Food and Nutrition Sciences, 2017, 8, 126-140
http://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

Nutritional, Chemical and Organoleptical Characteristics of Low-Calorie Fruit Nectars Incorporating Stevioside as a Natural Sweetener

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How to cite this paper: Barakat, H., Al-Furaydi, A., Al-Harbi, A. and Al-Shedookhi, A. (2017) Nutritional, Chemical and Organoleptical Characteristics of Low-Calorie Fruit Nectars Incorporating Stevioside as a Natural Sweetener. *Food and Nutrition Sciences*, **8**, 126-140.
http://dx.doi.org/10.4236/fns.2017.81009

Received: December 12, 2016
Accepted: January 17, 2017
Published: January 20, 2017

Abstract

The study is aiming at preparation of low-calorie fruit nectars for diabetes and weight maintaining approaches as well as consumer satisfaction. Therefore, twenty low-calorie fruit-based formulated nectars were prepared mainly from orange, pomegranate, guava and mango pulps which sweetened with sucrose or sucrose—replaced at 25%, 50%, 75% and 100% using stevioside. Primitively, the yield of fresh fruits had been calculated. Consequently, nutritional, chemical and organoleptical characteristics of prepared fruit nectars have been determined. Results indicated that total solids content was in range of 5.57% - 13.20%, 9.90% - 14.37%, 8.25% - 13.27% and 8.25% - 16.50% for orange, pomegranate, guava and mango nectars, respectively. Dependently, caloric value resulted 21.57 to 51.08, 38.31 to 55.62, 31.93 to 51.37 and 31.93 to 63.86 kcal 100 g^{-1} fw for orange, pomegranate, guava and mango nectars, respectively. Total phenols content [TPC, mg GAE 100 g^{-1} dw] ranged from 665.12 to 747.41, 1180.42 to 1319.47, 742.54 to 848.27 and 418.01 to 472.42 for orange, pomegranate, guava and mango nectars, respectively. The antioxidant capacity by DPPH method [μmol TE g^{-1} dw] ranged from (20.79 to 26.51), (47.13 to 56.56), (60.68 to 69.25) and (8.39 to 13.32) for orange, pomegranate, guava and mango nectars, respectively. Total carotenoids [mg 100 g^{-1} dw] were the highest in mango nectars ranged from (102.99 to 110.52) in mango nectar with 100% sugar and mango nectar with 100% stevioside, respectively. Anthocyanins content recorded 6.14 mg 100 g^{-1} dw in pomegranate nectar with 100% sugar, while increased to be 9.01 mg 00 g^{-1} dw in pomegranate nectar with 100% stevioside. Ascorbic acid [mg 100 g fw] ranged from 23.41 to 27.53, 15.73 to 18.32, 25.72 to 30.87 and 18.07 to 20.98 for orange, pomegranate, guava and mango nectars, respectively. The results of organoleptical attributes showed no effect of sugar substituting by stevioside on color, odor and mouth feel. The most dramatic effect of sugar substituting had been observed on taste, bitter after taste and the overall acceptability of prepared nectars with high substitution levels. Practically, using stevioside to produce low-calorie nectars was shown to be satisfactory up to 50% - 75% substituting level, resulting low-calorie nectars and could be applied commercially.

Keywords

Low-Calorie Nectar, Chemical, Nutritional, Organoleptical Characteristics

1. Introduction

Recently, health concerns associated with high sugar intake include excessive calories consumption and related diseases are considered as crucial issues for many foods organizations [1]. Several organizations recommend consumption of fresh vegetables and fruits as well as reduce total calories daily intake [2] [3] [4]. The growing concern with health and higher incidence of obesity, metabolic syndrome and diabetes has resulted in an increase in interest of low-calorie food consumption [5] [6]. Indeed, consumption of low-calorie and light products for diabetics or other medical restrictions, including obesity was increased [7] as well as for aesthetics and health concerned peoples. Increasing of consumer interest in reducing sugar intake, food products made with sweeteners rather than sugar have become more popular and depleted quickly with high market share [8].

The first WHO Global report on diabetes demonstrates that the number of adults living with diabetes has almost quadrupled since 1980 to 422 million adults in KSA. More than 1 in 3 adults were overweight and more than 1 in 10 were obese in 2014. Blood glucose control is an important in preventing and slowing the complications progression. In 2012 alone diabetes caused 1.5 million deaths (FAO, 2014). Its complications can lead to heart attack, stroke, blindness, kidney failure and lower limb amputation. In fact, the production of low-calorie products must comprise low-calorie raw materials and low-calorie sweeteners [9]. To meet the recommended reduction of calories, several foods have been introduced into the market as low-calorie products incorporating natural and/or artificial sweeteners. Low-calorie sweeteners (LCSs) are added to many foods and beverages, for reducing total calories, while maintaining palatability [10]. LCSs has only begun to develop over the past 30 years, concomitant with the increase in obesity and type 2 diabetes, which led to an increased interest in methods of losing weight or maintaining weight loss [11] [12]. The LCSs currently licensed for use in many countries [13]. The varying chemical properties of each LCS means that they are suited to diverse uses and wide applications could be presented [12]. Typically, the energy difference between regular and LCS-sweetened products is more pronounced in beverages and processed fruits and vegetables more than foods [14] [15].

Stevia is a natural sweetener, extracted from leaves of the plant (*Stevia rebaudiana* Bert.) produces diterpene glycosides that are low-calorie sweetener. Stevia extracts, besides having therapeutic properties, contain a high level of sweetening compounds, known as steviol glycosides [16] [17]. Stevia contains intensely sweet substances that are 250 to 350 times sweeter than sugar [18]. Steviol glycosides are safe (GRAS) by the

FDA. Steviol glycosides can be particularly beneficial to those suffering from obesity, diabetes mellitus, heart disease and dental caries [19]. Stevioside (St) is remarkably stable over a wide range of pH values and temperatures. Under thermal treatment stevioside at elevated temperatures for 1 h showed good stability up to 120˚C, whilst at temperatures exceeding 140˚C forced decomposition was noticed [20]. Recently, it's clearly demonstrated that functional similarity of steviol and stevioside with that of insulin in controlling the level of glucose in both the cell lines has been confirmed and insulinomimetic property them was evident [21] [22] [23]. Also, dietary stevioside can attenuate the pro-inflammatory response after stimulation of the innate immune response [24].

It encourages us all as individuals to eat healthily, be physically active, and avoid excessive weight gain and sugar intake. As surveyed, there is no enough satisfaction of low-calorie foods being marketed to consumers especially from nectars, jams and beverages. Nowadays the dietary awareness of consumers has led to the growth of health food industry thus alternative nectars containing non-nutritive sweeteners should be available. Recently, production of low-calorie nectar could be an important issue for many people groups whose suffer from obesity, diabetics, sugar allergic, and dental decay. In addition, it will be a satisfaction to consumers, whose maintaining their health or for weight management programs. Therefore, the current work is aimed at determining the chemical, nutritional properties and sensory attractiveness of the prepared low-calorie fruit nectars incorporated stevioside as natural sweeteners comparing to common sweetened nectar.

2. Materials and Methods

2.1. Fresh Fruits and Ingredients

The raw materials used for preparing low-calorie nectars are: orange (*Citrus sinensis* L.) of fully matured Egyptian baladi orange fruits, pomegranate (*Punica granatum* L.), guava (*Psidium guajava* L.), mango (*Mangifera indica* L.) of fully mature Egyptian fruits varieties and edible sugar (sucrose) were obtained from Abdullah Al-Othaim local markets at Buraidah city, Al Qassim region, KSA, while, stevioside was imported by Rebat company for food stuffs trade, Egypt.

2.2. Fresh Juices Extraction

Orange fruits were washed. Capsules were removed then cut into halves and extracted by electric extractor (Santos, VITA-MAX CORP-Light Industrial Food Preparing Machine Model, VM0122E, USA). Afterword, extracted juice was pasteurized at 90˚C for 5 min after being diluted to 7.5˚Brix, filtered then cooled down to 25˚C. Pomegranates were washed, cut to halves then pummeled with big spoons on the peel sides and juicy seeds crushed and squeezed. The juice was pasteurized, filtered and cooled down after being diluted to 9˚Brix. Guava puree was prepared from fresh fully ripe guava fruit after removing the guava seeds. Fresh guava juice was prepared from guava puree by diluting with distilled water to obtain 10˚Brix, pasteurized, filtered then cooled down. The ripe mango was washed, peeled, de-seeded and cut in a cubic shape then homogenized by fruit blender and mixed with water till 7.5˚Brix. The fresh mango juice was pasteurized, filtered and cooled down. Exactly 1 kg from each fruit nectar was filled in a polyethylene bag and sealed after removing the air then kept under −18˚C ± 1˚C. At the end of each extraction procedure, the yield was calculated even the fruits wastes were also calculated as well.

2.3. Formulation of Low-Calorie Nectars

Twenty nectars formulas were prepared by replacing sucrose by stevioside as 0%, 25%, 50%, 75% and 100% according to Table 1. The previously prepared juices were taken directly and sweeteners have been dissolved by vigorous mixing using blender at speed 4 for 2 min.

2.4. Analytical Methods

2.4.1. Total Solid and Ash Contents

About ten ml of nectar weighed accurately in a suitable dish previously dried then dried

Table 1. Low-calorie orange, pomegranate, guava and mange fruit nectars prepared with replacing sucrose at 0%, 25%, 50%, 75% and 100% by stevioside* (formulas presented in gm).

Formula No.	Substituting level of sugar %	˚Brix	Ingredients [g]		
			Fruits nectar	Sucrose	Stevioside
O1	0	12	4000	295	–
O2	25	9	4000	220	0.22
O3	50	7.5	4000	150	0.44
O4	75	7	4000	75	0.66
O5	100	5	4000	-	0.88
P1	0	13	4000	235	–
P2	25	12	4000	177	0.18
P3	50	11	4000	11.8	0.36
P4	75	10	4000	59	0.54
P5	100	9	4000	-	0.73
G1	0	12	4000	240	–
G2	25	11	4000	180	0.19
G3	50	10	4000	120	0.38
G4	75	8.5	4000	60	0.57
G5	100	7.5	4000	-	0.76
M1	0	15	4000	353	–
M2	25	13.5	4000	265	0.27
M3	50	11.5	4000	177	0.54
M4	75	10	4000	883	0.81
M5	100	7.5	4000	-	1.09

*: the sweetness of stevioside calculated as 325 time of sugar as provided by the manufacture, O1-O5: formulated orange nectars, P1-P2: formulated pomegranate nectars, G1-G5: formulated Guava nectars and M1-M2: formulated mango nectars.

at 70˚C until weight being constant. The TS was calculated and expressed as percentage [25]. Determination of the ash content of nectar samples was performed by the method described in AOAC [25]. Ten grams were weighed, dried then ashed into muffle furnace at 550˚C until weight being constant. The ash content calculated and expressed as percentage on fresh weight.

2.4.2. Ascorbic Acid Determination

Ascorbic acid content was determined by redox titration method using iodine solution according to Silva *et al.* [26].

2.4.3. Nutritional Value

The nutritional value of different formulated nectars was calculated basically on the TS hence the major content considered as carbohydrates according to suggested method [25] with ignoring the protein and fat contents whereas very low-content is expected.

2.4.4. Physicochemical Properties

pH, titratable acidity, color by Hunter lab. apparatus and density have been determined according to AOAC [25].

2.5. Phytochemicals Analysis

2.5.1. Determination of Total Phenolic Compounds

After extraction of total phenolic compound, concentration of TPC was determined by Folin-Ciocalteau method. After 1 h at ambient temperature, the absorbance was measured at 765 nm and The TPC was expressed as milligram gallic acid equivalents per gram sample (mg GAE 100 g^{-1} dw) according to Ough and Amerine [27].

2.5.2. Determination of Carotenoids

Carotenoids were determined in the acetonic extract and expressed as mg 100 g^{-1} dw according to Wettestein [28].

2.5.3. Determination of Anthocyanins

The Anthocyanins content of prepared pomegranate fruit nectars were determined according to Deubert [29]. A 0.5 g of freez-dried nectars were extracted with 5 mL of acidified ethanol (95% ethanol: HCl 1.5 N 85:15) for 2 h at room temperature in the dark, filtered and measured at 535 nm. The data were expressed as mg 100 g^{-1} dw.

2.5.4. Determination of Radical DPPH-Scavenging Activity

Antioxidant activity was measured spectrophotometrically using the 2,2-diphenylpicrylhydrazyl (DPPH) radical. According to this method, extracted samples, which were made to react with the radical solution and rest for 60 minutes at room temperature, were measured for absorbance at 517 nm, and the inhibition percentage of DPPH free radical was calculated and results were compared to Trolox then results were expressed as µmol TE g^{-1} dw [30].

2.6. Organoleptical Attributes

Organoleptical attributes of the different formulas was carried out. Twelve panelists of the staff members from the Food Science and Human Nutrition Department, Faculty of

Agriculture and veterinary medicine, Qassim University were asked to evaluate the prepared nectar towards color, taste, odor, clarity, bitter after taste, mouth feel and overall acceptability. Results were subjected to analysis of variance and average of the mean values of the aforementioned attributes and their standard error were calculated according to Mosqueda-Melgar *et al.* [31].

2.7. Statistical Analysis

The statistical analysis was carried out using SPSS program (ver. 19) with multi-function utility regarding to the experimental design under significance level of 0.05 for the whole results and multiple comparisons were carried out applying LSD with Duncan according to Steel *et al.* [32].

3. Results and Discussion

3.1. Yield of Fresh Fruits

Currently, orange, pomegranate, guava and mango fruits were extracted and exuded raw pulp as 60.08, 51.34, 84.14 and 71.47 kg 100 kg^{-1} fresh fruits. The large amount of fruit peels was relevant to orange fruits while the lowest one was mango whereas guava fruit not peeled before the extraction, **Table 2**. The large amount of seeds was recorded for mango fruits followed by guava and pomegranate, respectively. Pomace and bagasse waste recorded high amount in guava and orange, respectively. The obtained results were more or less in agreement with relevant recorded reviews [33] [34] [35] [36].

3.2. Total Solids, Ash, Ascorbic Acid Contents and Caloric Values of Low-Calorie Nectars

Twenty low-calorie fruit nectars were prepared mainly from orange, pomegranate, guava and mango then sweetened using sucrose or stevioside at substitution level of 0%, 25%, 50%, 75% and 100%. Subsequently TS, ash, ascorbic acid were determined and relevant caloric values were calculated, data presented in **Table 3**. A significant differences ($p < 0.05$) were observed among TS, ascorbic acid and caloric values in each fruit nectar regardless sucrose substitution while, no significant differences ($p > 0.05$) was recorded in ash content. In all prepared nectars, TS were decreased by increasing the substitution level. TS were ranged from 6.08% to 14.4%, 10.80% to 15.68%, 9.0% to 14.48% and 9.11% to 18.01% for orange, pomegranate, guava and mango nectars, re-

Table 2. Yield of orange, pomegranate, guava and mange fruits.

Items	Fruits yield %			
	Orange	Pomegranate	Guava	Mango
Pulp	60.08 ± 3.48	51.34 ± 4.71	84.14 ± 0.319	71.47 ± 2.45
Peel	36.68 ± 2.57	35.58 ± 5.74	–	6.88 ± 0.49
Seeds	–	9.42 ± 2.48	12.35 ± 1.21	20.13 ± 2.14
Pomace	–	1.37 ± 0.78	3.51 ± 1.57	–
Bagasse	3.24 ± 0.49	2.29 ± 0.97	–	1.52 ± 0.84

Data are expressed as means ± SE, ($n = 3$).

Table 3. Total solids, ash, ascorbic acid contents and caloric value of low-calorie orange, pomegranate, guava and mange nectars prepared with replacing sucrose at 0%, 25%, 50%, 75% and 100% by stevioside as natural sweetener.

Formula No.	Substituting level of sugar %	Chemical composition			
		Total solids [%]	Ash [%]	Ascorbic acid [mg 100 ml^{-1} ^{fw}]	Caloric value* [kcal/100 ml ^{fw}]
O1	0	14.4 ± 0.21^{a}	0.37 ± 0.04^{a}	23.41 ± 0.46^{c}	55.73 ± 0.54^{a}
O2	25	10.8 ± 0.17^{b}	0.43 ± 0.07^{a}	24.38 ± 0.57b^{c}	41.80 ± 0.54^{b}
O3	50	9.00 ± 0.12^{c}	0.45 ± 0.01^{a}	24.86 ± 0.41b^{c}	34.83 ± 0.54^{c}
O4	75	8.40 ± 0.27^{d}	0.47 ± 0.04^{a}	25.53 ± 0.74^{b}	32.51 ± 0.54^{d}
O5	100	6.08 ± 0.16^{e}	0.41 ± 0.01^{a}	27.53 ± 0.42^{a}	23.53 ± 0.56^{c}
P1	0	15.68 ± 0.15^{a}	0.51 ± 0.01^{b}	15.73 ± 0.38^{b}	60.68 ± 0.56^{a}
P2	25	14.40 ± 0.18^{b}	0.53 ± 0.02^{ab}	16.44 ± 0.43^{ab}	55.73 ± 0.54^{b}
P3	50	13.20 ± 0.27^{c}	0.57 ± 0.04^{a}	16.75 ± 0.39^{ab}	51.08 ± 0.54^{c}
P4	75	12.12 ± 0.19^{d}	0.6 ± 0.01^{a}	17.44 ± 1.17^{ab}	46.44 ± 0.54^{d}
P5	100	10.80 ± 0.08^{e}	0.67 ± 0.06^{a}	18.32 ± 0.58^{a}	41.80 ± 0.54^{e}
G1	0	14.48 ± 0.11^{a}	0.41 ± 0.01^{c}	25.72 ± 1.11^{b}	56.04 ± 0.56^{a}
G2	25	13.28 ± 0.19^{b}	0.44 ± 0.03^{c}	26.56 ± 1.26^{b}	51.39 ± 0.56^{b}
G3	50	12.00 ± 0.24^{c}	0.50 ± 0.01^{b}	27.25 ± 0.44^{b}	46.44 ± 0.54^{c}
G4	75	10.20 ± 0.15^{d}	0.45 ± 0.05^{b}	28.15 ± 0.30^{b}	39.47 ± 0.54^{d}
G5	100	9.00 ± 0.21^{e}	0.55 ± 0.01^{a}	30.87 ± 0.78^{a}	34.83 ± 0.54^{e}
M1	0	18.01 ± 0.19^{a}	0.60 ± 0.04^{a}	18.07 ± 0.41^{b}	69.66 ± 0.54^{a}
M2	25	16.21 ± 0.11^{b}	0.65 ± 0.05^{a}	18.30 ± 0.55^{b}	62.69 ± 0.54^{b}
M3	50	13.81 ± 0.17^{c}	0.65 ± 0.03^{a}	20.56 ± 0.42^{a}	53.41 ± 0.54^{c}
M4	75	12.17 ± 0.24^{d}	0.70 ± 0.04^{a}	21.00 ± 0.38^{a}	46.44 ± 0.54^{d}
M5	100	9.11 ± 0.08^{e}	0.65 ± 0.01^{a}	20.98 ± 0.95^{a}	34.83 ± 0.54^{e}

O1-O5: formulated orange juices, P1-P2: formulated pomegranate juices, G1-G5: formulated Guava juices and M1-M2: formulated mango juices. *: caloric value calculated as mentioned in materials and methods. Data are expressed as means ± SE (n = 3). a, b, c, ...: means with the same letter in the same column are not significantly different ($p > 0.05$) in each nectar group.

spectively. Opposite finding have been found in ash content being it was increased with increasing the substitution level. The ash content was in range of 0.37% - 0.41%, 0.51% - 0.67%, 0.41% - 0.55% and 0.6% - 0.65% for orange, pomegranate, guava and mango nectars, respectively. Ascorbic acid is involved in protein metabolism, collagen synthesis and an important physiological antioxidant [37]. Similar finding had been observed in ascorbic acid content. Calculated caloric values decreased accordingly with decreasing the TS. Ascorbic acid content was ranged from 23.41 to 27.53, 15.73 to 18.32, 25.72 to 30.87 and 18.07 to 20.98 mg 100 ml^{-1} fw in orange, pomegranate, guava and mango nectars, respectively. These results are in harmony with mentioned results by [33] [38] [39]. The calculated caloric values in orange, pomegranate, guava and mango nectars, were ranged from 23.53 to 55.73, 41.80 to 60.68, 34.83 to 56.04 and 34.83 to 69.66, respectively. These results are more or less in agreement with [39] [40] [41].

3.3. Physicochemical Properties of Low-Calorie Nectars

The pH, titratable acidity, instrumental colour and density of different prepared nectars were illustrated in Table 4. No significant difference ($p > 0.05$) have been found among different substituted nectars reflects that incorporation of stevioside in fruits nectars had no impact on pH, color parameters and TA. The pH valve was not affected significantly by replacing sucrose in all formulated fruit nectars. The titratable acidity was slightly increased by increasing the incorporation of stevioside in fruits nectars which harmonised with decreasing of sucrose content. This may be due to sucrose content in the taken samples during the titration as low sugar mean high juice content. No significant difference have been found between L^*, a^* and b^* upon substituting the sucrose by stevioside.

Table 4. Physicochemical properties of low-calorie orange, pomegranate, guava and mange nectars prepared with replacing sucrose at 0%, 25%, 50%, 75% and 100% by stevioside as natural sweetener.

Formula No.	Substituting level of sugar %	Physicochemical properties					
		pH	Titratable acidity	CIE			Density (g·ml^{-1})
				L^*	a^*	b^*	
O1	0	$3.52^a \pm 0.04$	$1.12^{ab} \pm 0.01$	$35.31^a \pm 1.22$	$-6.58^a \pm 0.32$	$23.66^a \pm 2.62$	$1.0477^a \pm 0.0008$
O2	25	$3.43^a \pm 0.02$	$1.12^{ab} \pm 0.01$	$37.02^a \pm 1.43$	$-6.21^a \pm 0.05$	$25.86^a \pm 2.90$	$1.0353^b \pm 0.0005$
O3	50	$3.47^a \pm 0.04$	$1.09^b \pm 0.04$	$36.38^a \pm 1.41$	$-6.34^a \pm 0.14$	$23.85^a \pm 2.57$	$1.0293^c \pm 0.0008$
O4	27	$3.47^a \pm 0.01$	$1.18^a \pm 0.01$	$36.90^a \pm 1.54$	$-6.51^a \pm 0.35$	$26.56^a \pm 2.20$	$1.0273^c \pm 0.0008$
O5	100	$3.48^a \pm 0.03$	$1.19^a \pm 0.01$	$36.38^a \pm 1.41$	$-6.34^a \pm 0.14$	$23.85^a \pm 2.57$	$1.0196^d \pm 0.0005$
P1	0	$4.59^a \pm 0.01$	$1.43^d \pm 0.01$	$52.27^a \pm 2.01$	$-4.26^a \pm 0.33$	$6.03^a \pm 2.54$	$1.0521^a \pm 0.0005$
P2	25	$4.50^a \pm 0.01$	$1.48^c \pm 0.01$	$50.06^a \pm 0.47$	$-3.95^a \pm 0.09$	$3.34^a \pm 0.51$	$1.0477^a \pm 0.0008$
P3	50	$4.45^a \pm 0.06$	$1.50^c \pm 0.01$	$51.26^a \pm 1.67$	$-4.08^a \pm 0.21$	$4.21^a \pm 1.38$	$1.0435^b \pm 0.0009$
P4	75	$4.38^{ab} \pm 0.01$	$1.54^b \pm 0.01$	$50.06^a \pm 0.47$	$-3.95^a \pm 0.09$	$3.34^a \pm 0.51$	$1.0394^b \pm 0.0005$
P5	100	$4.27^b \pm 0.03$	$1.58^a \pm 0.01$	$51.26^a \pm 1.67$	$-4.08^a \pm 0.21$	$4.21^a \pm 1.38$	$1.0353^b \pm 0.0009$
G1	0	$3.62^a \pm 0.01$	$0.38^a \pm 0.01$	$36.58^a \pm 0.27$	$21.65^a \pm 0.6$	$9.08^a \pm 0.16$	$1.0480^a \pm 0.0008$
G2	25	$3.60^a \pm 0.01$	$0.38^a \pm 0.01$	$37.31^a \pm 0.71$	$21.76^a \pm 0.59$	$8.68^a \pm 0.25$	$1.0438^a \pm 0.0005$
G3	50	$3.60^a \pm 0.01$	$0.38^a \pm 0.01$	$38.26^a \pm 0.6$	$22.17^a \pm 0.31$	$8.43^a \pm 0.22$	$1.0394^a \pm 0.0008$
G4	75	$3.60^a \pm 0.01$	$0.40^a \pm 0.02$	$37.09^a \pm 0.77$	$21.31^a \pm 0.3$	$8.85^a \pm 0.35$	$1.0333^a \pm 0.0005$
G5	100	$3.58^a \pm 0.00$	$0.42^a \pm 0.03$	$37.45^a \pm 0.84$	$21.82^a \pm 0.6$	$8.70^a \pm 0.23$	$1.0293^a \pm 0.0008$
M1	0	$4.66^b \pm 0.01$	$0.48^c \pm 0.02$	$49.12^a \pm 0.82$	$3.24^a \pm 0.94$	$58.76^a \pm 0.81$	$1.0603^a \pm 0.0009$
M2	25	$4.82^a \pm 0.04$	$0.52^c \pm 0.02$	$50.52^a \pm 0.60$	$4.44^a \pm 0.31$	$59.04^a \pm 0.54$	$1.0540^b \pm 0.0005$
M3	50	$4.80^a \pm 0.01$	$0.58^b \pm 0.02$	$51.31^a \pm 0.59$	$4.53^a \pm 0.31$	$58.58^a \pm 0.34$	$1.0456^b \pm 0.0008$
M4	75	$4.84^a \pm 0.02$	$0.63^{ab} \pm 0.02$	$49.63^a \pm 1.21$	$3.59^a \pm 1.12$	$58.37^a \pm 0.80$	$1.0394^c \pm 0.0005$
M5	100	$4.68^{ab} \pm 0.01$	$0.65^a \pm 0.03$	$50.66^a \pm 0.73$	$4.33^a \pm 0.21$	$59.19^a \pm 0.40$	$1.0293^d \pm 0.0008$

O1-O5: formulated orange juices, P1-P2: formulated pomegranate juices, G1-G5: formulated Guava juices and M1-M2: formulated mango juices. Data are expressed as means ± SE ($n = 3$), L^*: lightness; a^*: redness; b^*: yellowness. a, b, c,…: means values in the same column within each parameter bearing the same superscript do not differ significantly ($p \le 0.05$).

Practically, even slight change could be observed in color intensity the fruit nectar, manufacture can adjust the color using safe color additives. These results have been confirmed by [38] [39] [42]. The density of prepared nectars was decreased significantly ($p < 0.05$) by decreasing the sucrose content in all prepared fruit nectars. The obtained results are in accordance with mentioned data before [17] [38] [43].

3.4. Phytochemicals and Their Antioxidant Activity of Low-Calorie Nectars

Phenolics are naturally occurring compounds widely distributed in the plant kingdom and beneficial components of human daily diet Le *et al.* [44]. Presented data in **Table 5**, indicated that formulated fruit nectars had valuable total phenolic content (TPC)

Table 5. Phytochemicals and their antioxidant activity of low-calorie orange, pomegranate, guava and mange nectars prepared with replacing sucrose at 0%, 25%, 50%, 75% and 100% by stevioside as natural sweetener.

Formula No.	Substituting level of sugar %	Phytochemicals			Antioxidant activity
		TPC [mg GAE 100 g^{-1dw}]	Carotenoids [mg 100 g^{-1dw}]	Anthocyanins [mg 100 g^{-1dw}]	DPPH [μmol TE g^{-1dw}]
O1	0	665.12 ± 7.25^{e}	14.12 ± 0.89^{a}	−ND	20.79 ± 0.24^{a}
O2	25	678.42 ± 4.89^{d}	14.82 ± 0.44^{a}	-	22.86 ± 0.45^{a}
O3	50	696.69 ± 4.97^{c}	15.39 ± 0.78^{a}	-	24.94 ± 0.25^{a}
O4	75	727.01 ± 5.28^{b}	16.66 ± 1.12^{a}	-	25.11 ± 0.49^{a}
O5	100	747.41 ± 6.25^{a}	17.15 ± 1.22^{a}	-	26.51 ± 0.39^{a}
P1	0	1180.42 ± 14.25^{a}	-	6.14 ± 0.48^{a}	47.13 ± 2.11^{a}
P2	25	1204.03 ± 8.25^{a}	-	6.44 ± 0.16^{a}	49.49 ± 1.25^{a}
P3	50	1227.63 ± 12.25^{a}	-	7.06 ± 0.85^{a}	52.79 ± 1.11^{a}
P4	75	1283.49 ± 8.25^{a}	-	8.74 ± 0.75^{a}	54.2 ± 0.89^{a}
P5	100	1319.47 ± 11.24^{a}	-	9.01 ± 0.94^{a}	56.56 ± 0.27^{a}
G1	0	742.54 ± 5.25^{e}	3.07 ± 0.58^{a}	-	60.68 ± 0.25^{a}
G2	25	757.35 ± 6.25^{d}	3.38 ± 0.63^{a}	-	63.71 ± 0.49^{a}
G3	50	782.13 ± 9.95^{c}	3.84 ± 0.23^{a}	-	65.53 ± 0.99^{a}
G4	75	825.13 ± 4.25^{b}	4.46 ± 0.48^{a}	-	68.16 ± 0.78^{a}
G5	100	848.27 ± 4.84^{a}	4.63 ± 0.78^{a}	-	69.25 ± 1.25^{a}
M1	0	418.01 ± 2.58^{a}	102.99 ± 2.51^{a}	-	8.39 ± 0.98^{a}
M2	25	426.37 ± 4.25^{a}	106.08 ± 5.24^{a}	-	9.65 ± 0.68^{a}
M3	50	434.73 ± 3.58^{a}	107.11 ± 4.59^{a}	-	10.48 ± 0.74^{a}
M4	75	459.53 ± 4.28^{a}	107.48 ± 3.25^{a}	-	13.02 ± 1.01^{a}
M5	100	472.42 ± 2.58^{a}	110.52 ± 2.45^{a}	-	13.32 ± 0.75^{a}

O1-O5: formulated orange juices, P1-P2: formulated pomegranate juices, G1-G5: formulated Guava juices and M1-M2: formulated mango juices, ND: Not determined. Data are expressed as means ± SE ($n = 3$), Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($p \le 0.05$). a, b, c, ...: means with the same letter in the same column are not significantly different ($p > 0.05$) in each nectar group.

ranged from 665.12 to 747.41, 1180.42 to 1319.47, 742.54 to 848.27 and 418.01 to 472.42 mg GAE 100 g^{-1}. The TPC increased by increasing the substitution level. This may be due to increasing the sample content from juice which increased the TPC content or may be due to increasing of stevioside content [20]. Tadhani *et al.* [45] indicated that stevia plant containing 25.18 mg·g^{-1} TPC in stevia leaves and may increase the TPC in prepared nectars. The highest content of TPC was recorded for pomegranate as mentioned previously [46] and guava nectars [47].

The presented data in **Table 5**, illustrated the carotenoids content in prepared fruit nectars sweetened ascendingly by stevioside. Carotenoids content was ranged from 14.12 mg 100 g^{-1} dw in O1 to 17.41 mg 100 g^{-1} dw in O5. Guava nectar exhibited carotenoids content in range of 3.07 to 4.63 mg 100 g^{-1} dw. The highest carotenoids content was recorded for formulated mange nectars as ranged from 102.99 to 110.52 mg 100 g^{-1} dw. These results are lower than obtained results by Correa *et al.* [48] who observed that carotenoids content was 36.66 mg 100 g^{-1} fw mango nectars. However, for orange they were more or less in agreement with [33] [38] [39] [49]. In addition our results in accordance with [47] [50].

Data in the same table indicated that mean of antioxidant activity was ranged from 20.79 to 26.51 μmol TE g^{-1} in formulated orange nectars. Similarly, from 47.13 to 56.56 μmol TE g^{-1}, from 60.68 to 69.25 μmol TE g^{-1} and from 8.39 to 13.32 μmol TE g^{-1} were recorded for pomegranate, guava and mango nectars, respectively. The antioxidant activity was slightly increased by increasing the substituting level. Increasing the antioxidant activity may be a result of increasing the TPC content [33] [38] [39]. Data in **Table 5** illustrated the anthocyanins content in pomegranate, a content was not quantitatively analyzed in orang, guava and mango nectars being they may not contain valuable amounts. Anthocyanins content recorded 6.14 in P1 while increased to be 9.01 in P5, respectively. These results are in agreement with [51] [52].

3.5. Organoleptical Parameters of Low-Calorie Nectars

The mean panel score of twenty low-calorie formulated nectars was prepared mainly from orange, pomegranate, guava and mango then sweetened by incorporation of stevioside instead of sucrose. Data were illustrated in **Table 6**. Color, taste, odor, clarity, bitter after taste, mouth feel and overall acceptability were organoleptically evaluated.

The obtained data in **Table 6** indicated that no significant difference ($p < 0.05$) was found in color, odor, mouth feel and clarity scores among prepared nectars which were not dramatically affected. The mean score of taste, bitter after taste, and overall acceptability are decreased by increasing of substitution level of sucrose. These findings are in agreements with confirmed results that increasing the stevioside level associated with increasing the bitter after taste of sweetened fruit product and led to decreasing the mouth feel and overall acceptability [17] [31] [41] [43] [53]-[58]. However, the substitution level up to 50% - 75% from the sucrose content was not differed significantly from the fruit nectar contain 0 stevioside (control treatment). These results indicated that using stevioside instead of sucrose for reducing calories and produce such functional nectars for diabetes and weight maintaining peoples are become necessary for commercial production to sustain consumer satisfaction.

Table 6. Organoleptic properties of low-calorie orange, pomegranate, guava and mange nectars prepared with replacing sucrose at 0%, 25%, 50%, 75% and 100% by stevioside as natural sweetener.

Formula No.	Substituting level of sugar %	Organoleptic properties						
		Color	Taste	Odor	Clarity	Bitter after taste	Mouth feel	Overall acceptability
O1	0	$9.40^{a} \pm 0.22$	$8.50^{a} \pm 0.5$	$8.90^{a} \pm 0.28$	$9.40^{a} \pm 0.22$	$8.40^{a} \pm 0.4$	$8.50^{a} \pm 0.54$	$8.30^{a} \pm 0.5$
O2	25	$9.10^{a} \pm 0.23$	$8.10^{a} \pm 0.28$	$8.90^{a} \pm 0.31$	$8.60^{a} \pm 0.34$	$8.30^{a} \pm 0.34$	$8.55^{a} \pm 0.3$	$7.70^{a} \pm 0.58$
O3	50	$8.85^{a} \pm 0.28$	$8.10^{a} \pm 0.31$	$8.40^{a} \pm 0.58$	$8.50^{a} \pm 0.34$	$8.67^{a} \pm 0.27$	$8.55^{a} \pm 0.26$	$7.60^{a} \pm 0.6$
O4	75	$8.85^{a} \pm 0.38$	$7.90^{a} \pm 0.31$	$8.60^{a} \pm 0.34$	$8.50^{a} \pm 0.34$	$8.30^{a} \pm 0.4$	$8.45^{a} \pm 0.3$	$6.85^{a} \pm 0.62$
O5	100	$8.80^{a} \pm 0.33$	$6.2^{b} \pm 0.53$	$8.15^{a} \pm 0.46$	$8.44^{a} \pm 0.39$	$6.33^{b} \pm 0.61$	$8.55^{a} \pm 0.3$	$6.1^{b} \pm 0.54$
P1	0	$8.70^{a} \pm 0.5$	$8.70^{a} \pm 0.6$	$8.80^{a} \pm 0.44$	$9.00^{a} \pm 0.21$	$8.60^{a} \pm 0.54$	$8.10^{a} \pm 0.74$	$8.30^{a} \pm 0.3$
P2	25	$8.40^{a} \pm 0.58$	$8.05^{a} \pm 0.63$	$8.65^{a} \pm 0.42$	$8.85^{a} \pm 0.24$	$8.20^{ab} \pm 0.59$	$8.25^{a} \pm 0.66$	$7.70^{ab} \pm 0.13$
P3	50	$8.50^{a} \pm 0.48$	$7.95^{a} \pm 0.55$	$8.45^{a} \pm 0.45$	$8.55^{a} \pm 0.34$	$7.65^{abc} \pm 0.58$	$7.95^{a} \pm 0.71$	$7.70^{ab} \pm 0.22$
P4	75	$8.40^{a} \pm 0.56$	$7.65^{a} \pm 0.64$	$8.05^{a} \pm 0.58$	$8.45^{a} \pm 0.45$	$6.90^{bc} \pm 0.43$	$7.80^{a} \pm 0.73$	$9.60^{ab} \pm 0.45$
P5	100	$8.20^{a} \pm 0.55$	$6.35^{a} \pm 0.75$	$7.85^{a} \pm 0.67$	$8.15^{a} \pm 0.61$	$6.20^{c} \pm 0.53$	$7.90^{a} \pm 0.66$	$6.50^{b} \pm 0.26$
G1	0	$9.40^{a} \pm 0.31$	$9.20^{a} \pm 0.25$	$9.20^{a} \pm 0.36$	$9.00^{a} \pm 0.3$	$9.10^{a} \pm 0.28$	$9.10^{a} \pm 0.31$	$8.90^{a} \pm 0.23$
G2	25	$9.70^{a} \pm 0.15$	$8.80^{a} \pm 0.2$	$9.20^{a} \pm 0.29$	$9.10^{a} \pm 0.28$	$8.30^{a} \pm 0.4$	$8.80^{a} \pm 0.47$	$8.35^{a} \pm 0.32$
G3	50	$9.60^{a} \pm 0.22$	$8.80^{a} \pm 0.2$	$9.30^{a} \pm 0.26$	$8.90^{a} \pm 0.28$	$7.90^{ab} \pm 0.48$	$8.70^{a} \pm 0.47$	$8.30^{a} \pm 0.26$
G4	75	$9.70^{a} \pm 0.15$	$8.60^{a} \pm 0.31$	$9.20^{a} \pm 0.29$	$8.60^{a} \pm 0.34$	$7.80^{ab} \pm 0.44$	$8.10^{a} \pm 0.85$	$7.75^{ab} \pm 0.52$
G5	100	$9.60^{a} \pm 0.22$	$7.25^{b} \pm 0.31$	$9.10^{a} \pm 0.35$	$8.40^{a} \pm 0.48$	$6.30^{b} \pm 0.9$	$8.25^{a} \pm 0.49$	$7.40^{b} \pm 0.62$
M1	0	$8.80^{a} \pm 0.39$	$8.70^{a} \pm 0.37$	$9.20^{a} \pm 0.25$	$8.60^{a} \pm 0.27$	$9.00^{a} \pm 0.39$	$8.90^{a} \pm 0.43$	$8.30^{a} \pm 0.5$
M2	25	$9.20^{a} \pm 0.2$	$8.70^{a} \pm 0.26$	$8.70^{a} \pm 0.34$	$8.50^{a} \pm 0.34$	$9.20^{a} \pm 0.25$	$8.50^{ab} \pm 0.27$	$7.70^{ab} \pm 0.58$
M3	50	$8.90^{a} \pm 0.28$	$8.60^{a} \pm 0.37$	$8.60^{a} \pm 0.5$	$8.50^{a} \pm 0.43$	$8.95^{a} \pm 0.38$	$8.50^{ab} \pm 0.22$	$7.60^{ab} \pm 0.6$
M4	75	$9.10^{a} \pm 0.28$	$8.85^{a} \pm 0.33$	$8.70^{a} \pm 0.45$	$8.70^{a} \pm 0.34$	$8.80^{a} \pm 0.47$	$8.30^{ab} \pm 0.4$	$6.85^{ab} \pm 0.62$
M5	100	$9.00^{a} \pm 0.26$	$8.00^{a} \pm 0.52$	$8.60^{a} \pm 0.48$	$9.00^{a} \pm 0.39$	$6.70^{b} \pm 0.67$	$7.60^{b} \pm 0.45$	$6.50^{b} \pm 0.54$

O1-O5: formulated orange nectars, P1-P2: formulated pomegranate nectars, G1-G5: formulated Guava nectars and M1-M2: formulated mango nectars. Data are expressed as means ± SE ($n = 3$), Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($p \le 0.05$). a, b, c, ...: means with the same letter in the same column are not significantly.

4. Conclusion

The use of natural sweeteners such as stevioside in the manufacture of fruit nectar was shown to be satisfactory, resulting a reduction of nutritive calories content with acceptable flavor and color. Low-caloric values could be satisfaction for diabetics or people with restricted diet even for weight maintaining persons. It could be concluded that incorporating stevioside in fruit beverages is applicable commercially and increases the health benefits of produced products. Indeed, incorporating such low-calorie food products in human diets is urgently needed whereas diabetics are raised annually.

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