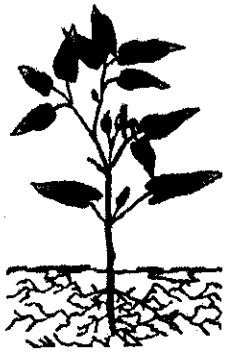

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PRICKLY PEAR PEELS AS A NEW SOURCE OF NATURAL LIQUID SWEETENER AND ITS APPLICATION IN TOFFEE MANUFACTURE

[18]

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ABSTRACT

Prickly pear peels liquid sweetener (PPPLS) was prepared from prickly pear peels (PPP) and used as substitute sweetening agent for glucose syrup or sucrose at levels of 25, 50, 75 or 100% in toffee manufacture. The physico-chemical and sensory properties were determined just after preparation and intervals every one month during storage at room temperature for six months. Prickly pear peels (PPP) considered as by product that characterized by their higher content of sugars reached to 11.43 %. The chemical and physical properties, sensory evaluation as well as utilization of natural liquid sweetener produced from prickly pear peels were studied. The data revealed that reducing sugars comprised about 86.06 %of total sugars, while, non reducing sugars comprised about 6.04 % of PPPLS. Results indicated that PPPLS is a good source of many important elements such as K, Ca, Mg, Na and Fe. Vitamin C was considered as the predominant vitamin (2.74 mg/100g) followed by B1 (0.471mg/100g). Sensory evaluation of PPPLS indicated the possibility of using such PPPLS as a sugar substitute in toffee. Toffee was prepared using PPPLS as substitutes of glucose syrup or sucrose in the percent 25, 50, 75 and 100 %. Relation between time and temperature during cooking of experimental samples were studied. No remarkable differences were obtained in the behavior of heating curve due to addition of PPPLS at the studied levels. Effect of cooking temperature on moisture content and hardness of toffee processed using PPPLS were also studied. Hardness value of control sample increased from 343 to 605 N when the cooking temperature was increased from 114 to 118 °C. Same behavior was noticed by PPPLS-supplemented samples. Changes that occur in sugars composition of toffee with processing using PPPLS were studied. The reducing sugars were gradually increased with the increasing sucrose substitution of PPPLS to reach its maximum 94.61% of the total sugars, adversely, non reducing sugars that reach its minimum 5.39% of the total sugars. Chemical composition of toffee tested samples was determined in the start of storage time while, acid value, peroxide value, fatty acid pattern and sensory attributes were determined during storage period at room temperature for six months. Generally, the difference in chemical composition between the formulas is slight. While, acid and peroxide values of all experimental manufactured samples were gradually increased versus storage period with significant difference. Total saturated fatty acids content of oil extracted from all samples increased, adversely, total unsaturated fatty acids content which decreased at the long storage period. In addition, all toffee manufactured samples showed acceptability in sensory evaluation after processing and at intervals during storage. Use of PPPLS up to 50% in toffee manufacture led to enhance all sensory attributes. The obtained information is useful for the further chemical and nutritional investigations of prickly pear peel, and also for industrial utilization of the major by-product of the prickly pear fruit.

INTRODUCTION

Opuntia is a genus of the family Cactaeae that grows world wide, the most usual and studied species of this genus is Opuntia ficus indica which is a

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tropical fruit that grows in tropical and subtropical areas (**Felker and Inglese, 2003**). Recently, there are several researches about processing prickly pear fruits, which usually are eaten fresh after peeling in all production regions, into many different products such as use juices, nectars, dehydrated sheets, marmalades, jelly, jams, natural sweetener, candies, pectin, mucilage and canned and frozen fruit, etc. (**Bunch, 1996; Thomas, 1998; Saenz, 2002; Goycoolea and Cardenas, 2003; Saenz *et al* 2004; Cardenas, *et al* 2007 and Cassano, *et al* 2010**). The whole fruit of the prickly pear fruit consists of three parts, the peel 33.35-48.00 %, pulp 45.00 – 61.40 % and the seeds 2.80 – 8.85 % (**Gurrieri *et al* 2000; Essa and Salama, 2002; and Diaz Medina *et al* 2007**). The processing of many fruits results in the accumulation of large quantities of by-products. Proper utilization of this by-product could reduce waste disposal problems and serve as a potential new source of fats and proteins for use in food and feed (**Kamel and Kakuda, 2000**). During processing prickly pear fruits into products large part makes up about 40 % of the whole fruit weight lost as by-product that characterized by their higher content of sugars, pectin, oil and other substances. Modification of wastes and or recovery of nutrients or valuable substances from by products of food industry as well as their use as foods or feed after their treatment, are the main trends of proper utilization. The chemical properties and composition of prickly pear wastes including seeds and peels was studied by **Sawaya *et al* (1983); El-Kossori *et al* (1998); Coskuner and Tekin, (2003) and Habibi, *et al* (2008)** to determine its suitability for human consumption. **Forni *et al* (1994) and Majdoub *et al* (2001)**, they studied the preliminary characterization of hot acid extracted pectin from prickly pear peel. There are also many studies on some physical and chemical properties of prickly pear seeds oil (**Sepulveda and Saenz, 1988; Krifa *et al* 1993; Ramadan and Morsel, 2003; Labib, *et al* 2005; Ennouri *et al* 2005 and Ennouri *et al* 2006**). Sweeteners are the most important component of confectionery as they contribute a broad range of functionalities influencing sweetness, texture, microbial stability, flavor, color, overall appeal and product stability (**Heim, 2003**). Sweeteners can be divided into tow classifications: bulk sweeteners, which provide calories; and alternative sweeteners, which have a sweet taste but are effectively non-caloric. The use of natural sweeteners other than sucrose is an interesting area for the food industry. The use of liquid sugars including corn syrup, high fructose corn syrup (HFCS), invert syrup, molasses, and honey has been developed in confectionary manufacturing (**Smith, 1998 and Alpaslan & Hayta, 2002**). The use of cactus pear (*Opuntia ficus indica* L.) juice to obtain a new natural liquid sweetener was previously studied by (**Saenz et al 1998**). They stated that the sensory evaluation revealed the same relative sweetness for cactus pear syrup and glucose, but lower than fructose. Also, cactus pear syrup had a relative sweetness value of 67 with respect to sucrose (100). Moreover, prickly pear juice can be of potential for manufacture of High Fructose Glucose Syrup (HFGS) **Hamdi, (1997).**

Therefore, the main objective of this work was to utilize prickly pear peels that characterized by their higher content of sugars to prepare natural liquid sweetener as a new source of sugars suitable for toffee manufacturing.

MATERIALS AND METHODS

Prickly pear peels

The mature prickly pear fruits (Opuntia ficus indica) were purchased from an prickly pear farm, El-Dar village, Kaluobia governorate (season 2009). The prickly pear fruits were thoroughly washed in running water to remove the big thorns, air dried at ambient temperature, and then manually peeled with knife, the fruits were then weighed before and after being peeled, to calculate the percentage of edible portion.

Preparation of prickly pear peels liquid sweetener

Peeled fruits were shredded and blanched in hot water (1/3 ratio) at 100 °c for 60 min with maintaining a continuous stirring over the extraction period. The mixture was transferred to a piece of fine mesh nylon cloth and handly pressed to recover the juice as completely as possible. Prickly pear peels juice was concentrated by Rotary vacuum evaporator to get concentrate of 50-55 ° Brix liquid sweetener (**Saenz *et al* 1998**). The product was named as prickly pear peels liquid sweetener (PPPLS) and kept in glass bottles and stored at refrigerator at 4°c till analysis and use.

Preparation of toffee: Prickly pear peels liquid sweetener (PPPLS) was used as a sugar substitute in the preparation of toffee in laboratory using the traditional procedure as described by **Sweet-**

maker, (1985). The formulation of control samples was sucrose (37.0%), glucose syrup (38.0 %), shortening (10.0 %), sweetened condensed whole milk (15.0 %) and salt (little). Substitution was carried out by replacement of glucose syrup or sucrose at the level 0, 25, 50, 75 and 100 %.

Heating curves obtained during cooking of experimental samples

Heating curves of time versus temperature were carried out during cooking of 1 Kg of each experimental samples. They were obtained by measuring temperature versus time every 5min.

Effect of cooking temperature on hardness and moisture content of experimental samples

Control and experimental samples were examined according to the method described by **Tonucci and Von-Elbe, (1988).**

Physico-chemical analysis

Moisture, total solid, ash, fat, protein, fiber, acidity and total sugars content, ascorbic acid, total soluble solids and refractive index were determined according to **A.O.A.C. (2000),** total carbohydrate was calculated by difference. Acid, peroxide values and fatty acid profile of extracted lipids were estimated according to **A.O.A.C. (2000).** Ph value was measured using pH meter (HANN – Instruments, USA). Minerals were determined by Atomic Absorption Spectrophotometer (Spectra AA-20, GTA-96, Varian, Australia) according to **A.O.A.C. (2000).** Sugar content was determined using HPLC (Hp 1050, Hewlett-packard, USA) as mentioned by **Macherey-Nagel, (1992).** Vitamins were determined by using HPLC (Hp 1100) according to **Czerwiecki and Wilczynska, (1999).** Browning index and clarity were determined as described by **Ramadan, (1995).**

Hardness

Hardness of toffee was measured according to the method described by **Tonucci and Von-Elbe, (1988)** using Instron Universal Testing Machine, model 4302 (England). Samples pieces were held at 22° C in an incubator for 24 hr. A load cell used had a maximum capacity of 1000 N. The rate of compression was 2 mm/minute and the chart speed was 50 mm/minute.

Microbiological analysis

Total bacterial count, yeast & mould and coliform bacteria were enumerated according to the methods recommended by **APHA, (1992).**

Sensory evaluation

Evaluation was made by 10 staff members of Food Science Department, Faculty. of Agriculture, Ain Shams University, who were asked to evaluate flavor, color, texture, mouthfeel and overall acceptability of the processed toffee according to **Venkatesh *et al* (1984).**

Statistical analysis

Data were averaged and presented as mean ± Standard Error (SE). The obtained data was exposed to analysis of variance. Duncan multiple ranges at 5 % level of significance was used to compare between means. Results followed by different alphabetical letters were significantly differed. The analyses were carried out using the PROC ANOVA procedure of Statistical analysis System **(SAS, 1996).**

RESULTS AND DISCUSSION

Physical characteristics of fresh prickly pear fruits

The observe number of fruits per kilogram was about 12.68. The percentage of edible portion (fruit pulp) reached to 51.55 % with high percentage of the peels reached to 43.03% and low percentage of seeds reached to 5.42 %. These results are in agreement with that reported in previous studies. **Essa and Salama, (2002)** and **Diaz Medina *et al* (2007).**

Physico-chemical characteristics of fresh prickly pear peels and prickly pear peel liquid sweetener (PPPLS) (means ± SE) (on wet weight basis)

Proximate chemical analysis of fresh prickly pear peels and prickly pear peels liquid sweetener (PPPLS) are listed in **Table (1).** Prickly pear peels samples contained high sugar level reached to 11.43 %, these results were in agreement with **(Sawaya *et al* 1983 and Mousa, 2004).** While fiber, protein and ash contents were 2.51, 0.79 and 0.53%, respectively. Fat content was low as 0.34%. Ascorbic acid was recorded 11.07 mg/100g.

Table 1. Physicochemical characteristics of fresh prickly pear peels (ppp) and prickly pear peel liquid sweetener (PPPLS) (means of three replicates ± standard error) (on wet weight basis)

Characteristics (%)	PPP	PPPLS
Moisture	82.39 ±0.96	42.61 ± 0.88
Total solid	17.61 ±0.4	57.39 ± 0.97
Total soluble solids	ND	53.82
p H value	5.77	5.34
Acidity (as citric acid)	0.054 ±0.012	0.42 ± 0.08
Refractive index (at 20 °C)	ND	1.4687 ± 0.001
Browning index (A at 420 nm)	ND	0.615 ± 0.083
Clarity (% T at 660 nm)	ND	26.73 ± 0.54
Total sugars	11.43 ±0.26	44.90 ± 0.65
Ash	0.53 ±0.15	1.05 ±0.13
Protein	0.79 ±0.13	1.97 ±0.24
Fat	0.34 ±0.10	0.48 ± 0.08
Fiber	2.51 ±0.11	0.54 ±0.10
Ascorbic acid (mg/100 g)	11.07 ± 0.43	-
Glucose	ND	21.83
Fructose	ND	16.81
Sucrose	ND	2.71
Total	ND	41.35

ND: not determined

Results given in the same Table show the physicochemical characteristics of PPPLS. The total solids and total soluble solids content of PPPLS were 57.39 % and 53.82° Brix, respectively. The sugars were the major soluble solids of prickly pear fruits. Sucrose content was relatively lower than glucose and fructose contents in pulp and juice as reported by **(Kuti and Galloway, 1994).** Sugars are considered as the predominant compounds in PPPLS, the total sugar about 44.90%. Glucose, fructose and sucrose contents of PPPLS were 21.83, 16.81 and 2.71%, respectively. The data revealed that reducing sugars comprised about 86.06 % of the total sugars, while, non reducing sugars comprised about 6.04% of the total sugars of PPPLS. Glucose concentration higher than fructose. Generally, the ratio of glucose and fructose in PPPLS can be of considerable interest since fructose is about twice sweet as glucose and one and half as sucrose and this sugar is important from view point of dibetogenic. These results are similar to that reported by **Kuti & Galloway, (1994) and Saenz *et al* (1998).** The protein, ash and fiber contents were 1.97, 1.05 and 0.54 %, respectively. pH value and acidity were 5.34 and 0.42 %, respectively. The obtained results were found in line with **Saenz *et al* (1998).** The browning index (A at 420 nm) and clarity (% T at 660 nm) were 0.615 and 26.73%, respectively.

Minerals and vitamins content

Both macro and micro elements were given in **Table (2).** The data showed that PPPLS is considered as a good source of many important elements. It exhibited higher amounts of K and Ca that reached to 1018.92 and 548.76 ppm, respectively, while, Mg and Na reached to 214.51 and 193.43 ppm, respectively. Fe was 24.88 ppm. Results revealed that heavy metals contamination levels in PPPLS are generally very low comparing with contamination levels described previously by **El-Kossori *et al* (1998).** Vitamins content of PPPLS were given in the same Table. Results indicated that vit. C was considered as the predominant vitamin (2.74 mg/100g) followed by thiamine (B1) (0.471 mg/100g). The difference in pyridoxine and folic contents is negligible (0.289 and 0.272 mg/100g). Riboflavin was detected at low level (0.132 mg/100g) in PPPLS. On the other

Table 2. Minerals content (ppm) and Vitamin content (mg /100g) of prickly pear peel liquid sweetener (PPPLS)

Elements	Concentration (ppm)	Vitamin	Concentration (mg per 100g)
Macro elements		Thiamine (B 1)	0.471
Potassium (K)	1018.92	Riboflavin (B 2)	0.132
Sodium (Na)	193.43	Pyridoxine (B 6)	0.289
Calcium (Ca)	548.76	Folic acid	0.272
Magnesium (Mg)	214.51	Ascorbic acid (C)	2.740
Micro elements			
Iron (Fe)	24.88		
Copper (Cu)	1.02		
Lead (pb)	0.21		
Manganese (Mn)	5.12		
Zinc (Zn)	1.65		
Arsenic (Ar)	0.07		
Mercury (Hg)	Nil		
Selenium (Si)	Nil		
Cadmium (Cd)	Nil		

hand, **(Diaz Medina *et al* 2007)** studied the chemical composition for the tow species of prickly pear fruits and they found that ascorbic acid ranged from 17.2 to 29.7 mg/100g. In another study, ascorbic acid in prickly pear juice was 31.5 mg/100g **Essa and Salama (2002).**

Effect of thermal processing on microbial load of PPP and PPPLS

The microbial load on raw vegetables and fruits is influenced by many factors; such as hands of personal, trimming, sorting and packaging and the equipment used in operations contribute to the number of microbial contamination and their distribution on the product **(ICMSF, 1980)**.

The total bacterial count, total coliform and yeast and moulds were determined by the plate count technique and found to be $6.2x10^5$, $3.4x10^3$ and $1.23x10^3$ cfu/g, respectively. Analysis after thermal processing at 100 °C for 60 min. the count was reduced to 4.6x10 cfu/g for total bacterial count, while the coliform and yeast and moulds were not detected.

Organoleptic evaluation of PPPLS

The prepared PPPLS were palatability tested in terms of color, taste, consistency and acceptability compared with cane molasses and mean scores were listed in **Table (3).** Significant difference between PPPLS and cane molasses in their attributes. It was evident that PPPLS recorded the highest average scores of color, consistency and acceptability, but on the other hand, it was the lowest score noticed in taste. While, PPPLS introduced with the addition of sesame paste (tehena) were high in sensory attributes scores compared with plain sample. Higher scores were obtained for taste and consistency. Therefore, tehena was added as improvement agent for taste and consistency of PPPLS. Generally, sensory evaluation showed that the prepared PPPLS as high desirable as cane molasses.

Application

Toffee Processing

Toffee is produced by blending glucose syrup, refined and / or brown sugar, milk solids (usually in the from of full cream condensed milk), fat and salt. The mix is then concentrated to high total solid content **(Sweetmaker, 1985).**

Relation between time and temperature during cooking of experimental samples

Figure (1) showed heating curve during cooking of toffee formulas. Generally, it could be noticed that temperature increased with extending cooking time until it reached the final cooking temperature and time. No remarkable differences were obtained in the behavior of heating curve due to addition of PPPLS at the studied levels. The final cooking time was recorded when the moisture content of the cooked toffee reduced to about

Table 3. Organoleptic evaluation of prickly pear peel liquid sweetener (PPPLS) and compared with cane molasses

Samples	Color 20	Taste 30	Consistency 20	Acceptability 30	Total 100
Molasses	18.35 A	28.15 A	18.35 A	28.15 A	93.00 A
PPPLS	18.85 A	27.20 A	19.00 A	28.50 A	93.55 A

The effect of sesame paste (tehena) addition on sensory properties

Samples	Color 20	Taste 30	Consistency 20	Acceptability 30	Total 100
Molasses	18.50 A	27.70 B	17.95 B	28.35 A	92.50 B
PPPLS	18.70 A	28.75 A	18.70 A	28.40 A	94.55 A

A,B there is no significant difference between any two means, within the same attribute, have the same letter

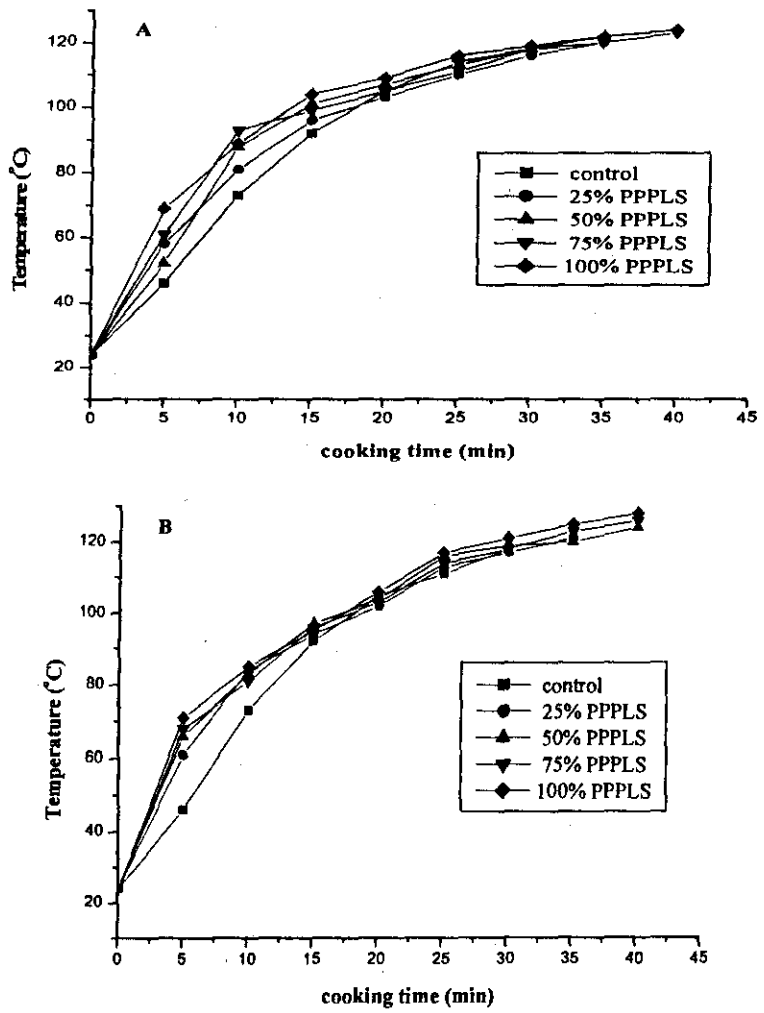

Fig.1. Heating curve recorded during cooking of toffee contained different concentrations of PPPLS as a glucose syrup (A) or sucrose (B) substitutes

10 ±0.5%. It was 30 min at which the cooking temperature reached 118 °C for the control toffee sample. The cooking time (32-41 min) and temperatures (120 -128 °C) were increased by increasing the addition percentage of PPPLS. Moreover, the sucrose substituted samples had the highest cooking time followed by the glucose syrup substituted samples comparing to the control sample. This may be due to the high moisture content of PPPLS-supplemented toffee samples.

Effect of cooking temperature on moisture content and hardness of toffee samples

Effect of cooking temperature on moisture content and hardness of toffee samples processed by glucose syrup and sucrose substitutes were also studied. Hardness value of control sample increased from 343 to 605 N when the cooking temperature was increased from 114 to 118 °C. Same behavior was noticed by PPPLS-supplemented samples. **Table (4)** shows the moisture content and hardness of PPPLS-supplemented toffee at the final cooking time. Although the final cooking temperature of PPPLS supplemented toffee were higher than those of the control samples, slight reduction in hardness of PPPLS-supplemented toffee was recorded comparing to that of control **(Table 4)**. Variations in toffee moisture and hardness have been attributed to variations in substitute ingredient used in toffee formulas. These results are in agreement with those reported by **Tonucci and Von-Elbe (1988).**

Effect of processing on sugars composition of toffee samples

Changes that occur in sugars composition of toffee with processing were studied. Comparison between the different toffee samples in their sugar contents was found in **Table (5).** The results showed that the sucrose and glucose contents in the control sample were 36.18 % and 39.04 %, respectively, while fructose was absent. However fructose was found in toffee processed with glucose syrup and sucrose substitutes. On the other hand, toffee processed with glucose syrup substitution of PPPLS were low in glucose content versus fructose content that in creased by increasing substitution. While, toffee processed by substituting sucrose with PPPLS had lower sucrose content, also, by increasing substituting percent glucose content was higher than fructose content. The reducing sugars were gradually increased with the increasing sucrose substitution of PPPLS to reach its maximum 94.61% of the total sugars, adversely, non reducing sugars that reached its minimum 5.39 % of the total sugars. The formentioned results showed variation in sucrose, glucose and fructose contents, this may be due to the different concentration and composition of the used substitute ingredients in toffee formulation and that contain a mixture of sucrose and inverted sugar (glucose and fructose).

Chemical evaluation of toffee processed by sugar substitutes with different levels of PPPLS after processing

Chemical analysis of toffee processed by glucose syrup and sucrose substitutes with PPPLS were evaluated after processing (untabulated data). Moisture content of all experimental samples (ranged from 10.34 ± 0.22% to 11.14 ± 0.22%) was slightly higher than control sample (10.23 ± 0.26%). These findings were in agreement with **Joshi *et al* (1989)** those of who mentioned that the final moisture content of soft toffee was ranged from 9 to 10%. On the other hand, no noticeable differences were obtained in fat, protein and ash contents of different samples.

Stability measurement of toffee prepared with different levels of PPPLS as sugar substitutes during storage at room temperature (20 ± 5° C)
Chemical characteristics of fat extracted of toffee

Data in **Table (6)** indicated that the extracted lipids from toffee prepared with different levels of PPPLS as sugar substitutes had acid values ranging between 0.06 to 0.17 without significant difference ($p>0.05$) at zero time. The acid values were gradually increased versus storage period with significant difference. The values reached their maximal ranging between 0.89 to 1.21 after 6 months. These increases were probably due to lipolysis occurred by lipases in ingredients such as condensed whole milk. Such enzymes, which are often very heat-resistant, break down the triglycerides of fat into its constituent fatty acids **(Young, 1983).** The free fatty acids may also produced in advanced state of double bonds oxidation of unsaturated fatty acids esters **(Mounts and List, 1996).**

Table 4. Final cooking temperature (FCT), moisture content and hardness of toffee processed by glucose and sucrose substitutes with PPPLS

	Control sample	Glucose syrup substitution %				Sucrose substitution %			
		25	50	75	100	25	50	75	100
FCT (°C)	118	120	122	122	122	120	124	126	128
Moisture content (%)	10.23	10.81	10.74	11.14	10.84	10.95	11.04	10.34	10.64
Hardness (N)	605	578	582	591	571	579	590	546	574

Table 5. Sugar composition (%) of toffee processed by glucose and sucrose substitutes with PPPLS

Sugars	Control sample	Glucose syrup substitution %				Sucrose substitution %			
		25	50	75	100	25	50	75	100
Sucrose	36.18	35.71	37.07	36.13	38.24	28.83	20.13	11.01	4.13
Glucose	39.04	38.15	31.64	28.83	21.45	44.25	49.81	53.36	56.93
Fructose	-	1.10	4.32	9.60	16.01	0.48	5.93	9.71	15.61
Total	75.22	74.96	73.03	74.56	75.70	73.56	75.87	74.08	76.67
R.S	51.90	52.36	49.24	51.54	49.49	60.81	73.47	85.14	94.61
N.R.S.	48.10	47.64	50.76	48.46	50.52	39.19	26.53	14.86	5.39

R.S.: Reducing Sugars as % of total sugars

N.R.S.: Non Reducing Sugars as % of total sugars

Table 6. Acid value of extracted lipids from toffee processed by glucose syrup and sucrose substitutes with different levels of PPPLS during storage at room temperature (20±5°C)

Storage Period (month)	Control sample	Glucose syrup substitution %				Sucrose substitution %			
		25	50	75	100	25	50	75	100
0	0.13^{Ca}	0.12^{Da}	0.14^{Da}	0.13^{Ba}	0.17^{Ba}	0.14^{Da}	0.13^{Da}	0.15^{Ca}	0.06^{Ca}
1	0.45^{Bca}	0.32^{Cda}	0.50^{Cda}	0.60^{Aba}	0.70^{Aba}	0.51^{Cda}	0.31^{Cda}	0.50^{Bca}	0.50^{Bca}
2	0.65^{ABCa}	0.50^{BCDa}	0.53^{Cda}	0.65^{Aba}	0.72^{Aba}	0.52^{Cda}	0.49^{BCDa}	0.52^{ABCa}	0.65^{Aba}
3	0.69^{ABCa}	0.55^{BCDa}	0.61^{Ca}	0.70^{Aba}	0.80^{Aba}	0.60^{Ca}	0.54^{BCDa}	0.53^{ABCa}	0.70^{Aba}
4	0.70^{ABCa}	0.66^{Bca}	0.70^{Bca}	0.70^{Aba}	0.80^{Aba}	0.69^{Bca}	0.65^{Bca}	0.55^{ABCa}	0.70^{Aba}
5	0.88^{Aba}	0.87^{Aba}	1.05^{Aba}	0.87^{Aa}	0.81^{Aba}	1.04^{Aba}	0.88^{Aba}	0.75^{Aba}	0.73^{Aba}
6	1.20^{Aa}	1.19^{Aa}	1.20^{Aa}	0.89^{Aa}	0.89^{Aa}	1.21^{Aa}	1.19^{Aa}	1.03^{Aa}	1.09^{Aa}

Capital and small letters were used for comparison between means in the vertical and horizontal directions, respectively

Means with the same letter are not significantly different, (p>0.05)

Table (7) showed that the extracted lipids from toffee samples had peroxide values ranging between 0.16 to 0.27 meq/kg at zero time without significant differences. These values were more than that of the fat (0.00 meq/kg) used in preparation, due to the cooking treatment. **Reifsteck and Jeon (2000)** reported that the thermal induced oxidation involves hydrogen radical abstraction on lipids with the addition of molecular oxygen to form the peroxide radical followed by the formation of hydrogen peroxide. On storage at room temperature, the peroxide values of extracted lipids substantially increased reaching their maximal values at the end of storage period in all samples with significant differences in comparison two values at zero time. The peroxide values of extracted lipids from toffee prepared by using 50 % and 25 % PPPLS as glucose syrup and sucrose substitutes were ranging between 6.17 to 7.74 meq/kg at the end of storage. The difference in values between formulas in the same month was minor, that may be due to the difference in moisture content which accelerated oxidation of double bonds.

Table (8) shows the fatty acid pattern of lipids extracted from toffee samples evaluated at zero time and after 6 months. The major fatty acids at the start of storage period were palmitic acid 42.40% followed by oleic acid 36.24%, linoleic acid 7.37% and stearic acid 6.64%. However, minor amounts, about 1% or less were detected for caproic, caprylic, capric, lauric, arachidic, behenic, myristoleic, palmitoleic, lenolenic and gadoleic. The total saturated fatty acids increased gradually from 54.58 % during storage at room temperature reached to their maximal values ranging between 55.31% to 57.62 % after 6 months. These increase was mainly due to the increase of palmitic and stearic acids and the reduction of unsaturated fatty acids, mainly mono-unsaturated ones. On the other side, the total unsaturated fatty acids, mainly mono and di-unsaturated were reduced from 45.42% to 42.38% during storage for 6 months. The decreased in total unsaturated fatty acids could be attributed to partially oxidation of double bonds in oleic and lenoleic acids to form peroxides, hydroperoxides, carbonyl compounds and further oxidative cleavage products **(Reifsteck and Jeon, 2000).**

Table 7. Peroxide value of extracted lipids from toffee processed by glucose syrup and sucrose substitutes with different levels of PPPLS during storage at room temperature (20±5°C)

Storage Period (month)	Control sample	Substitute glucose syrup					Substitute sucrose			
		25%	50%	75%	100%		25%	50%	75%	100%
0	0.18^{Ca}	0.27^{Da}	0.17^{Ca}	0.20^{Ca}	0.18^{Ba}		0.17^{Ca}	0.20^{Da}	0.16^{Ca}	0.18^{Ca}
1	0.46^{Ca}	0.53^{Da}	0.36^{Ca}	0.35^{Ca}	0.36^{Ba}		0.44^{Ca}	0.44^{Cda}	0.37^{Ca}	0.54^{Ca}
2	1.43^{Ca}	1.47^{Da}	1.08^{Ca}	1.15^{Bca}	1.25^{Aba}		1.43^{Ca}	1.58^{Cda}	1.00^{Ca}	1.15^{Bca}
3	5.00^{Ba}	4.57^{Ca}	2.53^{Bca}	2.50^{ABCa}	2.78^{Aba}		5.02^{Ba}	3.58^{BCDa}	2.50^{Bca}	2.27^{ABCa}
4	6.67^{Aba}	5.88^{Bca}	3.15^{ABCc}	3.33^{ABCc}	3.12^{Abc}		6.64^{Aba}	5.38^{ABCab}	3.12^{ABCc}	3.75^{ABCbc}
5	7.50^{Aba}	6.12^{Abab}	5.37^{Abbc}	4.17^{Abc}	4.28^{Abc}		7.49^{Aba}	7.47^{Aba}	5.35^{Abbc}	4.69^{Abc}
6	7.72^{Aa}	7.09^{Aa}	6.17^{Ab}	6.56^{Aab}	6.26^{Ab}		7.74^{Aa}	7.63^{Aa}	6.19^{Ab}	6.35^{Aab}

Capital and small letters were used for comparison between means in the vertical and horizontal directions, respectively
Means with the same letter are not significantly different, (p>0.05)

Table 8. Fatty acid composition of extracted lipids from toffee processed by glucose syrup and sucrose substitutes with different levels of PPPLS at zero time and after storage period for 6 months at room temperature (20±5°C)

Fatty acid	Zero time	Control sample	Substitute glucose syrup				Substitute sucrose			
			25%	50%	75%	100%	25%	50%	75%	100%
C:6	0.56	0.43	0.50	0.46	0.42	0.59	0.62	0.47	0.56	0.48
C:8	0.30	0.26	0.30	0.29	0.24	0.31	0.35	0.29	0.22	0.32
C:10	0.55	0.52	0.59	0.60	0.49	0.61	0.63	0.54	0.58	0.51
C:12	0.87	0.93	1.00	0.98	0.86	1.03	1.00	0.92	1.19	1.08
C:14	2.92	2.98	3.14	3.15	2.81	3.32	3.21	2.96	3.26	3.03
C:16	42.40	42.16	43.30	42.01	41.82	42.10	42.04	42.26	42.74	43.21
C:18	6.64	7.70	7.54	8.10	10.26	8.00	8.69	7.84	8.82	7.33
C:20	0.23	0.24	0.05	0.01	0.18	0.01	0.00	0.00	0.16	0.13
C:22	0.10	0.11	0.11	0.12	0.10	0.14	0.12	0.10	0.09	0.13
SFA[1]	54.58	55.31	56.52	55.70	57.18	56.10	56.65	55.39	57.62	56.22
C14:1	0.59	0.49	0.53	0.54	0.45	0.55	0.52	0.46	0.57	0.56
C16:1	0.75	0.48	0.33	0.61	0.26	0.62	0.49	0.43	0.68	0.30
C18:1	36.24	35.21	34.85	34.92	34.76	34.24	34.46	34.63	33.85	35.35
C18:2	7.37	8.01	7.28	7.73	6.89	7.99	7.36	8.60	6.86	7.08
C18:3	0.32	0.34	0.33	0.33	0.32	0.33	0.34	0.33	0.31	0.33
C20:1	0.14	0.16	0.16	0.16	0.14	0.17	0.17	0.14	0.11	0.16
USFA[2]	45.42	44.68	43.48	44.30	42.82	43.90	43.35	44.61	42.38	43.78

[1] SFA=Saturated fatty acids

[2] USFA=Unsaturated fatty acids

Sensory evaluation of toffee

Sensory evaluation of toffee prepared with different levels of PPPLS was calculated to select the best levels of PPPLS which improved or closed the color, flavor, texture, mouthfeel and overall acceptability of toffee prepared with glucose syrup and sucrose substitutes by PPPLS during storage periods and the results are given in **Table (9)**. No significant difference ($p>0.05$) were observed in flavor, color, texture and overall acceptability of toffee as a result of addition level different of PPPLS and control sample after processing in zero time. While, toffee prepared by 75 and 100 % substitutes glucose syrup and sucrose with PPPLS showed lower score and significant difference of mouthfeel compared with control sample after processing in zero time. The results show significant changes in all properties during storage at room temperature. It could be noticed that all properties of all samples till 90 days were similer without any significant differences in their mean score values. Also, during storage period all samples obtained higher values than 5 till 120 days and decreased significantly ($p>0.05$) at the end of storage. On the other hand, samples of toffee containing 75 and 100 % PPPLS as substitute sucrose showed faster slight changes in the texture and mouthfeel attributes. This could be explained by those mentioned previously by **Joshi *et al* (1989)**. They stated that sugar are the main constituent of toffee and the undesirable texture was probably due to the sucrose quality which would crystallized in finished product and the resulting product will become "short or sticky".

Table 9. Mean values of sensory evaluation of toffee processed by glucose syrup and sucrose substitutes with different levels of PPPLS during storage at room temperature (20±5°C)

Storage Period (month)	Control sample	Substitute glucose syrup				Control sample	Substitute sucrose			
		25%	50%	75%	100%		25%	50%	75%	100%
					Flavor					
0	8.20Aa	8.50Aa	8.50Aa	8.30Aa	8.20Aa	7.90Aa	8.50Aa	8.30Aa	8.60Aa	8.40Aa
1	8.20Aa	8.10Aba	8.00Aa	8.50Aa	8.10Aba	8.30Aa	8.00Aa	8.10Aa	8.20Aa	8.30Aa
2	7.90Aa	7.90Bca	7.70Ba	8.10Aa	8.00Aba	8.10Aa	8.40Aa	8.30Aa	8.50Aa	8.50Aa
3	7.60Aa	7.70Bca	7.60Ba	7.90Aba	7.80Aba	7.80Aa	8.00Aa	8.10Aa	8.00Aa	8.00Aa
4	7.00Ba	7.40Bca	7.10Ca	7.30Ba	7.30Ba	6.90Ba	6.80Ba	6.90Ba	7.00Ba	6.70Ba
5	5.40Ca	5.20Ca	5.50Da	5.20Ca	5.60Ca	5.80Ca	5.70Ca	5.70Ca	5.50Ca	5.40Ca
6	5.20Ca	5.10Ca	5.30Da	5.10Ca	5.30Ca	5.50Ca	5.30Ca	5.60Ca	5.30Ca	5.00Ca
					Color					
0	8.80Aa	9.00Aa	8.70Aa	8.60Aa	8.80Aa	8.30Aa	8.40Aa	8.40Aa	8.20Aa	8.20Aa
1	8.30Aa	8.30Ba	8.50Aa	8.30Aa	8.50Aba	7.90Ba	8.30Aa	8.30Aa	8.00Aa	7.90Aa
2	8.10Aa	8.80Aba	8.70Aa	8.70Aa	8.80Aa	8.60Aa	8.30Aa	8.10Aa	8.30Aa	8.40Aa
3	8.10Aa	8.20Bca	8.00Aa	8.20Aa	8.30Aba	8.20Aa	7.90Aa	7.70Aa	7.90Aa	7.90Aa
4	7.80Ba	8.00Ca	7.80Ba	8.00Aa	7.90Ba	8.20Aa	8.30Aa	8.10Aa	7.80Aa	7.80Aa
5	6.80Ca	6.70Da	6.80Ca	6.70Ba	6.70Ca	6.50Ca	6.80Ba	6.60Ba	6.60Ba	6.40Ba
6	6.70Ca	6.50Da	6.50Da	6.40Ba	6.40Ca	6.20Ca	6.50Ba	6.30Ba	6.20Ba	6.10Ba
					Texture					
0	7.80Aa	7.60Aa	7.50Aa	7.40Aa	7.50Aa	8.00Aa	7.90Aba	7.70Aa	7.40Aa	7.40Aa
1	7.80Aa	7.50Aa	7.70Aa	7.70Aa	7.20Aa	8.50Aa	8.50Aa	8.20Ab	8.00Ab	7.70Ab
2	7.70Aa	7.60Aab	7.50Ac	7.60Aab	7.10Ac	7.60Bab	7.90Abb	8.20Aa	7.70Ab	7.30Ab
3	7.40Ac	8.10Aa	7.80Ab	7.40Abc	6.90Ac	7.50Ba	7.70Ba	7.90Aa	7.50Aa	7.20Aa
4	6.90Ba	6.80Bab	6.70Bbc	6.20Bbc	6.00Bc	6.30Ca	6.10Ca	6.00Ba	6.20Ba	6.00Ba
5	5.90Ca	5.60Ca	5.70Ca	5.40Ca	5.30Ba	5.60Ca	5.20Da	5.20Ca	5.20Ca	5.10Ca
6	5.80Ca	5.30Da	5.70Ca	5.30Ca	5.30Ba	5.30Da	5.00Da	5.00Ca	4.80Ca	4.80Ca
					Mouthfeel					
0	8.10Aa	7.80Bab	8.10Aa	7.20Abc	7.00Ac	7.90Aa	7.70Babc	7.80Ab	7.20Ac	7.10Ac
1	8.50Aa	8.60Aa	8.30Aa	7.60Ab	7.10Ab	8.50Aa	8.40Aa	8.20Aa	7.40Ab	7.00Ab
2	7.50Bab	7.80Ba	7.90Aa	7.40Aab	7.10Ab	7.60Ba	7.90Aa	8.00Aa	7.50Ab	7.20Ab
3	7.40Ba	7.60Ba	7.60Ba	7.30Aab	6.90Ab	7.50Ba	7.70Ba	7.70Aa	7.50Ab	7.00Ab
4	6.80Ca	6.40Cab	6.30Cab	6.60Bab	6.10Bb	6.70Ca	6.50Ca	6.30Bb	6.30Bab	5.90Bb
5	5.60Da	5.20Da	5.40Da	5.40Ca	5.10Ca	5.60Da	5.40Dab	5.40Cb	5.20Cab	5.10Cb
6	5.40Da	5.00Da	5.20Da	5.10Ca	5.10Ca	5.30Da	5.10Da	5.20Ca	4.90Ca	4.80Ca
					Acceptability					
0	8.70Aa	8.70Aba	8.70Aa	8.70Aa	8.80Aa	8.20Aa	8.30Aa	8.10Aa	8.00Aa	7.90Aa
1	9.00Aa	8.80Aba	8.90Aa	8.90Aa	8.80Aa	9.00Aa	8.80Aa	8.70Ab	8.00Ac	7.80Ac
2	9.40Aa	8.90Aa	8.90Aa	9.10Aa	9.00Aa	8.00Ba	8.20Aa	8.60Aa	8.10Aa	7.80Aa
3	8.80Aa	8.70Aba	8.60Aa	8.70Aa	8.60Aa	7.70Ca	8.00Aa	8.20Aa	7.80Aa	7.60Aa
4	8.00Ba	8.10Ba	7.90Ba	7.60Ba	7.30Ba	6.90Ca	7.10Ba	6.90Ba	6.90Ba	6.90Ba
5	5.80Ca	5.80Ca	6.00Ca	5.60Ca	5.50Ca	6.00Da	6.00Ca	6.10Ca	5.70Ca	5.90Ca
6	5.60Ca	5.50Ca	5.80Ca	5.50Ca	5.20Ca	5.80Ea	5.60Ca	5.90Ca	5.50Ca	5.50Ca

Capital and small letters were used for comparison between means in the vertical and horizontal directions, respectively

CONCLUSION

The obtained results showed that PPPLS could be considered as a good sweetener owing to its higher sugar content and nutritional value. The possible utilization of PPPLS as natural sweetener with replacement ratio up to 50% from either glucose syrup or sucrose in manufacturing of confectionery products especially toffee. In addition, using PPPLS led to improve the nutrition value of toffee as PPPLS was considered as a good source of many important elements and vitamins.

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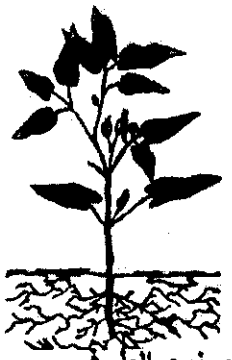

[١٨] استخدام قشور التين الشوكى كمصدر جديد للمحلى الطبيعى فى تصنيع الطوفى

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أجريت هذه الدراسة بهدف إنتاج محلي طبيعى من قشور ثمار التين الشوكى وتقييم جودته ودراسة خواصة الكيميائية والطبيعية والحسية لإمكانية الاستفادة منه فى تصنيع الطوفى كبديل لعسل الجلوكوز والسكروز بمستويات استبدال ٢٥ ، ٥٠ ، ٧٥ ، ١٠٠ % . كما تم التقييم الكيميائي للطوفى المصنع بالاستبدالات المختلفة فى بداية فترة التخزين وكذلك كل من رقم الحامض، رقم البيروكسيد، تركيب الأحماض الدهنية للبيبدات المستخلصة من عينات الطوفى بالإضافة إلى التقييم الحسى أثناء التخزين لمدة ستة شهور علي درجة حرارة الغرفة. أظهرت النتائج أن قشور ثمار التين الشوكى تتميز بارتفاع محتواها من السكريات الكلية التى تصل ١١,٤٣% ، كما أوضحت النتائج أن محلى قشور ثمار التين الشوكى يرتفع محتواه من السكريات المختزلة (٨٦,٠٦ %) بالمقارنة بالسكريات الغير مختزلة (٦,٠٤ %). بينت النتائج ان المحلى يعتبر مصدر جيد للعديد من العناصر الهامة مثل البوتاسيوم، الكالسيوم، الماغنسيوم، الصوديوم والحديد. كما تضمنت الدراسة تقدير محتوى المحلى من الفيتامينات حيث أتضح احتواء المحلى على فيتامين C بصورة سائدة يليه فيتامين B1 (٢,٧٤، ٠,٤٧١ مجم/١٠٠ جم علي التوالي)، إضافة إلى القبول الحسى للمحلي علي الصورة المنفردة مثل عسل قصب السكر وإمكانية الاستفادة منه في تصنيع الطوفي، كما درست العلاقة بين الوقت ودرجة الحرارة أثناء عملية الطبخ للطوفى المصنع بالاستبدالات المختلفة ولم يلاحظ اختلاف في سلوك المنحنيات الحرارية مقارنة بطوفي المقارنة. وتم دراسة تأثير حرارة الطبخ علي المحتوي الرطوبي والصلابة للعينات المختبرة ولوحظ أن درجة الصلابة زادت من ٣٤٣ الي ٦٠٥ نيوتن عندما زادت حرارة الطبخ من ١١٤ إلى ١١٨ درجة مئوية للعينة الكنترول، كما لوحظ نفس السلوك لعينات الطوفي المختبرة حيث زادت درجة الصلابة بزيادة حرارة الطبخ . وبدراسة التغير في تركيب السكريات وجد أن السكريات المختزلة وصلت أقصى تركيز (٩٤,٦١%) علي عكس السكريات الغيرمختزلة التي وصلت اقل تركيز (٥,٣٩ %) عند استبدال ١٠٠ % سكروز بالمحلي الطبيعي. لم تظهر عينات الطوفى المصنعة بالاستبدالات المختلفة اختلاف في التركيب الكيميائي، إضافة إلى ذلك فان النتائج المتحصل عليها عند تقدير رقم الحامض، رقم البيروكسيد للبيبدات المستخلصة من عينات الطوفي باستخدام الاستبدالات المختلفة أظهرت حساسية للتخزين حيث زادت التقديرات معلويا أثناء فترة التخزين. كما زادت الأحماض الدهنية الكلية المشبعة عكسيا مع الأحماض الدهنية الكلية الغير مشبعة أثناء فترة التخزين . فيما يتعلق بالتقييم الحسى لعينات الطوفى المصنعة بالاستبدالات المختلفة فقد أظهرت قبول معنوى بعد التصنيع وأثناء التخزين مقارنة بالعينة الكنترول بالإضافة إلى التحسن المعنوى فى اللون و النكهة لعينات الطوفي المستبدلة مقارنة بطوفي المقارنة .

ولهذا فإن استخدام المحلي الطبيعي المنـتج مـن قشور التين الشوكي يمكن ان يكـون بـديلا لعـسل الجلوكوز والسكروز في تـصنيع الطـوفي بنـسب استبدال اعلي من ٥٠ % فـضلا عـن أن اسـتخدام المحلي يحسن من القيمة الغذائية للطـوفى المـصنع لأنه يعتبر مصدر جيد للعديد من العناصر المعدنية و الفيتامينات ، ويعتبر ايضا إنتـاج المحلـي طريقـة تصنيعية للاستفادة من مخلف قشور التين الشوكي.

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