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Sensory analysis of jelly from prickly pear cactus fruit *(Opuntia ficus indica*)

Evaluación sensorial de gelatinas de tuna (*Opuntia ficus indica*)

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Technological innovation: New functional food suitable to people with no transmittable chronic disease.

Area of application: Food conservation which allows to extend tuna shelf life as a raw material; Development of new functional low calories products suitable to people with no transmittable chronic disease.

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Resumen

En las últimas décadas, el sobrepeso, la obesidad y la diabetes se han considerado una amenaza latente en el sector de la salud, ya que según la Organización Mundial de la Salud (OMS), cada año esta epidemia global cobra la vida de 2.8 millones de personas alrededor del mundo. Actualmente la prevención y el control de estas enfermedades se han vuelto una prioridad. Uno de los aspectos más importantes de la prevención es la buena nutrición, debido a esto, la creación y desarrollo de alimentos saludables para ayudar a la población en riesgo una actividad muy importante. El objetivo del presente trabajo fue desarrollar un alimento adaptado a las necesidades nutricionales de las personas con enfermedades crónicas no transmisibles, en particular la diabetes. Se elaboró una gelatina a base de tuna (*Opuntia ficus-indica*). Se eligió la tuna porque se ha reportado que algunos vegetales, incluido el nopal, modulan los niveles de azúcar en la sangre y se han utilizado los extractos de nopal en varias partes del mundo para controlar la *diabetes mellitus* como parte de la medicina alternativa. Se evaluaron dos variedades de tuna (verde y roja). En el análisis proximal, la variedad roja presentó un mayor contenido de azúcar (15.5 %). Para la formulación de la gelatina, se utilizaron 2 edulcorantes diferentes, azúcar y estevia. Se realizó un análisis sensorial de componentes principales de 4 gelatinas de tuna (*Opuntia ficus-indica*) mediante un panel de jueces

no entrenados. Los parámetros más importantes en la elección de los consumidores fueron: consistencia del paladar, sabor a cactus, sabor dulce, sabor agradable y sabor general. La gelatina de tuna variedad roja con azúcar fue la preferida por los jueces (p = 0.05), todas las formulaciones probadas tienen potencial en la industria de los alimentos debido a que tuvieron valores de aceptación positivos.

Palabras clave: diabetes, alimentos funcionales, gelatina de tuna, sensorial, sabor dulce.

Abstract

In the past decades, overweight, obesity and diabetes have been considered a latent threat in the health sector, since according to the World Health Organization (WHO), each year this global epidemic claims the lives of 2.8 million people around the world. Today the prevention and control of these diseases is a priority. One of the most important aspects of prevention is the food, due this the creation of healthy foods to help the population at risk it's a very important development and activity. The aim of the present work was to develop a food adapted to the nutritional needs of people with chronic diseases, in particular diabetes. In the present investigation a jelly based on prickly pear (*Opuntia ficus-indica*) was elaborated. Prickly pear was selected because medicinal plants including the prickly pear cactus have been reported to modulate blood sugar levels and the extracts of prickly pear cactus have been used in various parts of the world to manage diabetes mellitus. Two varieties of prickly pear were evaluated, (green and red). In the proximal analysis the red variety had the high sugar content (15.5 %). For the formulation of prickly pear jellies 2 different sweeteners where used, sugar and stevia. Un-trained panel performed sensory test and principal components of four jellies of prickly pear (*Opuntia ficus-indica*) was carry out. The evaluated parameters according to consumer preference were palate consistency, cactus taste, sweet taste, pleasant taste and general taste. The products had a positive acceptance in the sensory tests. The red prickly pear fruit with sugar was the preferred by the judges (p = 0.05).

Key words: diabetes, functional food, prickly pear fruit, sensory analysis, sweet taste.

1. Introduction

Currently there is a high interest in consuming natural foods that contribute to maintaining an optimal state of health, within which is the cactus pear (*Opuntia ficus-indica*), commonly known as prickly pear, belongs to the family *Cactaceae* [1,2]. Family *Cactaceae* is reported to contain about 130 genera and nearly 1500 species [1-3] which were originally native to America [4,5]. It is widely distributed in all American hemispheres as well as in Africa and in the Mediterranean basin [5, 6,7,]. Cactus is found wild in arid and semiarid regions, it produces sweet and nutritionally rich edible fruits [2,5]. The fruit is a berry, varying in shape, size and color and has a consistent number of hard seeds. The fairly high sugar content and low acidity of the fruit [3] make it very sweet and delicious. The fruit, as well are used to prepare value-added products, such as jam, juice, wine, pickle, jelly, and more recently supplements, many of them with associated health claims [2,9].

The functional characteristics of cactus pear have raised interest in the international markets [10,11], since they are beneficial for the treatment of various diseases [10] as diabetes mellitus because it can regulate the

levels of sugar and cholesterol in the blood [12-15]. Recent studies in cactus pears have shown notable antioxidant activities [9,13,16,17,18] which suggest that its consumption may reduce significantly the oxidative stress in patients and may help in preventing non-communicable diseases [16,18,19]. In specific, the fruit of cactus pear commonly called prickly pear, contain pigments such the betalain, [18, 20] which has a good potential for the use as a natural food colorant. This fruit contains also red-violet betacyanins in addition to the yellow betaxanthins [3,15,21] which are good antioxidants. Consumption of prickly pear affects positively the body's redox balance, decreases oxidative damage to lipids, and improves antioxidant balance in healthy humans [17, 21-24]. Prickly pears are also a source of vitamin C [19], minerals and soluble and insoluble fiber [10,11].

As prickly pear presents some problems in the conservation [17], and in crop period the losses are intensified by lack of technological alternatives, the processing of fruits in the jelly form presents a quite viable form to adding value [25].

Jelly is a good option in the conservation of cactus pear fruit because it allows a long shell life, providing an adequate texture due to its water retention capacity [26]. It can be made using pieces of pulp or fruit juice, added sugar [25], or some other sweetener like stevia, grenetine and water. Stevia (*Stevia rebaudiana*) can be used in the manufacture of jelly, resulting in a good alternative for people with noncommunicable diseases as the diabetes since it has been reported reduce the excess of glucose in the blood and enhance insulin secretion in albino rats [27, 28].

Stevia rebaudiana is an herbaceous perennial plant of the Asteraceae family, native to Paraguay (South America) [29-31]. The Stevia rebaudiana, produces stevioside, a non-caloric sweetener that does not metabolize in the human body [31]. This stevioside is present in the leaves and stem tissues of stevia [30, 32], it was first seriously considered as a sugar substitute in the early 1970s [31], it is 200 or 250 times sweeter than sucrose [32, 33] and is a good alternative to the synthetic sweetening agents available to the consumers.

Stevia rebaudiana may help in the prevention of various chronic and non-chronic diseases as diabetes, cardiovascular disease, cancer, renal disease, obesity, inflammatory bowel disease, dental caries [29, 33], diarrheal [30], and immunological disorders [34]. Stevia leaf extract has been used traditionally in the treatment of diabetes [29,33]. The aim of the present work was to evaluate the sensory characteristics of four jellies, of cactus pear fruit (*Opuntia ficus indica*) red and green varieties with sugar and stevia (*Stevia rebaudiana*) and your comparison.

2 Material and Methods

2.1 Manufacture of cactus pear fruit jelly

Prickly pear (*Opuntia ficus índica*) was purchased from a store in the municipality of Piedras Negras, Coahuila, Mexico in august of 2018. Four jellies, of cactus pear fruit were made. 500 g of prickly pear were washed and disinfected, peeled, cut into pieces and placed in the blender with 200 mL of water, the sample was liquefied for 15 seconds at maximum speed, 12 g of grenetine were added for every 200 mL of prickly pear juice and placed to hydrate in 100 mL of water for 5 minutes. It was heated in a water bath until obtaining a liquid consistency. Then it was proceeded to mix with the juice of tuna (Cactus pear fruit in spanish) obtained previously. Sweetener was added, using 5 g of sugar or 0.15 g of stevia per100 mL of juice. Finally, the samples were refrigerated

until the gelatin solidified and acquired the right consistency. Once ready, the sensory evaluation was performed.

2.2 Nutritional analysis of cactus pear fruit jelly

A nutritional analysis of the samples was carried out in which total fat, total sugars, dietary fiber and protein were determined [35]. In addition, the percentages of some vitamins and minerals were determined through established nutritional tables of Mexican System of Food [36].

2.3 Sensory analysis of jellies of cactus pear fruit

Sensory analysis of principal components of four jellies of prickly pear (*Opuntia ficus indica*) was performed by un-trained panel composed of 50 panelists. The distribution in age was in range between 17-42 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 hedonic scale was used from 1 to 7. Being 1 dislike very much and 7 like very much and 3 was the rejection point. The attributes of appearance, color pleasant, consistency, palate consistency, smell prickly pear, pleasant smell, prickly pear taste, sweet taste, pleasant taste and general taste were evaluated.

2.4 Experimental analysis

For the analysis of the nutritional analysis of jellies of prickly pear (*Opuntia ficus indica*), a multiple comparison test of Tukey HSD (p=0.5) was used. Sensory analysis data were analyzed using a Kruskhal-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

3. Results and Discussion

3.1 Analysis of nutritional content

Four jelly of prickly pear (*Opuntia ficus indica*) with sugar and stevia (*Stevia rebaudiana*) were nutritionally evaluated. It was determined that for each 64 g of jelly of prickly pear fruit, with sugar the product has energy value of 29.17 Cal, equivalent to 122.13 KJ, this energy was obtained of: 0.15 g of total fat, 5.86 g of carbohydrates and 1.57 g of protein and for each 64 g of jelly of prickly pear fruit with stevia, the product has energy of 20.69 Cal, equivalent to 86.62 KJ, this energy was obtained of 0.15 g of total fat, 3.68 g of carbohydrates and 1.57 g of protein (Table 1) resulting a product with low number of calories and sugars so it is also a product suitable for people with chronic diseases. It can be consumed as part of the breakfast or as a snack for those people who want without risk of increase your levels of sugar in blood.

3.2 Sensory analysis of jelly of prickly pear fruit

The sensory analysis data of the four jellies of prickly pear (*Opuntia ficus indica*) elaborated in the present project are shown in table 2. The samples elaborate with red prickly pear fruit had a major acceptance in the general taste (p=0.05) of the judges. The four samples showed significant differences (p=0.05) in some of the evaluated parameters, such as appearance, color, consistency, palate consistency, cactus taste, sweet taste, pleasant taste and general taste. The red prickly pear fruit with sugar and stevia, had the highest

acceptance in those parameters, this because they had a higher content of monosaccharides as glucose and fructose [37] which gave them a more pleasant sweet taste [38] and this influence in the acceptance of the product by the consumer [37-39]. However, all formulations had positive acceptance values and have development potential in the food industry.

Psychophysical studies have shown that the preference for sweet taste is universal and is more evident in younger ages of people [36]. More of judges in sensorial evaluation are young adults and some papers have described sweet taste preference among young adults, and although the taste for sweet flavors start lowing during adolescence this is still a preferred flavor and this could had influenced the result of the choice of red prickly pear fruit [37-41]. The judges did not distinguish between sugar and stevia because the taste of prickly pear fruit hidden the flavor remnant of stevia.

Palate consistency was an important parameter in the selection by the judges because the consistency and texture are of the sensory properties of foods that play a major role in consumer appeal, buying decisions and eventual consumption. It was found to be one of most dominant attribute of consumer preference of foods [42].

Principal component analysis (PCA) is the most widely used multivariate statistical tool in sensory analysis. The first principal component corresponds to the first eigenvalue and thus explains the largest percent of the total variability in the data, the second PC follows in the percent of the variance explained and it is not correlated with the first principal component and so on [43].

The statistical principal component analysis (PC) of four jellies of prickly pear (*Opuntia ficus indica*) (Table 3) shows that 80 % of the variation is explained by the principal components PC1, PC2 and PC3. The PC1 was influenced by attributes of palate consistency, cactus taste, sweet taste, pleasant taste and general taste. The PC2 was affected by appearance, color, consistency, and PC3 by cactus smell and pleasant smell (Table 4).

Table 1. Nutritional data of jelly of green prickly pear (*Opuntia ficus indica*).
* Based on a diet of 2000 Calories.

Nutritional facts	Green sugar	Green stevia	Red sugar	Red stevia
Energy	29.17 Cal/122.13 KJ	20.69 Cal/86.62 KJ	29.17 Cal/122.13 KJ	20.69 Cal/86.62 KJ
Protein (g)	1.57	1.57	1.57	1.57
Sugar (g)	5.86	3.68	5.86	3.68
Fiber (g)	1.12	1.12	1.12	1.12
Total Fat (g)	0.15	0.15	0.15	0.15
Vitamin A (µg RE)	1.55	1.55	1.55	1.55
Ascorbic acid (mg)	6.81	6.81	6.81	6.81
Iron (mg)	0.8	0.8	0.8	0.8
Sodium (mg)	4.04	3.41	4.04	3.41
Potasium (mg)	68.06	68.06	68.06	68.06

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

Sample	Tukey analysis HSD 0.05				
	Appearance	Color	Consistency	Palate consistency	Cactus smell
Green sugar	4.70^{c}	4.84^{b}	4.58^{b}	4.24^{b}	5.00^{a}
Green stevia	5.10^{bc}	4.94^{b}	5.16^{ab}	4.22^{b}	5.22^{a}
Red sugar	5.46^{b}	6.02^{a}	5.10^{ab}	5.38^{a}	5.58^{a}
Red stevia	6.20^{a}	6.34^{a}	5.48^{a}	5.08^{ab}	5.42^{a}
Sample	Tukey analysis HSD 0.05				
	Pleseant smell	Cactus taste	Sweet taste	Pleasant taste	General taste
Green sugar	5.26^{a}	4.74^{b}	4.48^{b}	4.28^{bc}	4.32^{bc}
Green stevia	5.18^{a}	4.28^{b}	3.52^{c}	3.60^{c}	4.12^{c}
Red sugar	5.62^{a}	5.54^{a}	5.44^{a}	5.56^{a}	5.00^{ab}
Red stevia	5.56^{a}	5.06^{ab}	4.64^{ab}	4.68^{b}	5.68^{a}

By plotting (Figure 1) the results of the first major component against the second, there is no defined trend as to which of the two jellies of red prickly pear (*Opuntia ficus-indica*) were the best samples for the consumer, which is a positive aspect because it means that both samples had approximately the same acceptance and can be used according to the taste of the consumer, with similar beneficial health effects due to its low sugar content and a person with a chronic disease and very limited requirement of sugar to take the alternative of jelly made with stevia (*Stevia rebaudiana*).This is consistent with the Tukey test of the general taste parameter p=0.05.

Table 3. Values of sensory analysis of four jelly of prickly pear (*Opuntia ficus indica*).

Number	Eigen value	Proportion	Proportion Accumulated
1	5.374	0.537	0.537
2	1.594	0.159	0.697
3	1.036	0.104	0.800
4	0.631	0.063	0.863
5	0.348	0.035	0.898
6	0.275	0.028	0.926
7	0.240	0.024	0.950
8	0.213	0.021	0.970
9	0.174	0.017	0.988
10	0.115	0.012	1.000

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

Variable	PC1	PC2	PC3
Appearance	0.262	-0.509	-0.191
Color	0.271	-0.412	-0.254
Consistency	0.277	-0.325	-0.251
Palate consistency	0.345	-0.041	-0.215
Cactus smell	0.279	-0.205	0.610
Pleseant smell	0.301	-0.129	0.592
Cactus taste	0.353	0.265	0.122
Sweet taste	0.345	0.311	-0.053
Pleasant taste	0.352	0.367	-0.150
General taste	0.356	0.322	-0.162

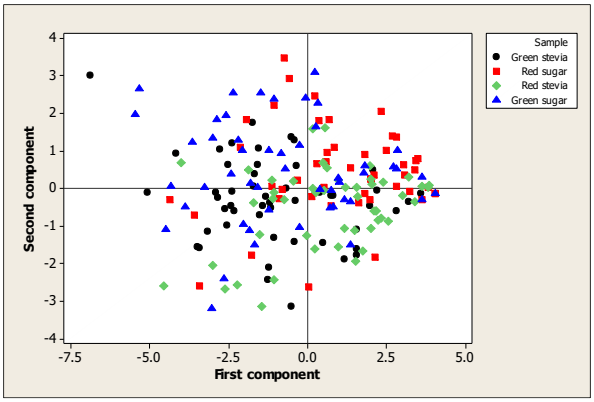

Figure 1. Comparison of the first major component versus the second major component in sensory analysis of samples of four jelly of prickly pear (*Opuntia ficus indica*).

4. Conclusions

Red prickly pear jelly with sugar and stevia was the preferred by the judges (p = 0.05), all jellies had a general positive acceptance and they have industrial potential. The most important parameters in the choice of consumers were: palate consistency, cactus taste, sweet taste, pleasant taste and general taste. Red prickly pear had significantly more sugar that green prickly pear. The preferred sweet flavors taste among young adults could have influenced the results of the test.

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