CANDIED FRUITS WITH SUGAR SUBSTITUTES

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Abstract

Dietetic foods suitable for diabetics may have the same "caloric value" as they have sugar substitutes, which are intended to replace sucrose or glucose. Fructose and non-nutritive sweeteners are allowed for diabetics, since their metabolism does not require insulin.

To prolong consumption of β-carotene-rich foods in Egypt during off-season, plant foods such as ripe mango, papaya, and pumpkin were preserved by candying using sucrose, fructose or mixture of sorbitol and stevia as sweeteners and stored for 3 months at room temperature.

Chemical analysis and caloric value were carried out for diabetic candied fruits as well as organoleptic evaluation during processing and storage periods.

Reducing sugars for candied fruits sweetened with fructose were higher than those sweetened with sucrose and mixture of sorbitol and stevia.

The low calorie, candied fruits varied for their calories, hence those prepared from sucrose or fructose had the highest caloric value than that processed from mixture of sorbitol and stevia which had the lowest value.

β-carotene loss in candied mango, the papaya, and pumpkin after processing ranged from 19 to 20%, and the loss continued during storage. Candied papaya lost most of the β-carotene, therefore might not be a good source of vitamin A.

INTRODUCTION

β-carotene has been used for many years as a health food product under the claim "anti-oxidant". Many epidemiological and oncological studies suggest that humans feed on a diet high in carotenoid-rich vegetables and fruits, who maintain higher than average levels of serum carotenoids, have a lower incidence of several types of cancer and cardiovascular disease, (Albanes *et al*, 1996; Hennekens *et al.* 1996).

Askar (1988) mentioned that food suitable for diabetics may contain the same caloric-value by using a sugar substitute, which is intended to replace glucose and sucrose, and he added that fructose is about 1.5 times as sweet as sucrose,

often allowed to diabetics since its metabolism does not require insulin, also non-nutritive sweeteners can be used in such diets.

Stevia rebaudiana bertoni is sweet herb found in Paraguay, dried leaves used for commercial food is about 100 times as sweet as sucrose, whereas stevioside (crystals) extracted from stevia herb, had about 200 sweet as sucrose. And he added that in 1994, Egypt registered stevia natural sweetener for the use in foods, (Kienle, 1995). Xili *et al,* (1992) suggested that the acceptable daily intake of stevioside for humans was 7.9mg/kg body weight per day.

Sorbitol is considerably less sweet than sucrose, about 0.5 times that of sucrose, when consumed in large quantities (25 to 50 gram) it can have a laxative effect, apparently because of its slow intestinal absorption (Newsome, 1986).

Mona, *et al.* (1992) studied the chemical and organoleptic evaluation of some selected sweet potato candied products using sucrose, sucrose + glucose, and high fructose glucose syrup as sweeteners. They stated that both fresh and dried candied samples were found to be in good scores either that treated with sucrose or any sugar substitute or they were in highly acceptable form by the panelists.

Ruya, *et al.* (2000) studied the effect of storage for 6 months at room temperature on chemical and physical characteristics of carrots and hard mature peaches candied sweetened with sucrose, high fructose corn syrup, and accesulfame– K. They stated that these products are low in caloric and costs which can be use for diabetes and obesity patients.

Most locally available β-carotene-rich fruits and vegetables are seasonal and not available yearlong. So appropriate preservation and storage method are usually performed in order to prolong the consumption of such β-carotene-rich foods all year. This study is intended to prepare and evaluate candied fruits for diabetes from β-carotene -rich fruits, ripe mango, ripe papaya, and pumpkin during processing with different sweetener and during storage periods.

MATERIALS AND METHODS

Materials:

Papaya fruit (*carica papaya L.*), balady variety and ripe mango (*mangifera indica*), zibdia cultivated were obtained from EL-kanater EL-khyria station, agriculture research center. Matured pumpkin (*cucurbita pepo*) was obtained from EL-Abor market, Cairo, Egypt. Sorbitol, crystalline, and sucrose, commercial grad crystalline, obtained from local market. Fructoses, crystalline, and dried stevia leaves (stevia

rebaudiana bertoni spanti variety), were obtained from from nutrition institute, ministry of health. Whereas, Citric acid, salt, calcium oxide, and sodium metabisulfite were obtained from local chemical companies.

Methods:

Storage of fresh whole pumpkin:

Six pumpkins of the same variety and similar age were obtained after harvest from a market. They were stored under the shade, in open-air condition, the temperature and relative humidity were measured daily and the average of each were calculated during the 3 months study "Aug. Sept. Oct. 2002".

Preparation of candied fruits:

Ripe mango, ripe papaya, and matured pumpkin were used in this study. Fruits were peeled, and cut into pieces 1 x 1 x 0.5 cm. then the fruits (except for pumpkin) were soaked overnight in lime-water. All fruits were blanched in boiling water for 3 min, and soaked overnight in a 30°Brix sucrose solution at the ratio of 1: 1.5 (fruit: syrup). The sucrose solution contained 1000 ppm of sodium metabisulfite, 0.5% salt, and was adjusted for pH with citric acid. The pH of the sucrose solution for candying mango was adjusted from 2.5 to 3.0, while the pH for papaya and pumpkin was 3.5. Sucrose was then added to the syrup to adjust concentrations to a level of 40°, 50° and again 50°Brix. The fruit was soaked in each sucrose concentration for 1 day, and finally dried in a hot air oven at 50°C for 24h, then cooled at room temperature and packed and sealed in polypropylene bags and stored at room temperature for 3 months.

Sucrose was substituted with some sweeteners according to their relative sweetness. The relative sweetness of the sweeteners used was: 1.5, 0.5, and 100 time of sucrose, (fructose, sorbitol, and stevia, respectively). Whereas, solution, PH, soaked, drying, cooling, package and storage was carried out as mentioned in sucrose treatment.

Chemical analysis:

Total and reducing sugars were determined according to Somogyi (1952). Moisture content was determined according to A.O.A.C. (1984). Approximate energy value was calculation in kilo-calorie per 100 gm of product according to the method described by Minifie (1989).

Determination of β-carotene:

Analysis were carried out using a Hewlett Packared 1050 liquid chromatograph equipped with a model HP1050 pump and UV detector (VWD) HP1050 adjusted at 436nm, the samples were injected by HP1050 auto sampler. Data were stored and analyzed by computer system (hp, HPLC chem. station, software).

β-carotene was extracted from fresh and processed fruits according to the method mentioned in Chandler and Schwartz (1987). Samples (100 gm fresh wt.) were blended for 5 min. at high-speed blender with 100 ml water to form a puree. Forty grams of the puree were mixed with 60 mL methanol and filtered. The filter cake was extracted by suspending in 70 mL acetone- hexane (1:1 v/v), filtered and the filtrate combined with the methanol extract. Acetone and methanol were removed by washing (3X) with 100mL water. The extract was dried over anhydrous sodium sulfate and filtered through a 0.45 µm nylon filter prior to HPLC analysis.

Standard β-carotene was purchased from Sigma Co. the solvents used were HPLC reagent grade. Samples were injected (20 µL) and eluted using an isocratic solvent system of acetone- hexanes (3: 997 v/v) at a flow rate of 0.9 mL/min and Lichrospher 100 CN (5 µm) 250 X 4mm column were used.

Vitamin A value:

Calculation was performed based on the vitamin A activity of β-carotene precursor. The vitamin A activity in food is thus currently expressed as retinol equivalents (RE): 1 RE is defined as 1 µg of all-trans retinol, 6 µg of all-trans β-carotene, or 12 µg of other pro vitamin A carotenoids, (Food and Nutrition Board, 1989).

Organoleptic tests and statistical analysis:

Organoleptic tests were carried out according to Amerine *et al.,* (1965). Ten panelists were asked to evaluate samples for their characteristics (color, sweetness, flavor and appearance); the score used for each quality in the sheet was 10.

Statistical analysis of data obtained from sensory evaluation was carried out according to the methods described by Snedecor and Cochron (1967). All data were presented as the mean ± standard deviation for the means (S.D.). Significant differences among means were distinguished according to the Duncan, multiple test range (Duncan, 1955).

RESULTS AND DISCUSSIONS

Data in Table (1) show the chemical composition of fresh mango, papaya, and pumpkin fruits. The percentage of moisture content of mango, papaya, and pumpkin fruits was 81.3, 88.63, and 85.50%, respectively. Also, it could be noticed that the total sugars for mango, papaya, and pumpkin fruits were 80.54, 77.31, and 70.96%, (on dry weight basis) respectively. These results agree with those obtained by EL-Ashwah *et al.* (1974), Abdel- magied, *et al.*(1991), and Mousa, (1998).

Data in the same table indicate that β-carotene in mango, papaya, and pumpkin fruits are 4.936, 3.632, and 5.566mg/100gm (on dry weight basis), respectively.

Table 1. Chemical composition of fresh ripe mango, papaya, and mature pumpkin.

Constituents	Mango		Papaya		Pumpkin	
	W. b	D. b	W. b	D. b	W. b	D. b
Moisture content%	81.3	-	88.63	–	85.50	–
Reducing sugars%	3.89	20.80	3.49	30.69	1.33	13.84
Non-reducing sugars%	11.87	63.48	4.93	43.36	5.16	53.69
Total sugars%	15.06	80.54	8.79	77.31	6.82	70.96
B-carotene (mg/100g)	0.923	4.936	0.413	3.632	0.807	5.566

W. b: wet basis D. b: dry basis

The percentage of reducing sugars in all treatments varied, due to the kind of sweetener. However, it was high in fructose treatment, which ranged from 51.53 to 52.31%, while it was low in sucrose treatment (18.93 to 20.42%) whereas the mixture of sorbitol and stevia were ranged from 3.66 to 7.29% (Table 2). From the same table, it was noticed that a slight increase in reducing sugars for all treatments during storage period, it may be due to the acid media for candied fruits caused a change of non reducing sugars to reducing sugars, these results agree with those obtained with Nury *et al.* (1960) and EL-sheaty *et al.* (1986).

From the same table it could be observed that the mango, papaya and pumpkin candied had 71.55, 68.6, 23.85%; 72.01, 68.13, 13.53% and 71.93, 69.21, 11.53% total sugars at zero time, respectively, this percentage had a little decrease during storage for 3 months this decrement may be due to Millard reaction between sugars and amino acid during storage (Heli *et al.* 1988).

Table 2. Effect of storage on reducing, total sugars content (%) and caloric values of different candied fruits.

Storage period (Months) / Treatment	Reducing sugars				Total sugars				Caloric value (kcal/100gm samples)			
	0	1	2	3	0	1	2	3	0	1	2	3
Mango candied with												
S	20.42	20.59	20.71	20.86	71.55	71.48	71.41	71.36	286.2	285.92	285.64	285.44
F	52.31	52.63	52.76	52.81	68.60	68.53	68.49	68.41	274.4	274.12	273.96	273.64
Sor+St	7.29	7.40	7.55	7.72	23.85	23.78	23.71	23.65	95.4	95.12	94.84	94.60
Papaya candied with												
S	18.93	18.99	19.23	19.38	72.01	71.95	71.88	71.81	288.04	287.80	287.52	287.24
F	51.96	52.08	52.21	52.43	68.13	68.06	67.92	67.84	272.52	272.24	271.68	271.36
Sor+St	6.71	6.84	6.93	7.08	13.53	13.43	13.38	13.31	54.12	53.72	53.52	53.24
Pumpkin candied with												
S	19.68	19.78	19.82	19.96	71.93	71.89	71.84	71.76	287.72	287.56	287.36	287.04
F	51.53	51.66	51.73	51.89	69.21	69.16	69.11	69.03	276.84	276.64	276.44	276.12
Sor+St	3.66	3.75	3.85	3.96	11.53	11.47	11.41	11.32	46.12	45.88	45.64	45.28

S: Sucrose F: Fructose Sor: Sorbitol St: Stevia

From data in Table (2) also it could be noted that sucrose treatment showed a high calorie it ranged from 286.2 to 288.04 kcal per 100g, whereas treatments with mixture of sorbitol and stevia had lower calories (95.4, 54.12 and 46.12 kcal) for mixture of sor and st of candied mango, papaya, and pumpkin.

It could be concluded that, some mild diabetes can use candied fruits with fructose, whereas, candied with mixture of sorbitol and stevia may be used for severe cases and old diabetic or obesity persons.

β-carotene content changes during processing and storage of candied fruits: β-carotene losses during the processing of candied fruits the losses were in the range of 19 to 20 % as compared to the fresh fruits (Table 3). The losses were mainly due to blanching, which allowed the fruits to be directly in contact with heat and oxygen. However, the heavy syrup could reduce losses, since it prevented fruits from exposure to oxygen during soaking and dehydration. The sugar glazed on the product surface also prevents β-carotene from being exposed to oxygen during storage. During processing, sulfur dioxide as a strong reducing agent also prevented oxidation of β-carotene.

From the same table it could be notice that the rates of RE and β-carotene loss during storage were different among the candied products. Candied papaya lost most of RE and β-carotene, 82.22 and 85.83%, respectively, after 3 months storage. Considering the content and rate of loss of RE and β-carotene in the product, candied papaya therefore might not be a good source of vitamin A. whereas candied mango lost 26.57and 40.73% of RE and β-carotene, respectively, also candied pumpkin lost about 23.94 and 38.96% of RE and β-carotene, respectively after 3 months storage.

β-carotene content change during storage of whole pumpkin:

During the 3 months storage, Aug., Sept. and Oct., the averages of room temperature were 30.4, 29.6, and 24.55°C, whereas relative humidity were 56, 54, and 52 respectively, β-carotene content in fresh whole pumpkin increased dramatically (Table 4). Fresh whole pumpkin could be stored for at least 3 months under the study conditions. Moreover, the more mature the pumpkin, the higher the β-carotene content. Generally, in Egypt people in rural areas can keep fresh whole pumpkin for about 3 months at room temperature.

Changes in fruit weight during storage are summarized in Table (4). The loss in fruit weight tended to increase gradually by increasing the storage period, the loss in fruit weight during storage is mainly due to the loss in water.

Organoleptic evaluation:

Organoleptic tests are generally the final guide to the quality from the consumer's point of view. Data in Table (5) show the average scores of organoleptic evaluation of different candied fruits. It could be noted that there is no significant difference between the means of color at zero time and after 3 months for any sweetener or between sucrose and any other sweetener at the same time of storage period within mango or pumpkin candied treatments. While in papaya candied there is significant difference between any means of color at zero time and after 3 months, also there is no significant difference between the means of color for sucrose and any sweetener at the same time of storage period. Means of color at pumpkin candied showed no significant different between any two means during storage period or between any two means of any sweetener at the same time of storage.

Table 3. Loss of β-carotene and RE* in candied mango, papaya, and pumpkin during processing and storage.

Storage period (week)	β-carotene (µg/100g)		RE	RE loss(%)**	β-carotene loss (%)***
	Wet basis	Dry basis			
Fresh ripe mango	923	4936	153.83	—	—
Candied ripe mango					
0	2766	3985	461.00	—	19.26
3	2381	3431	396.83	13.92	30.49
6	2289	3299	381.50	17.25	33.16
9	2128	3066	354.67	23.07	37.89
12	2031	2926	338.50	26.57	40.73
Fresh ripe papaya	413	3632	68.83	—	—
Candied ripe papaya					
0	2357	2899	392.83	—	20.16
3	1271	1563	211.83	46.08	56.97
6	1065	1310	177.50	54.82	63.92
9	694	853	115.67	70.55	76.52
12	419	515	69.83	82.22	85.83
Fresh pumpkin	807	5566	134.50	—	—
Candied pumpkin					
0	3551	4466	591.83	—	19.76
3	3126	3932	521.10	11.95	29.36
6	3097	3395	516.17	12.78	30.02
9	2919	3672	486.50	17.80	34.99
12	2701	3398	450.17	23.94	38.96

* RE: Retinol equivalent from β-carotene only for samples on wet basis.

** RE loss (%) is calculated based on the RE from β -carotene only (wet basis) of candied at zero time storage.

*** Amount of β-carotene loss (%) is calculated based on the β-carotene content (dry basis) of fresh fruit.

Table 4. Changes in fruit weight and β-carotene content of fresh whole pumpkin during 3 months storage.

Storage period (week)	Fruit weight (kg)	Wet basis* (mg/100gm)	Dry basis** (mg/100gm)
0	3.500	0.107	0.738
3	3.380	0.198	1.366
6	3.306	0.403	2.779
9	3.210	0.652	4.497
12	3.140	0.813	5.607

*Analyzed by using HPLC.

**Calculated from wet basis and moisture content.

The same table showed the average score of evaluation of sweetened candied fruits. Analysis of variance indicated that there is no significant difference between the means at zero and after 3 months storage period for any sweetener within the three kinds of fruits. Whereas there is significant difference between average sucrose of sweetens for samples sweetened with mixture of sorbitol + stevia and any other sweetener at the same time of storage at any kind of candied fruits, this may be due to the after taste of stevia.

The same table also indicates that there is no significant difference between any two means of flavor at the same time of storage periods, whereas during storage there is significant difference between the average of flavor at zero time and after 3 months of storage for any sweetener at any kind of candied fruits. The same observation was also found in appearance scores.

Table 5. Organoleptic evaluation of different candied fruits.

Kind of candied		Color				Sweetness				Flavor				Appearance			
		0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Mango with	S	9.3^{A} ±0.56	9.3^{A} ±0.67	9.0^{AB} ±0.72	8.8^{AB} ±0.55	9.0^{AB} ±0.49	9.1^{A} ±0.38	8.8^{AB} ±0.48	8.7^{B} ±0.53	9.4^{ABC} ±0.39	9.4^{ABC} ±0.33	9.2^{CD} ±0.71	9.0^{D} ±0.42	9.4^{AB} ±0.46	9.3^{BC} ±0.52	9.3^{BC} ±0.41	9.1^{DE} ±0.52
	F	9.2^{AB} ±0.68	9.0^{AB} ±0.53	9.0^{AB} ±0.67	8.7^{AB} ±0.61	9.0^{AB} ±0.59	9.0^{AB} ±0.64	8.9^{AB} ±0.42	8.7^{B} ±0.37	9.6^{A} ±0.34	9.5^{AB} ±0.36	9.3^{BC} ±0.61	9.0^{D} ±0.54	9.5^{A} ±0.38	9.3^{BC} ±0.40	9.3^{BC} ±0.49	9.2^{CD} ±0.46
	Sor+St	9.1^{AB} ±0.42	9.0^{AB} ±0.76	8.8^{AB} ±0.60	8.6^{B} ±0.63	8.2^{C} ±0.81	8.0^{C} ±0.59	7.9^{C} ±0.61	7.9^{C} ±0.46	9.5^{AB} ±0.40	9.5^{AB} ±0.28	9.2^{CD} ±0.48	8.9^{D} ±0.43	9.4^{AB} ±0.25	9.3^{BC} ±0.38	9.0^{E} ±0.39	9.0^{E} ±0.37
L. S. D.		0.5513				0.2981				0.2004				0.1312			
Papaya with	S	9.0^{AB} ±0.41	9.0^{AB} ±0.50	8.5^{DE} ±0.74	8.0^{FG} ±0.39	9.1^{A} ±0.40	9.0^{A} ±0.37	8.8^{AB} ±0.71	8.8^{AB} ±0.72	9.6^{A} ±0.29	9.5^{AB} ±0.31	9.4^{ABC} ±0.30	9.1^{DE} ±0.51	9.0^{AB} ±0.56	8.7^{BCD} ±0.38	8.5^{CDEF} ±0.62	8.2^{EFG} ±0.80
	F	9.0^{AB} ±0.58	9.0^{AB} ±0.60	8.6^{CDE} ±0.88	8.1^{F} ±0.82	9.0^{A} ±0.55	9.0^{A} ±0.42	8.9^{A} ±0.68	8.7^{AB} ±0.57	9.5^{AB} ±0.46	9.5^{AB} ±0.40	9.3^{BCD} ±0.42	9.0^{E} ±0.47	9.2^{A} ±0.49	8.8^{ABC} ±0.55	8.4^{CDEFG} ±0.49	8.1^{FG} ±0.71
	Sor+St	8.8^{BC} ±0.66	8.8^{ACD} ±0.42	8.4^{E} ±0.58	8.0^{FG} ±0.71	8.4^{BC} ±0.69	8.2^{C} ±0.92	8.1^{C} ±0.48	8.0^{C} ±0.86	9.5^{AB} ±0.27	9.4^{ABC} ±0.35	9.2^{CDE} ±0.49	9.0^{E} ±0.38	9.0^{AB} ±0.62	8.6^{BCDE} ±0.69	8.3^{DEFG} ±0.64	8.0^{G} ±0.52
L. S. D.		0.2334				0.3861				0.2395				0.3824			
Pumpkin with	S	9.4^{A} ±0.29	9.1^{ABCD} ±0.52	9.2^{ABC} ±0.48	9.1^{ABCD} ±0.42	9.3^{A} ±0.52	9.0^{AB} ±0.62	9.0^{AB} ±0.37	8.8^{BC} ±0.70	9.5^{AB} ±0.38	9.3^{BC} ±0.42	9.1^{CD} ±0.62	8.8^{E} ±0.72	9.4^{A} ±0.41	9.2^{ABC} ±0.39	9.1^{BCD} ±0.34	9.1^{BCD} ±0.51
	F	9.3 ±0.41	9.3^{AB} ±0.47	9.1^{ABCD} ±0.51	8.9^{BCD} ±0.82	9.2^{A} ±0.48	9.2^{A} ±0.52	9.0^{AB} ±0.46	9.0^{AB} ±0.61	9.5^{AB} ±0.42	9.3^{BC} ±0.47	9.3^{BC} ±0.43	8.9^{E} ±0.49	9.3^{AB} ±0.48	9.1^{BCD} ±0.37	9.1^{BCD} ±0.54	9.0^{CD} ±0.54
	Sor+St	9.1^{AB} ±0.62	8.8^{CD} ±0.61	8.8^{CD} ±0.81	8.8^{CD} ±0.67	8.5^{CD} ±0.70	8.4^{D} ±0.63	8.3^{D} ±0.80	8.2^{D} ±0.91	9.6^{A} ±0.29	9.5^{AB} ±0.29	9.3^{BC} ±0.50	9.0^{DE} ±0.52	9.3^{AB} ±0.52	9.0^{CD} ±0.42	9.0^{CD} ±0.80	8.9^{D} ±0.48
L. S. D.		0.3748				0.3257				0.2074				0.2334			

S: Sucrose F: Fructose Sor: Sorbitol St: Stevia ± : S.D.-L. S. D. Least significant difference at 0.05 level of significance.

-Row wise: Means not followed by the same latter (s) are significantly different ($p<0.05$) at the same organoleptic parameter.

-Column wise: Means between any two storage period at the same candied fruit not followed by the same latter(s) are significantly different ($p<0.05$).

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فاكهة مسكرة ببدائل السكر

فؤاد على عبد الجليل الشـــــريفة

معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – جيزة – مصر.

الأغذية الخاصة بمرضى السكر يمكن أن تحتوى على نفس السعرات بمثيلتها التي استبدل فيها السكروز أو الجلوكوز حيث يصرح للفركتوز والمحليات غير المغذية باستخدامها لمرضى السكر لأن عمليات التمثيل الغذائي لها لا تحتاج أنسولين.

ونظراً لان الأغذية الغنية بالبيتا كاروتين في مصر هي ناتجة من محاصيل موسمية وللحصول عليها في غير موسمها تم حفظ المانجو والبباظ وقرع العسل بالتسكير باستخدام السكروز أو الفركتوز أو خليط من السوربيتول والاستيفيا.

تم إعداد فاكهة مسكرة لمرضى السكر وتم دراستها من حيث التركيب الكيماوي والقيمة السعرية والتقييم الحسي للمنتج المصنع وأثناء فترات التخزين.

وأوضحت النتائج أن النسبة المئوية للسكريات المختزلة مرتفعة في الفاكهة المحلاة بالفركتوز في حين كانت منخفضة في الفاكهة المحلاة بالسكروز وكانت اقلها فى المحلاة بخليط السوربيتول والاستيفيا.

كما وجد أن الفاكهة المسكرة بالسكروز أو الفركتوز كانت أعلاها في القيمة الحرارية بينما الحلوى المسكرة بخليط السوربيتول والاستيفيا كانت منخفضة في القيمة الحرارية.

كما نلاحظ أن نسبة الفقد في البيتا كاروتين للمانجو والبباظ والقرع العسلي المسكر عقب التصنيع تراوحت بين١٩–٢٠% واستمر الفقد حتى نهاية فترة التخزين. البباظ المسكر اكثر المنتجات فقدا في محتواة من البيتا كاروتين ولذلك يحتمل أن لا يكون مصدر جيد لفيتامين أ.