

Sensory analysis of cereal bars enriched with prickly pear cactus fruit (*Opuntia ficus indica*) suitable for people with non-communicable diseases

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ABSTRACT

Fruits and fruit-based products are a major part of a healthy diet; epidemiological studies suggest that regular consumption of fruits may reduce the risk of noncommunicable diseases. Fruit bar is an alternative convenient and concentrated food product that has high nutritive value with a longer shelf life as compared to fresh fruits. Studies showed that consumption of cactus pear fruit is associated with a remarkable reduction of oxidative stress and may help in preventing chronic pathologies. The aim of the present investigation was to elaborate a cereal bar enriched with cactus prickly pear fruit (*Opuntia ficus indica*) suitable for people with noncommunicable diseases with good acceptance by consumers. Four different formulations of bars added with dried prickly pear fruit using the red and green varieties were elaborated and sensory was evaluated. The bars of amaranth and green tuna and granola and green and red tuna had the highest acceptance ($p = 0.05$) by 50 untrained judges. The parameters most important in the selection by the untrained judges were: consistency on the palate, pleasant smell, sweet taste, pleasant taste, and general taste.

Keywords - Prickly pear fruit; noncommunicable diseases; bars; sensory; quality

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I. INTRODUCTION

The snacks, defined as fast foods that can be eaten between main meals, are growing significantly in relation to other types of food products in the world [1]. Cereal bars can replace snacks that are high in sugars, sodium, and lipids and are found in the market under different brands, flavors, and nutritional compositions [2]. These products are obtained by blending dry ingredients and binders that taken together impart flavor, texture, and other physical properties to the bars [2]. The ingredients usually contained in cereal bars are mixtures of cereals (wheat, corn, oats, rice, and amaranth), dried fruits and nuts, corn syrup, honey, sugar, lecithin, and flavorings. In addition, from the point of view of its dimensions, it can have a portable food and proportions controlled, ideal for a meal like snack in any nutritional treatment [3]. Therefore, it is necessary to obtain this type of products of higher nutritional and functional quality, choosing and complementing the materials that constitute a food choice with health benefits [4]. For these reasons, the industry looks for new ingredients that can meet the demands of the consumer market

that wants products with the sensory and nutritional quality associated with benefits to health [5].

Fruits and fruit-based products are a major part of a healthy diet, and epidemiological studies suggest that regular consumption of fruits may reduce the risk of noncommunicable diseases [6], and fruit bar is a convenient and concentrated food product that has high nutritive value with longer shelf life as compared to fresh fruits. In addition, fruit bars can deliver high dietary fiber, proteins, carbohydrates, micronutrients, and many other bioactive compounds to human body, which are necessary to meet daily requirements of the body [6], in this sense, a little-used fruit is the prickly pear fruit (*Opuntia ficus indica*)

The cactus pear (*Opuntia ficus indica*) is a plant of the cactus family [7], that have spines and is thick. Its fruit has a pear form, has spines, and hence is named as Prickly Pear [8], [9]. The pulp of the fruit contains glucose up to 52% and fructose up to 46% [10]. The calorific value of the pulp is about 50 Cal 100 g⁻¹, comparable to different similar fruits. The other components present in cactus pear pulp are protein (0.21%–1.6%), fat (0.09%–0.7%), fiber

(0.02%–3.15%), and ash (0.3%–1 %) [10], [11], all of which are similar to other fruits. Prickly pear is also a source of vitamin C [12], minerals, and soluble and insoluble fiber [13], [14]. Finally, the analysis of prickly pear peel showed a significant amount of polysaccharides (25%), cellulose (29%), hemicelluloses (8.5%), pectin (3%), protein (8.3%), and minerals (12.13%) [15].

Opuntia ficus indica fruit has been very studied the last decade for its health-promoting properties related to its betalain content [16], [17], [18]. In particular, human studies showed that consumption of cactus pear at dietary-achievable amounts was associated with a remarkable reduction of oxidative stress in healthy subjects [16], [17], [18], [19], [20], [21], and may help in preventing chronic pathologies [12], [16]. This fruit contains other compounds with antioxidant activity how red-violet betacyanins and yellow betaxanthins [17], [22]. Medicinal plants, including prickly pear cactus, have been reported to modulate blood sugar levels. Extracts of prickly pear cactus have been used in various parts of the world to control diabetes mellitus [23].

Due to these characteristics, it is convenient to create food products that contain cactus prickly pear fruit to improve their properties. The aim of the present investigation was to elaborate a cereal bar enriched with cactus prickly pear fruit suitable for people with noncommunicable diseases with good acceptance by consumers

II. MATERIAL AND METHODS

2.1 Manufacture of cereal bar enriched with cactus pear fruit (*Opuntia ficus Indica*)

Prickly pear (*Opuntia ficus indica*) were purchased from a store in the municipality of Piedras Negras, Coahuila, Mexico. Four jellies of cactus pear fruit were made. The prickly pear was washed and disinfected, peeled, cut into pieces, and dehydrated used a convection dryer, Dikoin brand, model: IQ 01.5. The process was carried out with a drying air temperature of 65°C at a speed of 1 m⁻¹ for 5 hours. Two different ways of preparing bars added with tuna were tested, for which the two different varieties of tuna were used.

Amaranth, granola, and green and red tuna were weighed, then mixed in a bowl with the sesame seeds, the almonds, and cinnamon. In another bowl, only the granola was placed. The prickly pear fruit was added to both with the agave honey. Both masses were poured into a mold with waxed paper, trying to make it as uniform as possible. They were baked for 10 minutes at 200°C. They were allowed to cool to room temperature, subsequently, they were demolded. Finally, they were put in the fridge for 20 minutes. Once the time had passed, they were cut into thin sheets of approximately 21 g each.

2.2 Nutritional analysis of cereal bar enriched with cactus pear fruit (*Opuntia ficus Indica*)

A nutritional analysis of the samples was carried out in which total fat, total sugars, dietary fiber, and protein were determined using the AOAC (2005) methodology [24]. In addition, the percentages of some vitamins and minerals were determined through established nutritional tables.

2.3 Sensory analysis of cereal bars

Sensory analysis of four cereal bars enriched with prickly pear (*Opuntia ficus indica*) was performed by an untrained panel composed of 50 panelists. The distribution in age was in the range between 17 and 42 years old, and the distribution in female and male was 60% and 40%, respectively. The evaluation was conducted in the Bromatology Laboratory of the School of Health Sciences, of the Universidad Autónoma de Coahuila, México. The conditions of the sensory room were 25°C of temperature and white light illumination. A 7-point hedonic categorical scale (a scale with number and definition) was used, where 1 = extremely dislike, 3 = was the rejection point, and 7 = extremely like. The attributes of appearance, color pleasant, consistency, palate consistency, hardness, pleasant smell, prickly pear taste, sweet taste, pleasant taste, and general taste were evaluated.

2.4 Experimental design

For the analysis of the nutritional analysis of cereal bars fortified with prickly pear (*Opuntia ficus indica*), a multiple Tukey HSD comparison test ($p = 0.5$) was used. Sensory analysis data were analyzed using a Kruskal–Wallis test. Duncan test was applied to compare sums of ranks and principal component analysis ($p = 0.05$). Data analysis was carried out using Statgraphics Centurion XV software version 16.1.15

III. RESULTS AND DISCUSSION

3.1 Analysis of nutritional content

Four cereal bars of prickly pear (*Opuntia ficus indica*) were nutritionally evaluated. It was determined that for each 21 g of bar of amaranth with prickly pear fruit, the product has energy value of 79.94 Cal, equivalent to 330.53 kJ, this energy was obtained of: 3.31 g of total fat, 11.45 g of carbohydrates, and 2.26 g of protein and for each 21 g of bar of granola with prickly pear fruit, the product has energy of 58.65 Cal, equivalent to 245.39 kJ, this energy was obtained of 1.6 g of total fat, 10.93 g of carbohydrates, and 0.92 g of protein (Table 1) resulting in a product with low number of calories and sugars so it is also a product suitable for people with chronic diseases. It can be eaten as part

of breakfast or as a snack for those who want it without risk of increasing their blood sugar levels.

Table 1. Nutritional facts of bars of cereal with red prickly pear fruit (*Opuntia ficus indica*).

Nutritional facts	Bar of amaranth with prickly pear fruit	Bar of granola with prickly pear fruit
Energy	79.44 Cal / 330.53 KJ	58.65 Cal / 245.39 KJ
Protein (g)	2.26	0.92
Sugar (g)	11.45	10.93
Fiber (g)	0.59	0.48
Total Fat (g)	3.31	1.6
Vitamin A (µg RE)	0.06	0.06
Ascorbic acid (mg)	2.27	0.27
Sodium (mg)	0.98	3.82
Potassium (mg)	2.76	2.76

3.2 Sensory analysis of prickly pear fruit

Table 2 shows the sensory analysis data of the four prickly pear (*Opuntia ficus indica*) jellies produced in this project. A sensory analysis was performed to quantify the degree of acceptance of four bars of cereal enriched with dehydrated prickly pear fruit, finding that all the bars had a positive acceptance. However, the granola bars with green and red prickly pear fruit and the bar of amaranth with green prickly pear fruit were significantly superior to the amaranth with red prickly pear fruit ($p = 0.05$). In particular, the bar of granola with green prickly pear fruit was superior in all parameters evaluated, these being: appearance, pleasant color, hardness, consistency on the palate, pleasant smell, tuna flavor, sweet taste, pleasant taste, and general taste.

Table 2. Analysis of means by the Tukey test HSD $p = 0.05$ of sensory characteristics of four bars of cereal with of prickly pear fruit (*Opuntia ficus indica*).

Sample	Tukey analysis HSD 0.05				
	Appearance	Color	Hardness	Palate consistency	Pleasant smell
Amaranth red	5.68 ^a	5.34 ^b	5.06 ^a	4.94 ^a	5.36 ^b
Amaranth green	5.34 ^a	5.44 ^{ab}	4.10 ^b	5.22 ^{ab}	5.86 ^{ab}
Granola red	5.56 ^a	5.90 ^a	4.10 ^b	5.28 ^{ab}	5.82 ^{ab}
Granola green	5.38 ^a	5.86 ^{ab}	4.60 ^{ab}	5.74 ^b	6.00 ^a
Sample	Tukey analysis HSD 0.05				
	Cactus taste	Sweet taste	Pleasant taste	General taste	
Amaranth red	3.60 ^b	4.26 ^b	4.48 ^b	4.66 ^b	
Amaranth green	3.98 ^{ab}	5.28 ^a	5.80 ^a	5.82 ^a	
Granola red	4.62 ^a	5.74 ^a	5.76 ^a	5.82 ^a	
Granola green	4.14 ^{ab}	5.82 ^a	6.18 ^a	6.16 ^a	

The analysis of principal components (PC) for samples of added bars of prickly pear fruit dehydrated green and red varieties shows that 74% of the variation is explained by the main components PC1, PC2, and PC3 (Table 3); The PC1 was influenced by the attributes of consistency on the palate, pleasant smell, sweet taste, pleasant taste, and general taste. PC2 was influenced by the attributes of appearance and hardness and PC3 by the pleasant color (Table 4). However, pleasant color and cactus taste did not have an impact on the evaluation for the judges, especially the cactus taste, which was barely perceptible or imperceptible in most cases so it was not definitive on the evaluation. This is also appreciated in the figure of eigenvalues of the variables dependent on sensory analysis, in which the cactus taste is mentioned, but it does not show a trend line. This is very positive on the other hand because many people do not know the taste of cactus or do not like it very much, and being overshadowed by the taste of granola or amaranth and oats makes it easier for people to consume them when they are familiar with these flavors that are considered pleasant.

Table 3. Values of sensory analysis of four bars of cereal with prickly pear fruit (*Opuntia ficus indica*).

Number	Eigenvalue	Proportion	Proportion accumulated
1	4.6360	0.515	0.515
2	1.2350	0.137	0.652
3	0.8612	0.096	0.748
4	0.7519	0.084	0.832
5	0.4148	0.046	0.878
6	0.4062	0.045	0.923
7	0.3726	0.041	0.964
8	0.2307	0.026	0.990
9	0.0916	0.010	1.000

By plotting (Fig. 1) the results of the first major component against the second, it was observed that the sample of amaranth with red prickly pear fruit had a positive acceptance in terms of appearance and hardness which correspond to the second main component (y-axis) and the rest of the samples had a good acceptance in the first major component composed of the remaining parameters, except tuna flavor and pleasant color (x-axis). The samples of amaranth and green prickly pear, granola and green prickly pear were the samples that had a greater acceptance among the judges since the first major component was the most decisive in the choice with 51.5% of the value as observed in the cumulative frequency of the table of eigenvalues. (Table 4).

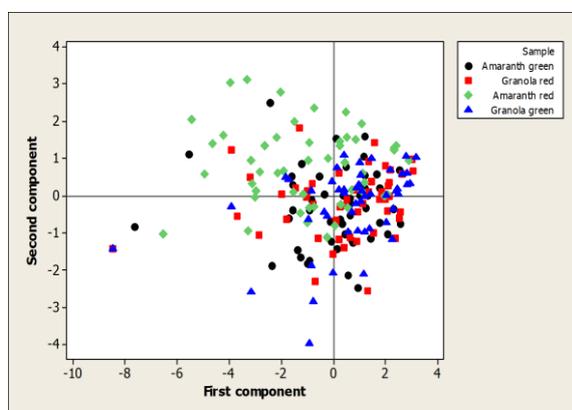


Figure 1. Comparison of the first major component versus the second major component in sensory analysis of samples of four bars of cereal with prickly pear fruit (*Opuntia ficus indica*).

Table 4. First three principal components of the sensory analysis of four bars of cereal with prickly pear fruit (*Opuntia ficus indica*).

Variable	PC1	PC2	PC3
Appearance	0.260	0.508	-0.474
Color	0.308	0.300	-0.521
Hardness	0.183	0.606	0.566
Palate consistency	0.361	0.092	0.330
Pleasant smell	0.365	-0.091	-0.000
Cactus taste	0.262	0.064	0.267
Sweet taste	0.376	-0.302	-0.036
Pleasant taste	0.407	-0.306	0.031
General taste	0.406	-0.282	-0.018

IV. CONCLUSION

It was found that both varieties of prickly pear fruit are statistically equal in nutritional content differing only in the content of total sugars ($p = 0.05$). Four different formulations of bars added with

dried prickly pear using the red and green varieties were developed. A sensory analysis was carried out on the different bars all of which were positively accepted by the judges. The bars of amaranth and green tuna and granola and green and red tuna had the highest acceptance ($p = 0.05$). The parameters that were most important in the selection by the untrained judges were: consistency on the palate, pleasant smell, sweet taste, pleasant taste, and general taste.

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