



Elaboration of a natural sweetener using Erythritol/Stevia

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Abstract

The food industry always searches for innovation, product improvement, quality and customer satisfaction. In relation to sweeteners, this search had an expressive increase in recent times due to the increase of diseases caused by the excessive consumption of sugar. Most tabletop sweeteners marketed in Brazil have bulking agents with characteristics not appreciated by consumers, substances that can cause intolerance such as lactose or caloric products such as maltodextrin (4 kcal/g). Considering this problem, the aim of the research was to develop a natural sweetener, without contraindications, using the erythritol / stevia blend to compose the formulation. Three formulations (standard, 10% sweeter and 10% less sweet) were developed, that in the sorting test there was no preferred sample, being able to opt for the formulation with lower cost – 10% less sweet. At the same time, a semistructured questionnaire was applied, characterizing the consumers of sweeteners. Of all respondents, 43% used sweeteners. The variable that increases the chance of its consumption is “being overweight”; when associated with the variable “overweight family”, the chance of consumption is greater. Another proof was that more than 40% of users search for natural substances in their sweetener, strengthening the possibility of developing a natural sweetener.

Keywords: erythritol; polyol; sweeteners; sensory analysis; glycosides of esteviol.

Practical Application: The food industry is increasingly seeking to improve sugar substitutes, along with the demand for natural products which is a trend. The objective of this paper was to describe the development of three formulations of tabletop sweeteners with natural substances and to choose one using sensory analysis techniques (preference ordering test). In addition, the study characterized the users through a questionnaire, using a sample for convenience, demonstrating which variables influence consumption or not.

1 Introduction

Food is something of great importance in everyday life, besides meeting basic physiological needs, it comprehends economic, social, scientific, political, cultural and psychological aspects (Proença, 2010). Regardless of sociocultural aspects, the sweet taste motivates all ages, races and cultures. This food preference is part of human evolution, since food rich in energy and nutrients had this sensorial characteristic (Reed & McDaniel, 2006).

Sucrose, popularly known as sugar, is one of the major sources of sweet taste, but excessive consumption of this substance may increase the risk of chronic diseases, such as diabetes (Yang, 2010). In order to serve consumers who are interested in the sweet taste, without the consequences of excessive consumption of sucrose, tabletop sweeteners have appeared. These are defined as the “product formulated to confer sweet taste to foods and beverages, constituted of sweetener (s) provided in technical regulation. The use of the intended bulking agent(s) is permitted”. Tabletop sweeteners may contain the following bulking agents in their composition: ethyl alcohol, starches, water, modified starches; dextrans; dextrose; fructo-oligosaccharides; isomalto-oligosaccharides; fructose and its syrups; glucose syrup; glycerol or glycerol; isomalte; lactose; maltitol and its syrup; maltodextrin; mannitol; polydextrose; polyethylene glycol; propylene glycol; sucrose; sorbitol; and others provided

for in specific Technical Regulations (Brasil, 2005). Among the sweeteners, it is possible to use substances such as: acesulfame, aspartame, cyclamates and their salts, saccharin and its salts, sucralose, thaumatin, steviol and neotame glycosides (Brasil, 2008).

The safety, solubility, stability, sensory profile close to sucrose and its cost are the main aspects evaluated in the choice of sweeteners (Casarotti, 2009). Considering these characteristics is of great importance to meet an increasingly demanding market. Another feature in the development of sweeteners is the blend of molecules (blend), which provides a synergistic effect, improving costs and sensorial characteristics (Simony & Geraldo, 2014).

The national market offers numerous combinations of sweeteners and bulking agents in tabletop sweeteners. The most used bulking agents in Brazil are maltodextrin and lactose. Maltodextrin offers 4 kcal / g and lactose can cause intestinal discomfort to people intolerant to it. Due to these characteristics, other substances have gained prominence in Brasil Foods Trends 2020 (Federação das Indústrias do Estado de São Paulo, 2010), inputs such as: Erythritol, Lactitol, Taumatine, Stevia and Glicerrizinato highlighted the health and fitness market in “health and wellness”.

Erythritol is a polyol that has only 0.2 kcal / g (Brasil, 2010) and it is natural, low glycemic index (Livesey, 2012), obtained by

Received 09 Jan., 2019

Accepted 23 Jul., 2019

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fermentative processes, without side effects and low absorption by the organism, 90% is eliminated in the urine (Grembecka, 2015), and the effects of the treatment on the gastrointestinal tract. As stevia is extracted from a plant of the same name, it has antioxidant and antihypertensive activity, among other benefits (Carvalho, 2017), but one can not disregard the characteristic bitter residual taste (Osman et al., 2013).

This study aimed to characterize the consumers of sweetener, their habits, to understand their motivations and preferences of choice, as well as to develop a natural sweetener using blend stevia and erythritol and to grasp whether, through the results of the questionnaire, such product can be accepted by them. The coffee was chosen for the tests because it is the second most consumed drink in Brazil (Empresa Brasileira de Pesquisa Agropecuária, 2018) and in industrial tests the sweetener is applied in it, since it is in this drink that the majority of the consumption happens.

2 Materials and methods

2.1 Development and application of the questionnaire

A semi-structured questionnaire was developed, containing questions about demographic data and about the consumption habits of sweeteners. The questionnaire contained 23 questions. The first 10 questions were answered by consumers and not consumers of sweeteners. From question 11, only the users of sweeteners answered specific questions of the theme. The questions were based and adapted from the following authors: Campos et al. (2012); Oliveira & Franco (2010); Zanini et al. (2011); Marques et al. (2012); Saito et al. (2013); Geraldo & Pinto-e-Silva (2016); and Santos et al. (2017).

The application of the questionnaire was through the use of social networks, having as prerequisite to be over 18 years old. Due to the use of the virtual means, the results generated a sample for convenience, that is, it selected a population that was accessible by the existing network of contacts of the applicators.

The questions addressed the following variables: gender, age, marital status, overweight, sports, the use of sweetener, composition, if the person has changed sweetener and why, overweight family, whether the person likes it or not and why he/she does not like, how it was chosen, how it is used, what foods it is used, income, number of people in the household, frequency of use and frequency of purchase, and age. The questionnaire was approved by the Ethics Committee (CEP) of UTFPR (Process CAAE n° 86817418.1.0000.5547)

2.2 Material for the preparation of the table-top sweetener

The development of the sweetener is consisted of: Erythritol- brand Vida em Grãos® - Steviol Glycosides and Silicon Dioxide - donated by Stevia Natus Natural Products.

2.3 Development of the sweetener

Three formulations of sweeteners were developed containing erythritol, steviol glycosides and silicon dioxide. The first formulation followed the recommendations of the supplier of steviol glycosides and silicon dioxide, the remainder of the

volume in the formulation being erythritol, in the other two formulations had 10% more and 10% less sweetness variation respectively by dosing of glycosides of esteviol (Table 1).

As the market works with specific characteristics of the products, empirical research was conducted in online markets to determine the weight per dose. It was found that tabletop powder sweeteners which contained stevia as the main sweetening molecule normally had the net weight of 0.6 g of sweetener per dose. Because of this, the same weight was used for this study.

Erythritol was weighed on a semi-analytical balance (Bel Engineering brand Mark 2200®, Londrina, Brasil), steviol glycosides and silicon dioxide on analytical balance (Shimadzu brand, model ATY224®, Londrina, Brasil). The homogenization was carried out in bags, it was closed hermetically by means of welding and applied circular movements for 5 minutes, simulating the effect of an industrial mixer.

2.4 Microbiological evaluation

The microbiological evaluations were carried out in triplicate, in an outsourced and credited laboratory. For this research, studies were carried out regarding total Coliforms, according to the ISO 4832: 2006 methodology. According to what was established by the Board of Directors of the National 235 Agency of Sanitary Surveillance - ANVISA, item 11-C (Brasil, 2001)

2.5 Physical and physical-chemical evaluations

The samples were characterized in triplicate for moisture, density and wettability. The moisture of the elaborated sweeteners followed the method 925.45B (Association of Official Analytical Chemists, 2016), the density of the sweeteners was determined according to the methodology described by the Instituto Adolfo Lutz (2008), using a stainless steel pycnometer, this information is required to determine package dimensions. The wettability was determined and compared among commercial sweeteners containing maltodextrin / stevia and lactose / stevia, and in the formulation elaborated in this work, containing erythritol / stevia. 0.6 grams of sweetener was placed in 50 ml of coffee at 60 °C, measuring the time required for total immersion of the sweetener in the beverage.

2.6 Sensory evaluation

The tasters were summoned verbally, taking into account their interest and availability in the consumption of coffee with sweetener. The study was approved by the Ethics Committee (CEP) of UTFPR (Process CAAE n° 86817418.1.0000.5547).

Table 1. Formulation of powered sweeteners (%).

Formulation	Erythritol	Glycosides of Esteviol	Silicon dioxide
	%	%	%
A	87.83	11.67	0.5
B	89.0	10.5	0.5
C	86.67	12.83	0.5

Source: Own authorship (2018).

As described by Dutcosky (2013), three coffee samples sweetened with the Erythritol / Stevia blend were presented to be sorted by preference. The coffee was prepared following the Associação Brasileira da Indústria de Café (2018) methodology, with the proportion of 80 grams of roasted, ground, vacuum-packed, traditional type Pilão® brand for each litre of boiling water. In the filtration process, a paper filter with support was used, the beverage being stored in thermal bottles for a maximum of two hours. The coffee was sweetened with the A (standard), B (10% sweeter) and C (10% less sweet) formulations in the proportion of 0.6 g for each 50 ml. The samples were randomly served and the reviewers were asked to write in order from minus to the most preferred in a sensory record.

2.7 Statistical analysis

The data collected from both the questionnaire and the sensory were analyzed using Software R Project for Statistical, version 3.5.1. The statistical analysis of the questionnaire had the purpose of verifying which variables were significant for the consumption or not of the sweetener. Logistic regression was used for the adjustment of the statistical model. For the data correlations, Pearson's Chi-square test was applied. Already for the preference test, the results were analyzed using the Friedman test with the Christensen Table and associated, according to Dutcosky (2013).

3 Results and discussion

3.1 Analysis of the questionnaire

The survey consisted of 234 people of both sexes, with an average age of 35 years and the highest frequency between 30 and 40 years, being the sample for convenience, that is, a sample that was accessible by its availability (Anderson et al., 2007). The results obtained until question 10 showed characteristics of the respondents consumers or not of sweeteners. The chi-square test was applied to evaluate which variables influenced the consumption of sweetener (Table 2).

The study showed that 43% of respondents use sweeteners, more than 23% of respondents in the study Zanini et al. (2011). Geraldo & Pinto-e-Silva (2016) showed that the odds of consuming sweeteners are 1.68 times higher among overweight people. By applying Pearson's Chi-square test in this study, the probability of consuming sweetener is 1.51 times higher among overweight respondents, showing a similarity in the results. This chance increased to 2.4 times when the variables "being overweight" and "overweight family" were associated.

Geraldo & Pinto-e-Silva (2016) also concluded that the use of sweeteners is indicated for diabetics (73.7%), obese (66.5%), hypertensive (15.6%), normal weight and for all people (32.1%). On the other hand, the results of this research showed that: the healthiest lifestyle is that the interviewees are more interested in (52.5%), followed by dieting (28.7%), preference and / or practicality (11.9%) and those who can not consume sugar (6.9%). The researches showed some discrepancies that may be caused by the indicators suggested by the interviewers, change of habits and by the samples reached.

In a study on the consumption of sweeteners by hypertensives and diabetics, Cotta et al. (2009) found that 90% of the users used artificial sweeteners. However, those who use natural sweeteners (21.8%) or blends between artificial and natural sweeteners (18.8%) are higher than the ones that use artificial sweeteners (45.5%). above 10%. These results justified the variable "why consume sweetener" being the "healthiest lifestyle".

This research generated other results. Those interviewed who had already changed their sweeteners totalled 82.2%; of those who have changed: 34.7% stated that they have done it by hearing "it is bad" what they consumed; and 15.8% have changed by hearing "it is good" another kind of sweetener. More than a half of the respondents (61.4%) like the taste of the sweetener and those who don't, they blame the residual flavour (84.6%).

The flavour still has the most influence on the choice of sweeteners (35.6%), followed by being beneficial / natural (28.7%), indication (26.7%) and price (8.9%). The increase in consumer interest in natural substances has been highlighted by Beltrami et al. (2018), but it also reminds us that natural sweeteners

Table 2. Characteristics of the interviewees on the consumption or not of sweeteners.

	Do not use		Use		p value
	n	%	n	%	
Sex					
Male	32	24.1	19	18.8	
Female	101	75.9	82	81.2	
Age					
18 to 29 years	36	27.1	26	25.7	0.329
30 to 39 years	70	52.6	51	50.5	
40 to 49 years	21	15.8	16	15.8	
50 to 59 years	3	2.3	1	1.0	
60 to 69 years	3	2.3	7	6.9	
Marital Status					
Single	57	42.9	36	36.7	0.332
Married	66	49.6	52	53.1	
Divorced	10	7.5	9	9.2	
Widow/Widower	0	0.0	1	1.0	
Schooling					
High school	4	3.0	0	0.0	0.265
College	50	37.6	34	34.0	
Postgraduate	79	59.4	66	66.0	
Income (wages)					
Up to 1	1	0.8	12	10.1	0.209
From 1 to 3	20	15.0	8	6.7	
From 3 to 6	33	24.8	22	18.5	
From 6 to 9	37	27.8	28	23.5	
From 9 to 12	17	12.8	22	18.5	
More than 12	25	18.8	27	22.7	
Overweight					
Yes	53	39.8	61	60.4	0.003
No	80	60.2	40	39.6	
Practices sports					
Yes	80	60.2	60	59.4	0.865
No	53	39.8	41	40.6	

Source: Own Authorship (2018).

can compromise taste. It was observed that the purchase of the product occurs between one and two months (40.6%), but a high number of respondents did not remember how much time they purchased (23.8%), suggesting that people may use the sweetener for a longer time than the recommendations of the suppliers, which results in losses, in particular the sensorial ones.

The use is made by 40% of respondents once a day; 22.8% twice daily; and three or more times add up to 37.6%. The dosage generated the following results: most put and experimented until reaching the desired flavor (65.3%), or places without observing the quantity (13.9%); only 16.8% follow the supplier's instructions. This unmeasured dosage is a complication, as excessive use of the sweetener increases the residual flavors creating possible consumer dissatisfaction with the product. Still with the emphasis on use, it was addressed "where they use" the sweetener. The results showed that 60.4% use in hot drinks (coffee and tea); 29.7% in hot and cold drinks (juices, iced tea); 5.9% in revenues and only 4% in cold drinks. The consumption in hot drinks is easy to correlate since coffee is the second most consumed beverage in Brazil (Empresa Brasileira de Pesquisa Agropecuária, 2018), but it has been noticed that the market has much to grow when exploring the consumption of sweeteners in the preparation of other formulations. The number of consumers who use it in hot drinks, such as coffee, justifies the choice of product to be tested in this drink.

Among the habits of the sweetener consumers, the associations of variables that presented a significant relationship at a level of 5% were: Already changed from sweetener versus because it changed ($p < 0.001$) until being related in the questionnaire. Already changed from sweetener versus sweetener choice ($p = 0.006$), this correlation refers to the characteristics of each variable, since the respondents stated that it was the unpleasant taste of what used to be the reason for the change and the flavor is more indicative in the purchase. Composition of sweetener versus frequency of sweetener use ($p = 0.006$). Composition of sweetener versus sweetener ($p = 0.018$) This correlation strengthens the indicative flavor in the choice, as well as the correlation Sweetener composition versus sweetener choice ($p = 0.019$).

Decreasing daily calorie intake while consuming sweet foods with a sugar-like taste is a consumer's wish, a characteristic that drives the sweetener market every day (Beltrami et al., 2018). Another interesting feature is the growing search for natural substances in the sweeteners (Chung & Lee, 2013; Suez et al., 2015), as an example of the formulations elaborated in this work.

3.2 Development of the sweetener

To develop a sweetener is not simply to weigh and mix the inputs, it must present both visual and palatable homogeneity, that is, the inputs must be distributed proportionally throughout the product avoiding phase difference, as well as larger and smaller sweetness caused by variation of the concentration of the sweetener in the product. Due to these characteristics, the product behaved satisfactorily since no apparent phases were found in the formulations containing the natural ingredients erythritol as bulking agent and stevia as sweetness, in addition to silicon dioxide as anti-humectant agent, commonly used in food.

3.3 Microbiological and physicochemical evaluations

The microbiological evaluations carried out on the sweetener samples complied with the requirements established by Brazilian legislation, which imposes a maximum limit of 2 CFU / g. These respected the values established by the Board of Directors of the National Agency of Sanitary Surveillance - ANVISA, item 11-C (Brasil, 2001).

Physical-chemical analyzes are of paramount importance in the development of products, showing characteristics that guarantee the integrity or needs for its conservation. The mean results of moisture and density assessments are described in Table 3. Density is widely used by the packaging industry to determine the dimensions of the primary packaging (sachet) and the food industry considers moisture values below 7% ideal to avoid possible stonework (industrial standard).

As most formulations are erythritol, the samples did not differ from each other, showing that regardless of the formulation, standard, or containing more or less sweetness, the moisture and density are similar.

The vehicles used in certain powdered sweeteners may impair their solubility, ie the powder floats on the surface of the liquid. The ability to penetrate is determined by the wettability, this is the time required for the powder to be absorbed by the liquid (Cavalcante, 2017). In view of this concept, it was decided to determine the wettability of the processed product by comparing commercial dietary sweeteners, with similar composition of high-power sweetener molecule and different bulking agents (Table 4).

The wettability test was interesting in two aspects. The first to show that the sweetener does not offer a supernatant, which is visually pleasing to the consumer; the second consists in comparing the time of the dipping powder in the coffee. The sweetener with erythritol had a similar time to that of sweetener with lactose carrier and lower than that with maltodextrin, showing that this characteristic is not an impediment to the product, that is, its wettability is similar to or better than dietary sweeteners

Table 3. Physical-chemical characterization of Erythritol / Stevia blends.

Samples	Moisture (%)	Density (g/ml)
A	2.1 ^a ± 0.2	0.81 ^a ± 0.05
B	2.2 ^a ± 0.2	0.82 ^a ± 0.04
C	2.3 ^a ± 0.1	0.81 ^a ± 0.05

A: standard; B: 10% sweetener; C: 10% less sweet. Averages ± standard deviation. Means followed by the same letters in the columns did not differ significantly by the Tukey test (5%). Source: Authorship (2018).

Table 4. Wettability test with sweeteners containing different bulking agents.

Sample	Wettability
Sweetener with Maltodextrin	1.9 ^{ab} ± 0.1
Sweetener with Erythritol	1.6 ^{ab} ± 0.1
Sweetener with Lactose	1.5 ^a ± 0.2

Averages ± standard deviation. Means followed by the same letters in the columns did not differ significantly by the Tukey test (5%). Source: Authorship (2018).

Table 5. Preference ordination test of Erythritol / Stevia blends.

Sample	Sum
A	117
B	127
C	128

A: standard; B: 10% sweeter; C: 10% less sweet. Source: Own Authorship (2018).

that are already commercialized. The results of the sweetener physical-chemical characterizations and the wettability tests were evaluated by ANOVA and the Tukey test to the level of 5% of significance.

3.4 Sensory analysis

The sensorial evaluation was carried out with 60 tasters, a quantity requested by Dutcosky (2013), coffee consumers, being users or with interest in the consumption of sweeteners, using the preference ordering test (Table 5).

The Friedman test provided a F_{test} of 1.193548. The critical value of the Christensen Table and associated for 3 samples, 60 evaluators at 5% significance is 5.99. It was observed that even though there were 3 different sweeteners, there was no significant difference in the preference of the evaluators.

The ratings resulted in some remarks on the records. Sample A (standard) generated few comments, some referring to residual and others that considered adequate sweetness. Of those who preferred sample B (less sweet), they mentioned that the sweetener did not interfere with the taste of the coffee; and those who did not choose, they found little sweet. Already the C (sweeter) was the one that had more comments on the residual flavor; of those who preferred it found the sweet taste appropriate.

In proportion, erythritol and silicon dioxide did not vary in the formulations (Table 1), but stevia presented the greatest differences. Knowing that this substance has the capacity both to sweeten and to leave residual taste can be considered that it is responsible for the preference of sweetness as well as for rejections by the residual taste.

Another point to note is that erythritol has a characteristic refreshing taste (Aditivos e Ingredientes, 2008), but no such mention has been made on any form. Based on this observation, it can be stated that erythritol was a bulking agent that did not interfere with the preference of table-top sweetener formulations when applied to coffee, other than stevia which causes significant changes in the perception of sweetness and residual taste.

4 Conclusions

The applied questionnaire showed that the tendency to use natural sweeteners is increasing when comparing with other studies; in addition, it has been realized that people are looking for a healthier lifestyle, without wanting to give up the taste; and considering yourself overweight is a factor that has increased the chances of consuming sweeteners, when associated with the overweight family this chance is even greater.

The present study showed that it is possible to develop a low-calorie, natural, no contraindications sweetener using the

erythritol / stevia blend. Although presented in three formulations, with sweetness profiles different from the evaluators, the results showed that they did not differ statistically, being able to opt for the formulation with lower cost (10% less sweetness). Erythritol has been shown to be an interesting bulking agent in sweeteners because it has similar or better wettability than normally encountered bulking agents, and does not create variation in sensory perceptions. The characteristic coolness of erythritol was not realized and comments on sweetness and residual taste were relevant to variations in stevia dosage.

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