DEVELOPMENT OF FUNCTIONAL CHOCOLATES ADDED WITH FRUCTOOLIGOSACCHARIDE WITH FREE OF LACTOSE AND SUGAR

DESENVOLVIMENTO DE CHOCOLATES FUNCIONAIS ADICIONADOS DE FRUTOOLIGOSSACARÍDEO COM ISENÇÃO DE LACTOSE E AÇÚCAR

DESARROLLO DE CHOCOLATES FUNCIONALES CON FRUCTOOLIGOSACÁRIDOS AÑADIDOS, LIBRES DE LACTOSA Y AZÚCAR

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ABSTRACT
In view of the growing demand for a healthy and quality lifestyle, the search for functional foods has been increasing significantly, as they provide beneficial effects when consumed correctly. To develop a functional food, this work aimed to develop a functional chocolate added to the prebiotic *fructooligosaccharides* (FOS). Factor design 22 and the Response Surface Methodology (RSM) were applied to evaluate the effects of the independent variables (FOS and sweetener) on chocolate acceptance and purchase intention. The acceptance test was carried out with 83 untrained tasters to evaluate the attributes aroma, appearance, flavor, texture and global acceptance by means of a hedonic scale from 0 to 10 points, as well as the purchase intention of the chocolates with a scale ranging from 0 to 10 points. It was possible to start the development of functional chocolate formulations, with the addition of FOS and sweetener. The linear models obtained by factorial design 22 did not show a significant curvature check and thus pointed to a direction of which concentrations of FOS and sweetener should be evaluated in the next studies, with the values obtained with FOS concentrations above 30% and sweetener at 3%.

Keywords: Functional Food. Diet. Light. Factorial Design. Prebiotic.

RESUMO
Tendo em vista a crescente procura por um estilo de vida saudável e de qualidade, a busca por alimentos funcionais vem aumentando significativamente, pois eles proporcionam efeitos benéficos quando consumidos de maneira correta. Com o intuito de elaborar um alimento funcional, este trabalho teve como objetivo desenvolver um chocolate funcional adicionado do prebiótico *frutooligossacarídeos* (FOS). Foi aplicado o planejamento fatorial 22 e a Metodologia de Superfície de Resposta (RSM) para avaliar os efeitos das variáveis independentes (FOS e adoçante) na aceitação dos chocolates e intenção de compra. Foi

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realizado o teste de aceitação, com 83 provadores não treinados, para avaliar os atributos aroma, aparência, sabor, textura e a aceitação global por meio de uma escala hedônica de 0 a 10 pontos, bem como a intenção de compra dos chocolates com uma escala que variou de 0 a 10 pontos. Foi possível iniciar o desenvolvimento das formulações do chocolate funcional, com a adição de FOS e adoçante. Os modelos lineares obtidos pelo planejamento fatorial 22, não apresentaram checagem da curvatura significativa e desta forma apontaram um direcionamento de quais concentrações de FOS e adoçante devem ser avaliadas nos próximos estudos, sendo os valores obtidos com concentrações de FOS acima de 30% e adoçante a 3%.

Palavras-chave: Alimento Funcional. Diet. Light. Planejamento Fatorial. Prebiótico.

RESUMEN

Dada la creciente demanda de un estilo de vida saludable y de calidad, la búsqueda de alimentos funcionales ha aumentado significativamente, ya que aportan efectos beneficiosos cuando se consumen de forma correcta. Con el objetivo de desarrollar un alimento funcional, este trabajo tuvo como objetivo desarrollar un chocolate funcional adicionado con el prebiótico fructooligosacáridos (FOS). Se aplicó el diseño factorial de 22 y la Metodología de Superficie de Respuesta (MSR) para evaluar los efectos de las variables independientes (FOS y edulcorante) sobre la aceptación de chocolates y la intención de compra. La prueba de aceptación se realizó con 83 catadores no entrenados para evaluar el aroma, apariencia, sabor, textura y atributos generales de aceptación utilizando una escala hedónica de 0 a 10 puntos, así como la intención de compra de los chocolates utilizando una escala de 0 a 10 puntos. Se logró iniciar el desarrollo de formulaciones de chocolate funcional, con la adición de FOS y edulcorante. Los modelos lineales obtenidos mediante el diseño factorial 22 no presentaron verificación de curvatura significativa y por tanto indicaron una dirección hacia la cual se deben evaluar las concentraciones de FOS y edulcorante en futuros estudios, siendo los valores obtenidos con concentraciones de FOS superiores al 30% y edulcorante al 3%.

Palabras claves: Alimentos Funcionales. Dieta. Luz. Diseño Factorial. Prebiótico.

1 INTRODUCTION

Chocolate is the most consumed cocoa product in the world by most people, regardless of age, because it has a pleasant flavor. Cacao is a fruit originating from the cacao tree, from the Gulf of Mexico cultivated by the Aztecs and Central America, cultivated by the Mayans since 1000 BC (COSTA, 2008), a tree native to regions with tropical and equatorial climates and belonging to the species Theobroma cacao, which in Greek means "food of the gods" (COENTRÃO, 2005).

Cocoa has been cultivated in Brazil, at first in the North Region, especially in Pará, since the seventeenth century. However, from the eighteenth century onwards, cocoa found favorable conditions for its development in the southern region of Bahia, making the state from then on, the largest national producer of the fruit (GONÇALVES; RAM; SENA, 2009). In this state, there are two main phases of cocoa harvest, the "early" harvest, which takes place from March to July and the "harvest", which runs from November to December. However, there are fruits that are produced and ripened on the tree, outside the main harvest seasons, being called "picking" (SENA, 2011).

The main product marketed for chocolate manufacturing is the fermented and dried cocoa bean. From it is obtained butter, pie, pulp and powder. They are widely used in the pharmaceutical and cosmetic industries, the chocolate industry and milling for the manufacture of sweets, confectionery and pasta. Cocoa pulp, on the other hand, is rich in sugars and is used in the manufacture of jam, wine, liqueur, vinegar and juice (SUFRAMA, 2003). For the manufacture of chocolate, ingredients such as cocoa mass, cocoa butter and sugar are used, which may or may not contain milk. It must go through five stages of processing, namely, malaxation, refining, shelling, tempering and molding (WAGNER, 2020).

The largest use in the industry for ingredients processed from cocoa is in the chocolate industries. In this context, Brazil has great potential for growth in the chocolate market, since the main raw materials used in the manufacture of chocolate are produced and available in the national territory. According to the Brazilian Institute of Geography and Statistics (IBGE), Brazil is the 7th largest cocoa producer in the world, producing about 250 thousand tons per year (IBGE, 2020). Sugar and milk, used as ingredients in the production of some types of chocolate, are also produced nationally, facilitating the supply of demands.

The consumption of fine chocolates in Brazil is related to functional attributes (design, quality, brand and tradition), benefits associated with consumption (health, chocolate as a gift and meaning) and environment and marketing (culture and geography, purchasing power) (Sato and Pépece, 2013). The Brazilian Association of the Chocolate, Cocoa, Peanut, Candy and Derivatives Industry points out that the brand and the quality of the ingredients are the main factors that define the value of chocolate perceived by the customer. Despite the pandemic period, chocolate consumption continued to grow in 2020, with about 80% of Brazilians buying this product to consume at home (KOPENHAGEN, 2022).

With regard to health, in recent years, people have been concerned with well-being and have sought functional foods to improve health and quality of life (BRASIL, 2008). Functional foods are defined as foods or ingredients that produce beneficial health effects, in addition to providing their basic nutritional functions. Among the beneficial effects, we can mention the reduction in the risk of chronic degenerative diseases, such as cancer and diabetes (BRASIL, 2009), reduction of cholesterol levels and blood glucose content (ROSA; CRUZ, 2017), prevention and/or reduction of the risk of developing cardiovascular diseases, allergies, intestinal problems, and other pathologies (RAUD, 2008).

Among a wide variety of functional foods available, the highlighted compounds are *fructooligosaccharides* (FOS) and inulin (ROSA; CRUZ, 2017). FOS are called unconventional sugars, which are not metabolized by the human body and are not caloric, being formed by several oligosaccharides that provide carbohydrates that the beneficial bacteria in the colon are able to ferment. They are oligosaccharides belonging to the group of fructans, which can be found in nature (PASSOS; PARK, 2003), in food or even industrially produced from sucrose. They are classified as functional foods, prebiotic foods and soluble dietary fibers (FORTES; MUNIZ, 2009) and called non-conventional sugars, because they are more soluble than sucrose and provide between 30-50% of the sweetness of sucrose (SPIEGEL et al., 1994), and can thus be substitutes for sucrose in specific diets for diabetics (YUN, 1996).

According to Fortes and Muniz (2009), FOS can be used as food supplements, which will result in an increase in the fiber content of foods, without contributing to an increase in viscosity, or undesirable changes in the organoleptic characteristics of the products. In addition, they can replace sugar partially or entirely, when combined with high-intensity sweeteners, providing a balanced flavor profile and concealing aftertaste (GONZALEZ-TOMAS et al., 2008).

The development of chocolates with fat substitutes has also been heavily researched. The most studied food products as fat substitutes are prebiotics, especially inulin, FOS, and alpha-cyclodextrin (SOUZA, 2020), which are not digested by the human gastrointestinal tract and are metabolized by microorganisms of the intestinal microbiota (Bifidobacterium spp. and Lactobacillus spp.) resulting in short-chain fatty acids (LANGA et al., 2019).

Thinking about this consumer search for quality food for special purposes that contributes to a balanced diet, the opportunity to propose alternatives to meet consumer demand was perceived. Therefore, the present work has as its general objective to develop chocolate formulations with the addition of FOS, aiming to obtain chocolates enriched with fibers and reduce sugar and fat content. For this, the simplex-centroid experimental design was applied to develop a functional chocolate formulation and verify the effect of the addition of FOS, as well as the interaction between FOS, sweetener and fat on the sensory characteristics of chocolates.

2 GENERAL OBJECTIVE

The objective of this study was to develop chocolate formulations with the addition of fructooligosaccharide (FOS) and sweetener, aiming to obtain chocolates enriched with fiber and without added sugars. For this, factorial design 22 was applied to develop the formulations of functional chocolates and verify the effect of the addition of FOS and sweetener, as well as the interaction between both, on the sensory characteristics of the chocolates.

3 MATERIAL AND METHODS

3.1 MATERIAL

The utensils used were a plastic chocolate melter (polypropylene), silicone spatula, digital infrared thermometer (GM400), acetate molds for chocolate molding, digital scale, microwave (brand: Midea, model: MTCS42 - 220v, Power: 900 W, Capacity: 31 liters) and refrigerator. The following ingredients were also used to make the chocolates: 100% cocoa chocolate bar 1 kg (Organic 100% Cocoa, Bean to bar - from bean to bar, Cacau da Bahia, manufactured by Java chocolates LTDA, CNPJ.:20.261.126/0001-27, Santa Efigênia - Belo Horizonte - MG) (Figure 2), FOS (Prebiotic manufactured by Maxinutri Laboratório Nutraceutico Eireli, CNPJ.: 08.646.787/0001-75, Arapongas/PR) (Figure 3), granular dietary sweetener powder (Linea Sucralose, Culinary Sweetener Oven and Stove, contains maltodextrin and sweeteners: sucralose and acesulfame potassium, manufactured by EIC do Brasil Indústria e Comércio de Alimentos S/A, CNPJ.: 05.207.076/0002-97, Anápolis - GO) (Figure 4) and cocoa butter powder (Mycryo, crystallized cocoa butter powder, manufactured by Barry Callebaut) (Figure 5).

3.2 METHODS

The development of the product and the acceptability tests were initiated after approval by the Research Ethics Committee (CEP) of the Federal Institute of Education, Science and Technology of Goiás - IFG, according to Opinion No. 52671021.7.0000.8082. The elaboration of chocolate formulations containing different concentrations of FOS and sweetener were developed in the Food Laboratory of the Institution itself.

3.2.1 Experimental planning

The preparation of the different formulations was based on a 22 factorial design with 3 replications at the central point. The center points allow you to test whether the curvature is zero. If it is null, that is, the curvature is not significant, the analysis is carried out with the linear model on the effect of the factors. From it, directions to more promising experimental regions can be determined (ZEVIANE; MAYER, 2019).

Seven chocolate formulations were made with different concentrations of fructooligosaccharide (FOS) and sweetener (Table 1). These were developed with the aim of evaluating the effects of these ingredients on the sensory characteristics of the product and verifying which of these formulations has the best acceptance.

Table 1 - Factorial design 2^2, coded levels and real levels of the components for the elaboration of functional chocolates

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Independent variables Essay				
	X1	X2	FOS* (%)	Sweetener (%)
01	-1	-1	10	3
02	1	-1	30	3
03	-1	1	10	9
04	1	1	30	9
05	0	0	20	6
06	0	0	20	6
07	0	0	20	6

Source: prepared by the author, 2022.

The independent variables studied were the different concentrations of FOS (*X1*) and sweetener (*X2*) and the dependent variables evaluated were: *y1* = aroma, *y2* = flavor, *y3* = appearance, *y4* = texture, *y5* = global acceptance and *y6* = purchase intention.

3.2.2 Chocolates Processing Testing

To start production, 100% cocoa chocolate, sweetener, FOS and butter were weighed according to each formulation (Table 2).

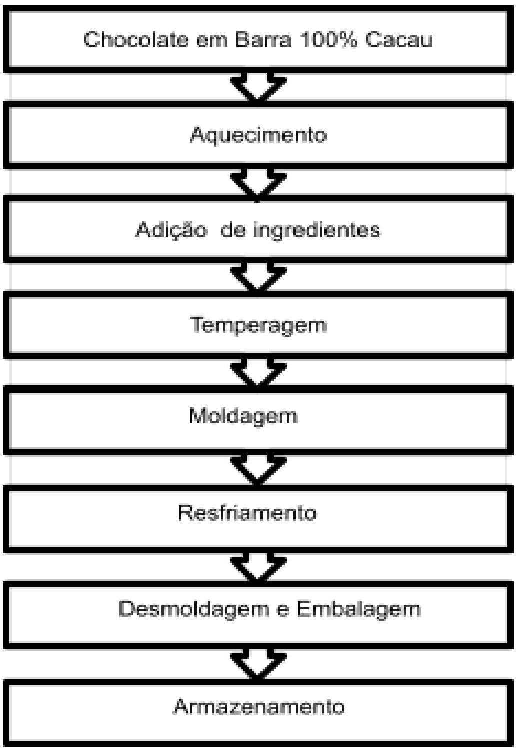
Table 2 - Formulations (g).

	F1	F2	F3	F4	F5	F6	F7
Cocoa	264	204	258	198	231	231	231
Butter	3	3	3	3	3	3	3
FOS	30	90	30	90	60	60	60
Sweetener	3	3	9	9	6	6	6
Total	300	300	300	300	300	300	300

Source: prepared by the author, 2022.

At first, the chocolate was chopped, transferred to a plastic container and then melted in a microwave until it reached a temperature of 45°C. In this process, the average power (50%) chocolate was heated for 30s. Two cycles of 30s were required for each amount of chocolate used in each formulation. After melting, the percentage of cocoa butter was added according to each formulation (Table 2) and homogenized. Then, the FOS with sweetener was added to the mixture (Table 2), at an average temperature of 30°C, mixing until all the ingredients were homogenized. Then, the mixture was cooled in a water bath until it reached a temperature of 28°C so that the chocolate tempering process could take place. The following are the stages of chocolate processing.

Figure 6 – Stages of chocolate processing.



Source: Prepared by the author, 2022.

The tempering process involves two steps. In the first step, the chocolate is heated to a temperature between 40°C and 45°C and cooled slowly, under constant movement until it reaches temperatures between 32°C and 27°C, to the crystallization temperature, which must be suitable for the growth of β-type crystals. In the second stage, the chocolate is heated to a temperature of 30-32°C, so that the unstable crystals melt. This temperature increase will influence the mass, improving the next processing steps (TALBOT, 1994).

After the chocolate tempering process, the molding of each formulation began, in which they were arranged in acetate molds for 5 g chocolates, the molds were shaken under a bench so that the chocolate was distributed homogeneously and removed the air bubbles inside, because when the chocolate solidifies, it contracts and molds easily (AWAD; MARANGONI, 2005) and chilled in the refrigerator for 30 min. Subsequently, they were demolded and wrapped in aluminum foil and stored in a Styrofoam box at room temperature.

According to Ghirardelli (2022), the storage temperature of chocolate should range from 15-24°C and should be stored in a cool, dry place, away from other foods, as it can absorb different aromas. Case the temperature of

storage is higher than 24 °C, the chocolate may appear whitish due to a part of the cocoa butter may appear on the surface

3.2.3 Sensory evaluation

To evaluate the degree of acceptability of the chocolates, the acceptance test was applied with 83 tasters, being students, professors and administrative technicians, not trained from the Federal Institute of Goiás, Inhumas campus. The test was conducted at the Sensory Analysis laboratory of the IFG, Inhumas campus, after reading and signing the "Informed Consent Form" by the tasters. The analysis was performed in a balanced incomplete block design, completing one block for every three trials, with three replications per formulation (Table 3).

Table 3 - Incomplete balanced block design, arranged in groups, of three plots, with three replications, totaling seven treatments.

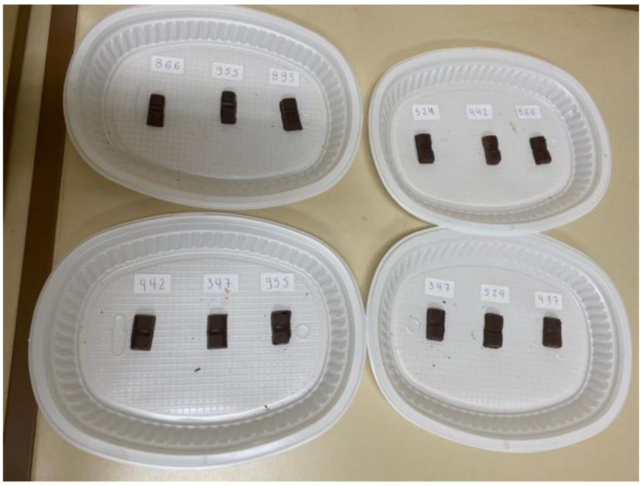
Group 1 (Repeat 1)			
Judge	1	7	4
Judge	2	6	3
Judge	3	5	2
Judge	4	2	7
Judge	5	1	6
Judge	6	4	5
Judge	7	3	1

Source: Prepared by the author, 2022.

Each taster received, in a monadic way, three samples of chocolate, accompanied by a glass of mineral water at room temperature, which was used by the tasters between sample tastings to cleanse the palate. Each chocolate sample, weighing approximately 3 grams, was served on disposable plates, coded with random three-digit numbers (Figure 7), and the judge was asked to taste the product from left to right and evaluate each sample, individually (without comparison) in relation to the attributes of appearance, aroma, flavor, texture and global acceptance, filling out a unique form for each sample. The evaluation was made through a hybrid hedonic scale between 0 and 10 points, where 0 corresponds to "extremely disliked" and 10 "extremely disliked", proposed by Villanueva, Petenate and Silva (2005). Purchase intention was assessed with a ten-point hedonic scale, where 0 represents certainly would not buy and 10 represents certainly would buy (Appendix A).

The tests were only carried out by the consumer with prior approval by the Research Ethics Committee of the Federal Institute of Goiás. The Informed Consent Form (ICF) was presented to the participants before the questionnaire was administered.

Figure 7 - Chocolates coded for sensory analysis.



Source: Prepared by the author, 2022.

3.2.4 Data analysis

The Response Surface Methodology (RSM) was used to evaluate the results, i.e., the effects of the independent variables (FOS and sweetener) on the sensory acceptance and purchase intention of the chocolate formulations. The response variables were evaluated using Analysis of Variance (ANOVA). Non-significant terms ($p > 0.05$) were not excluded from the models initially obtained, and the results were obtained according to Equation 1.

$$y = b0 + \text{b1}\,X1 + b2\,X2 \quad (1)$$

Where, *y* is the predicted response, *b0* is a constant, b1 and b2 are the regression coefficients, and X1 and X2 are the independent variables (FOS and sweetener, respectively). The quality of fit of the models obtained was made by the evaluation of the coefficient of determination (R2) and adjusted coefficient of determination (R2aadjust). All calculations, obtaining the equation and the graph, will be done through the STATISTICA 10.0 program.

4 RESULTS AND DISCUSSION

4.1 DEVELOPMENT OF CHOCOLATES

According to the preliminary tests carried out, it was noticed that the test samples with variation in the percentage of cocoa, FOS and sweetener, did not visually alter the characteristics of the product (Figure 8). The texture remained characteristic of chocolate, as well as its visual aspect.

Figure 8 - Test results of the formulations added with different concentrations of FOS.

Source: Prepared by the author, 2022.

In the formulation tests, during the manufacturing process it was observed that melting the chocolate in the microwave, it made the melting process faster, (compared to melting in a water bath) in addition to improving its handling. It was also observed that the best temperature for the addition of FOS is around 30°C, which caused all the prebiotic to be diluted in the chocolate.

Another point observed is that the FOS must be weighed seconds before its addition to the melted chocolate, as it agglomerates when out of its packaging, forming granules that make it difficult to homogenize the product and end up being noticeable in the final product. Thus, through preliminary tests, it was possible to establish the best way to process chocolates, according to the conditions available in the laboratory, as well as the concentrations of the ingredients that were applied

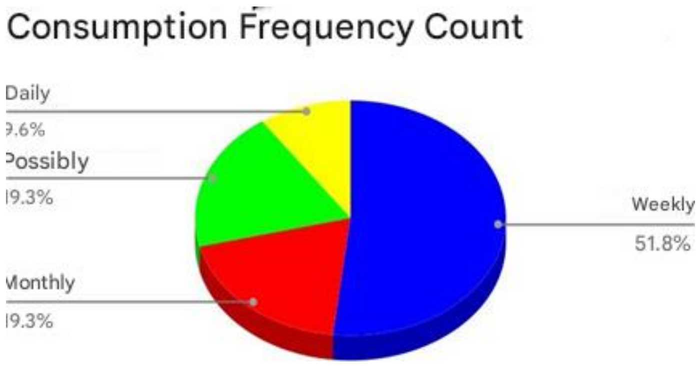
4.2 SENSORY EVALUATION

4.2.1 Profile of two participants

Of the 83 tasters who correctly answered the question about the frequency of chocolate consumption, 9.6% consume it daily, 51.8% consume it weekly, 19.3% consume it monthly and 19.3% consume it occasionally, verifying that all tasters are chocolate consumers, as none of the tasters answered the frequency of "never consumes" (Figure 9). The predominant age group among the tasters was 18-20 years (41.0%), followed by 33.7% from 21-25 years;

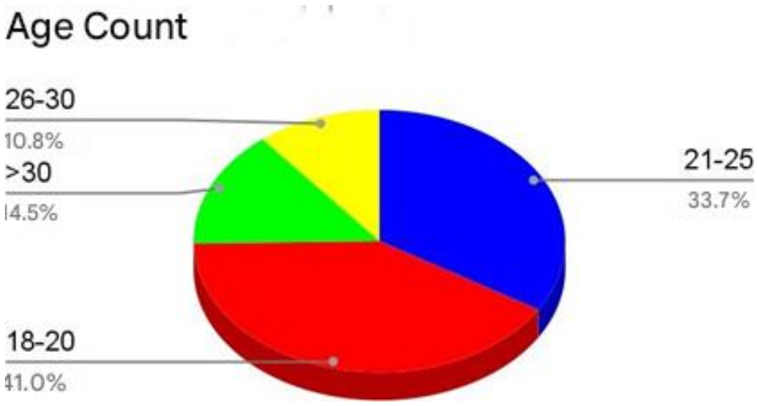
10.6% were 26-30 years old and 14.5% >30 years old (Figure 10). The predominant gender was female (51.8%) and male (48.2%) (Figure 11).

Figure 9 - Consumption Frequency Count



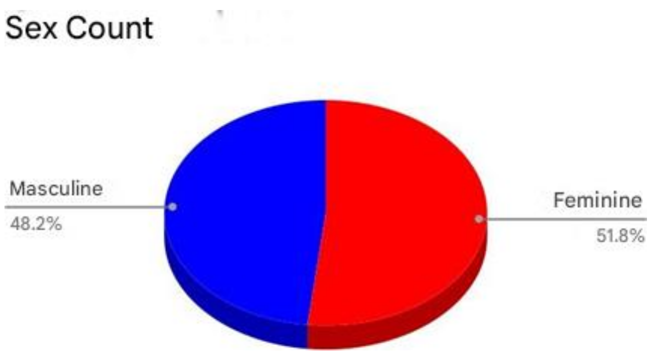
Source: Prepared by the author, 2022.

Figure 10 - Age Count



Source: Prepared by the author, 2022.

Figure 11 - Sex Count.



Source: Prepared by the author, 2022.

4.2.2 Evaluation of the effects of the addition of FOS and sweetener on the sensory acceptance of chocolates

The application of sensory analysis, through the acceptance and purchase intention test, aimed to verify possible changes resulting from the addition of the ingredients x1 (FOS) and x2 (sweetener) in different concentrations in the composition of the chocolates. From the means obtained for each variable (Table 4) of the seven trials performed and the application of factor design (Table 1), the models of equations y1 (aroma), y2 (flavor), y3 (appearance), y4 (texture), y5 (global acceptance) and y6 (purchase intention) were obtained with their respective regression coefficients. These coefficients were used to express the descriptive equations for each mixture variable, where y was the response predicted by the model for FOS (represented by x1) and for the sweetener (x2) that are presented together with the graphical responses given by the response surface, shown in Figures 12 to 17. The mathematical models y1, y2, y3, y4, y5 and y6 did not show significant linear effects at the level of 5 % of significance for all the variables studied. In addition, when checking the curvature, it was observed that it was not significant, which indicates that the model of the coefficients obtained through the linear models can be analyzed and will direct new experiments to be explored.

Table 4 - Responses of the dependent variables studied.

	FOS (X1)	Sweetener (X2)	*y1* = Aroma	*y2* = Taste	*y3* = Appearance	*y4* = Texture	*y5* = Global acceptance	*y6* = Purchase intent
F1	-1,0	-1,0	6,3	8	3,5	6,5	4	3
F2	1,0	-1,0	8	9	6,25	8	7	5
F3	-1,0	1,0	8	8	5	7	6	5
F4	1,0	1,0	7	8	5	7	5,6	5
F5	0,0	0,0	8,1	9	7,75	7	7	6
F6	0,0	0,0	8	9	6	8	6	5
F7	0,0	0,0	8	8	5	7	5	5

Source: Prepared by the author, 2022

4.2.2.1 Aroma

According to the statistical analysis of the data, the model presented for the answer y1 = aroma, presented all significant regression coefficients at a confidence level of 5%. A p-value of less than 0.05 (< 0.05) indicates that the variable is significant to the model, because the changes in its value are related to changes in the response variable. In addition, the model was considered predictive, with R2 = 0.99 and adjusted R2 = 0.99. According to Minitab (2013), R2 is a way to assess how close the data are to the adjusted regression obtained. Thus, the closer to 1 (100%), the better the model. Granato et al. (2010) point out that a high value of adjusted R2 indicates a good adequacy of the models to describe the influence of independent variables on the response, which suggests that the empirical models adjust to the real data, defining well the true behavior of the system.

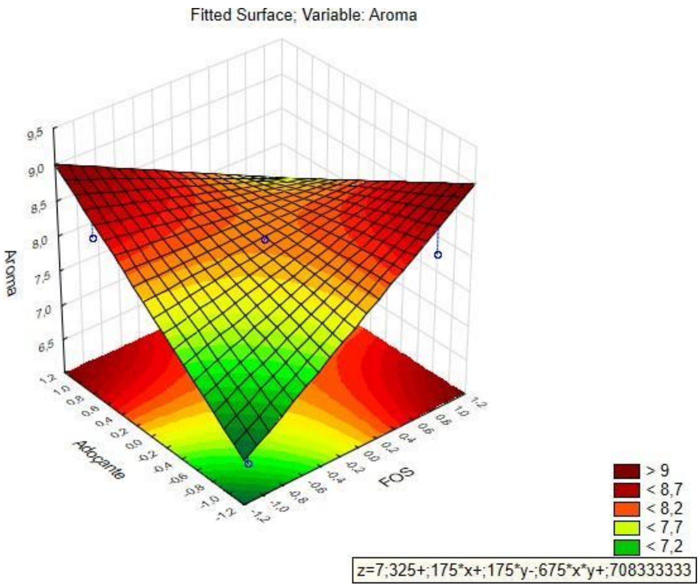
Equation 2 shows the coded model obtained for the aroma variable from the experimental data. The coefficients marked with * are significant (p < 0.05).

$$y1 = 7.325^* + 0.175.X1\ ^*+ 0.175.X2\ ^*- 0.675.X1.\ X2^* + 708333333^* \qquad (2)$$

By the coefficients of equation (2), it was possible to observe that both the addition of FOS (*X1*) and sweetener (*X2*) positively influenced the aroma of the chocolates, that is, the addition of both contributed to obtaining better scores in relation to this attribute. However, the interaction coefficient between *X1*X2* was negative. Thus, for a better response in the aroma attribute, it is desirable that these ingredients are not mixed, as they have an antagonistic effect.

Figure 12, which shows the response surface obtained for the aroma variable, it is observed that the response increases with the increase in the concentration of FOS or sweetener.

Figure 12 - Response Surface for the aroma variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

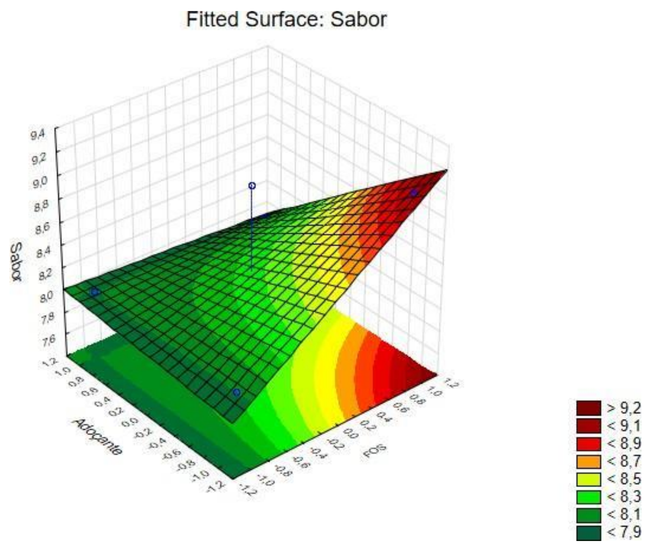
4.2.2.2 Taste

According to the statistical analysis of the data, the model obtained for the flavor attribute did not present predictive capacity, as it presented an adjusted R2 = 0 (and R2 *= 0.61111), in addition to not presenting* significant regression coefficient factors at a confidence level of 5%. According to Khuri & Cornell (1987), the coefficient of determination (R2) is a way of evaluating the proportion of the total variation of the response that is demonstrated from the model. Thus, the closer to 1 (100%), the better the model. Equation 3 shows the coded model obtained for the variable from the experimental data.

$$y2 = 8.25^* + 0.25.X1 - 0.25.\ X2 - 0.25.X1.\ X2 + 0 \qquad (3)$$

Figure 13 shows the Response surface obtained for the flavor variable.

Figure 13 - Response Surface for the flavor variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

4.2.2.3 Appearance

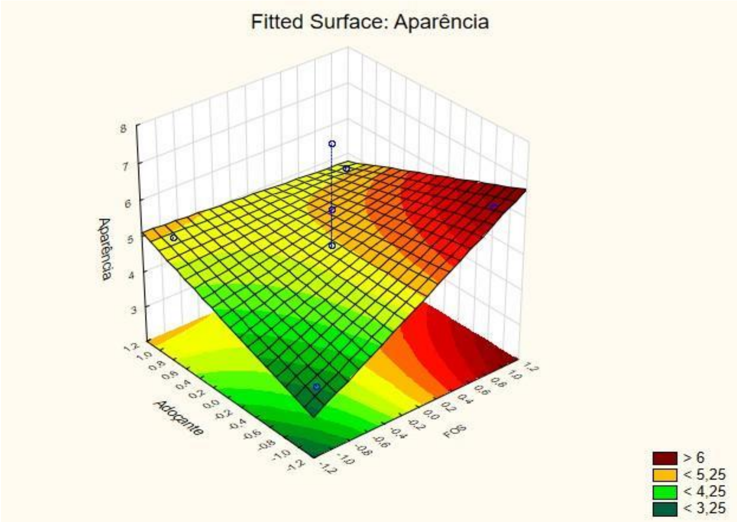
For the appearance attribute, according to the statistical analysis of the data, the model presented for the answer y3 = appearance, presented only the main significant regression coefficients at a confidence level of 5%. In this case, the model was not considered predictive, with R^2 = 0.63382 and adjusted R2 = 0.26765. According to Khuri & Cornell (1987), the coefficient of determination (R2) is a way of evaluating the proportion of the total variation of the response that is demonstrated from the model. Thus, the closer to 1 (100%), the better the model.

In equation 4 the coded model obtained for the variable from the experimental data is presented.

$y3 = 4.9375^{*} + 0.6875.X_1 - 0.6875 . 1X1. X2 + 0$ (4)

By the coefficients of equation (4), it was possible to observe that the increase in the addition of FOS (*X1*) contributed to obtaining better scores for the attribute appearance. The sweetener (*X2*) at levels +1 contributed with low intensity to obtain better scores in relation to this attribute. However, the interaction coefficient between *X1*X2* was negative. Figure 14 shows the Response surface obtained for the appearance variable. It was observed that the response increases with increasing FOS concentration.

Figure 14 - Response Surface for the appearance variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

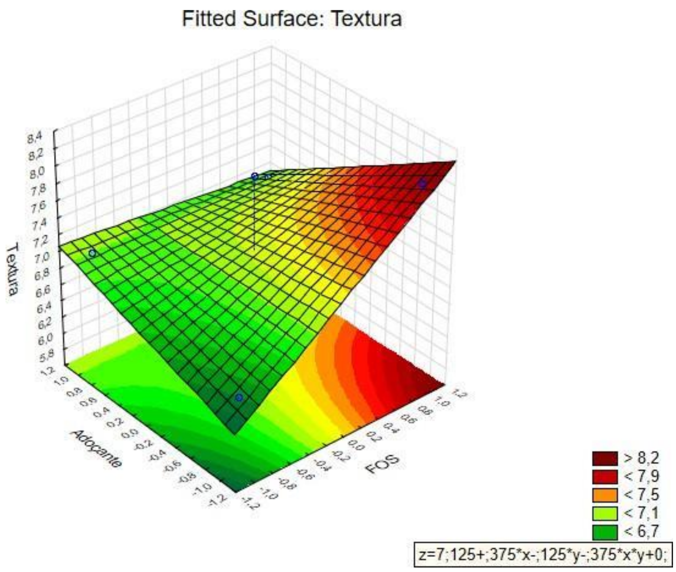
4.2.2.4 Texture

According to the statistical analysis of the data, the model obtained for the texture attribute did not present predictive capacity, as it presented an adjusted R2 = 0 (and R2 = 0.65432), in addition to not presenting significant regression coefficient factors at a confidence level of 5%. In equation 5 the coded model obtained for the variable from the experimental data is presented.

$$y4 = 7.125^{*} + 0.375.X1 - 0.125.X2 - 0.375.X1.\ X2 + 0 \qquad (5)$$

In Figure 15, which presents the surface of the response obtained for the texture variable, it is observed that the responses that presented the lowest scores for the texture of the chocolates are those found in the green region, with an increase in the addition of FOS that intensifies the acceptance of the texture attribute.

Figure 15 - Response Surface for the texture variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

4.2.2.5 Global Acceptance

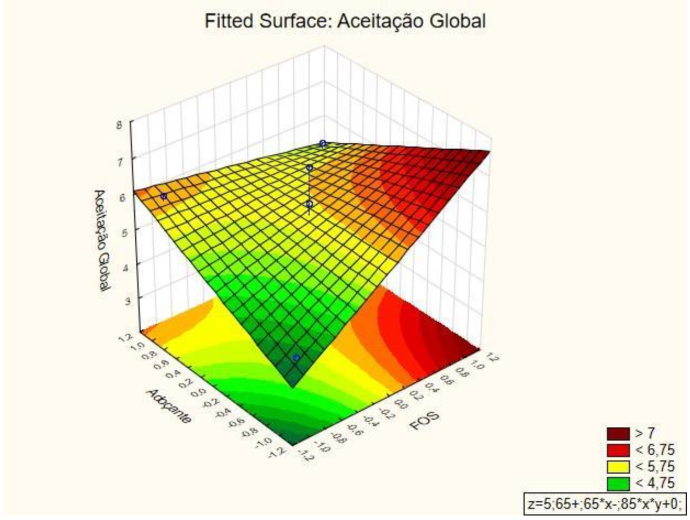
The model obtained for the global acceptance of chocolates showed R2 = *0.69622* and adjusted R2 = 0.39244*. It presented only the significant main coefficient*, according to the statistical analysis of the data, using ANOVA (ል 5%).

Equation 6 shows the coded model obtained for the variable from the experimental data.

y5 =5.65 + 0.65.X1 - 0.85.X1. X2 + 0* (6)

Figure 16, which shows the response surface obtained for the global acceptance variable, it is observed that the response increases with the increase in FOS concentration.

Figure 16 - Response Surface for the global acceptance variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

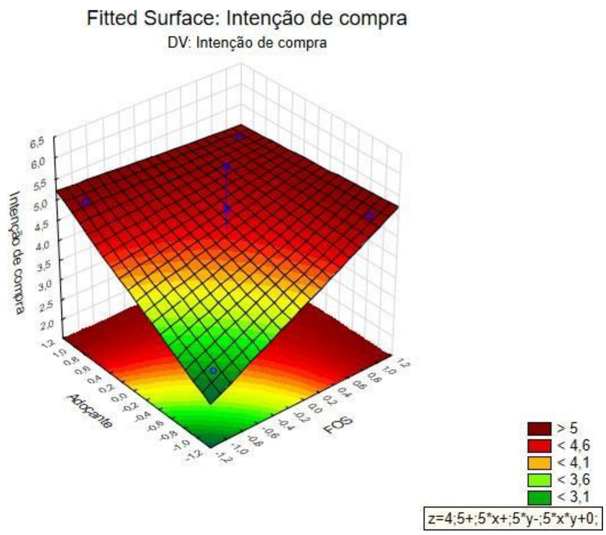
5.2.6 Purchase Intent Testing

Purchase intention showed satisfactory results, with R2 = 0.86275 and adjusted R2 = 0.58824. Equation 7 shows the coded model obtained for the variable from the experimental data.

y6 = 4.5* + 0.50.*1v1* + 0,50.*X2* - 0,50.*1X1. X2* + 0 (7)

By the coefficients of equation (7), it was possible to observe that both the addition of FOS (*X1*) and sweetener (*X2*) at levels +1 positively influenced the intention to purchase chocolates, that is, the addition of both contributed to obtaining better scores. However, the interaction coefficient between *X1*X2* was negative. From the response surface obtained for the purchase intention variable (Figure 17), it was observed that the response increases the purchase intention results in the red region due to the increase in the concentration of FOS or sweetener.

Figure 17 - Response Surface for the purchase intention variable.



Source: STATTITICA 10.0, prepared by the author, 2022.

5 FINAL CONSIDERATIONS

With the tests carried out, it was possible to work on new formulations in order to obtain a better nutritional and sensory quality in the final product.

Through the use of this factorial design (2^2), it was observed that the curvature check for all response functions was not significant ($p > 0.05$), which indicates that the linear model is appropriate for the variables in the regions studied. However, the linear models did not present good fit and significant coefficients, which indicates that new experiments should be carried out considering the increase in FOS concentrations, in order to obtain an optimized formulation. Thus, with this work, it was possible to obtain a direction of which prebiotic chocolate formulation should be studied in the next works, with FOS values above 30% and sweetener at 3%.

REFERENCES

Brazilian Association of the Chocolate, Cocoa, Peanut, Candy and Derivatives Industry. (2019). Statistics: Chocolate market data 2019. http://www.abicab.org.br/noticias

Brazilian Association of the Chocolate, Cocoa, Peanut, Candy and Derivatives Industry. (2022). Chocolate maintains penetration in 73% of Brazilian households during the pandemic. http://www.abicab.org.br/noticias

National Health Surveillance Agency. (1998). Ordinance No. 29 SVS/MU, of January 13, 1988. Approves the Technical Regulation on Food for Special Purposes. Federal Official Gazette, 15 Jan. 1998, section 1.

National Health Surveillance Agency. (2003). Resolution RDC No. 359, of December 23, 2003. Approves Technical Regulation of Packaged Food Portions for Nutritional Labeling Purposes. Official Gazette of the Federative Republic of Brazil, 26 Dec. 2003.

Awad, T. S., & Marangoni, A. G. (2005). Ingredient interaction affecting texture and microstructure of confectionery chocolate. In A. G. Gaonkar & A. McPherson (Eds.), Ingredient interactions: Effects on food quality (2nd ed., pp. 424–471). New York, NY: Taylor & Francis.

Brazil. Ministry of Health. Health Care Secretariat. (2008). Food guide for the Brazilian population: Promoting healthy eating. Brasília: Ministry of Health.

Brazil. Ministry of Health. Virtual Health Library. (2009). Functional foods. https://bvsms.saude.gov.br/alimento-funcionais/

Mars Center for Cocoa Science. (2011). Conditions for planting. [URL unavailable].

Coentrão, P. A. M. (2005). Evaluation of three polyphenol isolation techniques: Application in semisweet chocolate samples [Master's thesis, Fluminense Federal University]. Niterói, RJ.

Fortes, R. C., & Muniz, L. B. (2009). Effects of dietary supplementation with *fructooligosaccharides* and inulin in the human body: Evidence-based study. Sciences & Health, 20(3), 241–252.

Ghirardelli. (2022). Chocolate Q&A. http://www.ghirardelli.com/recipes-tips/chocolate-qa

Gonçalves, M. F., Carneiro, W. M. A., & Sena, J. V. C. (2009). The Brazilian cocoa market: Changes in the profile of international trade in the last twenty years. In Annals of the IV Meeting of the Brazilian Society of Rural Economics, Administration and Sociology – Northeast Region. Campina Grande, PB: SOBER/NE.

Gonzalez-Tomas, L., Coll-Marqués, J., & Costell, E. (2008). Viscoelasticity of inulin-starch-based dairy systems: Influence of inulin average chain length. Food Hydrocolloids, 22(7), 1372–1380.

Granato, D., Branco, G. F., Nazzaro, F., Cruz, A. G., & Faria, J. A. F. (2010). Functional foods and nondairy probiotic food development: Trends, concepts, and products. Comprehensive Reviews in Food Science and Food Safety, 9, 292–302.

Brazilian Institute of Geography and Statistics. (2022). Municipal Agricultural Production - PAM. https://sidra.ibge.gov.br/

Khuri, A. I., & Cornell, J. A. (1987). Response surface: Designs and analyses. New York, NY: Marcel Dekker.

Kopenhagen. (2021). Chocolate market 2021/2022: Projections, trends and expectations. https://blog-franquias.kopenhagen.com.br/2021/09/03/mercado-de-chocolates-2021-2022-projecoes-tendencias-e-expectativas/

Langa, S., van den Bulk, E., Peirotén, A., Gaya, P., Schols, H. A., & Arqués, J. L. (2019). Application of lactobacilli and prebiotic oligosaccharides for the development of a synbiotic semi-hard cheese. LWT - Food Science and Technology, 114, 108404.

Minitab Blog Editor. (2013). Regression analysis: How do I interpret R-squared and assess the goodness-of-fit? https://blog.minitab.com/en/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess-the-goodness-of-fit

Raud, C. (2008). Functional foods: The new frontier of the food industry analysis of Danone and Nestlé's strategies in the Brazilian yogurt market. Journal of Political Sociology, 16(31), 85–100.

Rosa, S. P. L., & Cruz, J. D. (2017). Applicability of *fructooligosaccharides* as a functional food. Nutrivisa - Journal of Nutrition and Health Surveillance, 4(1), 12–20.

Sato, C. C., & Pépece, O. M. (2013). Motivating factors for the consumption of fine chocolates in Brazil. Electronic Journal of Administration, 12(2), 1–20.

Sena, J. V. C. (2011). Cocoa production and herd in the Northeast. Informe Rural Etene - Banco do Nordeste, 5(2), 1–8.

Souza, C. V. B. (2020). Innovation in fermented meat sausages: Incorporation of probiotic microorganisms and prebiotic fiber in formulations with reduced fat content [Doctoral thesis, São Paulo State University]. São José do Rio Preto, SP.

Superintendence of the Manaus Free Trade Zone. (2003). Cacau - Project: regional potentialities: economic feasibility study. Manaus: Ministry of Development, Industry and Foreign Trade.

Talbot, G. (1994). Chocolate temper. In S. T. Beckett (Ed.), Industrial chocolate manufacture and use (2nd ed., pp. 156–166). London: Chapman & Hall.

Teberga, P. M. F. (2017). Evaluation of the effect of different prebiotics on the development of Lactobacillus strains [Master's thesis, University of São Paulo]. Lorena, SP.

Villanueva, N. D. M., Petenate, A. J., & Silva, M. A. A. P. (2005). Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. Food Quality and Preference, 16(8), 691–703.

Yun, J. W. (1996). *Fructooligosaccharides* – occurrence, preparation, and application. Enzyme and Microbial Technology, 19(2), 107–117.

Zeviani, W. M., & Mayer, F. de P. (2019). Industrial process control. http://web.leg.ufpr.br/ensino/CPI/apostila/index.html

APPENDAGES

APPENDIX A - Analysis Identification Form

FICHA DE IDENTIFICAÇÃO

Nome:____

Data:____/____/______

Idade: ( )18-20 anos ( ) 21-25 anos ( ) 26-30 anos ( ) > 30 anos

Sexo: ( ) Feminino ( ) Masculino

Qual a frequência que você consome chocolate?

( ) diário ( ) semanal ( ) mensal ( ) eventualmente ( ) nunca

Você está recebendo uma amostra de chocolate. Por favor, **PROVE-A** e marque um "X" em qualquer ponto da escala (**inclusive entre os pontos**) onde melhor representa quanto você gostou ou desgostou, com respeito a:

AMOSTRA: ________________

AROMA: 0 — 5 — 10
Desgostei extremamente | Não gostei nem Desgostei | Gostei extremamente

APARÊNCIA: 0 — 5 — 10
Desgostei extremamente | Não gostei nem Desgostei | Gostei extremamente

SABOR: 0 — 5 — 10
Desgostei extremamente | Não gostei nem Desgostei | Gostei extremamente

TEXTURA: 0 — 5 — 10
Desgostei extremamente | Não gostei nem Desgostei | Gostei extremamente

ACEITAÇÃO GLOBAL: 0 — 5 — 10
Desgostei extremamente | Não gostei nem Desgostei | Gostei extremamente

Você está recebendo três amostras codificadas. Avalie cada uma segundo a sua intenção de **COMPRA**, utilizando a escala abaixo:

AMOSTRA: ________________

INTENÇÃO DE COMPRA: 0 — 5 — 10
Certamente eu não compraria | Provavelmente eu não compraria | Talvez eu compraria/ Talvez eu não compraria | Provavelmente eu compraria | Certamente eu compraria

Comentários:____

____

____

____