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Optimization and Quality Attributes of Osmotic Solar Drying of Golden Berry (*Physalis peruviana*)

A. E. El-Beltagy[1], M. A. Naeem[2], A. M. Gaafar[3]

[1]*Food Science Dept., Fac. Of Agric., Minoufiya Univ., Shibin El Kom, Egypt.*
[2]*Clinical Nutrition Unit. Specialized Hospital, Ain Shams University, Cairo, Egypt.*
[3]*Food Technology Research Institute, Agric., Research Center, Cairo, Egypt.*

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Abstract

Cape golden berry (*Physalis peruviana L*) has been grown in Egypt, South Africa, India, Australia and Great Britain. It has been shown golden berry provide significant health benefits because of their high antioxidants, vitamins, minerals and fiber. The plant is fairly adaptable to wide variety of soils and good crops are obtained on poor sandy ground. Fresh golden berry *(Physalis peruviana L)* fruits (whole and halves) were quickly immersed for 1 min at 80 ± 2 °C in different three solutions (distilled water, 0.5% NaOH and 0.5% citric acid). The immersed samples were quickly cooled with tap water to room temperature (25 ± 2 °C). Also, both whole and halves fruits were freezed at -12 ± 2 °C for 24 h, then all the previously treated samples (freezed and boiled) were osmotic dehydration immersed in 70% (w/v) sucrose solution at room temperature for 16hr, drained for 30 min. and spreaded on the drying trays for solar drying.

The chemical composition, antioxidant activity, polyphynolics, flavonoids and Sensory attributes of fresh and dried fruits were evaluated. The fresh golden berry contained 0.29%, 0.18%, 18.47%, 4.56% and 1.05% of protein, fat, total carbohydrates, ash and crude fiber, respectively. It also contained a considerable amount of polyphones (7.35mg/100 g as tannic acid) and flavonoids (4.81mg/100gm. Fresh fruits produce a 45% decrease vs. the absorbance of DPPH radicals' control solution. Dried halves golden berry previously freezed as well as that previously boiled had significantly ($P \leq 0.05$) higher weight reduction than the whole fruits. Also, the pretreatment by boiling with NaOH 0.5% of whole and halve fruits had significantly ($P \leq 0.05$) higher weight reduction than the pretreated by boiling in water and citric acid 0.5%. The water loss of golden berry was closed with weight reduction of fruits. The best ($P \leq 0.05$) colour was observed in golden berry halves treated with NaOH and citric acid while the lowest colour values were detected in both whole and halves freezed golden berry. The dried halves golden berry previously boiled in H_2o had the highest ($P \leq 0.05$) ascorbic acid contents (20.59 mg/100gm) while, the previously freezed whole fruits had the lowest (11.12 mg/100gm). The moisture content of boiled halve dried golden berry were significantly lower than boiled whole. While, no significant differences ($P \leq 0.05$) were observed in dried golden berry among all pretreatments in protein, fat and total carbohydrates contents. Treating the Cape golden berry by 0.5% NaOH increased the ash content in both whole and halves fruits. Dried golden berry halves (Except the freezed halves golden berry) had significantly lower ($P \leq 0.05$) rehydration ratio compared with other dried samples. The same trend was observed with rehydration coefficient. Drying of golden berry as halves decreased ($P \leq 0.05$) the texture compared with the dried whole fruits.

Generally, Boiling of halve fruits in citric acid 0.5% had the highest ($P \leq 0.05$) taste, while no significant differences ($P \geq 0.05$) was observed among the type of pretreatment solution (H2O, NaOH and citric acid) in rehydration ratio and rehydration coefficient, meanwhile the dried golden berry previously boiled in H_2O had the highest ($P \leq 0.05$) Texture (20.00 N) and ascorbic acid (18.33 mg/100gm).

Also, no significant differences ($P \geq 0.05$) were observed in total polyphenolics and total flavonoids contents of dried goose berry previously boiled in citric acid and H_2O.

Keywords: golden berry, solar drying, osmotic dehydration

Corresponding author: *e-mail:* elbeltagy_alaa@yahoo.com

1. Introduction

Golden berry or Cape gooseberry (*Physalis peruviana L.*) is a solanaceous plant native to tropical South America. The berry is enclosed in a papery husk or calyx, with a smooth, orange–yellow skin and juicy pulp containing numerous small yellowish seeds. During ripening the fruit color turns from green to orange and progressive softening occurs [16,17,44]. Cape gooseberries are somewhat tomato-like in flavor and appearance, though the taste (sweet and sour) is much richer with a hint of tropical luxuriance. The plant is fairly adaptable to wide variety of soils and good crops are obtained on poor sandy ground [33,34,35].

Cape golden berry (*P. peruviana Linn., Solanaceae*) has been grown in Egypt, South Africa, India, New Zealand, Australia and Great Britain [24,32,38]. Berries have been shown to provide significant health benefits because of their high antioxidants, vitamins, minerals and fiber [47].

Osmotic dehydration is used as a pretreatment to many processes and improves nutritional, sensorial and functional properties of food without changing its integrity [43]. Osmotic dehydration is generally, used as an upstream step for the dehydration of food before they are subjected to further processing such as freeze drying [18], vacuum drying [11] and air drying [14,22,37].

Osmotic dehydration (OD) is useful as a preprocessing step prior to drying and freezing foods [10,21,31]. As OD is usually done at moderate temperatures, water is removed from the product without any phase change. This provides better retention of volatile flavors and reduces tissue damage compared with conventional air and sun drying processes [36]. Therefore applying different treatment before osmotic dehydration of plant tissue would be important effect in mass transfer controlling.

Pretreatments such as freezing, high-pressure, high intensity electric field pulses have been reported to enhance mass transfers [1,23,42,].

The introduction of solar dryers in developing countries can reduce crop losses and improve the quality of dried product significantly compared with traditional drying method [28-30]. Egypt has a high potential for the production of solar energy, which can be considered as a reliable energy source even during the winter season [27]. Although a lot has been known about osmotic dehydration, further investigations are needed to evaluate individual susceptibility of fruit and vegetables to osmotic dewatering with pretreatment applying to obtain new minimally processed food products by mass transfer controlling [20].

This study was mainly concerned with the development of osmosis-sun drying for golden berry using an indirect forced convection solar dryer and study of some pretreatments affecting the changes in the various chemical and physical constituents of golden berry.

2. Materials and Methods

2.1. Materials. The Ripe Golden berry (*Physalis peruviana*) fruits were obtained from local farm at Toukh, Qalyoubia Governorate, (one of the Delta Governorates located in north of Egypt). Intact fruits were carefully selected according to the degree of ripeness measured by fruit color (brilliant orange). The fresh fruits were analyzed immediately after harvesting.

2.1.1. Chemicals and Reagents: Oxalic acids, sodium hydroxide, hydrochloric acid, tannic and citric acid were purchased from El-Nasr Pharmaceutical Chemicals, El-Ameriea, Cairo, Egypt. Anhydrous glucose, Folin-Ciocalteu, was purchased from Sigma Chemical Co., St. Louis, Missouri, USA.

2.2. Methods

2.2.1. Osmosis treatment. The golden berry was brought to the laboratory within 24 hr of harvesting. The samples were washed and halve quantity of the samples were quickly sliced to a uniform halves then two kinds of pretreatment were applied, first both whole and halves quickly immersed for 1 min at 80 ± 2 °C in different three solutions (distilled water, 0.5% NaOH and 0.5% citric acid). Second, both whole and halves fruits were freezed at -12 ±2 °C for 16 hr.

The immersed samples were quickly cooled with tap water tell room temperature (25 ± 2 °C) then all the previously treated samples immersed in 70% (w/v) sucrose solution at room temperature for 16 hr then drained for 30 min (to remove access solution) and spreaded on the drying trays for solar drying.

2.3. Solar drying. An experimental forced convection solar dryer as schematically depicted in Fig (1) was used in all experiments. The dryer consisted of a solar collector and a drying chamber and made from readily available local materials. The dryer was constructed at the Agricultural Engineering Dept., Minoufiya University, Egypt and installed on the roof of the Agric. Eng. Building and was oriented so that collector faces south. The solar collector was tilted at an angle of 20 degree from the horizontal plane. A corrugated galvanized iron sheet 0.5 mm thickness painted black was used inside the heater as an absorber plate for absorbing the incident solar radiation. The solar collector was covered with one layer of an ordinary glass (3mm thickness). The drying chamber was constructed with insulated wooden walls. The drying trays were made of an iron frame on all four sides with wire mesh (2x2 mm) on the bottom.

A lid was connected on the north side of the drying chamber for loading and unloading the drying material.

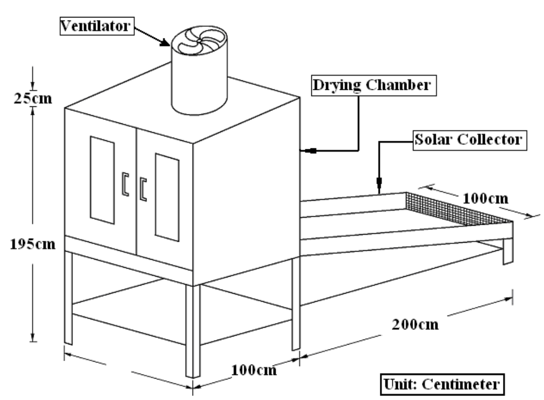

Figure 1. Schematic diagram of solar drying systems (Dim. In cm)

The pretreated fruits were spread evenly (single layer) with a near uniform distribution density on the drying trays. The loaded trays were then placed very quickly in the drying chamber. Drying started at 8.00 a.m. and continued till 6.00 p.m.

Drying data were monitored using labeled samples, which were individually weighed and positioned on the trays.

The weights of the labeled samples were recorded every 2 hr. throughout the drying test. The drying test was terminated when the decrease in the weight of the samples had almost ceased. The final moisture content of the dried samples was determined According to AOAC, (2003) [4].

2.2. Solar drying Measurements.

The temperature (°C) was measured using the thermocouple wires placed in the required measuring points. Temperature reading at a certain time intervals (60 min) was recorded using a data logging system and basic computer program.

Thermos hygrometer (model 37200, OAKTON, USA) was employed to measure the air relative humidity (RH %) outside and inside the drying chamber, and at the outlet point of the drying chamber.

Initial and final weights and weight changes during drying experiments of each sample were measured by a laboratory electric balance having accuracy of 0.001 gm.

2.3. Chemical Analysis.

Moisture was determined on three replicates by desiccation at 105°C for 24 hr. Ash was determined in triplicate by heating the residue of moisture determination at 550°C for 6 hr [4]. Nitrogen content was obtained by applying the Kjeldahl method, and the protein content was calculated using a nitrogen factor of 6.25 according to the method described in AOAC, (2003) [4]. Crude fiber content was determined as described in AOAC, (2003) [4]. Total carbohydrate was determined by the Phenol Sulphoric method [12]. Ascorbic acid was extracted in 2% oxalic acid and determined using 2, 6 dichlorophenolindophenol according to Anonymous, (1966) [2,3].

2.3.1. Rehydration ratio and Coefficient of rehydration. Rehydration ratio was measured as the total mass of rehydrated gooseberry per unit weight of dry mater. Coefficient of rehydration was determined according to [35] using the following equation:

$$CR = \frac{D_{WH} \times [100 - M_{CD}]}{[W_{DR} - M_{DR}] \times 100}$$

Where:

CR = Coefficient of rehydration
DWH = Drained weight of dehydrated sample
MCD = Moisture content of sample before drying
WDR = Weight of dried sample taken for rehydration
MDR = Amount of moisture present in the dried sample taken for rehydration

2.3.2. Weight reduction, water loss and solid gain. The water loss and solute gain during osmotic dehydrationwere calculated by the following equations [15]:

$$Weight\ Reduction\ (\%) = \frac{Wi - Wf}{Wi} X100$$

$$Water\ Loss\ (\%) = \frac{WiXi - WfXf}{Wi} X\ 100$$

$$Solid\ gain\ (\%) = \frac{(Wf\left(1 - \frac{Xf}{100}\right) - Wi\left(1 - \frac{Xi}{100}\right))}{Wi} X100$$

Where W_i is the initial weight of fruit (g), W_f the weight of fruit after osmotic-dehydration for anytime time (g), X_i and X_f are the initial and final (time t) samples moisture content respectively.

2.3.3. Sensory evaluation of rehydrated golden berry. Organoleptic quality of rehydrated golden berry was determined with the help of a 10-member consumer panel, using a 9-point hedonic scale, following standard procedure. The aspects considered for rehydrated golden berry were colour, appearance, taste, flavor, and overall acceptability. The average scores of all the 10 panelists were computed for different characteristics.

2.3.4. Total phenols. Total phenolic compounds were determined with Folin–Ciocalteu reagent using tannic acid as the standard according the method described by Taga et al., (1984) [41]. Absorbance was measured at 750 nm on a spectrophotometer (UNICO 2802 C/PCS Series Spectrophotometer, USA) and compared with tannic acid calibration curve.

2.5. Radical scavenging activity of juices (DPPH test). The radical scavenging activity of different gooseberry juices was tested as bleaching of the stable DPPH radicals according the procedure described by Brand-Williams et al., (1995) [6].

2.6. Total flavonoids. Aluminum chloride colorimetric method was used for determination of total flavonoids [6,8].

2.7. Statistical analysis

The data analysis of this experiment was carried out by using the Statistical Analysis System [39,40]. Measured data were analyses by ANOVA. Least Significance Difference test was used to determine differences between means. Significance was assumed at ($P \leq 0.05$).

3.Results and Discussion

3.1. Chemical characteristics of fresh golden berry fruits

The chemical analyses of fresh golden berry are shown in (Table 1). The pH of fresh golden berry fruits (3.28) was higher than citrus juices (pH 2.3 for lime, USDA-2006, [45]), while it was close to that of pineapple (pH 3.2; Joslyn 1970, [19]). Its total titratable acidity reached to 1.94%. This was higher than that reported for lemon juice 1.15% [19] but lower than that in two varieties of mango fruit juices (2.29% and 4.11%) [46]. The fresh golden berry fruits contained a high amount in total soluble solids (15.2%) it was higher than that reported by Elsheikha et al., (2010) [13] for fresh golden berry juice, while, it was lower than that reported for fresh mango juice 18.2% [46].

The fresh fruits also contained 0.29%, 0.18%, 18.47%, 4.56% and 1.05% of protein, fat, total carbohydrates, ash and crude fiber, respectively. Its high content of total carbohydrates and dietary fiber is of importance, wherein fruit pectin acts as an intestinal regulator [24,32]. It contained a considerable amount of polyphones (7.35mg/100 g) as tannic acid.

Good amounts of phenolic were estimated in Cape golden berry, wherein the level of total phenols was 6.30 mg/100 g juice as caffeic acid equivalents [34]. Meanwhile, the golden berry contained a considerable amount of flavonoids 4.81 mg/100 g.

Table 1. Physical and chemical characteristics of fresh golden berry

Constituents	%
PH	3.28 ± 0.10
Titratable acidity	1.94 ± 0.15
Total soluble solids	15.2 ± 1.32
Moisture	75.45 ± 2.58
Protein	0.29 ± 0.08
Fat	0.18 ± 0.09
Total carbohydrates	18.47 ± 1.36
Fiber	4.56 ± 0.17
Ash	1.05 ± 0.08
Totalpolyphenol (mg/100gm)	7.35 ± 0.56
Total flavonoids	4.81 ± 0.11
Ascorbic acid (mg/100gm)	51.3 ± 2.16
Antioxidant activity %	45.36 ± 1.95

Ascorbic acid level in Cape gooseberry fruits (51.3 mg/100 g) turns out to be higher than in most fruits such as pear (4 mg/100 g), apple (6 mg/100 g), peach (7 mg/100 g), and lower comparable with orange (50 mg/ 100 g) and strawberry (60 mg/100 g) [5].

The antioxidant activity of cape gooseberry fruits was assessed by means of a 1,1-diphenyl-2-picrylhydrazyl (DPPH) test. Fresh fruits produce a 45% decrease vs. the absorbance of DPPH radicals' control solution.

Phenolic are responsible for the antioxidant activity of juices and wines, while ascorbic acid plays a minor role in the antioxidant efficiency of juices [25,37].

Miller and Rice- Evans (1997) [26] underlined the significant contributory role of phenols to the antioxidant activity of orange juice, even if vitamin C was the most abundant antioxidant. The presence of a good amount of phenolic in Cape gooseberry fruits, could contribute to the high level of antioxidant capacity.

3.2. Weight reduction, water loss and solid gain of dried golden berry

Effect of pretreatment of whole and halve fruit by boiled water, NaOH and citric acid on some quality attributes Weight reduction (WR), water loss (WL) and solid gain (SG) of dried golden berry are shown in Table (2). Dried halves golden berry previously freezed as well as that previously boiled had significantly (P≤0.05) higher weight reduction than the whole fruits, this could be due to the easily exchange the moisture from tissue. Also, the pretreatment by boiled NaOH 0.5% of whole and halve fruits had significantly (P≤0.05) higher weight reduction than that pretreated by boiled water and citric acid 0.5%. Boiling of whole fruit in H_2O had significantly (P≤0.05) lower weight reduction compared to the other treatments.

The water loss (WL) of golden berry was closed with weight reduction of fruits. The water loss (WL) of boiled halves had significantly (P≤0.05) higher water loss than boiled whole pretreated with all solutions. The water loss and solid gain was increased when the dimension of golden berry is decreased this may be due to increasing of contact surface area and deforming of the cell. It is clearly seen from Table (2) that halves fruits are the best in osmotic dehydration of golden berry due to its high water loss and low solid gain. The rate of diffusion of water from any material made up of such tissues depends upon factors such as: temperature and concentration of the osmotic solution, the size and geometry of the material, the solution-to-material mass ratio and the level of agitation of the solution [15].

3.3. Sensory characteristics of dried golden berry

The values of colour, texture, taste, flavor and the overall acceptability of dried golden berry are illustrated in Table (3). The best (P≤0.05) colour was observed in golden berry halves treated with NaOH and citric acid while the lowest colour values were detected in both whole and halves freezed golden berry. Generally, treating golden berry (wholes and halves) with NaOH and citric acid improved (P≤0.05) its texture compared with those boiled in H_2O or freezed without treating.

The most acceptable ($P \leq 0.05$) texture and taste was detected in fruit halves treated with NaOH. Meanwhile, the fruits halves treated by citric acid 0.5% had significantly ($P \leq 0.05$) higher taste than the boiled in water and NaOH 0.5%.

3.4. Total phenolic, total flavonoids and ascorbic acid contents

Effect of pretreatment on total phenolic, total flavonoids and ascorbic acid content of dried golden berry are shown in Table (4). The highest content of total phenolic was observed in the previously freezed whole fruits. On average, this was 21.94 mg of tannic acid. Meanwhile, the boiled halve fruits treated by NaOH 0.5% had the lowest total phenolic content with 16.93 mg. these data agree well with [7], who reported that the thermal drying resulted in significant declines in total phenols

The dried halves golden berry previously boiled in H_2o had the highest ($P \leq 0.05$) ascorbic acid contents (20.59 mg/100gm) while, the previously freezed whole fruits had the lowest (11.12 mg/100gm). Also, the fruits pretreated with NaOH showed a lower content of ascorbic acid compared with the other pretreatment solutions. These results are significantly logic where the ascorbic acid is instability of in the alkaline solution. All values of ascorbic acid content for all dried fruits were lower than fresh fruit, such degradation of ascorbic acid maybe due to one or more of the following causes leaching out in the pretreatment solutions, concentration of sugars, pH and / or oxidation of ascorbic acid [9].

3.6. Quality attributes of osmotic dried golden berry (dry weight basis)

Dried golden berry halves (Except the freezed untreated whole gooseberry) had significantly lower ($P \leq 0.05$) rehydration ratio compared with other dried samples (Table 6). This may be due to the relatively low moisture content of the halves compared with the other samples. The same trend was observed with rehydration coefficient. As expected, the samples (halves and whole gooseberry) boiled with citric acid had a lower ($P \leq 0.05$) pH (3.00 and 3.01 for whole and halves golden berry, respectively) than that treated with NaOH. The titratable acidity of the dried golden berry had an opposite trend where the samples previously treated with citric acid had a higher titratable acidity than that treated with NaOH. The golden berry halves previously boiled in water, 0.5% NaOH and 0.5% Citric had significantly ($P \leq 0.05$) lower texture compared with the dried whole fruits. The freezed whole fruit had the highest texture (22.25 N), while the boiled halves golden berry was the lowest (16.25 N). These results may be due to the loss of calcium from the boiled halves which lead to softening of the fruit tissues.

Table 2. Effect of different pre treatments on Weight reduction, water loss and solid gain of dried golden berry.

Treatment	Freezing		Boiled whole			Boiled halves			LSD
	Whole	Halve	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Weight reduction (WR)	21.12^e	26.78^d	17.17^g	21.45^e	19.23^f	31.28^c	34.69^a	32.34^b	1.55
Water loss (WL)	27.22^d	37.64^c	21.35^e	27.37^d	26.02^d	47.26^b	53.47^a	49.53^b	2.37
Solids gain (SG)	6.47^d	11.19^c	4.24^e	7.32^d	6.68^d	16.25^b	19.62^a	17.31^b	2.15

Means in the same raw with different letters are significantly different ($P \leq 0.05$)

Table 3. Sensory characteristics of dried golden berry.

Treatment	Freezed		Boiled whole			Boiled halves			LSD
	Whole	Halve	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Colour	6.5^c	6.2^c	6.4^c	6.5^c	7.5^b	7.3^b	8.5^a	8.5^a	0.72
Texture	6.3^d	6.5^d	7.3^c	8.1^{bc}	8.5^b	7.3^c	9.6^a	8.8^b	0.64
Taste	7.2^c	6.5^c	5.5^d	6.6^c	8.5^b	7.5^c	8.6^{ab}	9.5^a	0.95
Flavor	6.3^c	6.6^b	6.4^{bc}	7.0^b	8.5^a	7.3^b	7.5^b	9.2^a	1.2
Over all accepality	6.58^c	6.45^c	6.4^c	7.05^c	8.0^b	7.35^b	8.83^a	9.03^a	0.88

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

Table 4. Effect of different treatments on total polyphenol, total flavonoids and ascorbic acid of dried golden berry

Treatment	Freezed		Boiled whole			Boiled halves			LSD
	Whole	halves	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Total polyphenolic	21.94^{a}	19.36^{b}	19.34^{b}	18.25^{c}	19.07^{bc}	18.74^{bc}	16.93^{d}	17.56^{cd}	0.75
Total flavonoids	13.68^{a}	12.21^{b}	12.46^{b}	11.63^{bc}	12.11^{b}	11.82^{bc}	10.55^{c}	11.08^{c}	0.95
Ascorbic acid (mg/100gm)	11.12^{d}	14.51^{c}	16.07^{b}	11.76^{d}	13.90^{c}	20.59^{a}	11.53^{d}	16.67^{b}	1.36

Means in the same raw with different letters are significantly different ($P \leq 0.05$)

Table 4. Effect of different treatments on total polyphenol, total flavonoids and ascorbic acid of dried golden berry

Treatment	Freezed		Boiled whole			Boiled halves			LSD
	Whole	halves	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Total polyphenolic	21.94^{a}	19.36^{b}	19.34^{b}	18.25^{c}	19.07^{bc}	18.74^{bc}	16.93^{d}	17.56^{cd}	0.75
Total flavonoids	13.68^{a}	12.21^{b}	12.46^{b}	11.63^{bc}	12.11^{b}	11.82^{bc}	10.55^{c}	11.08^{c}	0.95
Ascorbic acid (mg/100gm)	11.12^{d}	14.51^{c}	16.07^{b}	11.76^{d}	13.90^{c}	20.59^{a}	11.53^{d}	16.67^{b}	1.36

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

Table 5. Chemical compositions of dried golden berry (dry weight basis)

Treatment	Freezed		Boiled whole			Boiled halves			LSD
	Whole	halves	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Total polyphenolic	21.94^{a}	19.36^{b}	19.34^{b}	18.25^{c}	19.07^{bc}	18.74^{bc}	16.93^{d}	17.56^{cd}	0.75
Total flavonoids	13.68^{a}	12.21^{b}	12.46^{b}	11.63^{bc}	12.11^{b}	11.82^{bc}	10.55^{c}	11.08^{c}	0.95
Ascorbic acid (mg/100gm)	11.12^{d}	14.51^{c}	16.07^{b}	11.76^{d}	13.90^{c}	20.59^{a}	11.53^{d}	16.67^{b}	1.36

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

Table 6. Effect of osmosis-solar drying on some quality attributes of dried golden berry

Treatment	Freezed		Boiled whole			Boiled halves			LSD
	whole	halves	H_2o	NaOH 0.5%	Citric 0.5%	H_2o	NaOH 0.5%	Citric 0.5%	
Rehydration ratio	1.34^{a}	1.39^{a}	1.36^{a}	1.35^{a}	1.37^{a}	1.21^{b}	1.22^{b}	1.21^{b}	0.11
Rehydration coefficient	0.41^{a}	0.38^{ab}	0.39^{a}	0.37^{a}	0.39^{a}	0.30^{b}	0.29^{b}	0.30^{b}	0.08
pH value	3.10^{cd}	3.21^{c}	3.20^{c}	3.74^{b}	3.01^{d}	3.18^{c}	3.94^{a}	3.00^{d}	0.12
Titratable acidity	2.02^{a}	1.93^{ab}	1.95^{ab}	1.56^{b}	2.11^{a}	2.04^{a}	1.42^{b}	2.16^{a}	0.14
Texture (N)	22.25^{a}	20.36^{b}	21.50^{a}	19.60^{b}	20.35^{b}	18.25^{c}	16.25^{d}	17.75^{c}	0.95

Means in the same raw with different letters are significantly different ($P \leq 0.05$).

Table 7. Effect of fruit shapes and different pretreatments on the quality aspects of osmosis-solar dried golden berry

	Whole	halve	LSD	H_2o	NaOH	Citric	LSD
Rehydration ratio	1.37^{a}	1.24^{b}	0.11	1.29^{a}	1.26^{a}	1.30^{a}	0.09
Rehydration coefficient	0.39^{a}	0.33^{b}	0.07	0.36^{a}	0.34^{a}	0.36^{a}	0.07
Texture	20.75^{a}	17.75^{b}	1.31	20.00^{a}	17.50^{c}	18.5^{b}	0.98
Weight reduction	19.50^{b}	30.75^{a}	3.54	24.0^{b}	26.5^{a}	26.5^{a}	1.23
Water loss	25.25^{b}	46.50^{a}	2.98	34.31^{c}	39.75^{a}	38.45^{b}	1.31
Solid gain	5.75^{b}	15.75^{a}	1.75	10.0^{c}	13.0^{a}	11.5^{b}	0.68
Total polyphenolic	19.65^{a}	18.15^{b}	1.05	19.04^{a}	17.59^{b}	18.32^{a}	1.26
Total flavonoids	12.47^{a}	11.42^{b}	0.96	12.14^{a}	11.09^{b}	11.60^{a}	0.85
Ascorbic acid (mg/100gm)	13.21^{b}	15.83^{a}	1.12	18.33^{a}	11.64^{c}	15.28^{b}	1.64

Means in the same raw with different letters are significantly different ($P \leq 0.05$)

3.7. Effect of fruit shapes and different pretreatments on the quality of osmosis-solar dried golden berry.

The results illustrated in Table (7) represent that, the whole dried golden berry showed a significantly (P≤0.05) higher rehydration ratio, rehydration coefficient and texture (1.37, 0.33 and 20.75 N, respectively), while the dried halves had a higher (P≤0.05) weight reduction (30.75), water loss (46.50) and solid gain (15.75). On the other side, no significant differences was observed among the type of pretreatment solution (H_2O, NaOH and citric acid) in rehydration ratio and rehydration coefficient, meanwhile the dried golden berry previously boiled in H_2O had the highest (P≤0.05) Texture (20.00 N) and ascorbic acid (18.33 mg/100gm), while no significant differences was observed in total polyphenolics and total flavonoids contents of dried goose berry previously boiled in citric acid and H_2O.

4. Conclusion

Generally, treating golden berry (wholes and halves) with NaOH and citric acid improved its texture and taste compared with those boiled in H_2O or freezed without treating. Dried halves had a higher weight reduction, water loss and solid gain. The most acceptable texture was detected in the osmotic dried halves pretreated with NaOH. The obtained results will be important as an indication of the potentially economical utility of it as a new healthy dried fruit.

Compliance with Ethics Requirements:

Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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