Omega-3 Rich Jelly Candy Fortified with *Portulaca oleracea* Seeds Oil: Physicochemical Properties, Fatty Acids Composition and Acceptability

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Abstract: *Portulaca oleracea* seeds oil is considered a good source of essential omega-3 (ω-3) and omega-6 (ω-6) fatty acids. In the present study, physicochemical properties, fatty acid composition and sensorial acceptability of jelly candy prepared with sucrose or sucralose and fortified by 1% purslane oil in microencapsulation form were estimated. Four treatments were prepared and stored at 4±1 °C for 90 days. The obtained results revealed that adding microencapsulated purslane oil caused slight changes in moisture content and TSS of the resultant jelly candy while significantly decreased the pH value (from 3.17 to 2.31 for jelly prepared with 100% sucrose + 1% purslane oil and from 3.58 to 2.42 for jelly prepared with 100% sucralose + 1% purslane oil) during storage period. The physicochemical properties were changed significantly during storage. In addition, a significant increase in the peroxide value during storage period was noticed (from 0.64 to 0.98 meqO_2/ Kg for jelly prepared with 100% sucrose or 100% sucralose + 1% purslane oil). Adding purslane oil enhanced the fatty acid composition with a sum of polyunsaturated fatty acids more than 70%. The main fatty acids in the fortified samples were linoleic (41.93 and 41.95%), linolenic (32.91 and 33.00%) and oleic (19.97 and 19.90%) acids for sucrose and sucralose jelly candies, respectively, with slight changes during storage period. The sensorial analysis showed that the scores of the overall acceptance significantly decreased in sucralose jelly candy fortified with purslane oil, while there were no significant differences in the acceptability of the other samples. Therefore, by using purslane seeds oil, it is possible to produce jelly candy with high nutritional value along with health benefits.

***Keywords*:** Fatty acid composition; physicochemical properties; acceptability; purslane; jelly candy

INTRODUCTION

Essential fatty acids (EFAs) are important strategic factors that are currently being actively considered for fortification of foods by several food and drink companies to impart known health benefits and value addition, to their food products. Increasing consumer awareness of health benefits of the essential fatty acids, particularly ω-3, is generating a wealth of opportunities for their use in functional foods. Recently, a plethora of ω-3-fortified food products have entered the market, including cereals, cereal bars, and infant formula, in addition to meat, eggs, and dairy products (Panse and Phalke, 2016).

Foods fortified with omega-3 polyunsaturated fats (ω-3 PUFA) can be classified as functional foods by enhancing human health. It has been established that ω-3 PUFAs can serve as therapeutic agents and help in maintaining human health as well as their role in the treatment of inflammatory diseases, such as cardiovascular, neurodegenerative diseases has been discussed (Czyż *et al*., 2016).

As consumers continue to demand more nutritious products, food manufacturers are seeking many more opportunities to include ω-3 in their formulations. However, ω-3s are extremely sensitive to heat, light, and oxygen and go rancid very quickly due to oxidation, resulting in repelling flavor, and reduction in shelf life of the product. This is also likely to cause health damage due to increase free radical formation in the body (Vellido-Perez *et al*., 2021). To overcome this problem, antioxidants such as vitamin E and metal chelator (EDTA) are added (Kolanowski *et al*., 1999), is recommended. Omega-3 fatty acid oxidation can also be controlled by adjusting the pH of emulsions or creating low-viscosity emulsions for easier handling and incorporation into water-based foods (Panse and Phalke, 2016).

Frozen foods, soups, refrigerated foods, vinaigrettes, yogurt, spreads, juices, egg products and cheeses are some of the best omega-3 enrichment products. Products enriched with omega-3 must not be packaged in transparent packaging, as the light may oxidize them. Another technique used to protect oils is microencapsulation, which can guard against damage incurred during processing, and serve to render fish oil products tasteless and odorless (Kolanowski and Laufenberg, 2006). In liquid applications, essential fatty acids (EFA) should often be mixed with emulsifiers to avoid separation. As far as the practicalities of food fortification are concerned, each manufacturer must consider its target consumers as well as the particular health issue, it wishes to address, before deciding the type of omega-3s best suited for its products (Singh *et al*., 2020).

Purslane (*Portulac oleracea*) is a rich source of ω-3 and ω-6 fatty acids. Purslane has been described as a power food due its high nutritive and antioxidant properties and activities, mainly acting as a free radical scavenger, metal quencher and lipid peroxidation inhibitor, thanks to its phenolic constituents and several fatty acids (Petropoulos *et al*., 2020). Purslane is abundant in ω-3 fatty acids, particularly in α-linolenic acid (0.83 mg g^{-1}), for which it is considered one of the richest plant sources. In addition to α-linolenic acid, which represents nearly up to 30% of purslane oil, other essential fatty acids have also been found in plant tissues, such as palmitoleic, palmitic, linoleic, oleic and stearic acids, as well as trace amounts of $C_{20:5}$ ω-3 and

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$C_{22:6}$ ω-3, namely eicosapentaenoic acid and docosahexaenoic acid, respectively. In addition, purslane is rich in β-carotene and had been reported as a healthy food for patients with cardiovascular diseases (Petropoulos *et al*., 2020; 2021; Melilli *et al*., 2020; Desta *et al*., 2020). It is used in traditional medicine to prevent or to treat various diseases such as hypoglycemic, hypocholesterolemic and cancer. Recently, it has been demonstrated that purslane is also a good source of essential amino acids, alkaloids, coumarines, flavonoids, polysaccharide, α-tocopherols, ascorbic acid, organic acids and glutathione phenols (Aberoumand, 2011; Youssef and Mokhtar, 2014; Sallam and Anwar, 2015).

However, studies on utilization of purslane seeds oil and its uses in food applications are very little. Therefore, this study aims to investigate the possibility of using purslane seed oil in production of jelly candy and its effect on some quality parameter and sensory characteristics of the resultant jelly as well as the fatty acids profile.

MATERIALS AND METHODS

Materials

Purslane seeds (*Portulaca oleracea*), and other major ingredients needed to prepare jelly candy such as gelatin, sucrose, glucose syrup, citric acid (food grade), and coloring and flavoring agents were purchased from local markets at Ismailia Governorate, Egypt.

Chemicals and reagents

All chemicals and reagents used for the analysis were of analytical grade. Maltodextrin, Arabic gum, methylcellulose, sucralose and butylated hydroxy anisole (BHA) were purchased from Sigma-Aldrich (St. Louis, MO, USA).

Methods

Extraction of purslane seeds oil

Extraction of purslane seed oil was carried out using a hydraulic cold pressing machine (Kern Kraft, Germany) at room temperature with pressure (10 MPa) for 10 min according to the method of Uquiche *et al*. (2008). The extracted oil was filtered, then centrifuged at 3500 rpm for 20 min in order to separate the components that were settled. The resultant oil was stored in dark bottles in refrigerator (at 4±1°C) till used.

Microencapsulation of purslane seeds oil

Microencapsulated purslane seed oil was prepared according to the modified method described by Tirgar *et al*. (2015). The emulsion was prepared by using purslane oil, maltodextrin, Arabic gum and methyl cellulose. Aqueous phase was prepared by dispersion of maltodextrin, methylcellulose in distilled water. Arabic gum was added to distilled water (60ºC) and stirred for 3 min to help the hydration. Prepared mixture was set over night at 10-12ºC to ensure that full hydration was attained. Coarse emulsion was made by adding the core material (purslane oil, 9% w/w) along with butylated hydroxy anisole (BHA, 0.02% w/w) gradually into the aqueous phase containing the coating material while mixing. Fine emulsification was achieved using a warring blender (Matsushita, ELEC, IND, CO, LTD, Japan). The slurry was homogenized with ultra Turrax homogenizer at 10,000 rpm for 5 min at 4-6ºC.

The prepared emulsion was frozen at -18ºC then freeze-dried in freeze dryer (Alpha 1-4 LSCplus – Martin Christ, Germany) at -50ºC, 0.1 mbar pressure for 36 hours. The resultant microencapsulated purslane seeds oil was stored at freezing conditions (-18 ºC) till used.

Jelly purslane candy formula and processing

The jelly formula was as follows: 9% gelatin, 23.5% water, 33% sucrose, 31.5% glucose syrup and 3% citric acid. Also, 0.2 mg/Kg of red, yellow, green and orange colorings and 0.5 mg/Kg of pineapple, strawberry, green apple and mango flavorings were added separately in all treatments (Jiamjariyatam, 2018).

The gelatin was dissolved in water (a water ratio of 1:2 w/w) to obtain a homogeneous mix and subsequently added to the sugar syrup). All the ingredients were mixed in 12 cm diameter pot stirred on an electrical hot plate at 110ºC for 5 min. The flavoring and coloring agents were added to the mixture and then poured into 15 × 10 cm plastic molds. The molds were placed in a chamber at 7ºC for 18 h. The samples were removed from their molds and cut into 1×1×1 cm^3 and the surface was sprinkled with corn starch. The resultant samples were stored at 4±1°C for 90 days.

Four treatments of jelly candy, about 200 g each, were prepared:

J_1: Treatment 1 (Control, 33% sucrose sugar),

J_2: Treatment 2 (33% sucrose sugar and microencapsulated purslane seeds oil, adjusted to contain 1% purslane seed oil),

J_3: Treatment 3 (0.006 g sucralose, equivalent 33 g sucrose)

J_4: Treatment 4 (0.006 g sucralose and microencapsulated purslane seeds oil, adjusted to contain 1% purslane seed oil)

Determination of physicochemical properties of purslane oil

Specific gravity, refractive index, acid (mg KOH/g oil), saponification, iodine and peroxide values (meq O_2/kg oil) were performed based on the official methods of AOAC (2019).

Physicochemical properties of jelly candy

The moisture content, total soluble solids (TSS, expressed as ºBrix) and pH value of jelly candy samples were determined according to methods of AOAC (2019).

Oxidative stability of processed jelly candy

The oxidative stability of the resulting jelly candy during storage at 4±1°C for 90 days was studied by determination of peroxide value. The analysis of peroxide value for a known weight of samples was

accomplished based on the official method (AOAC, 2019).

Extraction and analysis of fatty acids

The extraction of oil from jelly candy samples was carried out according to the method of Breil *et al*. (2017). A 100 g of fortified samples was homogenized in a warring Blender for 2 minutes with a mixture of 100 ml chloroform and 200 ml methanol. The solution was re-homogenized with 100 ml chloroform, following 100 ml of distilled water was added. After filtration under suction, the final biphasic system was allowed to separate into two layers and the lower (chloroform) phase was collected. For quantitative lipid extraction, the sample residue was then re-homogenized with 100 ml chloroform, filtered, and the filtrate was added to the collected lower phase. The collected extract was then evaporated to dryness under nitrogen.

Fatty acids methyl ester (FAME) synthesis was performed according to the method of O'fallon *et al*. (2007). Oils (40 µl) were placed into a 16 × 125 mm screw-cap Pyrex culture tube to which 1.0 ml of the $C_{13:0}$ internal standard (0.5 mg of $C_{13:0}$/ml of Methanol (MeOH; HPLC grade), 0.7 ml of 10 *N* KOH in water, and 5.3 ml of MeOH were added. The tubes were incubated in a 55 ºC water bath for 1.5 h with vigorous hand-shaking for 5 s every 20 min to properly permeate, dissolve, and hydrolyze the sample. After cooling the tubes below ambient temperature, 0.58 ml of 24 *N* H_2SO_4 in water was added. The tubes were mixed by inversion and the precipitate was incubated again in a water bath at 55ºC for 1.5 h with hand-shaking for 5 s every 20 min. After FAME synthesis, the tubes were cooled in a cold tap water bath. Hexane (3 ml) was added, and the tubes were vortex-mixed for 5 min on a multi tube vortex. The tube was centrifuged for 5 min in a tabletop centrifuge, and the hexane layer, containing the FAME, was placed into a GC vial. The vial was capped and placed at -20ºC until GC analysis.

The fatty acid composition of the FAME was determined by capillary GC on a SP-2560, 100 m × 0.25 mm × 0.20 µm capillary column (Supelco) installed on a Hewlett Packard 5890 gas chromatograph equipped with a Hewlett Packard 3396 Series II integrator and 7673 controllers, a flame ionization detector, and split injection (Agilent Technologies Inc., Santa Clara, CA). The initial oven temperature was 140ºC, held for 5 min, subsequently increased to 240ºC at a rate of 4ºC min^{-1}, and then held for 20 min. Helium was used as the carrier gas at a flow rate of 0.5 ml. min^{-1}, and the column head pressure was 280 kPa. Both the injector and the detector were set at 260ºC. The split ratio was 30:1. Fatty acids were identified by comparing their retention times with the fatty acid methyl standards.

Sensory evaluation of jelly candy

The (5) points hedonic scale (1“disliked extremely” 5“liked extremely”) was used to evaluate the following attributes: appearance, texture, flavor, color and overall acceptability of jelly candy samples by 12 semi trained panelists (Jiamjariyatam, 2018).

Statistical analysis

Analysis of data was carried out using SPSS statistical software version 21 (SPSS Inc., Chicago, IL). In order to identify any significant differences between the jelly candy sample analysis of variance (ANOVA) followed by the Duncan’s multiple range procedure was used at level of $p \leq 0.05$(Duncan, 1955). All experiments were performed in triplicate, and results were expressed as mean ± standard division (SD).

RESULTS AND DISCUSSIONS

Physicochemical properties and fatty acid composition of purslane oil

Physicochemical properties of purslane oil including refractive index, specific gravity, acid, peroxide, iodine and saponification values and the fatty acid composition are illustrated in Table (1). The obtained results show that the purslane oil had high and acceptable quality characteristics. The main unsaturated fatty acids of purslane oil were oleic 20.23%, linoleic 42.82% and linolenic 33.60% acids. Petropoulos *et al*. (2021) found that purslane seed oil was a rich source of linoleic (34.10%) and linolenic (41.25%) acids with minor content of oleic acid (5.24%). Dubois *et al*. (2007) reported a slightly lower content of α-linolenic acid (32.4%) than linoleic acid (34.1%). The differences in fatty acid composition may be attributed to extraction methods, tested genotypes and environmental conditions (Petropoulos *et al*., 2018 and 2020).

Table (1): Physicochemical properties and fatty acid composition of purslane seed oil

	Purslane oil
Physicochemical properties	
Refractive index	1.481±0.001
Specific gravity	0.935±0.015
Acid value (mg KOH/g oil)	1.83±0.02
Peroxide value (meq O_2/ kg oil)	0.353±0.008
Iodine value (g I_2/ 100 g oil)	138.53±0.97
Saponification value (mg KOH/ g oil)	188.40±1.21
Fatty acids (%)	
$C_{16:0}$	3.34±0.02
$C_{18:1}$	20.23±0.03
$C_{18:2}$	42.82±0.10
$C_{18:3}$	33.60±0.09
$C_{22:0}$	0.37±0.01
Saturated fatty acids (SFAs)	3.71
Unsaturated fatty acids (UFAs)	96.65
Polyunsaturated fatty acids (PUFAs)	76.42
Monounsaturated fatty acids (MUFAs)	20.23
PUFAs/SFAs	20.59
Omega-6/omega-3	1.27

Data represented as mean ± SD (n=3)

Physicochemical properties of the resultant jelly candy

Physicochemical properties such as moisture content, total soluble solids (TSS) and pH value for jelly purslane candy are shown in Table (2). The moisture content for jelly candy samples of treatments J_1, J_2, J_3 and J_4 significantly decreased from 20.31, 20.50, 20.80 and 20.12% at zero time to 11.58, 11.12, 12.53 and 11.30% by the end of the storage period (90 days), respectively. These results are in agreed with those reported by Achumi *et al*. (2018).

The TSS is primarily represented by sugars, with acids and minerals contributing. According to the Codex Alimentarius standard (Codex Alimentarius, 2009), normal fruit conserves or preserves must contain 60% soluble solids. The TSS changes were significant ($p \leq 0.05$) by storage time. The average of TSS content for J_1, J_2, J_3 and J_4 significantly increased from 78.67, 78.17, 78.23 and 78.78 ˚Brix at zero time to 87.40, 87.50, 86.20 and 87.77 by the end of storage period, respectively. The increase in TSS could be attributed to the decrease in moisture content of the investigated samples. Similar total soluble solids contents (77 to 79 ˚Brix) for four different fruit (strawberry, raspberry, orange, and peach) jellies were obtained by Delgado and Bañón (2015).

Table (2): Physicochemical properties of jelly candy as affected by adding purslane oil during cold storage at 4°C±1 for 90 days

Treatment	Storage period (days)			Mean of Treatment
	0	45	90	
		Moisture content (g/ 100g)		
J_1	20.31 ± 0.02	17.57 ± 0.10	11.58 ± 0.08	**16.49^{a}**
J_2	20.50 ± 0.05	17.39 ± 0.04	11.12 ± 0.08	**16.34^{ab}**
J_3	20.80 ± 0.20	15.87 ± 0.57	12.53 ± 0.46	**16.40^{ab}**
J_4	20.12 ± 0.03	17.08 ± 0.14	11.30 ± 0.50	**16.17^{b}**
Mean of storage period	**20.43^{a}**	**16.98^{b}**	**11.63^{c}**	
		TSS (°Brix)		
J_1	78.67 ± 0.06	81.13 ± 0.06	87.40 ± 0.10	**82.40^{b}**
J_2	78.17 ± 0.06	81.60 ± 0.10	87.50 ± 0.10	**82.42^{b}**
J_3	78.23 ± 0.42	83.13 ± 0.35	86.20 ± 0.72	**82.52^{ab}**
J_4	78.78 ± 0.03	81.80 ± 0.17	87.77 ± 0.06	**82.78^{a}**
Mean of storage period	**78.46^{c}**	**81.92^{b}**	**87.22^{a}**	
		pH value		
J_1	3.03 ± 0.06	2.82 ± 0.03	2.44 ± 0.04	**2.77^{c}**
J_2	3.17 ± 0.02	2.63 ± 0.03	2.31 ± 0.01	**2.70^{d}**
J_3	3.58 ± 0.10	2.69 ± 0.04	2.42 ± 0.10	**2.90^{a}**
J_4	3.12 ± 0.03	2.90 ± 0.02	2.51 ± 0.04	**2.84^{b}**
Mean of storage period	**3.23^{a}**	**2.76^{b}**	**2.42^{c}**	

J_1= control (100% sucrose), J_2= 100% sucrose + 1.0% purslane oil, J_3= 100% sucralose, J_4= 100% sucralose+ 1.0%purslane oil

Values are means ± standard deviation.

Means with different character (a, b, c and d) in the same column or row are significantly different at $p \leq 0.05$.

The pH value is one of several physicochemical parameters, which affect the product quality; to a large extent, the decrease in pH (increases in acidity) protects against the development of microorganisms (Touati *et al*., 2014). During storage, the decrease in pH value was significant ($p \leq 0.05$). The pH values at zero time for J_1, J_2, J_3 and J_4 treatments were 3.03, 3.17, 3.58 and 3.12 which decreased to 2.44, 2.31, 2.42 and 2.51, respectively at the end of storage period (90 days). The same trend has been observed by Jiamjariyatam *et al.* (2018) for gummy jelly and Shigihalli *et al.* (2018) for ivy gourd jelly.

Peroxide value of the resultant jelly candy

Table (3) shows the peroxide values of the resultant jelly candy as affected by adding purslane oil during cold storage at 4 °C±1 for 90 days. For jelly candy samples (J_2 and J_4), there were no significant differences among the treatments ($p > 0.05$). The peroxide value significantly increased from 0.64 after processing to 0.98 after 90 days of storage at 4°C as shown in Table (3). The increase in peroxide value during storage might be attributed to the formation of oxidation products. However, the peroxide value for jelly candy samples was very low indicating that microencapsulation is an effective method to protect the polyunsaturated fatty acids from oxidation during food processing and storage (Lacatusu *et al*., 2013; Bakry *et al*., 2019).

Table (3): Peroxide value (meqO_2/ Kg) of jelly candy as affected by adding purslane oil during cold storage at 4°C±1 for 90 days

Treatment	Storage period (days)			Mean of Treatment
	0	45	90	
	Peroxide value (meqO_2/ Kg)			
J_1	nd	nd	nd	**nd**
J_2	0.64 ± 0.01	0.85 ± 0.01	0.98 ± 0.03	**0.82^a**
J_3	nd	nd	nd	**nd**
J_4	0.64 ± 0.00	0.85 ± 0.01	0.98 ± 0.00	**0.83^a**
Mean of storage period	**0.64^c**	**0.85^b**	**0.98^a**	

J_1= control (100% sucrose), J_2= 100% sucrose + 1.0% purslane oil, J_3= 100% sucralose, J_4= 100% sucralose+ 1.0% purslane oil; nd = not detected;
Values are means ± standard deviation.
Means with different character in the same column or row are significantly different at $p \leq 0.05$.

Fatty acids composition

For jelly candy samples (Table 4), fatty acids were not detected in the control samples (100% sucrose (J_1) or 100% sucralose (J_3)), this may be attributed to the nature of the product which does not contain any source for plant or animal fats. However, five fatty acids were detected in treatments: J_2 (100% sucrose + 1.0% purslane oil) and J_4 (100% sucralose + 1.0% purslane oil); the most predominant ones were palmitic, oleic, linoleic and linolenic acids. The main unsaturated fatty acids at zero time of storage were linoleic (41.93 and 41.95%), linolenic (32.91 and 33.00%) and oleic (19.97 and 19.90%) acids for J_2 and J_4 samples, respectively.

Table (4): Fatty acid composition (%) of jelly candy as affected by adding purslane oil during cold storage at 4°C±1 for 90 days

Fatty acid	Storage period (days)	J_1	J_2	J_3	J_4
$C_{16:0}$	0	nd	3.30	nd	3.25
	45		3.22		3.20
	90		3.20		3.21
$C_{18:1}$	0	nd	19.97	nd	19.90
	45		19.90		19.80
	90		19.70		19.88
$C_{18:2}$	0	nd	41.93	nd	41.95
	45		41.33		40.35
	90		40.80		40.05
$C_{18:3}$	0	nd	32.91	nd	33.00
	45		32.11		32.85
	90		31.80		31.80
$C_{22:0}$	0	nd	0.37	nd	0.37
	45		0.37		0.36
	90		0.37		0.33
Sum saturated fatty acids	0	nd	3.67	nd	3.62
	45		3.59		3.56
	90		3.57		3.54
Sum unsaturated fatty acids	0	nd	94.81	nd	94.85
	45		93.34		93.00
	90		92.30		91.73
Sum monounsaturated fatty acids	0	nd	19.97	nd	19.90
	45		19.90		19.80
	90		19.70		19.88
Sum polyunsaturated fatty acids	0	nd	74.84	nd	74.95
	45		73.44		73.20
	90		72.60		71.85
PUFA/ SFA	0	nd	0.21	nd	0.22
	45		0.22		0.23
	90		0.22		0.22

J_1= control (100% sucrose), J_2= 100% sucrose + 1.0% purslane oil, J_3= 100% sucralose, J_4= 100% sucralose+ 1.0%purslane oil
nd: not determined.

A slight decrease in the polyunsaturated fatty acid contents (including omega-3 fatty acid) was observed for fortified jelly candy samples during the storage period. This might be attributed to the role of microencapsulation in protecting the oils from oxidation (Bakry *et al*., 2019). The total unsaturated fatty acids for jelly candy were 94.81 and 94.85% for J_2 and J_4 samples, respectively. It can be concluded that intrinsic characteristics of this food matrices can improve the quality of jelly candy to bring health benefits for the consumers.

Sensory characteristics of the resultant jelly candy

The jelly purslane candy samples were subjected to organoleptic evaluation by semi-trained judges using a 5-point hedonic scale. The samples were evaluated for flavor, color, texture, appearance and overall acceptability. The organoleptic scores are presented in Table (5), it can be observed that there were no significant differences between all jelly candy samples in their color. However, significant differences in flavor were noticed between all jelly candy samples. There were no significant differences ($p > 0.05$) in texture, appearance and the overall acceptability between J1, J2 and J3 compared with J4 jelly candy sample. J_3 at zero time recorded significantly higher values for flavor, color, texture, appearance, and overall acceptability when compared to other treatments, while at the end of the storage period the values of all sensory attributes were slightly decreased through all the investigated samples. It can be concluded that addition of purslane seed oil did not cause any negative impact on the sensory attributes of the resultant jelly candy.

Table (5): Sensory characteristics of jelly candy as affected by adding purslane oil during cold storage at 4°C±1 for 90 days

Treatment	Storage period (days)			Mean of Treatment
	0	45	90	
Flavor				
J_1	4.60 ± 0.52	4.50 ± 0.53	3.10 ± 0.74	**4.07^{b}**
J_2	4.10 ± 0.74	4.40 ± 0.52	3.80 ± 0.63	**4.10^{b}**
J_3	4.70 ± 0.48	4.50 ± 0.53	4.10 ± 0.74	**4.43^{a}**
J_4	3.40 ± 0.52	2.50 ± 0.53	1.30 ± 0.48	**2.40^{c}**
Mean of storage period	**4.20^{a}**	**3.98^{a}**	**3.08^{b}**	
Color				
J_1	4.40 ± 0.52	4.20 ± 0.42	3.30 ± 0.67	**3.97^{a}**
J_2	4.70 ± 0.48	4.10 ± 0.74	3.30 ± 0.82	**4.03^{a}**
J_3	4.70 ± 0.48	4.60 ± 0.52	3.20 ± 0.63	**4.17^{a}**
J_4	4.70 ± 0.67	4.50 ± 0.53	2.80 ± 0.92	**4.00^{a}**
Mean of storage period	**4.63^{a}**	**4.35^{a}**	**3.15^{b}**	
Texture				
J_1	4.40 ± 0.52	4.50 ± 0.53	4.50 ± 0.53	**4.47^{ab}**
J_2	4.40 ± 0.52	4.70 ± 0.48	4.50 ± 0.53	**4.53^{a}**
J_3	4.70 ± 0.48	4.40 ± 0.52	4.10 ± 0.32	**4.40^{ab}**
J_4	4.50 ± 0.53	4.00 ± 0.82	4.00 ± 0.82	**4.17^{b}**
Mean of storage period	**4.50^{a}**	**4.40^{a}**	**4.28^{a}**	
Appearance				
J_1	4.40 ± 0.52	4.50 ± 0.53	4.50 ± 0.53	**4.47^{ab}**
J_2	4.40 ± 0.52	4.70 ± 0.48	4.50 ± 0.53	**4.53^{a}**
J_3	4.70 ± 0.48	4.40 ± 0.52	4.10 ± 0.32	**4.40^{ab}**
J_4	4.50 ± 0.53	4.00 ± 0.82	4.00 ± 0.82	**4.17^{b}**
Mean of storage period	**4.50^{a}**	**4.40^{a}**	**4.28^{a}**	
Overall acceptability				
J_1	4.60 ± 0.52	4.00 ± 0.67	3.20 ± 0.42	**3.93^{a}**
J_2	4.40 ± 0.52	3.90 ± 0.74	2.90 ± 0.57	**3.73^{a}**
J_3	4.60 ± 0.52	4.60 ± 0.52	3.00 ± 0.82	**4.07^{a}**
J_4	3.10 ± 0.99	3.00 ± 0.94	1.40 ± 0.52	**2.50^{b}**
Mean of storage period	**4.18^{a}**	**3.88^{b}**	**2.63^{c}**	

J_1= control (100% sucrose), J_2= 100% sucrose + 1.0% purslane oil, J_3= 100% sucralose, J_4= 100% sucralose+ 1.0%purslane oil

Values are means ± standard deviation.

Means with different character (a, b, c and d) in the same column or row are significantly different at $p \leq 0.05$.

CONCLUSION

The nutritional value of jelly candy can be improved by adding purslane seed oil. Purslane represents a promising source of PUFAs and used from long times as a medicinal herb. Purslane seed oil was found to be effective for increasing the polyunsaturated fatty acids content (PUFA) content in fatty acid profile of jelly candy. The addition of purslane seed oil did not have a negative effect on the physico-chemical properties and sensory attributes of the resultant jelly during storage at 4±1°C for 90 days.

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حلوي الجيلي الغنية بأحماض الأوميجا-٣ المدعمة بزيت بذور الرجلة: الخصائص الطبيعية الكيميائية ومحتوي الأحماض الدهنية ودرجة القبول

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يعتبر زيت بذور الرجلة مصدر جيد للأحماض الدهنية الأساسية اوميجا-٣ واوميجا-٦. في هذه الدراسة، تم تقدير الخصائص الطبيعية الكيميائية ومحتوي الأحماض الدهنية والقبول الحسي لحلوي الجيلي المعدة باستخدام السكروز أو السكرالوز والمدعمة بزيت الرجلة بنسبة ١٪ والمغلف في شكل كبسولة دقيقة. تم تجهيز أربع معاملات وتخزينها على ٤°م ± ١ لمدة ٩٠ يوما. أوضحت النتائج المتحصل عليها أن إضافة زيت الرجلة المغلف أدي إلي حدوث تغيرات طفيفة في محتوى الرطوبة والمواد الصلبة الذائبة لحلوى الجيلي الناتجة بينما أدى إلى انخفاض معنوي في قيمة الأس الهيدروجيني (من 3.17 إلي 2.31 لحلوي لجيلي المعدة باستخدام ١٠٠٪ سكروز + ١٪ زيت الرجلة ومن 3.58 إلي 2.42 لحلوي الجيلي المعدة باستخدام ١٠٠٪ سكرالوز + ١٪ زيت الرجلة) خلال فترة التخزين. تغيرت الخصائص الطبيعية الكيميائية بشكل معنوي خلال فترة التخزين. بالإضافة إلي حدوث زيادة معنوي في قيمة رقم البيروكسيد أثناء فترة التخزين (من 0.62 إلي 0.98 مليمكافئ بيروكسيد / كجم لحلوي الجيلي المعدة باستخدام ١٠٠٪ سكروز أو ١٠٠٪ سكرالوز + ١٪ زيت الرجلة). كما أدي إضافة زيت الرجلة الي تعزيز محتوي الأحماض الدهنية بنسبة محتوي احماض دهنية عديدة عدم التشبع أكبر من ٧٠٪. كانت الأحماض الدهنية الرئيسية في العينات المدعمة هي اللينوليك (٤١.٩٣ و ٤١.٩٥٪) واللينولينيك (٣٢.٩١ و ٣٣.٠٠٪) والأوليك (١٩.٩٧ و ١٩.٩٠٪) في حلوي الجيلي المدعمة بزيت الرجلة والمعدة من السكروز والسكرالوز على التوالي، مع حدوث تغييرات طفيفة خلال فترة التخزين. أظهر التحليل الحسي أن درجات القبول الكلي انخفضت بشكل معنوي في حلوي الجيلي المعدّة من السكرالوز والمدعمة بزيت الرجلة، بينما لا توجد فروق معنوية في درجة قبول العينات الأخرى. وبالتالي، باستخدام زيت بذور الرجلة، من الممكن إنتاج حلوى جيلي ذات قيمة غذائية عالية إلى جانب الفوائد الصحية.