Formulation of gummies with Persian lemon bagasse (*Citrus latifolia* Tanaka) and stingless bee honey (*Scaptotrigona mexicana*): acceptance and purchase intention

Formulación de gomitas con Bagazo de limón persa (*Citrus latifolia* Tanaka) y miel de abeja sin aguijón (*Scaptotrigona mexicana*): aceptación e intención de compra

ALATRISTE-PEREZ, Ismael†, CONTRERAS-OLIVA, Adriana, ZARATE-CASTILLO, Gregorio and HERRERA-CORREDOR, José Andrés*

Departamento de Procesos Alimentarios. Universidad Tecnológica del Centro de Veracruz, Campus Cuitláhuac. Av. Universidad No. 35, Carretera Federal Cuitláhuac-La Tinaja, Congregación Dos Caminos, Cuitláhuac, C.P. 94910, Veracruz, México. Colegio de Postgraduados Campus Córdoba. Carretera Federal Córdoba-Veracruz km 348, Congregación Manuel León, Amatlán de los Reyes, C.P. 94946, Veracruz, México.

ID 1st Autor: *Ismael, Alatriste-Pérez* / **ORC ID:** 0000-0002-1192-7106, **CVU CONAHCYT ID:** 658107

ID 1st Co-author: *Adriana, Contreras-Oliva* / **ORC ID:** 0000-0002-9686-7447, **Researcher ID:** AAC-7016-2019, **CVU CONAHCYT ID:** 96857

ID 2nd Co-author: *Gregorio, Zarate-Castillo* / **ORC ID:** 0000-0003-2102-4565, **CVU CONAHCYT ID:** 230991

ID 3rd Co-author: *José Andrés, Herrera-Corredor* / **ORC ID:** 0000-0002-2392-2521, **Researcher ID:** D-2244-2014

Abstract

Objectives: This project proposes the integration of stingless bee honey (*Scaptotrigona mexicana*) and Persian lemon bagasse (*Citrus latifolia* Tanaka) in the formulation of a functional product to promote its commercial use as by-products of food generated in supply chains. supply. Methodology: Seven formulations of Persian lemon bagasse, glucose and stingless bee honey were evaluated for the gummy candy proposal. The study was conducted with consumers in a centralized location setting. The level of liking was measured with a 9-point hedonic scale. Acceptability and purchase intention were measured with a binomial scale. Contribution: it was observed that the samples with the highest acceptance by consumers were those that did not contain Persian lemon bagasse.

Resumen

Objetivos: En este proyecto se propone la integración de miel de abeja sin aguijón (*Scaptotrigona mexicana*) y bagazo de limón persa (*Citrus latifolia* Tanaka) en la formulación de un producto funcional para potenciar su aprovechamiento comercial como subproductos de alimentos generadas en las cadenas de suministro. Metodología: Siete formulaciones de bagazo de limón persa, glucosa y miel de abeja sin aguijón se evaluaron para la propuesta de dulce gomoso. El estudio se realizó con consumidores en una modalidad de ubicación centralizada. El agrado se midió con una escala hedónica de nueve puntos. La aceptabilidad y la intención de compra se midieron con una escala binomial. Contribución: se observó que las muestras con mayor aceptación por los consumidores fueron las que no contiene bagazo de limón persa.

Confectionery, Stingless bee honey, Mixes design

Confitería, Miel de abeja sin aguijón, Diseño de mezclas

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† Researcher contributing first author.

Introduction

Losses and waste of plant origin are a worldwide concern, since a large amount of fruit and food peels are wasted in good condition and can be reused and consumed. Globally, organic solid waste accounts for about 46% of total solid waste (Matiacevich, S., et al., 2022).

It is estimated that just over one million tons of food is lost or wasted during industrial processes, post-harvest, storage and transportation, an amount that could feed approximately two million people (FAO, 2019). Within these food losses, the largest share corresponds to fruits and vegetables (40-50 %), followed by fish, cereals and meat and dairy products (35, 30 and 20 %, respectively) (Preciado-Saldaña, A., et al. 2022).

Circular economy (CE) is primarily a system that attempts to maximize the utility and value of the products, components and raw materials used in each process and in each period of the life of the material (Matiacevich, S., et al., 2022). A CE system must be restorative and regenerative, so that products, components and materials at all levels are always maintained at a high level, and materials that were previously discarded can be converted into a resource for the creation of new products (Preciado-Saldaña, A., et al. 2022)

This project seeks that the synergy of these two components (stingless bee honey and dietary fiber) can give us a product with added value that is functional for human beings and of greater economic importance, thus making use of two losses obtained from two systems (lemon and bees), to enhance their commercial use.

Today's consumers are concerned about their health, showing interest in plant foods that contain bioactive or functional ingredients (Younesi, M., et al, 2023).

A gummy consists of hydrocolloids as gelling agents, sweeteners, acids, flavorings, and colorings. Hydrocolloids are large molecules large molecules that are dispersed in water and bind to form a gel composed of the three-dimensional network that absorbs water and particles under the right conditions (Gerry Renaldi, G. et al., 2022).

When evaluating a product, consumers are influenced by sensory characteristics (appearance, aroma, taste and texture) resulting from the balance of compounds in food, and also by non-sensory characteristics that include extrinsic product information such as brand, price, product origin, color and illustrations stamped on the label and several other factors, such as those related to the consumer himself.

Acceptance of the food depends on its sensory characteristics and the psychological aspects of the consumer. Sensory acceptance can be affected by information about the new product. Therefore, providing detailed information about the technology used can increase the expectation and liking of a product, although information in itself does not guarantee greater consumer acceptance (Alvés Mauricio, R., et al., 2022).

Problem

Food losses and wastes are generated in the supply chain due to lack of specific quality attributes; Persian lemon (Citrus latifolia Tanaka) for not complying with size, weight and appearance standards and bee honey (Scaptotrigona mexicana) due to lack of freshness, are discarded or not cultivated; therefore, integrating them as an option for their valorization is a fundamental part.

Hypothesis

It is feasible to identify the effect of ingredients in a gummy based on stingless bee honey (*Scaptotrigona mexicana*) and Persian lemon bagasse (*Citrus latifolia* Tanaka) and to determine the sensory factors of acceptance and purchase intention of the product.

Methodology to be developed

The study was conducted at the Sensory Analysis

Sensory Analysis Laboratory of the Colegio de Postgraduados Campus Córdoba, located at Km 348 of the Federal Highway Córdoba-Veracruz in Amatlán de los Reyes, Veracruz, Mexico.

Sample Collection and Conditioning

Honey was collected from stingless honey bees (Scaptrotigona mexicana) harvested from the period January - March 2017 from the Córdoba Campus of the Colegio de Postgraduados located at km 348 of the Córdoba-Veracruz federal highway, whose coordinates are 18° 51.347' LN and 96° 51.622' LO, within the south-central zone of the state of Veracruz, Mexico. The honey was cultivated in clay pot hives which were removed with syringes and filtered to avoid extracting foreign matter.

The second quality Persian lime (Citrus Latifolia Tanaka) was provided by a producer in the municipality of Cuitlahuac, Veracruz, and selected at medium ripening stage. This ripening stage is characterized mainly by green-yellow shades, as well as by a slight adherence of the bagasse to the peel, making bagasse removal easy. The fruit was washed with water to remove possible foreign organic matter for subsequent handling and sliced into 2 mm thick cuts manually with a sharp stainless-steel knife. Drying was carried out in a Felisa® digital drying oven (Feligneo, Zapopan Jalisco, Mexico) at a temperature of 60°C for 6 h. The bagasse was then separated from the water and dried. The bagasse and husk were then separated manually. The samples were ground in a moulinex® blender with a 250 mL beaker. At the end, they were sieved in a Montinox No. 60 (0.245 mm) physical test sieve (Manufactured by Montiel inoxidable México) to obtain the dry Persian lime bagasse.

Mix design

The mix design used for the proposed gummies was

The mixture design used for the gummies proposal was carried out in the simplex coordinate system where the total proportions of each ingredient (Persian lime bagasse, stingless honey and glucose) in the confection was adjusted to 100 % according to Table 1.

As a restriction, a maximum of 70% and a minimum of 0% were used.

% and a minimum of 0 % were used for all ingredients.

Preparation of gummy candy For the optimization process, seven gummy candy formulations were designed. The formulations consisted of variable ingredients (142.5 g) representing 38.25 % and fixed ingredients (230 g) representing 61.74 %. The ingredients that were varied in the formulations were: dry bagasse of Persian lime, glucose and stingless bee honey (Scaptotrigona mexicana). The fixed ingredients were: grenetin and water.

No.	Code	Bagasse	Glucose	Honey	Total
1	257	0	70	30	100
2	943	15	55	30	100
3	591	30	40	30	100
4	739	0	55	45	100
5	861	10	50	40	100
6	524	15	40	45	100
7	391	0	40	60	100

Table 1 Percentages of ingredients used for the formulation of the confectionery

For the preparation of each formulation 372.5 g were used, the ingredients were weighed according to the corresponding formulation and 200 mL of water and 30 g of grenetin were added in a stainless-steel container. The mixture of ingredients was heated over direct heat at 145°C until lumps were eliminated.

145°C until the dried Persian lime bagasse lumps were eliminated. It was then removed from the heat and cooled to 90°C. The mixture was transferred to silicone molds and the gummies were left to set.

Physicochemical characterization of gummies

The pH was determined according to the AOAC methodology.

14.002 of the AOAC (1984), which consists of weighing 10 g of sample, mixing it with 100 ml of distilled water, shaking it for 5 minutes and letting it stand for 5 minutes to later take the reading by introducing the electrode into the supernatant. The potentiometer (Thermo Scientific Orion 3-star benchtop, 115/220 VAC) was adjusted to a temperature of 25 °C (± 1°C) with a reference buffer of pH 7; the determination was carried out in triplicate.

For moisture, a moisture determinator (Moisture Analyzers, MX-50, A&D's Company, limited USA) was used, for the determination a weight of 5 g. of the sample was used and placed in the tray of the meter, then the lid was lowered and the determination began, after a few minutes the equipment gave the results, the determination was carried out in triplicate.

Consumption study

The study was carried out with inexperienced

The study was carried out with inexperienced Mexican consumers N = 119, who regularly consume candy, participated in this study.

In this study. The participating consumers reside in the State of Veracruz, the tests were performed in the facilities of the Universidad Tecnológica del Centro de Veracruz (UTCV) in the State of Veracruz, Mexico. The tests were conducted in a room illuminated with natural and fluorescent light, as well as air-conditioned. The questionnaire was written in Spanish. Consumers were informed about the questionnaire, particularly the sensory attributes and their meaning, and the handling of the samples during their evaluation.

Scale	Value numeric
I am extremely displeased	1
I dislike myself very much	2
I dislike myself moderately	3
I dislike slightly	4
I neither liked nor disliked	5
I liked it slightly	6
I liked it moderately	7
I liked it very much	8
I liked it extremely	9

Table 2 Hedonic scale

Each consumer received a set of three (1 piece per sample) out of the 7 samples for evaluation according to the incomplete balanced block design (an arrangement in which each block contains only some of the complete pieces), in the following order: general appearance, color, transparency, odor, consistency, general taste; sweet, bitter and/or sour. They rated the samples in the order in which they were presented using a 9-point hedonic scale. Part III: The binomial (yes/no) was used as a scale to determine the overall acceptability and purchase intention of each sample (Sae-Eaw et al., 2007).

Statistical analysis

Seven (7) formulations were used, A block balance design was employed to reduce consumer fatigue. With this statistical design, each consumer evaluated 3 formulations according to the 11.7 plan (t = 7 k = 3 r = 3 b = 7 λ=1, E = 0.78, Type V (Cochran and Cox 1957).

The design was repeated 3 times. For the analysis of data collected on liking from the hedonic scale, a balanced incomplete block design was used to reduce consumer fatigue at the 0.05 significance level. Tukey's test was used to compare between formulations. To identify similarity between formulations, all attributes were considered simultaneously using principal component and cluster analysis. To identify the critical attributes for acceptability and purchase intention, a multiple regression analysis was used (Prinyawiwatkul and Chompreeda, 2007), where the significance level of each of the coefficients associated with each of the attributes was according to the following model:

t = 7 k = 3 r = 3 b = 7 λ=1, E = 0.78, Type V)

(Cochran and Cox 1957) and allow to reduce consumer fatigue. In this study, each sample was tested 30 times. Additional test samples were given to consumers upon request. To reduce bias and allow consumers to focus only on sensory acceptability no filler was provided. Water and expectoration cups were provided to consumers for use during testing to minimize any residual effects between samples. Consumers were asked to respond to the questionnaire which consisted of three parts. Part I: They were asked to provide demographic information, including age, sex, place of origin. These questions were asked prior to performing the sensory evaluation of the samples. Part II: Consumers were asked to evaluate the acceptability of each gummy attribute.

To identify the effect of providing more information to the information to the consumer (the use of Persian lemon bagasse in the confection) on purchase intention, McNemar's test was used. R software version 4.0.2 and the integrated development environment RStudio 1.3.959 were used.

Results

In the analysis of variance of taste level for sensory attributes, no differences were found. In the analysis of variance of the taste level for sensory attributes, no significant differences were found in the attributes appearance, color and odor. In general, consumers indicated that they liked the confectionery in the range of 4 (I slightly disliked it) to 6 (I slightly liked it). These results suggest that even with different ratios of ingredients in the formulations, liking the confectionery ingredients and adding the Persian lemon bagasse had no effect on consumer taste. A significant difference was found for transparency, consistency and overall flavor in a range of attributes from 2 (I disliked it very much) to 6 (I liked it slightly). In the case of overall taste the lowest value was for formulation 2 (dried Persian lemon bagasse 15%, glucose 55%, honey 30%), which has an intermediate proportion of dried Persian lemon bagasse.

No.	Apariencia	Color	Transparencia
257	6.45 ± 1.05 a	6.63 ± 1.08 a	6.96 ± 0.98 a
943	4.55 ± 1.65 b	4.53 ± 1.96 c	4.58 ± 1.44c
591	4.22 ± 2.04 b	5.12 ± 1.71 bc	4.61 ± 1.51c
739	6.4 ± 1.23 ⓐ	6.17 ± 1.54 a	6.27 ± 1.67ab
861	5.58 ± 1.45 a	5.81 ± 1.62 ab	6.04 ± 1.33b
524	6.16 ± 1.62 a	6.14 ±1.68 a	5.9 ± 1.46 b
391	6.2 ± 1.45 a	6.24 ± 1.66 a	6.33 ± 1.44 ab

No.	Olor	Consistencia	SaborGral
257	6.61 ± 1.67a	6.2 ± 1.6a	6.45 ± 1.08a
943	4.45 ± 2.08b	5 ± 2.04b	2.67 ±1.61d
591	4.65 ± 1.45b	3.8 ± 1.78c	3.59 ± 1.9 d
739	5.71 ± 1.74a	5.65 ± 1.57ab	5.76 ± 1.83 ab
861	6.06 ± 1.93 a	5.74 ± 1.83ab	4.64 ± 1.93c
524	6.38 ± 1.95a	5.58 ± 2.25ab	5.18 ± 1.64 bc
391	6.1 ± 1.48a	5.41 ± 1.82 ab	6.02 ± 1.94ab

Table 3 Agreeableness values for the attributes of the formulations

Multivariate analysis of the results of the principal component and cluster analysis is shown in Figure 1 and 2. The formulations were projected on the first of the two principal components: AXIS1 (which explains 91.27 % of the total variability) and AXIS2 (which explains 6 % of the total variability), for a total of 97.27 %.

The formulations were projected along this line, where more clarity is observed between the values with the hedonic scale assigned to the attributes. Formulation 1 (257), with the highest proportion of glucose and lowest amount of bee honey, was the most consumers in the six attributes appearance, color, transparency, odor, consistency, and overall taste. Formulations 7 (391) and 4 (739) show similar characteristics in lacking dried Persian lemon bagasse content and consumer preference in appearance, color and transparency. Formulations 6 (524) and 5 (861) are similar in attributes such as transparency and odor. While formulations 2 (943) and 3 (591) which have the same amount of stingless bee honey. DISCUSSION. Cluster analysis allowed visualizing two groups, clearly separating formulations 2 (943) and 3 (591).

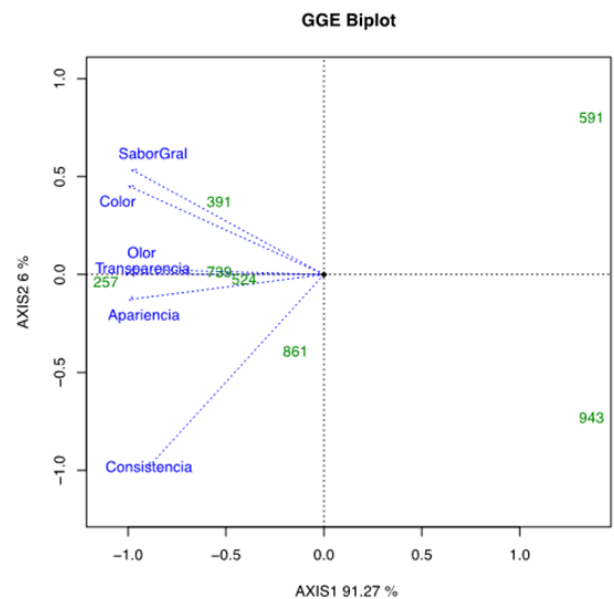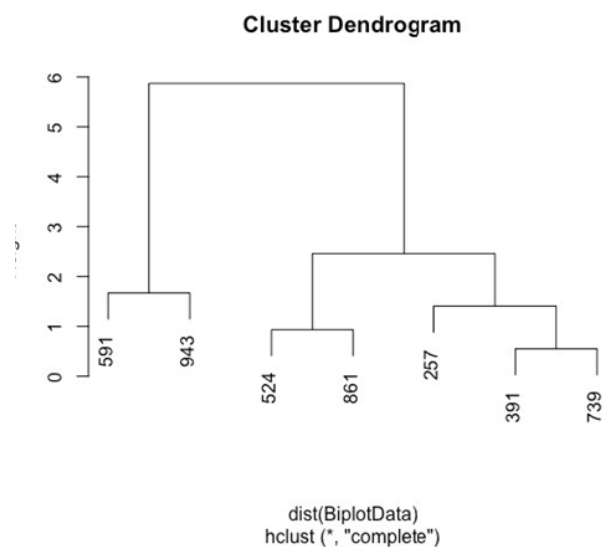**Figure 1** Principal component analysis relating the attributes of the gummies

Figure 2 Dendogram of formulations

ALATRISTE-PEREZ, Ismae, CONTRERAS-OLIVA, Adriana, ZARATE-CASTILLO, Gregorio and HERRERA-CORREDOR, José Andrés. Formulation of gummies with Persian lemon bagasse (*Citrus latifolia* Tanaka) and stingless bee honey (*Scaptotrigona mexicana*): acceptance and purchase intention. Journal-International Economy. 2023

The multiple logistic regression analysis is presented in Table 3. In this analysis, the coefficient for each attribute in the model for acceptability was significant with the attributes; odor, consistency and overall taste. Purchase intention was mainly determined by appearance, odor, consistency and overall taste. Buying fiber was significant with appearance, consistency and overall taste.

g o	Aceptaría			Compraría		
	Esti mat e	Pr > z	Odds ratio	at e	Pr > z	Odds ratio
Aparie ncia	0.15	0.36	1.16	0.4856	0.02	1.62
Olor	- 0.17	0.30	0.83	-0.6293	0.005	0.53
Trans parenc ia	0.01	0.93	1.01	-0.0961	0.54	0.90
Olor	-0. 25	0.01	0.77	0.0746	0.47	1.07
Consis tencia	0.45	0.0000 02	1.58	0.4213	0.000 1	1.52
Sabor genera l	0.63	0.0000 000003	1.88	0.7338	0.000	2.08

Table 4 Coefficients for the multiple logistic regression model for acceptance and purchase intention

It is worth mentioning that our consumers were young people who tend to consume gummies eventually, therefore, they reflected an interest in a new product with health benefits. In the study of attributes we observed that there is a significant difference between the formulations, obtaining markedly different formulations. After analyzing all the results obtained from this project, we could observe that the honey content in the formulations was important since the formulations obtained a better preference since they have an adequate level of sweetness.

In this way we can recommend formulations F1, F4 and F7 as they are the ones that could be more successful when introduced to the market, since they were the best qualified by the panelists.

This product would be aimed at all types of consumers, since they can consume the product providing the aforementioned nutrients from both honey and fiber.
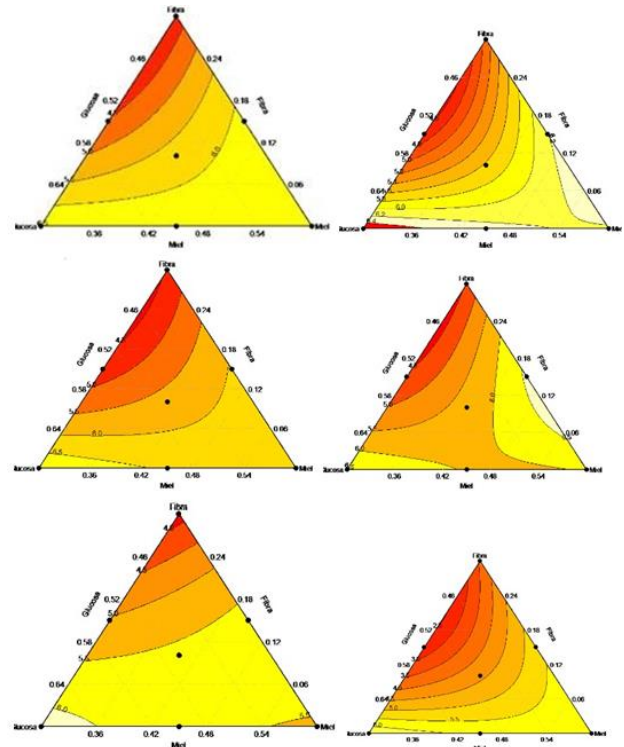

Figure 3 a) Appearance, b) color, c) transparency, d) odor, e) consistency and f) general flavor.

Conclusions

Based on the results obtained in the present work, it was Based on the results obtained in this study, it was observed that the samples with the highest consumer acceptance were those with the least amount of lemon fiber.

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