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Evaluation of a new baby food prepared from *Opuntiaficusindica* fruit in Wistar rats with either calcium deficient or vitamin A depletion

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ABSTRACT

Vitamin A and calcium deficiency are a major health problem worldwide and represents one of the main reasons for malnutrition in childhood. Opuntia fruit is a wild plant rich in minerals and vitamins and can replenish vitamin A and calcium deficiency. The present study aimed to prepare a baby food from Opuntia ficus indica fruit after selecting a good drying technique that maintain the vitamin content of the dried fruit and to evaluate its biological impact in Wistar rats which were either vitamin A depleted or calcium deficient. Three drying methods were trialed for the opuntia fruit; the oven, the microwave and the solar energy. Sensory evaluation and proximate analysis for the prepared baby food from dried opuntia fruit were done. Then, thirty six male Wistar rats with body weight of 70 ± 10 g were grouped into 6 groups with 6 rats in each. The groups were: a control negative group, a control group + 150 g dried opuntia fruit, a group fed on vitamin A depleted diet, a group fed on vitamin A depleted diet + 150 g dried opuntia fruit a group fed on calcium deficient diet and a calcium deficient diet group + 150 g dried opuntia fruit. The experiment lasted for four weeks, then, serum vitamin A, serum ionized calcium and total calcium were determined as well as serum urea, creatinine, albumin, total protein and hemoglobin. Results revealed a very good acceptability of the prepared baby food, and the best method for drying that gave the highest B-carotene content was the solar energy method. Feeding rats with opuntia fruit restored serum calcium in the group that was fed on calcium deficient diet and restored serum vitamin A in the group that was fed on vitamin A depleted diet. Thus, it is recommended that the prepared baby food can be introduced for babies safely as it doesn't have any drawbacks on body weight gain or different body functions and it can protect babies from calcium and vitamin A deficiency.

Keywords: *Opuntiaficusindica*, vitamin A deficiency, calcium deficiency, baby food, drying methods.

Introduction

Vitamin A deficiency and calcium deficiency are among the most frequent reasons for childhood malnutrition. Approximately 228 million children are affected by vitamin A deficiency. It is the most common form of malnutrition leading to blindness and co-morbidity of childhood worldwide. It was reported that 1 to 3 million child deaths are due to eye disease; 5 to 10 million cases among whom half a million children get blinded every year. Vitamin A deficiency has many clinical manifestations, ranging from xerophthalmia (a spectrum of ocular disease arising from VAD) to susceptibility to infections and anaemia[1]. The World Health Organization (WHO) recommends breastfeeding since breast milk is a good natural source for vitamin A, also it recommends vitamin A supplementation along with increasing the intake of vitamin A-rich diets and vitamin A fortified foods [2].

Calcium deficiency represents a public health problem in developing countries and in many developed countries[3]. Calcium is important for many biological processes, such as provision of structural support for teeth and bones, muscle contraction, enzyme regulation, signal transduction, blood

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clotting in addition to other important roles [4]. Its deficiency leads to rickets in children and osteoporosis in adults [3].

Many plants either edible or non-edible have been known and used for their medicinal values since thousands of years ago in traditional medicine. Recently, in the era of medicine, lights are spot on the natural compounds to replace some of the natural compounds of plant origin with synthetic drugs because of a lower cost and fewer side effects [5]. *Opuntiaficusindica* is Among those medicinal plants, which is a plant of wide distribution native to Mexico [5]. It grows wild in arid and semiarid climates and in the semi-dry countries such as Italy, South-western USA, Tunisia, Morocco, Argentina, Brazil, Iran, Peru, Spain, and South Africa [6]. It belongs to Cactaceae family [7] and it is evergreen modified stem plant. *Opuntiaficusindica* is also known as prickly pear or cactus pear and it is consumed as food and in folk medicine due to its nutritional and beneficial properties [8, 9]. The fruits of different varieties are of many colors including red, yellow, orange, and green differing in their physical and chemical composition and properties [10]. From the health point of view, opuntia contains many compounds of health values including polyphenols, fibers, minerals, and vitamins. Its fiber content is of considerable amount and of distinct health benefits such as lowering blood cholesterol, weight control, diabetes control and reducing the risk of some types of cancer including the colon cancer [11, 12]. Opuntia fruit is a good source of vitamins and minerals [5, 13]. The red and yellow varieties comprise considerable amounts of vitamin A and carotenes, which are known for their antioxidant properties and not only having an essential role in the processes of vision, reproduction, and cellular growth but also needed for the maintenance of healthy skin and mucosa and protects against lung cancer [14]. Vitamin A deficiency leads to blindness, xerophthalmia, and premature death [15]. Moreover, Opuntia is a good source of minerals such as calcium, manganese, magnesium, and iron. Calcium and magnesium are required for bone-strengthening. It was reported previously that consuming cactus improves the density of bone mineral in women with low bone mass [16].

Cactus pear is a crop of economic importance that has numerous uses [15]. Recently, this plant has been used to prepare some beverages and many other food products [6]. Opuntia has been used in the elaboration of jellies, candies and beverages [17]. Also, it has been incorporated in cake and bread [18].

Bad feeding practices and the lack of suitable, convenient, and affordable baby foods are responsible mainly for malnutrition in children especially in developing countries [19]. Nowadays, there is an increasing demand for complementary baby foods all over the world. There are a wide variety of complementary baby foods in the market including the cereal-based baby foods, vegetables, and fruits baby foods either ready-to-use or prepared by rehydration in milk or water [20]. Recently, powdered food products are increasingly gaining more preference among consumers' choices as they meet their everyday life demands for convenient, smart, and easy-to-use applications [21].

The aim of the present study was to prepare a low cost powdered ready-to-use baby food from *Opuntiaficusindica* fruit which is a wild plant rich in minerals and vitamins and has good acceptability after selecting the best drying method for the fruit to ensure safety, longer shelf life, as well as better and easier handling of the prepared product. Also, to evaluate its biological effect in Wistar rats, which were calcium deficient or vitamin A depleted on different biochemical parameters as well as body weight gain and feed intake.

Materials and Methods

Materials

Opuntiaficusindica fruits were obtained from the Egyptian local market during their ripening season in 2018.

Materials used for chemical analysis of the Opuntiaficus fruit

All solvents that were used for determination of calcium and β-carotene in opuntiaficus fruit and those which were used for determination of vitamin A in serum by HPLC technique were of the analytical grade for HPLC and were obtained from Sigma-Aldrich Chemical Co. (St. Louis, Mo, 63103, USA).

Materials used for the animal experiment

Most of the components of the diet, introduced to the rats (table 1) were obtained from the local market, while, casein was obtained from Scerma Co., (France). The constituents of the salt and the vitamin mixtures used for the formulation of the diet were of analytical grade and obtained from Fluka (Germany) and BDH (England) Chemical Companies.

Animals used in this experiment were Wistar male albino rats obtained from the Central Animal House, National Research Centre (NRC), Egypt. The animal experiment was carried out according to the guidelines for Animal Care and Ethics Committee of the NRC (Egypt) and the study protocol was approved by the committee.

Materials used for biochemical analysis

Kit used for determination of blood hemoglobin was obtained from Biodiagnostic Co., (Egypt). Serum urea and creatinine determination kits were purchased from Chronolab Systems S.L., (Barcelona, Spain). Kits used for determination of total calcium, total protein, and albumin were obtained from Olympus Company for automated Olympus Autoanalyzer, Ireland.

Methods

Technological treatments

1. Preparation of the dried opuntia fruit

All tested samples of opuntia fruit were peeled, one sample was kept fresh and the other samples were dried on perforated trays by using the different drying methods according to Mahmoud et al., [22] as follows:

a) Fresh opuntia fruit.
b) Air oven drying: Opuntia fruit was placed on stainless steel trays in one layer and then placed on the oven and dried at a temperature of 40 °C for 8 hrs, the trays were removed out of the oven when the weight of samples was being constant.
c) Solar drying: One layer of opuntia fruit was placed on stainless steel trays and dried for 48 hrs at 40 °C with

ambient air temperature of 19.4 ºC, relative humidity of 57%, relative humidity inside the dryer of 10% and global solar radiation of 845 W/m^2, the trays were removed out of the solar dryer when the weight of the sample was being constant.

d) Microwave drying: One layer of opuntia fruit was placed in a microwave oven which was Samsung (Model MF245) with oven cavity dimensions of 419 × 245 × 428 mm and operation frequency of 2.450 MHz, with a power source of 230 V-50 Hz. The nominal microwave power outputting was 900 Ws, the air temperature was 40 ºC /6 min.

2. Preparation of the baby food from opuntia fruit

Baby food was prepared according to Szulc and Lenart[23] with some modifications. Solar dried opuntia was collected after fine milling blended to powder form (0.5 mm) in a high-speed blender (Braun KMM 30 mill, type 3045, CombiMax, Germany) and kept in a dry place to prevent aggregation of granules. A sample of baby food powder weighing 25 g was tested for rehydration as flowing: 25 g of powder was rehydrated in 100 ml water and examined for its taste.

Chemical analysis

1. Proximate composition

Proximate composition of the opuntia fruit samples was analyzed for moisture, protein, ash, and fat content according to the methods described in the AOAC [24]. Their analyses were performed in triplicate.

2. Determination of β-carotenoids in Opuntiaficusindica fruit

According to Neves et al., [25] with some modifications, one g of the sample was placed in a test tube with 50 mL of an acetone extraction solution, then the tube was covered with aluminum foil. The extract was stirred for 1 min, incubated for 9 min, filtered through cotton, and immediately read in triplicate with a spectrophotometer (Shimadzu UV-2401 PC, Australia) at a wavelength of 450 nm. The calibration curve was obtained using β-carotene as a standard (Sigma-Aldrich Chemical Co., St. Louis, Mo, 63103, USA). The results were expressed as mg β-carotene/100 g sample.

3. Determination of calcium in Opuntiaficusindica fruit

The samples were subjected to analyze for the determination of calcium according to the method of Sahari et al., [26] using Optima 2000 DV inductively coupled plasma atomic emission spectrometer with full PC control (Perkin Elmer-Germany). The concentrations were obtained based on the calibration curve. High purity Merck standards were used.

Animal experiment

Thirty-six white male Wistar albino rats with a body weight ranging from 60 to 80 g were used. The standard control diet was prepared according to Reeves et al. [27]. Animals were divided into 6 groups, each comprising 6 rats as follows;

Group 1: was given the control diet.

Group 2: was given the control diet + 15% dried opuntia fruit.

Group 3: was given the control diet which is vitamin A depleted.

Group 4: was given the vitamin A depleted diet + 15% dried opuntia fruit..

Group 5: was given the control diet which is calcium deficient as 1 g Ca/Kg diet according to Hunt et al., [28].

Group 6: was given the calcium deficient diet + 15% dried opuntia fruit.

Rats were housed individually in separate cages. The experiment lasted for 4 weeks during which, food and water were allowed ad-libtum to each rat. Body weight was measured twice a week. Food intake of each rat was daily recorded. At the end of the experiment, body weight gain, feed intake, and feed efficiency ratio for each rat were calculated (feed efficiency ratio = body weight gain/feed intake).

At the end of the experimental period, rats were fasted overnight and in the early morning, each rat in different groups was subjected to slight anesthesia by diethyl ether. Blood was withdrawn by open heart puncture and each sample was delivered into one heparinized tube and one dry tube.

Biochemical analysis

Blood hemoglobin concentration was immediately measured for each sample according to Betke and Savelsberg[29]. Serum was separated from the second tube for each sample after centrifugation at 3000 rpm for 15 min and delivered into clean tubes, then, stored at -20 °C until analysis.

Serum urea and creatinine were assessed as described previously by Fawcett and Scott [30] and Murray [31], respectively. Serum total calcium, total protein, and albumin were measured according to the manufacturer's instructions using auto-analyzer Olympus Au 400. Serum ionized calcium was calculated based on data obtained for serum total calcium, total protein, and albumin from the following equation as described previously by Sava et al. [32]:

Ionized Ca (mg/dl) = ((((6*Ca) - (((0.19*T.P) + Alb/3))) / (6+((0.19*T.P)+ Alb)))/4

whereCa is total calcium, T.P is total protein, and Alb is albumin.

Determination of serum vitamin A by HPLC analysis

Vitamins A in serum was determined by the HPLC technique as described previously by Hussein et al. [33].

Sample extraction

First, 400 µl of serum was added to 400 µl of ethanol and 400 µl of hexane, mixed well-using vortex and centrifuged for 5 min at 5000 rpm using cooling centrifuge (Laborzentrifugen, 2K15, Sigma, Germany). Then, the upper layer was removed and the precipitate was washed by 400 µl of hexane. This step was repeated to collect the upper layer (hexane layer), which was then dried by nitrogen stream. Finally, the extract was redissolved in 500 µl of mobile phase (ethanol and acetonitrile)

and filtered by hydrophilic 0.45 µm PVDF filter for removing any insoluble materials.

HPLC condition

Determination of vitamin A was carried out using a high-performance liquid chromatography (HPLC) system, Agilent technologies 1100 series (Agilent Technologies, Hewlett-Packard-Strasse 8, 76337 Waldbronn, Germany) equipped with a quaternary pump (Quat pump, G1310A model), G1328A manual injector (MI), UV detector, and a reversed phase column (C18-25cm, 5 µm particle size). Twenty µl of the filtrate was injected onto the reversed phase column and isocratically eluted with acetonitrile/ethanol 50:50 (v/v) with 0.1% triethylamine as a mobile phase and was delivered at a flow rate of 1ml/min. The UV detector was set at 325 nm. Serial dilutions of vitamin A standard were injected into HPLC; the peak areas were determined. A linear standard curve was constructed by plotting peak areas vs the corresponding standard concentrations. The concentrations of the samples were obtained from the standard curve.

Statistical analysis

Data were statistically analyzed using the computerized program SPSS software, version "20" for Windows. The one way ANOVA test was done followed by the Duncan test. Data were represented as mean ± SE. The level of significance P< 0.05 was considered as significant, otherwise non-significant.

Results and Discussion

Effect of drying on the chemical composition of opuntia

The primary goal of the drying was to reach the minimum moisture content in the samples to increase the shelf-life of the products but taking into account and being cautious not to burn the samples and also to avoid loss of nutrients during processing to maintain the nutritional quality of the prepared baby food product and therefore to support a satisfactory nutritional status when being introduced to babies [34]. The analysis of the proximate composition of the opuntia fruit either fresh or dried (Table 1) showed that there was a significant difference between the fresh and dried (powder) forms in the content of moisture, protein, fat, ash, and carbohydrates (P<0.05). The obtained data for the proximate composition of the dried fruit was more or less similar to that obtained in other studies [35]. The ash content of the dried fruit was considered relatively high due to the high mineral content of opuntia and in particular, the calcium content, which was detected as 380.2 mg/Kg dry weight (Table 2) that was considered relatively high when compared to other plants. It was mentioned that the calcium content of opuntia fruit was relatively high which was in agreement with our results [36].

Table 1: Proximate composition of opuntia fruit.

	Moisture %	Protein %	Fat %	Ash %	Carbohydrates* %
Fresh	83.93 ± 0.27a	0.96 ± 0.06b	2.96 ± 0.02b	0.38 ± 0.01b	11.78
Powder	4.65 ± 0.15b	4.54 ± 0.23a	14.78 ± 0.15a	1.89 ± 0.04a	74.14

All values are represented as means of triplicate determinations ± standard deviation (SD). Values that share the same letters at the same column are significantly different (P<0.05).*Total carbohydrates: calculated by difference (100—Sum of all components).

Table 2: Concentration of calcium in opuntia fruit.

Group	Calcium (mg/ Kg dry wt.)
Opuntia fruit	380.2

Evaluation of the prepared baby food

1. Proximate composition and calcium content of opuntia fruit

Opuntiaficusindica fruit was chosen in the present study to prepare baby food as it is a rich source for vitamins and minerals particularly vitamin A and calcium [5]. Moreover, the opuntia fruit is mostly a wild plant, which means that no fertilizers and no pesticides are added to it in addition to its low cost that renders opuntia to be the plant of choice and the most suitable source for the baby food. In addition to its benefits, the sugar content of the opuntia fruit is relatively high [15], which makes it of a very good taste and acceptable when introduced to babies. Also, the form of the prepared baby food as a dried powder, which is ready to use by rehydration, easy to market, and has relatively longer shelf-life than other types of baby foods give advantages to the prepared baby food in the present study over other commercial types of baby foods, found in the local market. It can be used as it is or it can be added to cereal-based baby food.

2. Sensory evaluation of the prepared baby food

Table (3) summarizes the results of the sensory evaluation of Opuntia baby food sample formulated compared to the commercial one. Data indicated that there were significant differences (P<0.05) between samples for the sensory attributes of color, taste, odor, flavor, and overall-acceptability. The results showed that Opuntia baby food had an acceptable and very good panel scores that may be due to its high sugar content besides its accepted flavor.

Table 3: Sensory evaluation of baby food formulated from opuntia powder.

Treatment	Color	Taste	Odor	Flavor	Overall acceptability
Opuntia powder	8.0±0.8^b	8.2±0.8	7.7±0.1^b	8.4±0.3^b	8.6±0.82^b
Com. baby food	8.2±0.5^a	8.7±0.5^a	8.8±0.8^a	8.6±0.6^a	8.8± 0.83^a

3. Effect of different drying methods on β-carotene content of the prepared baby food

β-carotene content was detected in the present study to have varying concentrations according to the method of drying. As shown in fig. (1) drying opuntia fruit with any of the methods selected for drying, which were solar energy, oven, and microwave kept β-carotene content in the samples but with

different concentrations. It is obvious that solar energy was the best method of drying, which gave the highest β-carotene concentration followed by microwave method, and then the oven method gave the least β-carotene concentration. So, solar energy was chosen to be the method for drying to prepare baby food. These obtained results are in accordance with the results obtained in a previous study for our team for the effect of drying methods on the antioxidant activity of orange peel, which revealed that solar energy is the best drying method[22].

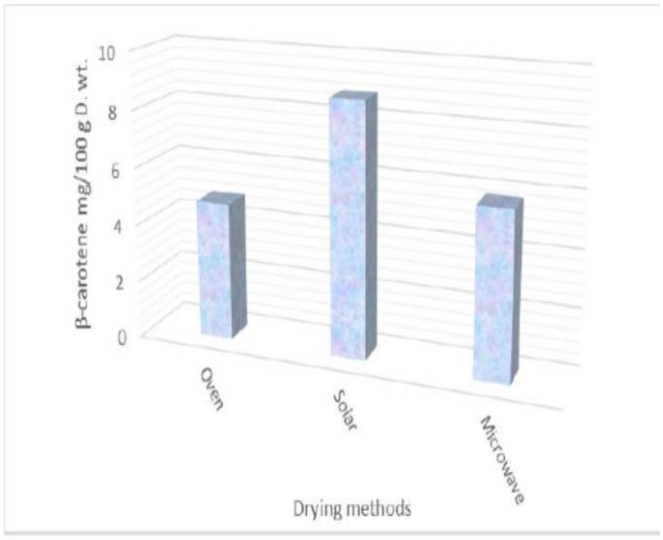

Figure 1: Effect of drying methods on β-carotene content

It is the worth mentioning that the fresh sample recorded a value for β-carotene content of 3.19 mg/100 g sample, which is less than that for the sample that was dried by solar energy and also less than any of the values detected for dried samples by different drying techniques (Table 4).

Table 4: Concentration of β-carotene in fresh opuntia fruit and dried opuntia fruit as baby food.

sample	β-carotene (mg/100 g sample)
Fresh fruit	3.19
Dried fruit (solar energy)	8. 24

Biological evaluation of the baby food

1. Effect of feeding opuntia fruit on body weight gain, feed intake, and feed efficiency ratio

Data obtained for the feed intake, body weight gain and feed efficiency ratio (FER) of the different groups (Table 5) showed a significant reduction in the body weight gain and feed intake for the group with calcium deficiency compared to the control negative group and the control group that received the opuntia fruit. These results seem to be in accordance with those obtained by Alomaim et al., [37] who reported that low dietary calcium reduced body weight and fat mass. Meanwhile, the group that with calcium deficiency and received opuntia fruit showed a rise in the body weight gain compared to the group with calcium deficiency, which did not receive opuntia fruit, but it was still significantly lower than the control negative group. It was previously reported that opuntia fruit is a rich source of calcium [18, 36]. Moreover, Aguilera-Barreiro et al., [16] mentioned that the consumption of opuntia in women with low bone mass improved the density of bones mineral.

Table 5: Feed intake, body weight gain, and food efficiency ratio (FER) of different groups compared to the control group.

Group	B. wt. gain(g)	Feed intake(g)	F E R
Control (-ve)	124.50±4.42^{a}	397.33±12.99^{a}	0.489±0.02^{ab}
Control+ OF	125.83±5.61^{a}	395.83±11.64^{a}	0.516±0.01^{ab}
Vit. A dep.	118.33±5.91^{ac}	365.00±1.59^{a}	0.528±0.01^{b}
Vit. A dep. + OF	124.33±7.96^{a}	357.50±5.55^{a}	0.537±0.02^{b}
Ca def.	92.67±26.74^{b}	276.67±17.35^{b}	0.402±0.03^{c}
Ca Def.+ OF	103.33±1.36^{bc}	290.00±31.31^{b}	0.473±0.02^{a}

Values are expressed as mean ± SE and the mean difference is significant at $P<0.05$. Values that share the same letters at the same column are not significant while values that share different letters at the same column are significant.

2. Effect of feeding opuntia fruit on serum total and ionized calcium

Determination of total calcium and ionized calcium in serum revealed that there was a significant drop in both total and ionized calcium for the group of rats with calcium deficiency, however, this drop was more or less normalized in the group of rats with calcium deficiency, which received the opuntia fruit (fig. 2 & 3). It is well known that calcium deficiency leads to so many problems in the body among which is low bone mineralization that may further lead to osteoporosis. It was previously reported that the consumption of opuntia boosts the density of bone mineral in women with low bone mass [16]. It seems that these results are in accordance with the results obtained in this study.

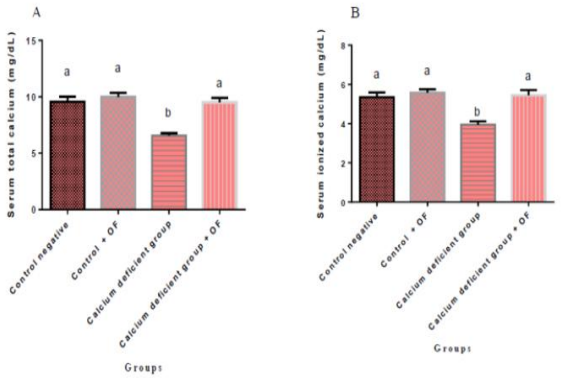

Figure 2: A- Total calcium and B- Ionized calcium of group with calcium deficiency and group with calcium deficiency + opuntia fruit and the control groups. Bars represent mean ± SE and the mean difference is significant at $P<0.05$. Bars that share the same letter are not significant, while, those that share different letters are significant.

3. Effect of feeding opuntia fruit on serum vitamin A levels

Vitamin A has an important role in visual health, development, skin and mucosa maintenance, fetal growth and immune

function. Vitamin A deficiency represents a public health problem worldwide, especially in South-East Asia and Africa. It can lead to visual impairment as night blindness and in children, may rise the risk of illness and death due to childhood infections, including those causing diarrhea and measles [38]. Data obtained in the present study revealed that there was a very highly significant drop of serum vitamin A in the group of rats that were fed on vitamin A depleted diet. On the other hand, the group of rats that were fed on vitamin A depleted diet and received opuntia fruit showed a rise in serum vitamin A, which is significantly higher compared to the group fed on vitamin A depleted diet, but still significantly lower than the control negative group. Opuntia was reported to contain β-carotene which is vitamin A precursor with a comparatively higher amount than other plants [39]. Also, from the data obtained in this study, it can be obvious that vitamin A precursor of the opuntia fruit has good bioavailability.

4. Effect of feeding opuntia fruit on kidney function, blood proteins, and hemoglobin

No significant change was noticed for serum urea, creatinine, or total protein for all groups compared to the control negative group indicating normal kidney function for all groups (Table 6). However, there is a slight non-significant decrease in serum albumin for vitamin A depletion, vitamin A depletion + opuntia, and calcium deficient groups compared to the control negative group, but this decrease was significant when compared to the control group that received the opuntia fruit. No significant change was noticed for hemoglobin concentration for all groups compared to the control negative group. However, the non-significant decrease noticed in the group with vitamin A depletion and the group with calcium deficiency was restored in the group with vitamin A depletion that received the opuntia fruit and also the group with calcium deficiency that received the opuntia fruit. It was previously reported that opuntia fruit contains vitamins and minerals such as iron, folate, and vitamin B12 that are necessary for hemoglobin synthesis [40].

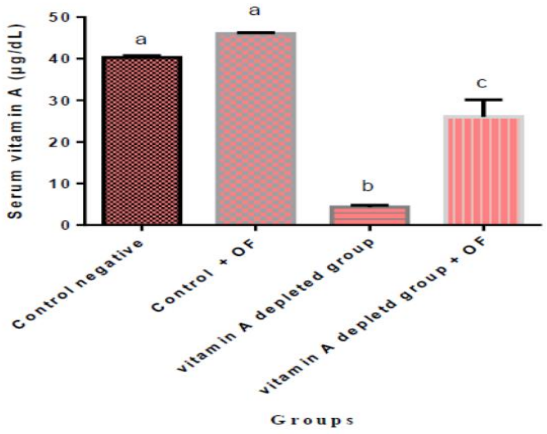

Figure 3: Serum vitamin A by HPLC of the group with vitamin A deficiency, the group with vitamin A deficiency + opuntia fruit and the control groups. Bars represent mean ± SE and the mean difference is significant at P<0.05 level. Bars that share the same letter are not significant, while those that share different letters are significant.

Table 6: Serum urea, creatinine, total protein, albumin, and hemoglobin (Hb %) of all groups.

Group	s.Urea (mg/dl)	s.Creat. (mg/dl)	s.T.prot. (g/dl)	s.Alb (g/dl)	Hb (%)
Control (-ve)	41.57± 4.01^{a}	0.48± 0.16^{a}	9.38± 1.38^{a}	4.37± 0.60^{ab}	13.80± 0.44^{abc}
Control + OF	42.86± 5.04 ^{a}	0.45± 0.08^{a}	9.57± 0.55 ^{a}	5.54± 0.40a	14.99± 0.53a
Vit.A depleted	50.60± 3.65 ^{a}	0.36± 0.08^{a}	9.16± 0.40 ^{a}	3.90± 0.44^{b}	12.80± 0.23^{c}
Vit.A dep.+ OF	40.50± 4.54 ^{a}	0.42± 0.03^{a}	9.44± 0.14 ^{a}	4.00± 0.49^{b}	13.61± 0.12a^{bc}
Ca def.	45.05± 5.06 ^{a}	0.40± 0.07^{a}	9.49± 0.37^{a}	4.23± 0.11^{b}	13.14± 0.31^{bc}
Ca Def. + OF	42.69± 2.63 ^{a}	0.36± 0.07^{a}	9.24± 0.31 ^{a}	4.36± 0.17^{ab}	13.96± 0.49^{abc}

Values are expressed as mean ± SE and the mean difference is significant at P<0.05. Values that share the same letters at the same column are not significant, while values that share different letters at the same column are significant.

Conclusion

It can be concluded from the obtained results in the present study that the prepared form of the baby food was of a very good and accepted sensory evaluation. Solar energy was found to be the best drying method that gave the highest value of β-carotene content among other used methods for drying, which were oven and microwave. The biological evaluation of the prepared baby food revealed that feeding rats with calcium deficient foods + dried opuntia fruit caused a rise in their serum total and ionized calcium since opuntia is a rich source of calcium. Also, feeding rats on a diet with vitamin A depletion + dried opuntia fruit had a good impact on serum vitamin A of these rats. Thus, it is recommended that the prepared baby food can be safely introduced for babies as it doesn't have any drawbacks on body weight gain or different body functions and it can protect babies from calcium and vitamin A deficiency. In addition, it can be used for babies in those populations that have vitamin A or calcium deficiency.

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