Evaluation of cookies made with bean flour

Evaluación de galletas elaboradas a base de harina de frijol

Avaliação de biscoitos feitos de farinha de feijão

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Abstract

The common bean (*Phaseolus vulgaris* L.) is a legume rich in protein, carbohydrates, vitamins, and minerals that can be used for food processing. The objective of this study was to evaluate the acceptance of cookies made from bean flour by consumers in Zacatecas, Mexico, for which four formulations of cookies with different combinations of bean flour were prepared. The information was obtained from a sample of 398 consumers over 18 years of age in Zacatecas, Mexico, and was analyzed by multidimensional scaling. In general, the quality attributes relevant to consumers were size, aroma, sweetness, texture, color, consistency, and flavor. Cookie number 873 obtained higher consumer acceptance and its ingredients were 90 % bean flour, 10 % whole wheat flour and walnut. Therefore, the results of this research showed that cookies made from bean flour could be a feasible alternative that allows providing more nutritious food to the Mexican population.

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Resumen

El frijol común (*Phaseolus vulgaris* L.) es una leguminosa rica en proteínas, carbohidratos, vitaminas y minerales que puede utilizarse para la elaboración de alimentos. El objetivo de este estudio consistió en la evaluación de la aceptación de galletas elaboradas a base de harina de frijol por parte de consumidores en Zacatecas, México, para lo cual se elaboraron cuatro formulaciones de galletas con diferentes combinaciones de harina de frijol. La información se obtuvo de una muestra de 398 consumidores mayores de 18 años de Zacatecas, México y se analizó por escalamiento multidimensional. En general, los atributos de calidad relevantes para los consumidores fueron el tamaño, aroma, dulzura, textura, color, consistencia y sabor. La galleta número 873 obtuvo mayor aceptación por los consumidores y sus ingredientes fueron 90 % harina de frijol, 10 % harina de trigo integral y nuez. Por lo tanto, los resultados de esta investigación mostraron que las galletas elaboradas a base de harina de frijol podrían ser una alternativa factible que permite aportar alimentos más nutritivos a la población mexicana.

Palabras clave: producto agroalimentario, harina de frijol, análisis sensorial.

Resumo

O feijão comum (*Phaseolus vulgaris* L.) é uma leguminosa rica em proteins, carbohydrates, vitaminas e minerais que pode ser usada para a transformação de alimentos. O objetivo deste estudo foi avaliar a aceitação de biscoitos à base de farinha de feijão pelos consumidores em Zacatecas, México, para os quais foram desenvolvidas quatro formulações de biscoitos com diferentes combinações de farinha de feijão. A informação foi obtida de uma amostra de 398 consumidores com mais de 18 anos de idade em Zacatecas, México, e foi analisada por escalonamento multidimensional. Em geral, os atributos de qualidade relevantes para os consumidores foram o tamanho, o aroma, a doçura, a textura, a cor, a consistência e o sabor. A bolacha número 873 teve a maior aceitação por parte dos consumidores e os seus ingredientes eram 90 % de farinha de feijão, 10 % de farinha de trigo integral e noz. Portanto, os resultados desta investigação mostraram que as bolachas feitas com farinha de feijão podem ser uma alternativa viável que permite fornecer alimentos mais nutritivos à população mexicana.

Palavras-chave: produto agroalimentar, farinha de feijão, análise sensorial.

Introduction

Historically, the common bean (*Phaseolus vulgaris* L.) has been one of the main crops in Mexico, with Zacatecas being the entity that allocates the largest area for the production of this legume (660,566 hectares). In Zacatecas, beans are mainly grown under rainfed land and their yield barely reaches 0.6 kg.h^{-1} (SIAP, 2022).

Although the common bean is part of the diet of the Mexican population and other Latin American countries, its consumption has decreased by 53.4 % in recent years (Sánchez-Toledano *et al.,* 2021). However, this legume contains B vitamins such as niacin, riboflavin, folic acid, thiamine, and pyridoxine; and minerals such as iron, zinc, potassium, magnesium, phosphorus, copper and manganese. It is also an excellent source of dietary fiber (soluble and insoluble), complex carbohydrates (starch) (Bennink and Rondini, 2008) and is a source of polyunsaturated fatty acids (Financiera Rural, 2011). On the other hand, there is scientific evidence that shows that beans contain a variety of phytochemicals, such as polyphenols, trypsin inhibitors, lectins, fiber, and biopeptides, among others that provide health benefits to those who consume them, for example, in the prevention of overweight, obesity, constipation, diabetes mellitus, hypertension, colon cancer, among others (Campos *et al.,* 2009; Díaz *et al.,* 2006).

Thus, the health agencies of the United States of America have defined the traditional Mexican diet as an axis of preventive strategies for public health and recommend the consumption of Mexican foods for their nutritional value and for their ability to protect against certain chronic-degenerative diseases (Garnica *et al.,* 2019). However, Mexico is among the countries with the highest prevalence of obesity (Shamah-Levy *et al.,* 2022). Among the main causes of obesity is the excess consumption of foods and beverages with high energy density, fat, and sugars replacing natural foods (Aburto *et al.*, 2016), as well as prolonged time in front of screens and lack of physical activity (Ruiz *et al.,* 2020; Ochoa *et al.,* 2014). In the adult population, the combined prevalence of overweight (39.1 %) and obesity (36.1 %) affects eight (8) out of 10 people aged 20 years and older (Kanter, 2021). Processed cereals (pasta, cereal box, cookies, among others) have a high consumption in Mexico, in particular, the consumption of cookies per *capita* in the country has reached 12 kg per year. The cookies preferred by Mexican consumers are *Marías*, sandwiches, *saladitas*, crackers, *animalitos*, and those containing chocolate chips (Tena *et al.,* 2021).

Therefore, developing foods commonly consumed by the population with flours from Mexican crops that provide health benefits can be an alternative to improve the diet of the population and in turn, improve the income of producers. Several authors have developed bean-based products such as *totopo* and churros (Figueroa-González *et al.*, 2023), tagliatelle (Sánchez-Toledano *et al.*, 2021), bars and pancakes (Figueroa-González *et al.,* 2015). Limitations in bean starch digestibility classify it as a low-glycemic food, which is advantageous compared to other foods made with wheat (Losada and Morales, 2022; Osorio *et al.,* 2002).

In response to this situation, the Zacatecas Experimental Field belonging to the National Institute of Forestry, Agricultural and Livestock Research (INIFAP) has developed cookies with bean flour, with the consequent decrease in wheat flour. However, the food industry faces a high rate (80 %-90 %) of failure to launch new products. Therefore, sensory analysis techniques help to know the consumer's preferences, desires, and why they accept or reject a product. From this information, new food products are formulated with a clear competitive advantage.

The cookies made from bean flour were subjected to a sensory study so that producers and developers have the certainty that the product or products were tested scientifically. Sensory evaluation is a scientific discipline that measures the properties of products perceived through the senses (Severiano-Pérez, 2019; Stone and Sidel, 2004; Rousset and Martin, 2001). In this regard, Cordero-Bueso (2013) mentioned that sensory studies could be carried out with untrained judges (Hedonic Tasting) and in this case, consumers who frequently consume cookies were chosen.

The sensory analysis technique has been used in several studies around the world to evaluate innovative products before launching them on the market, particularly those foods modified in the traditional way, adding healthier elements or ingredients to make a change in

consumer behavior, for example, in Mexico: mesquite flour cookies (*Prosopis* spp.) (De La Cruz Silva *et al.,* 2021). In this context, the objective of this study was to evaluate the acceptance of cookies made from bean flour by consumers in Zacatecas, Mexico.

Materials and methods

Preparation of bean-based cookies

Four cookie formulations were developed in different bean flour/wheat flour (w/v) ratios as described in table 1. The bean variety used was Pinto Saltillo grown at INIFAP Zacatecas Experimental field.

Table 1. Cookie formulations made with bean flour.

Ingredient	80/20 (Sample 793)	90/10 (Sample 925)	90/10 walnut (Sample 873)	100 % beans (Sample 052)
Bean flour	80 g	90 g	90 g	100 g
Whole wheat flour	20 g	10 g	10 g	0 g
Oatmeal	100 g	100 g	100 g	100 g
Margarine	75 g	75 g	75 g	75 g
Water	50 mL	50 mL	50 mL	50 mL
Pecan nut	0 g	0 g	24 g	0 g
Vanilla	10 mL	10 mL	10 mL	10 mL
Baking powder	1 g	1 g	1 g	1 g
Salt	0.75 g	0.75 g	0.75 g	0.75 g
Cinnamon	0.75 g	0.75 g	0.75 g	0.75 g
Stevia	0.75 g	0.75 g	0.75 g	0.75 g

*Quantities to make 34 cookies of 15 g each.

The first step for the preparation of the cookies was the cleaning of the bean, it was washed with running water, rinsed with purified water, and dried in a laboratory stove (Bosch Brand) at 60 °C for a week in order not to subject the bean to a severe heat treatment. Next, the bean was processed in the pilot plant of the Zacatecas Experimental Field of INIFAP with a stone mill and, once the flour was obtained, it was hermetically stored in a cool, dry place protected from light until its use.

In a bowl, the margarine was melted in a bain-marie, and stevia powder was added until it was homogeneously incorporated. To this mixture, beans, whole wheat, oats, baking powder, cinnamon, and pecan nut flours were added. In another container, salt was dissolved in water and added to the mixture along with the vanilla. All ingredients were mixed manually until a homogeneous mixture was obtained. Subsequently, the mixture was left to stand for 30 minutes in refrigeration. Once the time had elapsed, the mixture was removed, and with the help of 3.4 cm molds the dough was cut to form the cookies. They were placed on a stainless steel tray previously greased with margarine and baked in a stove (Bosch Brand) at 185 ± 2 °C for 40 minutes (figure 1). Finally, the cookies were taken out of the oven,

allowed to cool to room temperature, and packaged in previously identified cellophane bags. Once the cookies were prepared, they were nutritionally assessed using the methods described in the AOAC (2002): moisture (method 925.23), ash (method 945.46), proteins (method 920.105), and fats (method 920.39).

Figure 1. Cookies made with bean flour.

Empirical application

The instrument used for the research was a face-to-face consumer survey conducted in Zacatecas, Mexico, during the months of June and July 2018. The questionnaire used consisted of 17 closed questions. The questions were divided into three sections that allowed to obtain relevant consumer information: 1) knowledge of the product, 2) sensory analysis, and 3) socio-demographic characteristics. Initially, the instrument was validated with a pilot sample of consumers ($n = 20$) to measure the consistency and reliability of the questions through the correlation of the items according to the procedure of Hair *et al.* (1999).

Sampling was performed using the finite populations' formula with a significance level of 95% and a maximum margin of error of 5 % (Grande and Abascal, 2014; Cochran, 1980). Population data were obtained from the National Institute of Statistics and Geography (INEGI, 2020). A total of 398 consumers stratified by age and interested in evaluating bakery products participated.

Consumers assessed, in a blind condition, the acceptability of the four individual samples of cookies. Samples were labeled with three-digit random numbers according to William's Latin square design method (Table 1) (Kwon and Ju, 2018). To assess the acceptance of the participants, extrinsic attributes (appearance, color, size, and aroma) and intrinsic attributes (texture, flavor, softness, and consistency) were used. The samples were presented randomly, following a complete and balanced block design to avoid the bias produced by the effect of the order of presentation of the samples (Di Monaco *et al.,* 2004); In addition, consumers rinsed their mouths with water between samples. Each consumer scored acceptability using a scale from 1 to 9 (1: "I dislike it extremely", 2: "I dislike it very much", 3: "I dislike it moderately", 4: "I dislike it slightly", 5: "I neither like it nor dislike it", 6: "I like it slightly", 7: "I like it moderately", 8: "I like it very much", 9: "I like it extremely").

Data were analyzed with multivariate techniques, in particular, multidimensional scaling (MDS) (Malhotra, 2008) through the ALSCAL procedure of SPSS Statistics (version 21) (Carbonell *et al.,* 2008).

Results and discussion

Description of the sample

The sample of individuals surveyed consisted of 63.7 % women and 32.7 % men. Age was concentrated between 20 and 24 years (16.5 %), followed by individuals aged between 20 and 24 years (14.3 %). However,

the sample included people with greater academic preparation than that manifested at the population level (36.1 %). Gender and age variables were correlated with official population statistics (INEGI, 2020) (table 2).

Table 2. Sociodemographic characteristics of the sample and its national correlation.

Characteristics of the sampled population	Sample (*n*= 398) (%)	Population of the Mexican Republic	(%)
Age			
15-19 years	9.9	15-19 years	9.0
20-24 years	14.3	20-24 years	14.6
25-29 years	6.5	25-29 years	13.0
30-34 years	11.4	30-34 years	12.5
35-39 years	11.6	35-39 years	12.3
40-44 years	9.7	40-44 years	10.3
45-49 years	8.0	45-49 years	8.7
50-54 years	7.5	50-54 years	7.5
55-59 years	8.0	55-59 years	5.7
60-64 years	9.0	60-64 years	4.6
Gender			
Female	63.7	Female	51.2
Male	32.7	Male	48.8
Level of education			
Primary	11.1	Primary	28.1
Secondary school	20.3	Secondary school	23.2
High school	24.9	High school	18.9
University	36.1	University	13.1
Graduate	3.9	Graduate	8.0

*Source INEGI, 2020.

Regarding the knowledge they expressed about commercial cookies, 94.9 % of respondents have bought this product, so they evaluated a known product. As for the frequency of consumption, 33.1 % of respondents consume it at least once a week, followed by twice a month with 24.3 %. The consumption of cookies in Mexico is frequent because cookies are considered a food to eat between meals and not so much as a snack. According to data from CONEVAL (2023) in Mexico, 86 out of every 100 people buy and consume cookies in the corner or convenience store, which is why in the last five years (2016-2020) the production of breadmaking wheat grew 3.7 % at an annual rate (Fideicomisos Instituidos en Relación a la Agricultura, 2021).

The cookie market in Mexico is divided into convenience cookies (e.g. *Gamesa*, *Nabisco, Lara,* and *Marinela*), those consumed as a gratification and gift (*Mac'Ma, Marian*), and, to a lesser extent, imported cookies. However, for consumers who seek to consume healthy products, nutritional bars, and cookies can be an alternative purchase.

Forty-one-point-two percent of consumers say they do not usually look at the product label, followed by 33.6 % who always read the label of the products they buy. Food labeling establishes a means of communication between producers and consumers. Food labels provide nutritional information, size or portion, ingredients, and expiration date (FAO, 2007). In this way, 58 % of consumers mentioned that they prefer to buy cookies in supermarkets, followed by traditional stores (on the corner) with 33.6 %.

Nutritional value of bean cookies

The nutritional quality of a food is directly related to its chemical composition. Table 3 shows the chemical composition of the cookie made from bean flour and a commercial cookie (with oatmeal, vanilla, and sugar-free).

Table 3. Chemical composition of the cookie made from bean flour and commercial cookie.

Sample	Moisture	Ashes	Proteins	Grease
Cookie made from bean flour	3.23 ± 0.26^a	2.51 ± 0.02^a	9.65 ± 0.49^a	3.93 ± 0.61^b
Commercial cookie	2.65 ± 0.13^b	1.80 ± 0.16^b	5.66 ± 0.11^b	9.59 ± 0.07^a

*Results are presented as the mean ± standard error of two experiments with two repetitions each. Different letters between samples indicate significant differences (Tukey α=0.05).

As expected, bean flour presented more protein, fiber, and lower fat content. Likewise, bean flour-based cookies had more protein (9.6 %) and less fat (3.93 %) than commercial cookies (Cruz-Bravo *et al.,* 2015).

Sensory analysis of cookies made from bean flour

The results of multidimensional scaling showed a good fit between the model and the data; two dimensions best explained the spatial distribution with a stress index of 0.057, according to the suggestion of Kruskal (1964).

The analysis graphically showed the preference of attributes by type of cookie (figure 2).

Regarding sample 793, the results indicated that the best valued attribute was size and the least accepted for that cookie was flavor. Regarding sample 925 the most important attributes were size and aroma, on the contrary, the least important attribute was sweetness. However, the sweetness of cookie 052 was the attribute best appreciated by consumers. With respect to sample 873, sweetness, texture, color, flavor, and consistency were the most relevant attributes. These findings are similar to those of other research (De La Cruz Silva *et al.,* 2021; Guzmán *et al.,* 2009), in which participants mentioned that the attribute flavor is usually the most important.

Overall, in food acceptance studies, flavor remains the most important factor (Kim *et al.,* 2020; Kim *et al.,* 2018; Mai and Hoffman, 2012). In addition, when participants know the health benefits of the product they are testing, they rate it with a better score and mention that the probability of choosing it for their next purchases is higher (Buhrau and Ozturk, 2018).
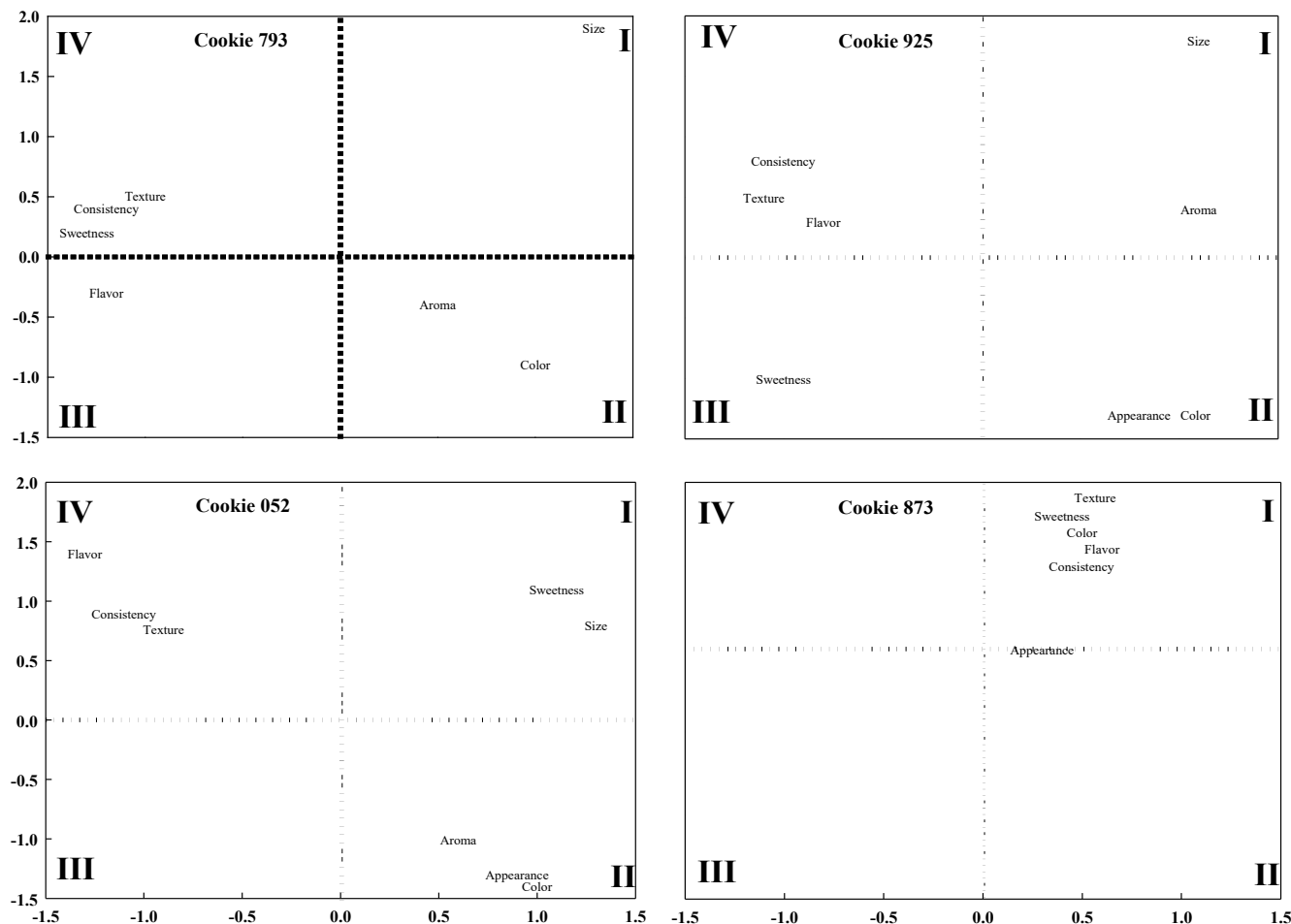
Figure 2. Relevant attributes for consumers about cookies made from bean flour.

Global acceptability of cookies made from bean flour

The results of the MDS showed that the cookie with the possibility of positioning itself quickly in the market, due to consumer acceptance, was cookie 873 (figure 3; quadrant I) containing 90 % bean flour, 10 % whole wheat flour and walnut. Consumers gave it the highest score on sensory acceptability and physical appearance. Samples 925 and 798 (figure 3; quadrant IV) were accepted primarily for their physical appearance. However, cookie 052 (figure 3; quadrant II), which contained 100 % bean flour was associated with better sensory attributes.

Therefore, one of the beliefs that was broken in this study using tastings with consumers was that healthy or functional products can have a palatable taste on the palate. This contributes to the commercialization of food, consumers are increasingly aware and concerned about their well-being and seek options that meet this need (De La Cruz Silva *et al.,* 2021; Mai and Hoffman, 2012; Raghunathan *et al.,* 2006).

The multivariate approach distinguished three main groups of cookies (quadrant I, II, and IV), which means an acceptance of the different attributes. It is evident that certain aspects must be improved to achieve greater acceptance and a sustainable competitive advantage as mentioned by Porter (2007). However, there was no cookie that displeased them in all aspects (quadrant III), so it is possible to implement marketing strategies that allow achieving a positioning

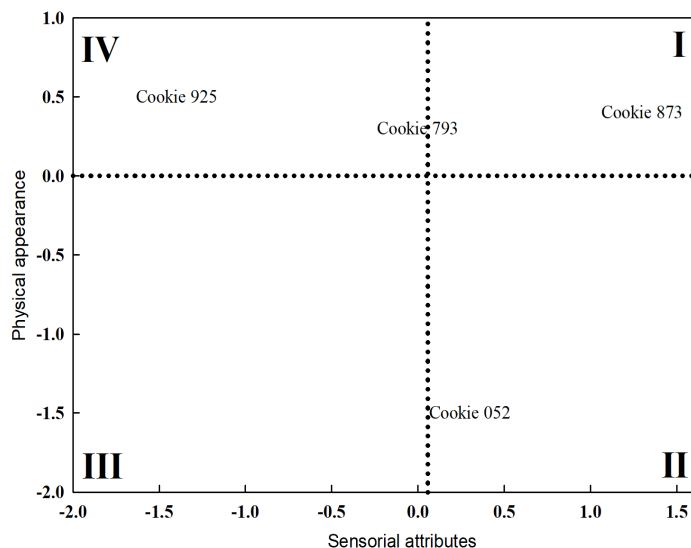against the rest of the substitute products in the market (Kotler and Gertner, 2002).

Figure 3. Two-dimensional representation of the acceptance of cookies made with bean flour.

In this regard, Teixeira and Rodrigues (2021) indicated that modern consumer lifestyles and expectations drive the market to use new processing methods and technologies to deliver fast, nutritious, and sensory accepted products (Saldaña *et al.,* 2021). On the other hand, De Oliveira *et al.* (2022), mentioned that sensory enjoyment is vital for the well-being and memory of the consumer in the short and long term.

However, the preference for innovative products that benefit health is related to the financial capacity and educational level of consumers, as this is greater, the interest in acquiring food increases in quantity and quality of nutrients (Realini *et al*., 2022; Ceballos and Guadarrama, 2020). Similarly, the social aspect, that is, the group of people with whom the consumer relates is a clear influence in the search for new foods (Sobal and Bisogni, 2009). It is important to note that the success of any new product depends on objective and subjective consumer acceptance and technical skills (Dang *et al*., 2018).

Conclusions

Although cookies made from bean flour are considered a new food, a high evaluation in attributes is observed. However, it is necessary to pay attention to the attributes with less preference (lower score) and perform the necessary tests to improve them, using a lower proportion of bean flour and other nutritious ingredients in its preparation can improve its acceptance by consumers. These findings can be used to improve the organoleptic quality of cookies and provide basic data to expand the consumer market, due to their nutritional and sensory quality.

The extrapolation of the data from this study should be carried out with caution because the valued foods respond to a specific geographical segment.

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