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ORIGINAL ARTICLE

Impact of adding goldenberry (*Physalis peruviana* L.) on some quality characteristics and bio-functional properties of pasteurized carrot (*Daucus carota* L.) nectar

Hassan El-Sayed Embaby[1] · **Sayed Mohamed Mokhtar**[1]

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Abstract Goldenberry juice was added in ratios of 0% (T1), 20% (T2), 30% (T3), 40% (T4) and 50% (T5) to carrot juice. Then the blends were mixed with sucrose solution (1:1), and pasteurized at 98 °C for 2 min. The produced carrot–goldenberry nectars were analyzed for physicochemical, sensory and microbial characteristics, in comparison to the carrot nectar, during 28 days of a cold storage at 4 °C. Results showed that the addition of goldenberry juice significantly increased the levels of acidity, total soluble solids, ascorbic acid and total phenolic compounds along with antioxidant activity for all nectars when compared to the control carrot nectar (T1). In contrast, the levels of turbidity and β-carotene were significantly decreased by the addition of goldenberry. For color parameters, both L^* and a^* values were significantly decreased, while b^* values were significantly increased by the addition of goldenberry. Goldenberry improved the organoleptic properties of the carrot nectar, and reduced deterioration in these properties during storage. Moreover, the results of microbial analysis indicated that all nectars were microbiologically safe (counts of total aerobic count and yeast and mold were less than 1 $\log_{10}$ CFU/mL). The carrot–goldenberry nectar (T3) had the highest overall acceptability during storage time. The obtained results valorize exploiting of goldenberry juice in processed fruit products like jams, juices and syrups.

✉ Sayed Mohamed Mokhtar
smmokhtar@yahoo.com

Hassan El-Sayed Embaby
h_embaby@yahoo.com

[1] Department of Food Technology, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt

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Introduction

Consumer's attention towards foods low in calories and rich in bioactive compounds is notably increasing worldwide. There is also acknowledged a positive correlation between high consumption of fruits and vegetables, that are rich in bioactive compounds such as vitamin C and phenolic compounds, and reducing risks of degenerative diseases such as cancer, cardiovascular diseases, stroke and alzheimer disease (Boeing et al. 2012). The goldenberry (*Physalis peruviana* L.) is an annual plant that belongs to the family Solanaceae, and is cultivated for commercial production in some tropical and subtropical regions worldwide. World's goldenberry fruit cultivation area is approximately 29,438 ha and 169,370 tonnes of yield is obtained from this area (FAOSTAT 2017). The goldenberry fruit (*Physalis peruviana* L.), is a juicy berry protected by a calyx (a papery husk) and has a shelf life that favors exporting from the producing regions to different markets worldwide (Puente et al. 2011). In Egypt, goldenberry (so-called "harankash"), is produced in different regions and consumed as a fresh product. Also, goldenberry can be exploited in the production of different foods such as jams, juices, syrups, marmalades and desserts (Puente et al. 2011).

Different studies have reported the high nutritional value of goldenberry fruit (El Sheikha et al. 2010; Puente et al. 2011; Yıldız et al. 2015). Besides carotenoids and withanolides, the goldenberry fruit contains high level of vitamin C and phenolic compounds (i.e. flavonoids). These bioactive compounds may contribute to the overall antioxidant, anti-inflammatory and antimicrobial properties of goldenberry fruits. As a consequence, the goldenberry fruits are used in the traditional medicine and for protection from some degenerative diseases (Martínez et al. 2010; Puente et al. 2011; Ramadan 2011; Ramadan and Moersel 2007). Because of their nutritional value and health benefits, the goldenberries have been increasingly distributed worldwide. With regard to the techno-functional properties, goldenberry juice has a high content of total soluble solids (10–16 °Brix) and exhibits a low pH (3.6–3.8) (Ramadan and Moersel 2007; Sharoba and Ramadan 2011). In addition to its positive impact on the microbial safety of industrially processed fruit juices, this low pH value of goldenberry juice may enhance also the balance between sweetness and acidity of some non-acidic fruit or vegetable juices such as carrot juice.

Though high content of bioactive compounds (in particular carotenoids) in the carrot (*Daucus carota* L.) juice, the low acidity (high pH value, > 6) of juice may require high thermal treatment during industrial processing with regard to inactivation of microbial activity. This may impact the quality characteristics of the food product. For instance, high thermal processing treatments may impact negatively bioactive compounds such as ascorbic acid and organoleptic characteristics such as color. Hence, acidification of carrot juice by citric acid for prolonging the shelf-life and improving the taste is needed (Demir et al. 2004). In this context, exploiting acidic fruit juices such as orange juice or goldenberry juice may improve the quality characteristics, including the content of bioactive antioxidants, of carrot juices. Therefore, the present study is aiming to evaluate the impact of the addition of different ratios of the goldenberry juice on the techno-functional properties (acidity, pH, TSS, turbidity and color attributes L^*, a^* and b^*), microbial safety, content of bioactive compounds (β-carotene, ascorbic acid and phenolic compounds), antioxidant activity and organoleptic characteristics (color, taste, odor, appearance and mouthfeel) of the pasteurized carrot nectar (a carrot juice diluted with sugar solution 1:1). These quality characteristics of carrot–goldenberry nectars compared to the carrot nectar were measured during 28 days of cold storage at 4 °C.

Materials and methods

Materials and chemicals

Fresh carrots (*Daucus carota* L.) and goldenberry (*Physalis peruviana* L.) fruits were procured from a local market in Ismailia, Egypt. The carrots and goldenberry fruits were carefully selected in terms of ripeness and shape. Pectinex Smash XXL, with an activity of 30.000 UPTE/mL was purchased from Novozymes Co. (Beijing, China). DPPH (2,2-diphenyl-1-picrylhydrazyl) and Folin–Ciocalteu were obtained from Sigma-Aldrich (St, Louis, USA). All other solvents and chemicals were purchased from Fisher Scientific (Mumbai, India).

Methods

Processing of goldenberry pulp

Fresh goldenberry fruits were washed with tap water, dried in air, and pulped by using a Moulinex juice extractor (type 753, Moulinex, Spain).

Processing of carrot pulp

According to Liao et al. (2007), fresh carrots were washed with clean running tap water, both ends were removed and sliced into 2 cm thickness, blanched with 0.2% citric acid solution at 95–98 °C for 2 min, and pulped by using a juice extractor.

Processing of carrot–goldenberry nectar blends

The obtained pulps were macerated for 90 min at 40–45 °C with pectinex Smash XXL (0.1 mL/Kg), after adjustment of pH to 4.5–4.8, at the end of maceration the juices were heated at 98–100 °C for 3–4 min using microwave oven (Microchef 2335, Moulinex, France) to inactivate the added enzymes, and cooled using running tap water. The resulting juices were homogenized for 5 min, in a homogenizer (ultra-turrax T50, Janke&Kunkel Co., Germany). Carrot and goldenberry juices were filtered through muslin cloth. Five blends (with three replicates) were prepared from carrot and goldenberry juices, they included: T1 (carrot juice, as a control), T2 (carrot and goldenberry juices, 80:20), T3 (carrot and goldenberry juices, 70:30), T4 (carrot and goldenberry juices, 60:40) and T5 (carrot and goldenberry juices, 50:50). For nectar production, the obtained blends were mixed with sucrose solution (18%) at ratio of 1:1. Each prepared nectar was filled in a 250 mL glass bottle, sealed and then heated up to 98 °C. The pasteurization holding time was for 2 min at 98 ± 2 °C. All nectars were suddenly cooled and then stored at 4 ± 1 °C for 28 days.

Determination of total soluble solids, pH, titratable acidity and ascorbic acid

The level of total soluble solids (TSS) was measured in Brix degrees using an Abbe refractometer (C10, Vee Gee, USA) at 20 °C. The pH of the juice samples was monitored by means of a Jenway pH meter (Jenway 3510, Bibby

Scientific Ltd., Stone, Staffs, UK). Titrable acidity (TA) was determined by titrating 10 ml of the carrot–goldenberry nectar with standardized NaOH 0.1 N reaching pH 8.1 (the obtained results were expressed as %, citric acid) (AOAC 2000). The ascorbic acid (vitamin C) content of the samples was estimated by titration method using freshly prepared 2.6-dichlorophenolindophenol dye solution (AOAC 2000).

Determination of total phenolic compounds and antioxidant activity

Total phenolic compounds (TPC) were determined in the methanolic extract using the Folin–Ciocalteu colorimetric method (Osorio-Esquivel et al. 2011). Antioxidant activity of the methanolic extract was determined by DPPH (2,2-diphenyl-1-picrylhydrazyl) method according to Ravichandran et al. (2013).

Measurement of color and β-carotene

Color parameters (CIE L^*, a^*, and b^*) were performed using a color reader CR-10 (Konika Minolta, Inc., Osaka, Japan). β-Carotene content was determined with the method described by Barros et al. (2011) using acetone:hexane mixture (4:6, v/v).

Measurement of turbidity

Measurement of turbidity is a spectrophotometric test to determine the cloud stability. Turbidity was determined according to the method of Stähle-Hamatschek (1989) with little modification. Nectar samples were centrifuged at $4200\times g$ for 15 min, and the turbidity of the supernatant was measured at 660 nm by a spectrophotometer (6505 UV/Vis, Jenway Ltd., Felsted, Dunmow, UK).

Microbiological analysis

Ten g of nectar samples were taken for microbiological assessment, the samples were serially diluted with 0.1% buffered peptone water. Appropriate dilutions were enumerated on nutrient agar for total aerobic count (TAC), and on potato dextrose agar for yeast and mold count (YMC). The plates were incubated at 37 °C for 48 h for TAC and at 25 °C for 5 days for YMC. The mean numbers of colonies counted were expressed as log colony forming units (CFU)/g.

Sensory evaluation

Nectar samples were evaluated according to the method described by Min et al. (2003) using 9-point hedonic scale (9 = like extremely and 0 = dislike extremely). Sensory evaluation was carried out by ten panelists of the staff members of Food Technology Department, Faculty of Agriculture, Suez Canal University. The panelists were asked to assign suitable score for characteristic color, taste, aroma, mouth feel and overall acceptability.

Statistical analysis

Data were presented as mean ± SD of three replications. Analysis of variance (ANOVA) for determining the significance at $p < 0.05$ level between means of treatments, and further, Pearson's correlation between antioxidant activity and each of total phenolic compounds, ascorbic acid and β-carotene were provided by SPSS software (version 17, SPSS Inc., Chicago, USA).

Results and discussion

Physicochemical properties of fresh carrot and goldenberry juices

Data presented in Table 1 show the properties of goldenberry and carrot juices. Significant differences ($p < 0.05$) for all examined properties were found between goldenberry and carrot juices. Goldenberry juice had higher levels of total soluble solids (TSS) (13.42), acidity (1.41%, with lower pH 3.76), ascorbic acid (71.06 mg/100 mL), total phenolic compounds (TPC) (39.42 mg/100 mL) and antioxidant activity (85.44%) when compared to those of the carrot juice (TSS 8.33, acidity 0.05%, ascorbic acid 14.41 mg/100 mL, TPC 19.76 mg/100 mL and antioxidant activity 21.11%). In the present results, goldenberry juice had lower level of TSS (13.42) when compared to that reported by Sharoba and Ramadan (2011) for goldenberry juice, but it had a higher level of ascorbic acid. Also, the levels of acidity and pH were close to those reported by Sharoba and Ramadan (2011), indicating that goldenberry juice is acidic with a sour taste. The color of goldenberry juice was yellowish green color (L^* 40.84, a^* 3.76 and b^* 20.68), but carrot juice had orange color (L^* 41.96, a^* 10.4 and b^* 19.58). In general, the levels of some properties (pH, acidity and TSS) for carrot juice were close to those previously reported by Vandresen et al. (2009) for carrot juice. Also, carrot juice contained a higher level of ascorbic acid than that reported by Quitão-Teixeira et al. (2009) for carrot juice, but it had a lower level of TPC. Comparing to carrot juice, the goldenberry juice had a higher nutritional value with a higher stability because of its higher contents of ascorbic acid, TPC and antioxidant activity.

Table 1 Physicochemical properties of fresh carrot and goldenberry juices

Parameter	Carrot juice	Goldenberry juice
TSS (°Brix)	8.33 ± 0.076^{b}	13.42 ± 0.144^{a}
pH	6.31 ± 0.03^{a}	3.76 ± 0.035^{b}
Titratable acidity (%, as citric acid)	0.05 ± 0.002^{b}	1.41 ± 0.006^{a}
Ascorbic acid (mg/100 mL)	14.41 ± 0.759^{b}	71.06 ± 0.320^{a}
Total phenolic compounds (mg/100 mL)	19.76 ± 0.527^{b}	39.42 ± 0.532^{a}
Antioxidant activity (%)	21.11 ± 0.789^{b}	85.44 ± 0.558^{a}
Color attributes		
*L**	41.96 ± 0.478^{a}	40.84 ± 0.385^{b}
*a**	10.4 ± 0.596^{a}	3.76 ± 0.167^{b}
*b**	19.58 ± 0.295^{b}	20.68 ± 0.507^{a}

Means with different letters (^{a,b}) in each row means significant difference ($p < 0.05$) between values in the row

Total soluble solids, pH, titratable acidity and turbidity of carrot and carrot–goldenberry nectar blends

Changes of total soluble solids (TSS), pH, titratable acidity (TA) and turbidity in carrot and carrot–goldenberry nectar blends during cold storage are presented in Table 2. TSS, pH, TA and turbidity of the five nectar samples were significantly different ($p < 0.05$) due to the different carrot–goldenberry juice ratios. Nectar blends containing goldenberry had higher levels of TSS and TA (lower pH values) when compared to the control. Also, the increase of TSS

Table 2 Changes in total soluble solids, pH, titratable acidity and turbidity of carrot–goldenberry nectar blends during 28 days storage at 4 °C

Parameter	Treatment	Storage time (days)				
		0	7	14	21	28
TSS	T1	12.48 ± 0.029^{eA}	12.42 ± 0.144^{dA}	12.38 ± 0.126^{cA}	12.35 ± 0.173^{cA}	12.30 ± 0.132^{dA}
	T2	12.83 ± 0.144^{dA}	12.75 ± 0.250^{cA}	12.62 ± 0.126^{cA}	12.60 ± 0.100^{cA}	12.55 ± 0.278^{cdA}
	T3	13.17 ± 0.144^{cA}	13.12 ± 0.126^{bA}	13.17 ± 0.382^{bA}	13.05 ± 0.180^{bA}	12.88 ± 0.126^{bcA}
	T4	13.70 ± 0.087^{bA}	13.72 ± 0.104^{aA}	13.60 ± 0.304^{abAB}	13.43 ± 0.115^{aAB}	13.25 ± 0.250^{abB}
	T5	13.92 ± 0.144^{aA}	13.80 ± 0.087^{aAB}	13.75 ± 0.150^{aAB}	13.62 ± 0.126^{aBC}	13.45 ± 0.180^{aC}
pH	T1	4.86 ± 0.015^{aA}	4.85 ± 0.013^{aAB}	4.85 ± 0.010^{aAB}	4.83 ± 0.010^{aBC}	4.81 ± 0.006^{aC}
	T2	4.69 ± 0.008^{eA}	4.68 ± 0.010^{eA}	4.65 ± 0.010^{eB}	4.66 ± 0.006^{eBC}	4.63 ± 0.015^{dC}
	T3	4.77 ± 0.006^{dA}	4.77 ± 0.010^{dA}	4.76 ± 0.006^{dA}	4.75 ± 0.006^{dAB}	4.73 ± 0.026^{cB}
	T4	4.80 ± 0.012^{cA}	4.79 ± 0.003^{cAB}	4.78 ± 0.003^{cABC}	4.77 ± 0.012^{cBC}	4.77 ± 0.012^{bC}
	T5	4.83 ± 0.006^{bA}	4.81 ± 0.006^{bAB}	4.81 ± 0.010^{bB}	4.80 ± 0.015^{bB}	4.78 ± 0.006^{bC}
TA	T1	0.080 ± 0.002^{eB}	0.088 ± 0.002^{eA}	0.089 ± 0.002^{eA}	0.089 ± 0.002^{eA}	0.090 ± 0.002^{eA}
	T2	0.154 ± 0.002 ^{dB}	0.166 ± 0.005^{dA}	0.168 ± 0.003^{dA}	0.170 ± 0.002^{dA}	0.170 ± 0.003^{dA}
	T3	0.188 ± 0.004^{cB}	0.203 ± 0.002^{cAB}	0.203 ± 0.005^{cAB}	0.206 ± 0.002^{cAB}	0.208 ± 0.004^{cA}
	T4	0.229 ± 0.002^{bC}	0.245 ± 0.003^{bB}	0.247 ± 0.002^{bAB}	0.247 ± 0.002^{bAB}	0.250 ± 0.002^{bA}
	T5	0.247 ± 0.002^{aC}	0.272 ± 0.002^{aB}	0.274 ± 0.006^{aB}	0.274 ± 0.004^{aB}	0.281 ± 0.002^{aA}
Turbidity	T1	0.585 ± 0.002^{aA}	0.530 ± 0.003^{aB}	0.476 ± 0.006^{aC}	0.442 ± 0.002^{aD}	0.314 ± 0.003^{aE}
	T2	0.547 ± 0.003^{Ba}	0.461 ± 0.004^{bB}	0.406 ± 0.003^{bC}	0.400 ± 0.002^{bD}	0.271 ± 0.002^{bE}
	T3	0.404 ± 0.005^{cA}	0.359 ± 0.007^{cB}	0.348 ± 0.001^{cC}	0.325 ± 0.005^{cD}	0.257 ± 0.002^{cE}
	T4	0.386 ± 0.006^{dA}	0.313 ± 0.002 ^{dB}	0.300 ± 0.010^{dC}	0.265 ± 0.005^{dD}	0.221 ± 0.004^{dE}
	T5	0.325 ± 0.001^{eA}	0.280 ± 0.011^{eB}	0.260 ± 0.006^{eC}	0.218 ± 0.003^{eD}	0.201 ± 0.003^{eE}

^{a,b,c,d,e}Mean values in the same column (corresponding to the same storage day) bearing different letters are significantly different ($p < 0.05$) between nectar treatments. ^{A,B,C,D,E}Mean values in the same raw (corresponding to the same treatment) bearing different letters are significantly different ($p < 0.05$) between days of storage; T1 (carrot nectar), T2 (carrot–goldenberry, 80:20), T3 (carrot–goldenberry, 70:30), T4 (carrot–goldenberry, 60:40) and T5 (carrot–goldenberry, 50:50) and TA was proportional with the goldenberry ratio, thus T4 and T5 had the highest levels. This was due to the high levels of TSS and TA in goldenberry juice (Table 1). However, T1 had the highest level of the turbidity comparing to the nectar blends.

During storage, carrot nectar and all nectar blends had the same pattern of increasing TA and decreasing TSS, pH and turbidity over storage period. Present results are in agreement with those reported by Gao and Rupasinghe (2012) for apple–carrot juice blends, Hashem et al. (2014) for orange–carrot juice blends and Liao et al. (2007) for carrot juice. Also, Bal et al. (2014) found a significant increase in acidity in guava nectar during storage. In contrast, Gao and Rupasinghe (2012) reported that turbidity of all apple–carrot juice blends significantly increased after 21 days of cold storage.

Ascorbic acid, total phenolic compounds and antioxidant activity of carrot and carrot–goldenberry nectar blends

The levels of ascorbic acid, total phenolic compounds (TPC) and antioxidant activity in nectar blends during cold storage are summarized in Fig. 1a–c. Significant differences ($p < 0.05$) of ascorbic acid were noticed among the nectar blends (Fig. 1a), and nectars containing goldenberry juice (T2, T3, T4 and T5) had higher levels of ascorbic acid than that of the control (carrot nectar; T1). This is due to the higher level of ascorbic acid in goldenberry juice than that of carrot juice as shown in Table 1. Also, the level of ascorbic acid in nectars was directly proportional to the level of goldenberry juice, thus T5 had the highest levels. During the storage, a significant decrease in ascorbic acid was recorded for all nectar blends. This reduction was attributed to the oxidation of ascorbic acid and exposure to the light. Present results are in agreement with those of Bal et al. (2014) for guava nectar, Karav et al. (2015) for pomegranate juice and Liu et al. (2014) for mango nectar during the storage. Also, a significant decrease in ascorbic acid during cold storage of commercial orange and grapefruit juices was reported by Kabasakalis et al. (2000). Later, Piljac-Žegarac et al. (2009) reported similar findings during cold storage of black currant, cranberry, blueberry, pomegranate, strawberry and cherry juices.

The results indicate that the use of goldenberry juice in nectar blends significantly ($p > 0.05$) affected the levels of TPC As shown in Fig. 1b, the nectars containing goldenberry juice (T2, T3, T4 and T5) had higher levels of TPC and this was attributed to the higher levels of TPC in goldenberry juice when compared to the carrot juice (Table 1). The highest addition level of goldenberry juice (T5) resulted in the highest increase in TPC even after 28 days of storage. However, during cold storage, a significant decrease of TPC were observed in all nectar blends (Fig. 1b). Clearly, phenolic compounds of carrot and carrot–goldenberry nectar blends were not stable during the storage. Similarly, a decrease in TPC content during cold storage has been previously reported by Liu et al. (2014) for mango nectars. In contrast, Piljac-Žegarac et al. (2009) reported an increase in TPC content during cold storage (29 day) for black currant, cranberry, blueberry, pomegranate, strawberry and cherry juices. On the other hand, phenolic compounds content of some fruits and vegetables may remain stable during cold storage (Kevers et al. 2007).

As for ascorbic acid and TPC, nectars containing goldenberry juice exhibited higher antioxidant activity during the storage, and T5 had the highest levels (Fig. 1c). Also, a similar significant decreasing trend of antioxidant activity was recorded during the cold storage. Similarly, Liu et al. (2014) and Piljac-Žegarac et al. (2009) reported a gradual decrease in antioxidant activity for some fruit nectars during cold storage. In fact, antioxidant activity has been correlated with the levels of phenolic compounds and ascorbic acid in strawberries and black grapes (Kevers et al. 2007). Conclusively, goldenberry juice improved the levels of ascorbic acid, phenolic compounds and antioxidant activity in nectar blends, hence, the aforementioned compounds enhanced the stability of these products.

Color parameters and β-carotene of carrot and carrot–goldenberry nectar blends

Changes in the color parameters (L^*, a^* and b^*) and β-carotene in carrot and carrot–goldenberry nectar blends during storage of 28 days are presented in Table 3. Blending of goldenberry juice with carrot juice significantly decreased L^* and a^* values, and significantly increased b^* values of all nectar blends. Therefore, nectar samples containing goldenberry juice (T2, T3, T4, and T5) had lower levels of L^* and a^* values, and higher levels of b^* values than that of the control (T1). This might be due to the lower L^* and a^* values and the higher b^* values of goldenberry juice (Table 1). All examined nectar samples showed a significant decrease in L^*, a^* and b^* values during storage. Similar results were observed by Liu et al. (2014) who reported that all treated mango nectar samples showed a decrease in the L^* value during storage. In addition, a significant decrease was noticed in L^* values during storage of goldenberry juice (Rabie et al. 2014), and treated and untreated pineapple juices (Chia et al. 2012). Furthermore, a considerable decrease was found in a^* and b^* values of high hydrostatic pressure treated pomegranate juice during cold storage (Varela-Santos et al. 2012). In contrast, an increase in the L^* and a^* values was noticed in

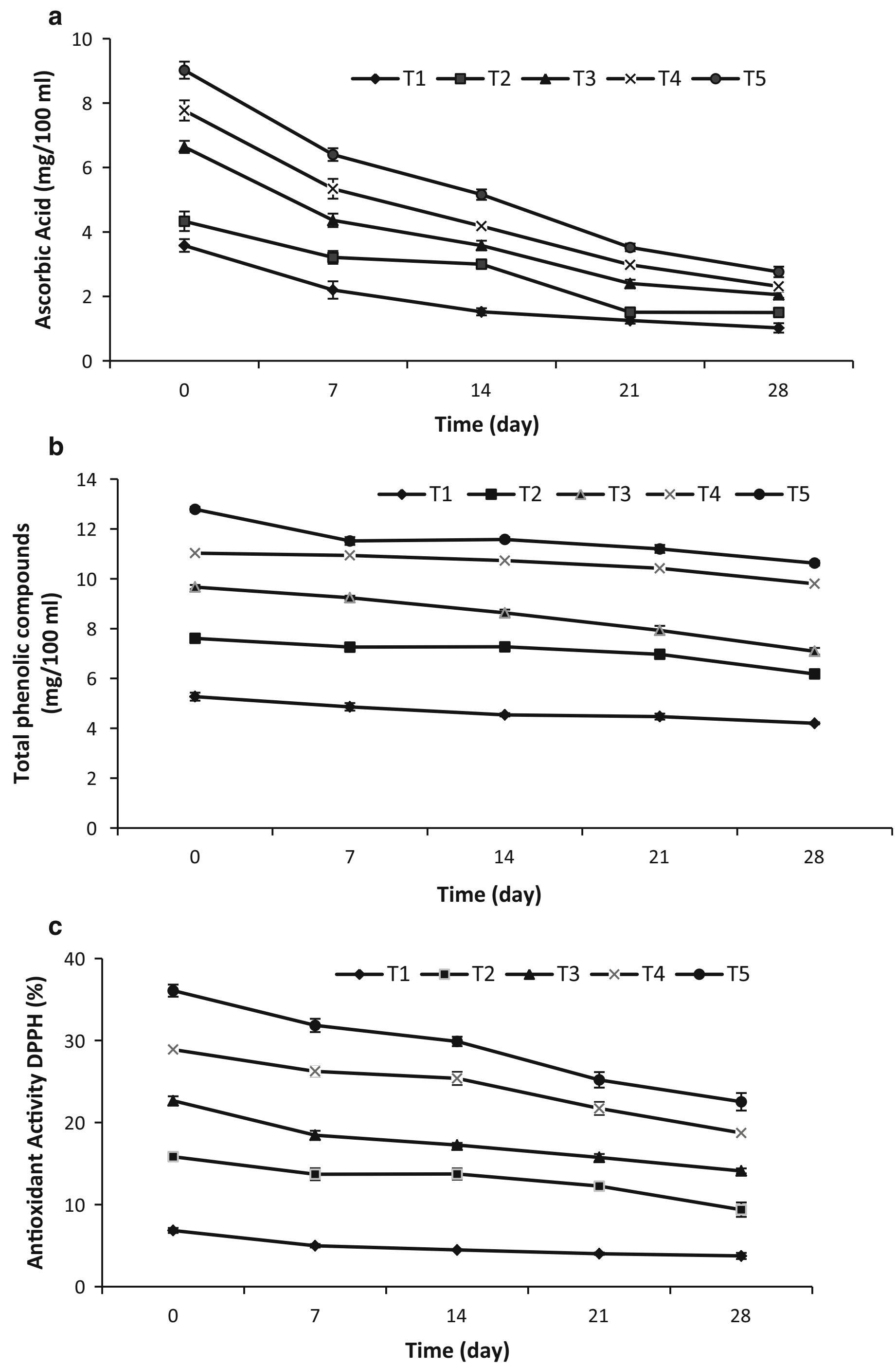

Fig. 1 Levels of ascorbic acid (**a**), total phenolic compounds (**b**) and antioxidant activity (**c**) in nectar blends: T1 (carrot nectar), T2 (carrot–goldenberry, 80:20), T3 (carrot–goldenberry, 70:30), T4 (carrot–goldenberry, 60:40) and T5 (carrot–goldenberry, 50:50). Results represent mean values of triplicate determinations ± SD. Standard deviations are shown by error bars

ultrasound treated grape juice (Sengun and Karapinar 2004).

The β-carotene content of the examined nectar samples varied from 11.73 to 17.63 mg/L (Table 3). The β-carotene content of carrot nectar was the highest and β-carotene content of the nectar blend of carrot–goldenberry (T5) was the lowest during the period of cold storage (Table 3). β-carotene content was significantly decreased during storage of all nectar samples. After 28 days storage, β-carotene content decreased by 19.34 and 55.16% in T1 and T5, respectively. Similar results in orange–carrot juice blends, goldenberry juice and papaya-bael juice blend were observed by Hashem et al. (2014), Rabie et al. (2014) and Tandon et al. (2007), respectively. These results are in contrast with Gao and Rupasinghe (2012) and Rivas et al. (2006) who reported that β-carotene content was stable and did not exhibit significant changes during storage for

Table 3 Changes in color parameters (*L**, *a** and *b**) and β-carotene of carrot–goldenberry nectar blends during 28 days storage at 4 °C

Parameter	Treatment	Storage time (days)				
		0	7	14	21	28
Color						
*L**	T1	39.02 ± 0.205^{aA}	38.62 ± 0.356^{aA}	38.52 ± 0.356^{aA}	38.00 ± 0.381^{aB}	37.66 ± 0.522^{aB}
	T2	38.64 ± 0.493^{abA}	38.36 ± 0.288^{aAB}	38.26 ± 0.152^{abAB}	37.92 ± 0.733^{aBC}	37.38 ± 0.421^{abC}
	T3	38.20 ± 0.561^{bcA}	38.02 ± 0.228^{aA}	37.96 ± 0.483^{bA}	37.70 ± 0.187^{aA}	36.58 ± 0.760^{bB}
	T4	37.78 ± 0.634^{cA}	37.20 ± 0.696^{bAB}	36.42 ± 0.228^{cBC}	35.96 ± 0.228^{bC}	35.62 ± 0.901^{cC}
	T5	37.04 ± 0.230^{dA}	35.68 ± 0.694^{cB}	35.66 ± 0.456 ^{dB}	35.04 ± 0.817^{cB}	34.84 ± 0.650^{cB}
*a**	T1	10.54 ± 0.261^{aA}	9.74 ± 0.288^{aB}	9.42 ± 0.887^{aBC}	9.30 ± 0.400^{aBC}	9.02 ± 0.259^{aC}
	T2	9.58 ± 0.390^{aA}	8.60 ± 0.316^{bB}	8.56 ± 0.397^{bB}	8.34 ± 0.321^{bBC}	8.00 ± 0.122^{bC}
	T3	8.56 ± 0.971^{bA}	8.30 ± 0.400^{bAB}	8.14 ± 0.498^{bAB}	7.86 ± 0.344^{cAB}	7.64 ± 0.673^{bB}
	T4	7.90 ± 0.903^{bA}	6.94 ± 0.336^{cB}	6.68 ± 0.614^{cB}	6.60 ± 0.158 ^{dB}	6.24 ± 0.513^{cB}
	T5	6.42 ± 0.884^{cA}	6.28 ± 0.835^{dAB}	5.58 ± 0.286^{dBC}	5.32 ± 0.130^{eC}	5.02 ± 0.492^{dC}
*b**	T1	18.80 ± 0.608^{bA}	18.28 ± 0.432^{cAB}	18.16 ± 0.451^{bAB}	18.02 ± 0.712^{bB}	18.04 ± 0.134^{cB}
	T2	18.98 ± 0.669^{bA}	18.32 ± 0.630^{cA}	18.30 ± 0.721^{bA}	18.26 ± 0.391^{bA}	18.22 ± 0.319^{bcA}
	T3	19.10 ± 0.274^{bA}	18.88 ± 0.661^{bcA}	18.76 ± 0.378^{abA}	18.66 ± 0.261^{abA}	18.58 ± 0.626^{abcA}
	T4	19.50 ± 0.570^{abA}	19.32 ± 0.084^{abAB}	19.30 ± 0.361^{aAB}	19.16 ± 0.336^{aAB}	18.78 ± 0.540^{abB}
	T5	19.82 ± 0.084^{aA}	19.96 ± 0.695^{aA}	19.42 ± 0.427^{aA}	19.18 ± 0.646^{aA}	19.18 ± 0.597^{aA}
β-Carotene	T1	17.63 ± 0.054^{aA}	17.11 ± 0.710^{aA}	15.08 ± 0.325^{aB}	14.85 ± 0.097^{aBC}	14.22 ± 0.254^{aC}
	T2	15.70 ± 0.350^{bA}	13.61 ± 0.360^{bB}	12.18 ± 0.075^{bC}	11.38 ± 0.176^{bD}	10.33 ± 0.257^{bE}
	T3	15.17 ± 0.206^{cA}	12.91 ± 0.611^{bB}	11.28 ± 0.202^{cC}	10.00 ± 0.050^{cD}	9.04 ± 0.260^{cE}
	T4	11.96 ± 0.245^{dA}	9.70 ± 0.361^{cB}	8.57 ± 0.161^{dC}	7.18 ± 0.284^{cD}	6.03 ± 0.252^{dE}
	T5	11.73 ± 0.167^{dA}	9.60 ± 0.350^{cB}	7.82 ± 0.225^{eC}	6.22 ± 0.306^{eD}	5.26 ± 0.159^{eE}

[a,b,c,d,e]Mean values in the same column (corresponding to the same storage day) bearing different letters are significantly different ($p < 0.05$) between nectar treatments. [A,B,C,D,E]Mean values in the same raw (corresponding to the same treatment) bearing different letters are significantly different ($p < 0.05$) between days of storage; T1 (carrot nectar), T2 (carrot–goldenberry, 80:20), T3 (carrot–goldenberry, 70:30), T4 (carrot–goldenberry, 60:40) and T5 (carrot–goldenberry, 50:50)

apple–carrot juice blends and orange–carrot juice blends, respectively.

Microbiological analysis of carrot and carrot–goldenberry nectar blends

For all examined nectar samples, immediately after processing and during the whole storage period, counts of total aerobic count and yeast and mold were less than 1 $\log_{10}$ CFU/mL, which agreed the requirements of Egyptian juice standards and indicated that nectar samples were microbiologically safe. These obtained results may due to the thermal pasteurization and/or the low pH values of the processed nectars. Similar results were observed by Liu et al. (2014) who reported that counts of total aerobic bacteria and yeasts and molds of treated mango nectar samples after processing and during storage were less than 2.00 $\log_{10}$ CFU/mL and 1.00 $\log_{10}$ CFU/mL, respectively.

Sensory properties of carrot and carrot–goldenberry nectar blends

Sensory scores of the carrot and various nectar blends are presented in Table 4. The color, taste, odor, appearance, mouth feel and overall acceptability were evaluated. As shown in Table 4, all nectars had high scores for color and appearance with insignificant differences at zero time. However, for all nectar blends, the color and appearance scores gradually decreased with progress of storage time. Also, the nectars containing goldenberry juice (20%, 30% and 40%) had less rates of color and appearance deterioration and T3 (30%) had the best scores. The decrease in color score during cold storage might be due to the browning reactions and the high acidity in the goldenberry juice inhibited some of these reactions. Similar results were found by Bal et al. (2014) for guava nectar and by Chakraborthy et al. (1991) for canned mango nectar. Significant differences ($p < 0.05$) of taste and odor scores were recorded among the nectar blends. The results

Table 4 Changes in the sensory parameters of carrot–goldenberry nectar blends during 28 days storage at 4 °C

Parameter	Treatment	Storage time (days)				
		0	7	14	21	28
Color	T1	8.33 ± 0.611^{aA}	7.50 ± 0.500^{abB}	7.17 ± 0.289^{abBC}	7.17 ± 0.289^{abBC}	6.50 ± 0.500^{abC}
	T2	8.67 ± 0.586^{aA}	8.17 ± 0.289^{abAB}	7.83 ± 0.289^{aABC}	7.33 ± 0.577^{abBC}	7.00 ± 0.500^{aC}
	T3	8.67 ± 0.611^{aA}	8.33 ± 0.577^{aAB}	7.83 ± 0.289^{aABC}	7.50 ± 0.500^{aBC}	7.17 ± 0.289^{aC}
	T4	8.33 ± 0.577^{aA}	8.00 ± 0.200^{abAB}	7.33 ± 0.577^{abBC}	7.17 ± 0.351^{abC}	7.03 ± 0.252^{aC}
	T5	8.33 ± 0.651^{aA}	7.33 ± 0.577^{bB}	6.83 ± 0.289^{bBC}	6.50 ± 0.500^{bBC}	6.17 ± 0.473^{bC}
Taste	T1	6.67 ± 0.577^{abA}	6.17 ± 0.289^{bAB}	5.60 ± 0.361^{cBC}	5.10 ± 0.361^{cC}	4.07 ± 0.513^{dD}
	T2	6.83 ± 0.764^{aAB}	7.33 ± 0.577^{aA}	6.77 ± 0.322^{bAB}	6.37 ± 0.322^{bB}	6.00 ± 0.300^{bB}
	T3	7.67 ± 0.577^{aAB}	8.17 ± 0.764^{aA}	7.60 ± 0.361^{aAB}	7.30 ± 0.300^{aAB}	7.00 ± 0.200^{aB}
	T4	7.00 ± 0.500^{aA}	7.50 ± 0.500^{aA}	7.00 ± 0.200^{abA}	6.90 ± 0.361^{abA}	6.20 ± 0.265^{bB}
	T5	5.67 ± 0.577^{bA}	5.83 ± 0.289^{bA}	5.50 ± 0.500^{cA}	5.00 ± 0.436^{cA}	5.07 ± 0.306^{cA}
Odor	T1	7.40 ± 0.529^{abA}	7.07 ± 0.306^{abAB}	6.87 ± 0.208^{bAB}	6.57 ± 0.404^{aB}	5.80 ± 0.300^{bcC}
	T2	7.70 ± 0.608^{aA}	7.23 ± 0.404^{aAB}	7.20 ± 0.265^{abAB}	6.97 ± 0.351^{aAB}	6.47 ± 0.473^{abB}
	T3	7.90 ± 0.557^{aA}	7.60 ± 0.458^{aAB}	7.47 ± 0.252^{aAB}	7.10 ± 0.361^{aB}	7.03 ± 0.322^{aB}
	T4	7.07 ± 0.208^{abA}	7.00 ± 0.200^{abA}	7.00 ± 0.200^{bA}	6.73 ± 0.252^{aA}	6.57 ± 0.379^{aA}
	T5	6.67 ± 0.586^{bA}	6.43 ± 0.404^{bAB}	6.17 ± 0.289^{cAB}	5.80 ± 0.265^{bBC}	5.20 ± 0.361^{cC}
Appearance	T1	8.63 ± 0.473^{aA}	7.77 ± 0.306^{abB}	6.57 ± 0.551^{bcC}	6.07 ± 0.306^{bcCD}	5.33 ± 0.351^{cE}
	T2	8.63 ± 0.404^{aA}	8.10 ± 0.656^{aAB}	7.23 ± 0.351^{abBC}	6.60 ± 0.557^{abCD}	6.13 ± 0.351^{bE}
	T3	8.60 ± 0.458^{aA}	8.27 ± 0.666^{aAB}	7.47 ± 0.473^{aBC}	7.20 ± 0.265^{aC}	6.90 ± 0.265^{aC}
	T4	8.23 ± 0.404^{aA}	7.97 ± 0.666^{abAB}	7.27 ± 0.379^{abBC}	6.77 ± 0.252^{aCD}	6.33 ± 0.493^{abD}
	T5	8.03 ± 0.153^{aA}	6.97 ± 0.252^{bB}	6.27 ± 0.379^{cC}	5.80 ± 0.300^{c}C	5.20 ± 0.265^{cD}
Mouth feel	T1	7.30 ± 0.625^{bcA}	7.03 ± 0.651^{bcAB}	6.17 ± 0.666^{cBC}	5.60 ± 0.361^{cC}	5.33 ± 0.306^{cC}
	T2	8.37 ± 0.569^{aA}	7.73 ± 0.306^{abAB}	7.17 ± 0.493^{abcBC}	6.60 ± 0.625^{bCD}	6.13 ± 0.252^{bE}
	T3	8.63 ± 0.473^{aA}	8.37 ± 0.569^{aAB}	8.17 ± 0.379^{aAB}	7.70 ± 0.458^{aBC}	7.17 ± 0.404^{aC}
	T4	7.73 ± 0.379^{abA}	7.37 ± 0.723^{abcA}	7.23 ± 0.416^{abAB}	6.33 ± 0.493^{bcB}	6.40 ± 0.436^{bB}
	T5	6.53 ± 0.493^{cA}	6.33 ± 0.416^{cAB}	6.30 ± 0.700^{bcAB}	5.70 ± 0.436^{bcAB}	5.40 ± 0.361^{cB}
Overall acceptability	T1	7.60 ± 0.557^{bA}	6.53 ± 0.551^{cB}	6.30 ± 0.529^{bcBC}	5.43 ± 0.351^{cCD}	4.67 ± 0.404^{dD}
	T2	8.33 ± 0.586^{abA}	7.67 ± 0.493^{abA}	6.63 ± 0.681^{bcB}	6.33 ± 0.493^{bB}	6.10 ± 0.300^{bB}
	T3	8.70 ± 0.361^{aA}	8.43 ± 0.493^{aA}	8.13 ± 0.252^{aA}	7.43 ± 0.416^{aB}	7.20 ± 0.361^{aB}
	T4	7.60 ± 0.458^{bA}	7.50 ± 0.458^{bA}	7.07 ± 0.306^{bAB}	6.73 ± 0.306^{abB}	6.60 ± 0.300^{bB}
	T5	6.43 ± 0.586^{cA}	6.03 ± 0.208^{cAB}	5.93 ± 0.208^{cABC}	5.47 ± 0.473^{cBC}	5.27 ± 0.208^{cC}

^{a,b,c,d,e}Mean values in the same column (corresponding to the same storage day) bearing different letters are significantly different ($p < 0.05$) between nectar treatments. ^{A,B,C,D,E}Mean values in the same raw (corresponding to the same treatment) bearing different letters are significantly different ($p < 0.05$) between days of storage; T1 (carrot nectar), T2 (carrot–goldenberry, 80:20), T3 (carrot–goldenberry, 70:30), T4 (carrot–goldenberry, 60:40) and T5 (carrot–goldenberry, 50:50)

indicated that goldenberry juice improved the taste and the odor of the nectars and T3 (30% goldenberry juice) had the best scores, but the control (T1; carrot nectar) had the lowest one. Also, a significant decrease was observed in taste and odor score during the storage and the minimal changes were found in carrot–goldenberry nectar blends. The improvement of the taste for carrot–goldenberry nectars may be due to the higher acidity in the goldenberry juice, which caused a balance with the sugar. In fact, the sugar/acid ratios of fruit products are important in determining their taste acceptability (Imungi and Choge 1996).

For mouth feel and overall acceptability, significant differences ($p < 0.05$) were noticed among the nectar blends when compared to the control. Nectar blends (20%, 30% 40% and 50% of goldenberry juice) had higher scores of mouth feel and overall acceptability and T3 (30%) had the highest scores. Again a gradual decrease of mouth feel and overall acceptability was found during the cold storage with a similar trend of other sensory properties. Definitely, goldenberry juice improved the sensory properties of nectars (blending with carrot) with less rate of deterioration during the cold storage. Similarly, Imungi and Choge

(1996) reported improvements in the sensory attributes of nectar blends from four tropical fruits (mango, papaya, pear and passion fruits). Also, similar findings were reported by El-Mansy et al. (2005) for mango and papaya nectar blends.

Conclusion

The results obtained by this study confirmed that goldenberry (*Physalis peruviana* L.) juice is a promising fruit juice rich in different bioactive compounds such as vitamin C and phenolic compounds. In the present study, the addition of goldenberry juice in carrot nectar improved its techno-functional (such as pH and TSS values) and organoleptic properties (color, taste, odor, appearance, mouth feel and overall acceptability). In addition, the goldenberry juice added at a ratio of 30% to the carrot juice resulted in producing a carrot–goldenberry nectar with the highest overall acceptability in comparison to either carrot or other carrot–goldenberry nectars produced in the present study. For bioactive compounds and antioxidant activity, the goldenberry juice significantly increased the content of vitamin C and phenolic compounds in the carrot nectar and the overall antioxidant activity of the carrot–goldenberry nectars was higher than that of carrot nectar during the storage. The degradation in vitamin C during storage period was significant and higher compared to that of phenolic compounds. Thus, the degradation of the overall antioxidant activity of all nectars correlated to the content of phenolic compounds ($r = 0.981036$) more than the content of vitamin C ($r = 0.827837$) and β-carotene ($r = -0.56683$). This finding may suggest further investigations with regard to the identification of phenolic profile of goldenberry cultivated in Egypt. The present study suggests exploiting of goldenberry juice in enriching some fruit and vegetable juices with vitamin C and phenolic compounds.

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