Innovation and development of a new snack based on blue corn and grasshopper.

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ABSTRACT

Objective: Develop a similar snack to marzipan, with higher nutritional quality by adding protein to provide a healthy consumption alternative.

Design/methodology/approach: A snack made from blue corn flour, grasshopper, agave honey and cocoa was elaborated. The proportions of the aforementioned ingredients were modified in four different formulations. Acceptance tests were conducted with 140 individuals to determine the formulation with the highest degree of approval and laboratory tests were carried out to determine its nutritional quality.

Results: In this research it was possible to develop an innovative nutritional product such as marzipan containing protein, which had a 72% acceptance rate by the participants in the sensorial test. Furthermore, it was managed to use a carbohydrate source from blue corn, which is low on the glycemic index. On the other hand, an attractive packaging design was proposed to capture the consumer's attention, so not only a nutritious snack was developed, but also a marketing package was proposed for its commercialization.

Limitations on study/implications: During the development of this product, no preservatives were used, therefore the shelf life for this product is shorter if no preservatives are added.

Findings/conclusions: A considered functional snack was successfully developed which also has great potential for becoming a distinguished quality product since it is made with local ingredients from the region or country. The product was well accepted; besides it was suggested a packaging for its preservation and distribution.

Keywords: Corn, grasshopper, agave honey, cocoa

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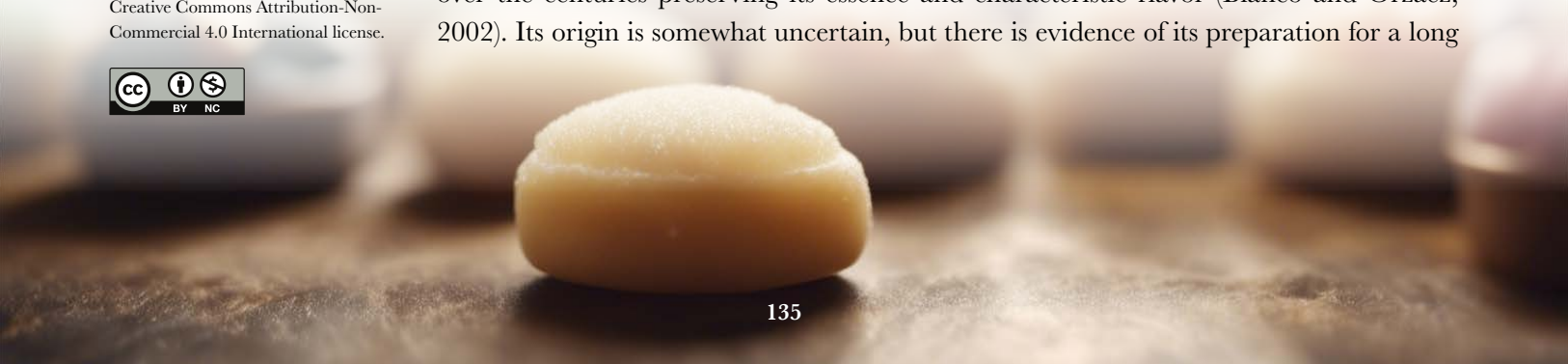
INTRODUCTION

The marzipan is a sweet food product mainly for its high sugar content, it is considered as a dessert. This product is traditionally made from a mixture of almonds, peanuts or nuts and sugars, in the market there are different derivatives of this product that has endured over the centuries preserving its essence and characteristic flavor (Blanco and Orzáez, 2002). Its origin is somewhat uncertain, but there is evidence of its preparation for a long



time, for example, in medieval times, specifically in Venice, it was known as "marzipane", although older records describe it as a preparation based on almonds, sugar and oil carried out by the Arabs in the 10th century. The current term "marzipan" possibly has a Spanish origin, since it is described as a dessert in the festivities of Toledo, where in the absence of wheat, the nuns devised this sweet taking advantage of the sugar and almonds abundance, which were peeled and crushed together with the sugar using wooden mallets in stone mortars, obtaining a mixture that once baked would give rise to the marzipan (Blanco and Orzáez, 2002). The name has been kept in Spain until present, deriving from the word *maza*, in reference to the tool used to crush the almonds, sugar, and bread, which is the product aimed to obtain (Blanco and Orzáez, 2002). Nowadays and due to the different alterations that the product underwent over the years since its arrival to Mexico, such as the substitution of almond flour for peanut flour in order to make the product more economical, marzipan has become a typical Mexican sweet because of its great recognition and acceptance among the population at large.

Mexico is the second country in Latin America with the highest consumption of sweets, where *per capita* consumption was estimated at 4.5 kg from January to August 2018. Marzipan is one of the highest consumed products with a 15.9% increase (Higuera-Albarrán, 2021). Excessive intake of this sweet can result in consumer disorders such as: dental damage, increased appetite and weight, but sugars can also cause the pancreas to produce more insulin, responsible for transforming food into energy, which can lead to obesity, diabetes, among many other negative health aspects (Carbajal-Azcona, 2013). This over-consumption is related to unhealthy weight gain, development of diabetes and hypertension, as well as cardiovascular diseases. Therefore, the purpose of this project was to design, produce and analyze a similar product to marzipan with healthier components. Almonds were replaced by blue corn flour and grasshopper flour, which are the basis of the product, providing a source of carbohydrates and protein. Sugar was replaced by agave honey, which has been reported to have a prebiotic capacity and a low glycemic index compared to other natural syrups and honeys (Mellado and López, 2013), mainly due to the fructans present in agaves, especially insulin. In addition, it was decided to incorporate a touch of cocoa, in order to balance the flavor that could be influenced by the presence of grasshoppers and also to add sources of fatty acids. The idea was to create a product that would be a nutritious food, rather than a candy or a sweet, so that it could be consumed by the population as a healthy product, including those people with conditions related to glycemic control, diabetes, overweight, among other factors, as long as it is not consumed in excess.

To design this product, blue corn (*Zea mays* L.) was incorporated in its formula, offering some interesting nutritional features such as: a lower amount of starch, a lower glycemic index than conventional corn and a protein content up to 20% higher than that of white corn. On the other hand, this type of corn has nutraceutical properties related to its high content of anthocyanins which have a beneficial effect on health, due to their antioxidant activity, reduce mutagenesis and the proliferation of cancer cell growth, and anti-inflammatory, in addition, corn grain anthocyanins have a protective action against nephropathies that develop in patients with type 2 diabetes (Agama-Acevedo *et al.*, 2011).

Regarding the incorporation of grasshopper meal (*Sphenarium purpurascens* Charpentier) this edible insect is a devastating pest in central and southern Mexico (Guzman, 2018), however, if it is collected and used as food it can provide between 55 to 77%, of protein, given that these insects consume plants that have 4 to 14% of protein on a dry basis, it is obtained from 5. 5 to 17.5 times more than the protein content of animal origin combined an excellent quality, contains essential amino acids such as lysine, valine, threonine and isoleucine, it is rich in vitamin B and minerals such as sodium, potassium, phosphorus and calcium, (Ramos-Elorduy *et al.*, 2012; Van Huis *et al.*, 2013; Melo-Ruiz *et al.*, 2015; Aragón-García *et al.*, 2018). This protein is environmentally friendly as the production is less polluting than meat form cattle. Agave honey, from the *Agave tequilana*, provides a high content of fructo oligosaccharides, components that facilitate the proper functioning of the intestinal system, and can provide higher quality energy than refined sugars or industrial sweeteners. The cocoa (*Theobroma cacao*), is a tree that grows in many countries in the Americas, as Mexico. Chocolate is obtained from its seeds and it has been documented that it has more than 300 compounds with diverse beneficial activities for human health, including some with antioxidant activity, hypoglycemic, anti-inflammatory, with potential applications to mitigate diabetes (Kababie-Ameo *et al.*, 2022) was added to avoid the predominance of the grasshopper flavor, besides the fact that it is a source of fatty acids. Due to the characteristics of the raw material used in this product, this development can be considered a distinguished quality product because its manufacture uses raw material obtained in a sustainable and natural way, resulting in high quality products, and it can also be classified as a functional food because it contains anthocyanins that inhibit free radicals, which are known to be involved in the development of certain diseases.

MATERIALS AND METHODS

Formulation desing: This project was conducted in the Department of Food Science laboratories of the Universidad Autónoma Metropolitana-Unidad Lerma. The grasshoppers were recollected in Hidalgo State, México, which were dried in an oven, then crushed and ground in a porcelain mortar. The blue corn was purchased in San Miguel Totocuitlapilco, a town located in Metepec, Edo. de México and it was shelled, toasted, milled and crushed in a porcelain mortar. The agave honey used was of the brand "Tía Ofilia" marketed as organic agave syrup and the cocoa used was purchased at the central supply center, roasted and milled. With these four basic ingredients, four different formulations were developed, varying the proportions of each one of them.

Sensory evaluation: For the sensory analysis of the four proposed formulations, the effective method with a 9-point hedonic scale was applied. In this analysis, the following attributes were measured: flavor, colour, odor, sweetness, texture in the mouth and global acceptance.

Nutritional evaluation: To determine the nutritional quality of the developed product, tests were carried out to determine: carbohydrates, proteins, crude fiber, ashes and humidity content using the methods described in Association of Official Analytical Chemists (AOAC, 1984).

Product name and packaging proposal: In order to have an attractive name to identify this product, the Namelix website was used, which suggests names based on the combination of words that are entered on the website. The circular-shaped snack, silicone molds were used, which were filled with 30 grams of the formulation, then manual pressure was exerted and the blocks obtained were covered with food grade aluminum foil, labeled and stored in boxes.

RESULTS AND DISCUSSION

This project was carried out with the purpose of developing a product that has the necessary features to be considered a nutritious snack, rather than a candy when compared to the traditional marzipan. Since our country occupies the fifth place worldwide in obesity and has the seventh place in diabetes in the world and the second place in Latin America, also on international ranking, it is of great significance that in national government policies a goal is to ensure the population health, by showing the food products labeled information that shows the amount of sugars, fats, sodium and other food components that are above the parameters considered to be healthy and necessary for a wholesome growth and lifestyle, and that are needed to be consumed in the daily diet.

In this project, a similar product to marzipan was designed and produced, using ingredients that make it healthier. Figure 1 shows the general diagram for snack production.

The idea behind the product was to reduce the sugar levels and to increase the amount of protein in order to elaborate a product that had the potential to be considered functional and of differentiated quality. For this reason, local ingredients were used, and because of this, blue corn (*Zea mays* L.) was selected. This type of corn is nutritionally of better quality than white corn due to its nutritional quality, which is up to 20% higher in proteins. It also has anthocyanins, which are key molecules since they are antioxidants that help to degrade free radicals, which are highly reactive and in

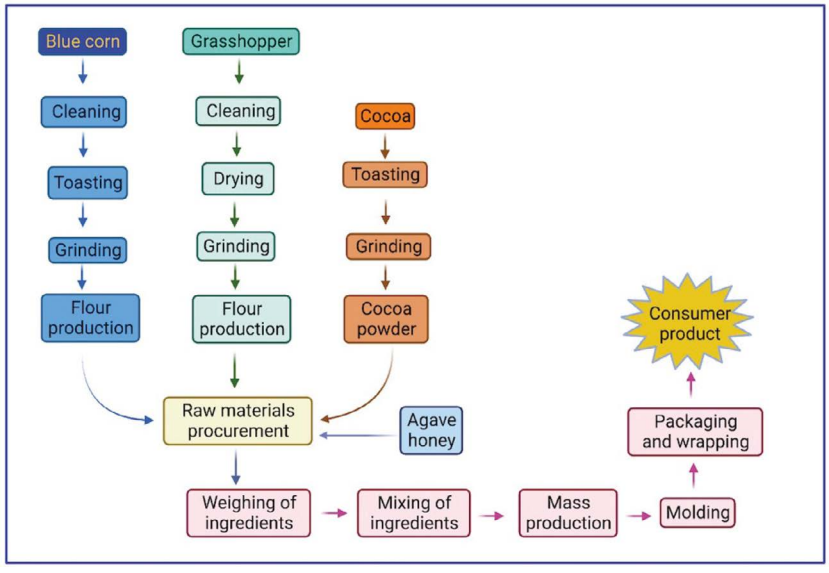


Figure 1. Flowchart used for the production of Mazalín.

extreme situations promote the appearance of cancer cells, therefore, this product can be considered as functional, as it not only fulfills a nutritional role, but it can also help in health protection. Furthermore, the grasshopper (*Sphenarium purpurascens* Charpentier) was chosen as a source of protein, because it was necessary to substitute the excess of carbohydrates in traditional marzipan with a protein source, besides the fact that this insect is deeply rooted in Mexican gastronomy and although its consumption remains popular, it is clear that younger generations in our country do not integrate it into their diet regularly, either by cultural issues, habit or aberration towards insects. In this product, the insect is milled, which is why it is not perceptible to the naked eye. To provide an attractive taste for the consumer, it was decided to use honey from the blue agave (*Agave tequilana* Weber var. azul), which is known to have a sweetening capacity of 1.4 times greater than common sugar, used in sweetening processes, and has a low glycemic index, which prevents increases in blood glucose. Lastly, the fourth ingredient was cocoa (*Teobroma cacao*), employed to balance the product's flavor, as well as for being a source of vegetable fats.

Table 1 shows the following four different formulations that we proposed.

To determine which of the four proposed compositions had the greatest acceptance among consumers, 140 acceptability tests were conducted, used a nine-point hedonic test was carried out allowing a sensory evaluation of the snacks in question; the evaluated categories and the scale used to measure each attribute are shown in Table 2.

From the results it can be seen that the most accepted formula was number 2 with 72.37% acceptance, followed very closely by formula number 1. Formulations number 3 and 4 were in third and fourth position with an acceptance of 67.83% and 67.64%, being

Table 1. Composition of the four different formulations.

Ingredients (%)	Formulations			
	1	2	3	4
Corn flour	63	60	62	69
Grasshopper flour	2	3	4	4
Agave honey	2	3	2	2
Cocoa	33	34	32	25

Table 2. Attributes evaluated using a 9 point hedonic scale.

Attribute	Level of acceptance
Flavor Colour Odor Sweetness Mouth texture General acceptance	1.- I extremely dislike 2.- I dislike it a lot 3.- I dislike moderately 4.- I slightly dislike 5.- I do not dislike or like it 6.- I slightly like 7.- I moderately like 8.- I really like it 9.- I extremely like

almost equal (Figure 2A). Various parameters were determined in the acceptability test such as odor, color, flavor, sweetness, mouthfeel and overall acceptability are presented in a radial plot, Figure 2B. It is observed that the most balanced formulation is formulation two (green). From the six parameters analyzed, five are balanced, odor being one of the weakest, for which it is proposed to use more cocoa or to use another fifth ingredient to improve this sensory characteristic perceived by the sense of smell.

For this reason, the nutritional analyses were conducted on formulation number 2, determining the carbohydrates, ether extract, proteins, crude fiber, ashes and humidity content. The results of the nutritional parameters are shown in Table 3 and reveal that proteins are in higher proportion than in commercial marzipan, these results suggest that the snack created in this project is healthier than traditional marzipan, as it has a higher carbohydrates content. The high protein value present in the product developed in this project is due to the use of grasshoppers, as well as the use of blue corn, which also contributes to increase the protein content. A commercial peanut-based marzipan was used as a control to determine these parameters.

To ensure this product does not only remain in a development stage, it was decided to find a name for its possible commercialization. On the Internet are different websites

A

Acceptance of formulations

Formulation	Percentage of acceptance	SD
1	70.28	0.87
2	72.37	0.41
3	67.83	0.32
4	67.74	0.29

B

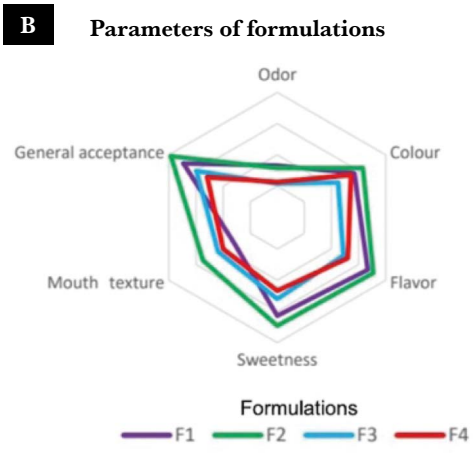


Figure 2. Statistical analysis of sensory tests. Panel A, shows the percentage of acceptance with the standard deviation of the four formulations. Panel B, is a radial plot showing the six parameters evaluated (odor, colour, flavor, sweetness, mouth texture and general acceptance) in the four formulations.

Table 3. Mazalin nutritional content.

Composition %	Control (commercial)	Foremulation 2
Carbohydrates	73.50±0.62	55.3±0.77
Proteins	5.47±0.23	17.03±0.47
Crude fiber	0.19±0.02	3.58±0.03
Ashes	1.02±0.03	2.65±0.41
Humidity	1.56±0.07	1.87±0.09

focused on business, providing names suggestions for newly created products, so it was used the website: http://www.namelix.com and based on the ingredients used, the site provided several alternatives for this product. To select the most suitable name, it was conducted a survey in which 50 people were given the opportunity to taste the product and to choose a name from the five options provided. The 85% chose the name *Mazalín* as they considered it to be the best option, since it is formed with the combination of *mazapán* and *chapulín* (grasshopper). With this progress, it was also considered the possibility of incorporating an attractive design that would give a distinctive feature to the snack, allowing its recognition as well as indicating its composition and nutritional information. It was decided to use food grade aluminum as the packaging to be in contact with the snack to protect it and prevent dehydration. In addition, the product logo label was placed on top and the nutritional information table was added on the reverse side. The snack packaging can be seen in Figure 3. It was also considered to design a box that could transport and contain several snacks while protecting them during transportation and storage, but that would also be eye-catching for the consumer. Different prototypes of boxes were made and it was decided to use the prototype shown in Figure 3.

This box has measures of 15.2 cm long, 11.3 cm wide and 3.4 cm high. The boxes contain 12 pieces. A major feature of this box is that the product can be visualized inside because, although it is mostly made of cardboard, the upper part has a space of 6 cm×10.6 cm cut out and covered with acetate-type plastic, so that the distribution of the snack can be seen inside it. Finally, we worked on a label for the individual pieces in the canva program.

Figure 3. Proposed package for mazalin gold aluminum wrapper with front label. Gold-plated box in which a total of pieces fit.

CONCLUSIONS

In this project a higher nutritional quality product than the traditional marzipan was developed due to the incorporation of blue corn and grasshopper flour, a better source of carbohydrates was obtained because blue corn is of greater quality than other types of corn, besides the fact that it was possible to avoid the use of common sugar, which was replaced by agave honey. The taste of the grasshopper was reduced by adding cocoa, and it also served as a source of vegetable fats, so the product developed is more like a food than a candy. In addition, the ingredients have low glycemic index, such as antioxidant and anti-inflammatory activity, leading the snack to be a functional food. Finally, a packaging and box was designed for its preservation and transportation, which was very attractive to the potential consumer.

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