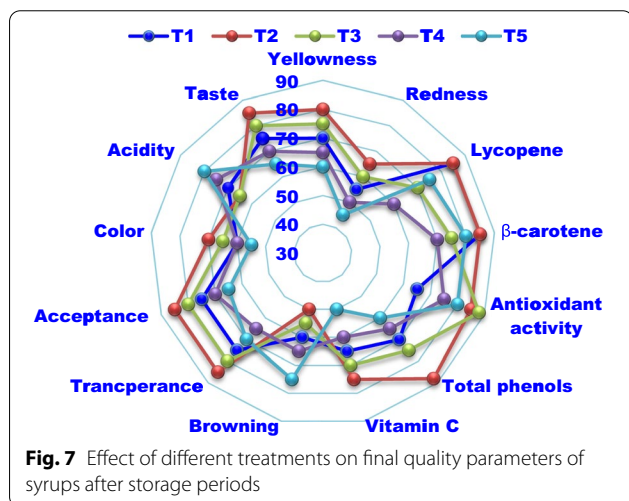


Fig. 7 Effect of different treatments on final quality parameters of syrups after storage periods

storage is related by the reduction of L^* (transparency) and increasing browning (non-enzymatic browning). The preference of the samples regarding ascorbic acid maintenance is T2, T3, T1, T4, T5, which resulted same in transparency and browning reduction. The reduction in ascorbic acid of all syrup blends during storage is due to ascorbic oxidation and light exposure. The present findings are compatible with those of Embaby and Mokhtar (2019) for carrot–goldenberry nectar blends after 28 days of storage at 4 °C.

Increasing the bioactive compounds like lycopene and carotenoids was improved transparency and reduction in the browning. The preferred findings of T2 showed the lowest browning rate and improved color transparency

due to an increase in lycopene and carotenoid levels. Overall, all four parameters decreased by the end of storage, except browning that increased. The changes in browning during storage are mainly due to non-enzymatic browning or oxidation of phenols, which leads to an increase in the browning as reported by Bhardwaj and Mukherjee (2011) for kinnow juice and Adeogun et al. (2017) for sweet orange juice. Also, Mokhtar and Ibrahim (2020) reported the same increase in the browning index of guava nectar during the 6-month storage at room temperature. The reduction in carotenoids over storage is due to the auto-oxidative degeneration or isomerization (Alkesh 2005; Sharma et al. 2009). Dhiman et al. (2017) stated similar findings on pumpkin beverages.

The findings showed a strong connection among the level of TP and AA, as shown in the T2 measurements, obtained the highest value of TP as well as a good AA after storing. Decreased TP and AA after storage of all syrup mixtures can be due to the condensation of poly-phenols into brown pigments. Existing results are close to those of Sharma et al. (2019) on the apple-whey beverage.

Slight variations were observed in lycopene and a^* (redness) value between different treatments at zero time due to the stable percent of tomatoes addition. Correlation between a^* (redness) and lycopene was monitored by storage end; the sample contains a higher amount of lycopene such as T2 which recorded the maximum redness. Also, the increase in the percent of carrots added significantly increased yellowness (b^*). The maximal carrot content was raised the yellow color as in the T1 at zero time. The rise percent of sweet potatoes greater than 4 percent resulted in a strong odor of sweet potatoes in a blend as in T4, T5,

whereas the percentage under 4 gave an odor close to that of apricot juice.

The color attributes are affected by transparency (L^*), redness (a^*), yellowness (b^*), vitamin C, total phenols, β -carotene, and lycopene. Increasing all previous parameters achieved the best color. Decreasing transparency, redness, and yellowness values of all diluted syrups dramatically lowered the average overall acceptability by storage end. The same findings were obtained by Elik et al. (2016), Ahmed et al. (2019), Sharma et al. (2019) during the storage of different types of juices.

Conclusion

The syrups prepared from carrots and sweet potatoes and tomatoes have higher acceptance of taste, color, flavor, and low production costs due to its production from locally available cheaper materials. Therefore, our data recommended by production the syrups from carrot, sweet potato, and tomato with the same composition of T2 and T3, which give a more attractive taste and flavor similar to apricot juice.

Abbreviations

TA: Titrable acidity; TP: Total phenols; AA: Antioxidant activity.

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Authors' contributions

IMAI designed the study, analyzed, interpretation of the data, and was a major contributor in writing the manuscript. HMHK participated in the design of the study, the analysis, and revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All the data obtained during the study are presented in this manuscript. Any further enquiries for additional information are available upon request from the corresponding author.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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