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Evaluation of the reconstituted drinks from the dried sheets prepared from the mixing of carrots, sweet potatoes, and tomatoes

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Abstract
The vegetables of carrot, sweet potato, and tomato are very acceptable for Egyptian consumers and contain high nutritional values. The purpose of this research is to prepare new dried sheets from carrots, sweet potatoes, and tomatoes to take advantage of the quality as well as the lower prices of these vegetables compared to fruits and evaluated the reconstituted drinks produced from them. The sheets were prepared by mixing the homogenized pulp of carrot, sweet potato, tomato, and sucrose sugar together to obtain blends ratio at 6:2:2:2, 5:3:2:2, 4:4:2:2, 3:5:2:2, and 2:6:2:2 (w/w/w/w) respectively. The electric oven at 60±1ºC was used until the weight of the samples was constant. The results referred that the pH values, non-reducing sugars, ascorbic acid, total phenolic compounds, carotenoids, lycopene, antioxidants, color parameters, and sensory attributes decreased after dehydration and reconstituted the drinks while acidity, color index, reducing sugar, and total sugars increased. After dehydration and reconstituted, the T2 and T3 recorded the lowest differences of physicochemical and sensory attributes followed by T1, while T4 and T5 showed large differences compared with fresh samples. It can conclude that mixing carrots, sweet potatoes, and tomatoes at a ratio of 5:3:2:2 improved the nutritional value and sensory attributes of reconstituted drinks from the dried sheets. Therefore, it recommends preparing dried sheets at this ratio on a commercial scale for its higher nutritional value and acceptance.

Keywords: drinks, sheets, reconstituted, dried, mixing

Introduction

One of the main directions of dietary guidelines is to enhance the consumption of fruits and vegetables that contain the more important antioxidants such as lycopene, β-carotene, flavonoids, and other phenolic compounds. These compounds help to reduce the risk of chronic diseases, such as cardiovascular disease, cancer, and age-related neuronal degeneration [1]. The human body creates free radicals by aerobic respiration in many forms, such as superoxide, hydroxyl, hydroperoxyl, peroxyl, and alkoxyl radicals. These free radicals eliminated by endogenous antioxidant enzymes in the body [2]. The antioxidants are effective in stopping free radicals in the body. A strong antioxidant diet including fruits and vegetables is also important to mitigate the detrimental effects of oxidative stress. Carrot is the essential source of antioxidants such as vitamins (A, C, and E), carotenoids, flavonoids, and phenolic compounds [3]. The phenols have an important effect on the human diet and provide a large variety of biological properties, including antioxidants, anti-cancer, and anti-atherosclerotic action [4], while carotenoids exhibited in recent years multiple health-promoting properties, such as anti-oxidation, anti-cancer, anti-night-blindness defense, aging, and liver damage [5]. Sweet potato is a vegetable with high nutrition benefits, including carbohydrates, dietary fibers, minerals, vitamins, and antioxidants, such as phenolic acids, anthocyanins, tocopherol, and β-carotene [6]. They are a premium source of vitamin A, C, B6, riboflavin, copper, pantothenic acid, and folic acid [7]. Tomato consumption has been related to the prevention of many diseases in recent decades [8, 9], mostly due to the antioxidant content, including carotenoids (lycopene and β-carotene), ascorbic acid, tocopherol, and phenolic compounds [10]. Tomato has been shown protective effects upon cardiovascular illness, diabetes, and stroke [11, 12]. The higher intake of tomatoes and their products lessens the hazard of cardiac diseases and cancer [13].

The purpose of this study is to evaluate the quality of reconstituted drinks from dried sheets prepared by different recipes of carrot, sweet potato, and tomato pulp mixture.

Materials and Methods

Materials

The carrots used for this study were collected from the Ismailia Governorate, Egypt (*Daucuscarota L.* sp. *Sativusvar. atrorobens Alef.*) Carrots were washed, trimmed, and chopped. The juice was obtained from the chopped carrots heated in water at 90°C. The carrot was mixed with boiling water in the ratio of 2:1 (w/w) to facilitate the extraction of the juice by a household extractor (Moulinex T574, France).

The yam (sweet potatoes) was purchased from the Egyptian governorate of Ismailia. Products were washed well by tap water, heated to 90 ° C in water, and then skinned by hand. The pulp was obtained by mixing with boiling water at a ratio of 2:1 (w/w) to facilitate the extraction of the pulp by (Moulinex T574, France) extractor.

Tomato fruits were picked at the ripe stage from a certain farm in Kasasin, Ismailia Governorate. The fruits were washed, dried in the air, cut into small parts. Tomato juice was extracted by Moulinex extractor, then filtered through a strainer of stainless steel, passed through a muslin cloth for separating tomato juice, and disposed of seed and peels.

Preparation of Blends

The homogenized pulp of carrot, sweet potato, tomato, and sucrose sugar were mixed at different ratios as can be seen in Table 1. Sodium metabisulfite and sodium benzoate were added to the mixture by 0.2% and 0.1%, respectively. Pectin was applied to the blends at a rate of 0.1 %. All prepared blends have been modified to 14 Brix and pH 4. The mixtures were poured in stainless steel trays oiled with paraffin oil. The electrical oven was used at 60±1°C until a steady sample weight [14]. Dry sheets were packed within the aluminum foil and packaged in polyethylene bags and put in carton boxes contain CaCl2. Both fresh samples and reconstituted drinks from dried sheets were adjusted at 14 Brix and analyzed in three replicates.

Table 1: The different mixing ratios of carrot sweet potato, tomato, and sucrose

Treatments	Carrot	Sweet potato	Tomato	Sucrose
T1	6	2	2	2
T2	5	3	2	2
T3	4	4	2	4
T4	3	5	2	2
T5	2	6	2	2

Physicochemical analysis

Determination of total soluble solids (TSS), pH, titratable acidity (TA), ascorbic acid (AA), total sugars, and reducing sugars

TSS% for drinks were recorded by Abbe (C10) refractometer made in the USA at 20°C. The Jenway 3510 that made by the company of Bibby Scientific (UK) used to determine pH values. TA of drink samples was assessed by titrating 10 ml of the drink with 0.1 N sodium hydroxide (NaOH) using phenolphthalein as an indicator to pink color as an endpoint. TA values were represented as %, citric acid [15]. AA was obtained by titration using the 0.2% solution (2, 6-dichloro-phenol-indophhenol) until pink coloration according to [16] and the results were expressed in mg of ascorbic acid/per 100 g drink. Total and reducing sugars were analyzed according to methods described by [16].

Determination of instrumental color and color index

The Konika Minolta reader of color (CR-10) made in Osaka, Japan, used to determine CIE L*, a*, and b* values for drink samples. Browning caused by non-enzymatic reactions was deternined through the color index by the method [17]. Drink samples were centrifuged at 2000 rpm for 20 min, diluted with ethyl alcohol 95% (1:1, v/v) and then filtered by Whatman (No. 4) and the absorption read at 420 nm.

Determination of the total carotenoid and lycopene

β-Carotene content was measured as described by [18] using a mixture of hexane: acetone (6:4, v/v). The method of [19] was utilized to estimate lycopene. A mixture of hexane and ethanol (3:4) using to extract lycopene from the sample. The hexane layer reading by a spectrophotometer at 503 nm, lycopene recorded as µg /100g jam.

Determination of total phenolic content (TPC) and antioxidant Activity (AA)

Folin–Ciocalteu was used to determine total phenolic compounds as described by [20]. AA of drinks were assay according to [21].

Sensory analysis

The sensory evaluation was carried out using the method of [22] with some modifications. Ten semi-trained panelists from the Food Technology Research Institute, Agriculture Research Center, Ismailia were asked to show their observations from 10 degrees for each parameter of taste, odor, color, mouth feel, and appearance. The analysis was carried out on five samples. Overall acceptability was measured using the sum of the test attributes' ratings.

Statistical analysis

SPSS (version 17) program was used at level 0.05 % for comparison different means.

Results and Discussion

Table 2 shows the brix, pH, total acidity, reducing and non-reducing sugars values, and total sugars for each of the fresh and reconstituted drinks from dried sheets produced from mixing carrots, sweet potatoes, tomatoes, and sugar.

Brix

The total soluble solids had adjusted at 14 Brix for all drinks before analysis.

pH

As far as pH is concerned, a drop in pH is observed after drying and reconstituted the drinks. It is found that T2 and T3 were the better treatments. The rise in the percentage of sweet potato added as in T4, T5 indicated a strong decrease in the pH values.

Acidity

There was a marked rise in titratable acidity values when compared the reconstituted drinks with fresh samples. A similar increase of titratable acidity was obtained by [23] after drying and reconstituted guava juice. The lowest acidity change was achieved by T2 and T3 treatments.

Table 2: The chemical composition of fresh and reconstituted drinks at 14% TSS.

Analysis Samples	Brix°		pH		Acidity%		O.D. at 420nm		Reducing sugars %		Non-reducing sugars %		Total sugars %	
	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec
T1	14[a]	14[a]	4[a]	3.86[b]	0.39[a]	0.50[b]	0.035[a]	0.086[c]	6.83[d]	8.86[d]	4.44[a]	2.53[a]	11.27[c]	11.39[c]
T2	14[a]	14[a]	4[a]	3.92[a]	0.36[a]	0.42[d]	0.029[b]	0.063[e]	7.14[d]	8.94[d]	4.39[a]	2.89[a]	11.53[bc]	11.83[b]
T3	14[a]	14[a]	4[a]	3.89[ab]	0.31[b]	0.46[c]	0.025[c]	0.077[d]	8.22[c]	9.37[c]	4.43[a]	2.64[a]	11.67[ab]	12.01[b]
T4	14[a]	14[a]	4[a]	3.82[c]	0.30[b]	0.54[a]	0.016[d]	0.104[b]	8.88[b]	10.28[b]	2.97[b]	1.37[b]	11.85[ab]	12.65[a]
T5	14[a]	14[a]	4[a]	3.77[d]	0.28[b]	0.56[a]	0.013[d]	0.116[a]	9.53[a]	11.76[a]	2.49[c]	1.30[b]	12.02[a]	12.89[a]

Fre: Fresh drinks at 14% TSS
Rec: The reconstituted drinks at 14% TSS
The mean of the similar letter in the similar column is not substantially different at the level of 0.05.

Color index

Concerning the absorbance value of the alcohol extract at 420nm, the absorbance was reduced in the fresh drink samples by the increasing sweet potato percentage in the sample mixture. Whereas, after drying, the browning increased. On the other hand, the darker color of reconstituted drink can be attributed to dehydration temperature that enhances the formation of Amadori products such as Hydroxymethyl furfuraldehyde (HMF) from the interaction between amino acids and sugars during the Maillard reaction [24, 25]. Such effect is confirmed by previous studies on drum-dried mango flakes or powder by [26], carrot pomace powder by [27], and strawberry puree [28]. The least browning was recorded after drying and reconstituted the drinks obtained by T2 while T5 was the highest one.

Sugars

The data proved that a greater proportion of sweet potato and a smaller proportion of carrots increased the reducing sugars in the path from T1 to T5 in fresh samples. The proportion of reducing sugars increased after dehydrating in the same direction from T1 to T5. The increase in reducing sugars maybe due to the effect of the drying temperature and increasing acidity of the medium, which serves the decomposition of non-reducing sugars into reducing sugars, that clearing from the decrease in non-reducing sugars after drying. It is well known that the increasing reducing sugars or sugar degradation products play a major role in browning reactions, which effective in accelerating pigments (carotenoids and lycopene) breakdown and enhance non-enzymatic browning during thermal processing due to the react between reducing sugar with amino acid or peptides as recorded over the Maillard formation [29]. Generally, there has been a small rise in total sugars due to the decomposition of complex sugars due to the effect of temperature and the acidic medium.

Table 3 shows the values of ascorbic acid, phenols, carotenoids, lycopene, and antioxidants for both fresh and reconstituted drinks from the dried sheets produced from a mixture of carrots, sweet potatoes, tomatoes, and sugar.

Ascorbic acid

The highest value of ascorbic acid in fresh samples was belong to T5 (30.83 mg / 100 gm). After drying and reconstituted, the ascorbic acid content decreased in all drink samples. This loss of ascorbic acid is due to drying temperature and oxidation as stated by [30, 31]. In comparison between several treatments, T2 has a maximum vitamin level of 17.31 mg/100 g.

Phenolic compounds

The data shows an increase in the content of phenolic compounds in fresh samples with an increase in the percentage of carrots in the samples. T1 was the highest sample in total phenols (155.84 mg/100g). The production of dried and reconstituted sheets resulted in a significant reduction in phenolic compounds. The decrease may be due to the heat used in drying. There is a great similarity between the obtained results and that accomplished by [25] on dried prunes and [31] on different dried fruits. The order of samples in terms of preference remained the same as for fresh juice, T1 recording the highest content of 107.52 mg / 100g, while T5 was the lowest one.

Carotenoids

As for carotenoids, the increase in the percentage of carrots increased the carotenoids content in fresh samples. T1 revealed the highest level of carotenoids (5806.75 µg/100g), while T5 showed the minimum level. The decline in carotenoid was very pronounced due to heat drying, and the reduction increased from T1 to T5. A similar reduction in total carotenoids was given by [27] for reconstituted carrot pomace and [32] for mango.

Lycopene

Lycopene is highly resistant to thermal degradation, while other antioxidants (ascorbic acid, amino acids and β-carotene) are more quickly degraded during treating [33]. It is observed that the proportion of lycopene in fresh samples is close to each other because of the constant proportion of tomatoes added in the different samples. After drying and reconstituted, the lycopene values decreased significantly in all samples. Related results were reported by [34] who showed that the lycopene content of pink guava decreased after spray-dried it. Isomerization and oxidationare the major causes of the degradation of lycopene during processing [35]. T5 recorded the least value of lycopene (150.02 µg/100g), while T2 was the greatest (193.20 µg/100g).

Table 3: The ascorbic acid, total phenols, carotenoids, lycopene, and antioxidant activity of fresh and reconstituted drinks at 14% TSS.

Analysis Samples	Ascorbic acid mg/100g		Total phenols mg/100g		Carotenoids µg/100g		Lycopene µg/100g		Antioxidant activity %	
	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec
T1	24.11^e	12.79^c	155.84^a	107.52^a	5806.75^a	4877.50^a	237.40^b	170.92^c	48.21^a	28.74^c
T2	25.79^d	17.31^a	132.91^b	106.32^b	4669.08^b	4295.51^b	227.3^e	193.20^a	45.36^b	35.41^a
T3	28.72^c	14.00^b	95.89^c	71.91^c	3806.55^c	3349.76^c	235.79^c	183.91^b	38.14^c	32.85^b
T4	29.80^b	11.35^d	82.58^d	51.19^d	3122.64^d	2466.88^d	231.43^d	157.28^d	35.84^d	22.64^d
T5	30.83^a	9.93^e	42.94^e	23.61^e	2333.60^e	1750.20^e	238.14^a	150.02^e	31.58^e	20.81^e

Fre: Fresh drinks at 14% TSS
Rec: The reconstituted drinks at 14% TSS.
The mean of the similar letter in the similar column is not substantially different at the level of 0.05.

Table 4: The color parameters of fresh and reconstituted drinks at 14% TSS.

Analysis Samples	L*		a*		b*		Heu		Chroma	
	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec
T1	42.5^e	38.3^c	17.3^b	12.5^c	31.6^a	24.6^c	61.30^a	63.06^c	36.02^a	27.59^c
T2	43.1^d	41.2^a	17.6^a	13.3^a	30.7^b	27.6^a	60.17^b	64.43^a	35.08^b	30.81^a
T3	44.5^c	39.7^b	17.7^a	13.1^b	29.5^c	26.7^b	59.03^c	63.86^b	34.40^c	29.74^b
T4	45.3^b	37.8^d	16.8^c	11.1^d	27.7^d	20.3^d	58.76^d	61.33^d	32.39^d	23.13^d
T5	46.4^a	36.1^e	17.2^b	10.2^e	25.5^e	18.3^e	55.99^e	60.86^e	30.75^e	20.95^e

Fre: Fresh drinks at 14% TSS
Rec: The reconstituted drinks at 14% TSS.
The mean of the similar letter in the similar column is not substantially different at 0.05%.

Antioxidant activity (AA)

Antioxidants are significantly restricted or inhibit oxidation in low concentrations of oxidizing substrates [36]. Antioxidant strength is influenced by the phenolic composition and other components such as (lycopene, β-carotene, flavonoids, ascorbic acid, and tocopherols). It is clear from the antioxidant activity test that the best samples were T2 followed by T3 in samples after reconstituted, although the T1 sample was the highest AA in fresh.

Color parameters

The color parameters of fresh and reconstituted drinks displayed in Table 4. One of the most important sensorial properties of drinks is appealing color. Changing the color of a food product is an important indication of changes in its chemical and natural composition during processing. Hunter L*, a*, and b* values display the total color variations between fresh and reconstituted drinks. The change in the value of the Hunter "L" as a reduction implies a decrease in clarity, a rise in darkness and the destruction of pigments [29, 38]. The refracted color parameters of the L values were slightly increased ($P<0.05$) by a higher proportion of sweet potatoes applied to fresh mixtures. Compared with fresh samples, the L value of the samples was decreased after drying and reconstituted. T2 recorded the highest L value after drying by (41.20).

The a* parameter is a strong red lycopene color predictor. In fresh drinks, the highest Hunter a * scored by T2 and T3, who saw no major variations between them. After reconstituted the drinks, the same two samples also registered the highest Hunter a * rating. General the Hunter a* value decreased after drying and reconstituted the drinks.

Hunter b * has a strong yellow color index used as carotenoid pigments. The decrease in b* value was closely linked to the depletion of carotenoids. The data in Table (4) reveals that the b* value was improved by increasing the carrot in the same order from T5 to T1 in fresh samples, while the dehydration reduced the b* values associated with the reduction of carotenoids. Both color parameters L*, a*, b*, hue, and chroma were decreased after drying and reconstituted but T2 demonstrate that preferred treatment after dehydration. The reduction obtained in different color parameters are in agreement with the work of [28] on a drum-dried carrot puree, [37] on dried tomato powder, [27] on carrot pomace and [39] on spray-dried pink guava.

The sensorial properties

Table 5 illustrates the sensory features of fresh and reconstituted drinks. The findings revealed that T1 was the preferable treatment that recorded the optimal overall acceptability (49.4) compared with other fresh samples while T5 had the lowest acceptance. After drying and reconstituted, all sensory characteristics decreased. T 2 demonstrated the greatest degree of approval (43.8), followed by T3 (42.8) while the minimum acceptance was recorded by T5 as obtained in fresh samples.

Conclusion

The physicochemical and sensory attributes of reconstituted drinks from dried sheets prepared of carrots: sweet potatoes: tomatoes: sugar were significantly influenced after drying and recovery. After drying and reconstituted, T2 recorded the optimal physicochemical, sensory attributes, and nutritional value compared with other reconstituted samples. Therefore, it recommends preparing dried sheets at this ratio of 5:3:2:2 from carrots: sweet potatoes: tomatoes: sugar on a commercial scale.

Table 5: The sensory attributes of fresh and reconstituted drinks at 14% TSS.

Analysis Samples	Taste 10		Odor 10		Color 10		Mouth feel 10		Appearance 10		Overall acceptability 50	
	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec	Fre	Rec
T1	10a	8.3ab	10a	8.1b	10a	8.4bc	10a	8bc	9.5a	8.6b	49.4a	41.4c
T2	10a	8.8a	10a	8.5a	10a	8.8a	9.5b	8.6a	9.5a	9.1a	48.8b	43.8a
T3	10a	8.6ab	9.5b	8.3ab	10a	8.6ab	9.5b	8.3ab	9.5a	9a	48.2c	42.8b
T4	9.5b	8.1b	9.3bc	7.6c	10a	8.1c	9.2bc	7.9c	9.2a	8.2c	47.1d	39.9d
T5	9.5b	8.0b	9.2c	7.5c	10a	7.7d	9c	7.5d	9.2a	8c	46.7e	38.7e

Fre: Fresh drinks at 14% TSS
Rec: The reconstituted drinks at 14% TSS
The mean of the similar letter in the similar column is not substantially different at 0.05 %

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