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Physicochemical properties and use of chia mucilage (*Salvia hispanica* L.) in the reduction of fat in cookies

Propriedades físico-químicas e utilização da mucilagem de chia (*Salvia hispanica* L.) na redução de gordura em biscoitos

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Maria Clara Rocha
Master in Food Science
Food Science Department, Federal University of Lavras, CEP 37200-000, Lavras, MG, Brazil
E-mail: rocha.mariaclara@hotmail.com

Maria da Penha Píccolo
PhD in Food Science and Technology
Department of Food Engineering, Federal University of Espírito Santo, CEP 29500-000, Alegre, ES, Brazil
E-mail: penhapiccolo@gmail.com

Wilson César de Abreu
PhD in Food Science
Nutrition Department, Federal University of Lavras, CEP 37200-000, Lavras, MG, Brazil
E-mail: wilson@ufla.br

Antonio Manoel Maradini Filho
PhD in Food Science and Technology
Department of Food Engineering, Federal University of Espírito Santo, CEP 29500-000, Alegre, ES, Brazil
E-mail: antoniomaradinifilho@yahoo.com

Maria de Fátima Píccolo Barcelos
PhD in Food and Nutrition
Food Science Department, Federal University of Lavras, CEP 37200-000, Lavras, MG, Brazil
E-mail: piccolob@gmail.com

ABSTRACT

The prevention of non-communicable chronic diseases can be obtained, among other factors, by the reduction of fat of foods. In this context, chia seeds (*Salvia hispanica* L.) prove interesting to the making of foods with a reduced fat content for presenting in their composition a considerable amount of dietary fiber (mucilage) with potential use as a fat replacer. In this work, chia seed mucilage was extracted and some of their physicochemical properties as well their use in the fat replacement (butter) in cookies at the levels of 10, 20 and 30 g/100 g were investigated, which were analyzed, afterwards. Chia mucilage presented high values of solubility, water-holding capacity and emulsifying activity and displayed beige color. The cookies with fat replacement by chia mucilage presented reduction in the lipid contents and in the L* and b* parameters. Cookies presenting replacement of 20 and 30 g/100 g of the fat showed greater hardness. In the treatments with a replacement of 10 and 20 g/100 g variations of sensorial acceptance of 'I liked it slightly' to 'I liked it moderately" were observed. Chia mucilage proved a promising alternative to be utilized as a fat replacer in cookies.

Keywords: *Salvia hispanica* L., dietary fiber, biscuits, fat replacers.

RESUMO

A prevenção das doenças crônicas não transmissíveis pode ser obtida, entre outros fatores, pela redução da gordura dos alimentos. Nesse contexto, as sementes de chia (*Salvia hispanica* L.) mostram-se interessantes na produção de alimentos com reduzido teor de gordura por apresentarem em sua composição uma quantidade considerável de fibra alimentar (mucilagem) com potencial uso como substituto de gordura. Neste trabalho, foi extraída a mucilagem da semente de chia e investigadas algumas de suas propriedades físico-químicas bem como sua utilização na substituição de gordura (manteiga) em biscoitos nos níveis de 10, 20 e 30 g/100 g, os quais foram analisados posteriormente. A mucilagem de chia apresentou elevados valores de solubilidade, capacidade de retenção de água e atividade emulsificante e apresentou coloração bege. Os biscoitos com substituição de gordura por mucilagem de chia apresentaram redução no conteúdo lipídico e nos parâmetros L* e b*. Os biscoitos com substituição de 20 e 30 g/100 g da gordura apresentaram maior dureza. Nos tratamentos com substituição de 10 e 20 g/100 g foram observadas variações na aceitação sensorial entre 'gostei um pouco' e 'gostei moderadamente". A mucilagem de chia se mostrou uma alternativa promissora para ser utilizada como substituto de gordura em biscoitos.

Palavras-chave: *Salvia hispanica* L., fibra alimentar, biscoitos, substitutos de gordura.

1 INTRODUCTION

The increased risk of noncommunicable diseases (NCDs), such as cardiovascular diseases, type 2 diabetes, dyslipidemia and cancer, has been attributed, among others, to excess consumption of high energy density foods associated with sedentary lifestyle (WHO, 2005; WHO, 2010; AZEVEDO et al., 2014). Modifications in the diet and lifestyle such as reduction of total energy intake and practices of physical exercises can considerably prevent such problems (SWANSON & MUNSAYAC, 1999; LAGUNA et al., 2014).

Aiming to recover the quality of life, the consumer has become more and more demanding and worried about seeking a more wholesome diet. It is found in this context, the highlight for chia seeds (*Salvia hispanica L.*) that present quantities regarded as gluten-free proteins, essential fatty acids and dietary fiber, standing out the mucilage of relevant hydrocolloid action that acts as soluble fiber and exhibits water -holding properties, viscosity development, freshness preservation, high solubility in water and thickening properties, in addition to containing minerals, vitamins and phenolic acids, being a potential ingredient for the development of more wholesome foods (VIEBKE, AL-ASSAF & PHILLIPS, 2014; CAPITANI et al., 2015; PINTADO et al., 2016; LOPES et al., 2020).

The food industry has focused on producing low calorie foods in response to the great public interest. One of the strategies in the manufacture of more wholesome foods is established in obtaining products with reduced fat content. In this way, fat substitutes, *fat replacers*, described as ingredients of food formulations that replace some or all of the functions of fat, but do not present calories or have a reduced calorie value (LINDSAY, 2010; LI & NIE, 2016).

Biscuits present good acceptance and are consumed by children, teenagers and the elderly; however, some are high in fat and sucrose and are therefore generally avoided by consumers concerned with health maintenance (MAURO, SILVA, & FREITAS, 2010). However, cookies can become less caloric by replacing the amount of fat with ingredients with reduced or even devoid of caloric potential, such as fibers, which act as fat substitutes (SWANSON & MUNSAYAC, 1999).

Due to its structure, chia mucilage can be used in various applications in the food industry in the making of more wholesome products, thus presenting great potential as a fat substitute in cookies.

The objective of this work was to evaluate the physicochemical properties of the mucilage extracted form chia seeds and utilize it as a partial replacer of fat in cookies and evaluate both objectively and sensorially the biscuits made with fat replacements.

2 MATERIAL AND METHODS

2.1 MATERIAL

Chia seeds (*Salvia hispanica L.*) and the ingredients used in the manufacture of cookies (wheat flour, granulated sugar, butter, baking powder, vanilla essence, egg and salt) were purchased in Lavras commerce, Minas Gerais. In the laboratory, the packed chia seeds as well as some ingredients (butter and egg) were stored in a refrigerator (5 ° C to 8 ° C) till the moment of use and analysis. The mucilage extracted from the chia seed used in replacement in part of butter in the manufacture of the cookies was freeze-dried, packed in a plastic bag and stored in a desiccator. The lipid content of the butter of 86% was considered, as expressed in the Brazilian Table of Food Composition (TACO).

2.2 METHODS

2.2.1 Mucilage extraction

Chia mucilage was obtained according to Muñoz et al. (2012) with modifications. The chia seeds were ground in distilled water at the proportion water: seed of 1:40 (w/v) at the temperature of 85 °C for 30 minutes under gentle and constant stirring. The hydrated seeds were placed onto glass plates 14 cm in diameter with thin film formation and submitted to drying in an oven at 50 ºC for 16 h. After drying, the chia seeds were removed from the plate with the aid of a spatula and the mucilage was rehydrated with about 4 ml of distilled water per plate. The rehydrated mucilage was subjected to dehydration in L4KR lyophilizer (Edwards), crushed in MA350 ball mill (Marconi) for 2 minutes and packed in plastic package in desiccator.

2.2.2 Proximate composition of chia seeds and mucilage

Moisture, lipids, crude protein and fixed mineral residue (ashes) of the seeds and chia mucilage were performed according to AOAC methodology (1990). Crude fiber was determined by acid hydrolysis and quantified using the gravimetric method according to Van de Kammer and Van Ginkel (1952). The carbohydrates were obtained by the difference between 100 and the sum of the values of moisture, lipids, crude protein, crude fiber and ashes.

2.2.3 Physicochemical properties of chia mucilage

2.2.3.1 Solubility

The solubility of the mucilage was determined in triplicate following the technique proposed by Betancur-Ancona, López-Luna, and Chel-Guerrero (2003). 1% (w/v) mucilage solutions were prepared and placed in a water bath at the temperature of 30 °C with constant stirring for 30 minutes. The contents were transferred to centrifuge tubes, centrifuged at 980 x g for 15 min (Labor SP-701 refrigerated centrifuge, 116 mm of radius) and the pH of the solution was measured. Aliquots of 10 mL of the supernatant were placed in pre-weighed porcelain crucibles and then oven-dried at 120 ° C for 4 h. The crucibles were removed from the oven, allowed to cool in a desiccator and weighed. The solubility, in percent, was calculated according to the equation 1:

$$\%\ \text{solubility} = \frac{\text{mucilage weight after drying (g)}}{\text{weight of the initial sample (g)}} \times 100 \qquad (1)$$

2.2.3.2 Water-holding capacity and oil-holding capacity

The water-holding capacity (WHC) and oil-holding capacity (OHC) of chia mucilage were determined in triplicate according to the methodology proposed by Chau, Cheung and Wong (1997) with modifications. 0.1 g of sample (dry basis) was weighed and 10 mL of distilled water or corn oil (oil density = 0.92g / mL, Mazola) was added to a centrifuge tube. This suspension was homogenized in vortex for 1 minute and centrifuged at 2,200 x g for 30 minutes (Labor SP-701 refrigerated centrifuge, 116 mm of radius). The supernatant was discarded and the residue was weighed, determining the weight gain of water or oil by mucilage. The WHC of the mucilage was expressed in g of water retained per g of sample and the OHC in g of oil retained per g of sample (Equation 2).

$$\text{WHC and OHC (g/g)} = \frac{\text{residue weight (g)} - \text{initial weight of the sample (g)}}{\text{initial weight of the sample (g)}} \quad (2)$$

2.2.3.3 Emulsifying activity (EA)

The emulsifying activity (AE) was determined according to Chau, Cheung and Wong (1997) with modifications. 0.5 g of chia mucilage was weighed; 25 mL of distilled water was added and that solution was homogenized in a Turratec TE-102 homogenizer (Tecnal) at 20,000 rpm for 2 minutes. Then, 25 mL of corn oil (density = 0.92 g/mL) was added and homogenized at 22,000 rpm for 2 minutes. Then samples were centrifuged (Labor SP-701 refrigerated centrifuge, 116 mm of radius) at 2,000 rpm for 10 minutes and the remaining volume of the emulsion measured. The emulsifying activity was calculated as follows (Equation 3):

$$\text{EA (\%)} = \frac{\text{volume of the emulsion (mL)}}{\text{total volume of the solution (mL)}} \times 100 \quad (3)$$

2.2.4 Instrumental color

The analysis of instrumental color was performed on the mucilage samples in three replicates using a CM-5 (Konica Minolta Sensing) spectrophotometer, analyzing the color parameters L *, a * and b *. The L * (lightness factor) ranging from black (0) to white (100), a * from green (-a*) to red (+a*) and b * from blue (-b*) to yellow (+b*).

2.2.5 Scanning electron microscopy

The freeze-dried chia mucilage was characterized by scanning electron microscopy (SEM) using a LEO EVO 40 XVP (Carl Zeiss) microscope, according to Capitani et al. (2013). The samples were fixed in stands with the aid of double-sided carbon tape and covered by a layer of gold in a gold evaporator (Sputtering) SCD 050 (Bal-Tec). The images were increased from 10 to 200 x.

2.2.6 Preparation of the cookies

The dough of the biscuits was obtained following the formulation shown in Table 1. First, the butter, egg, sugar and vanilla were mixed and, after complete homogenization, the mixture was added to the dry ingredients (wheat flour, baking powder, salt and chia mucilage, when used). The biscuits were rolled, molded with 36 mm in diameter and 10 mm thick and baked at 160 ° C for 8 minutes. After the cooled, they were packed in closed containers till the moment of the analyses.

Table 1. Formulations of cookies with fat replacement of butter by freeze-dried chia mucilage.

	Formulations (g/100g)			
Ingredients	CC	CI	CII	CIII
wheat flour	50.30	50.30	50.30	50.30
sugar	14.90	14.90	14.90	14.90
butter	11.80	10.62	9.44	8.26
vanilla	3.15	3.15	3.15	3.15
chia mucilage	0	1.18	2.36	3.54
egg	18.85	18.85	18.85	18.85
baking powder	0.80	0.80	0.80	0.80
salt	0.20	0.20	0.20	0.20

CC= Control cookie without replacement of fat (butter); CI, CII e CIII= cookies with replacements of 10, 20 and 30% of the fat by chia mucilage, respectively.

2.2.7 Proximate composition of the cookies

The analyses of moisture, lipid, crude protein and ash were carried out according to the AOAC (1990). The crude fiber was determined by acid hydrolysis and quantified using the gravimetric method according to Van de Kammer and Van Ginkel (1952). The carbohydrates was obtained by the difference between 100 and the sum of the values of moisture, lipids, crude protein, crude fiber and ashes.

2.2.8 Physical properties of the cookies

The analyses of instrumental color were performed on the biscuits in four replicates using a Konica Minolta colorimeter (model CR400), analyzing the L*, a*, b* color parameters.

The texture of the cookies was obtained in a texturometer (Stable Micro Systems Model TA-XT2i) in four replications, under the following conditions: pre-test velocity of 2.5 mm /s, test velocity of 2.0 mm/s, post-test velocity of 10.0 mm/s, distance of 2.5 mm of compression with cylindrical probe of aluminum of 6.0 mm (PAREYT et al., 2009).

2.2.9 Sensorial analysis

The sensorial evaluation of the cookies was conducted with 100 untrained tasters in individual booths in the Sensory Analysis Laboratory of the Federal University of Lavras (Lavras - MG). Each evaluator was given four cookies at room temperature in disposable plastic containers, coded with three digit figures, in a balanced manner and under white light.

For the sensory acceptance test of the products, the tasters evaluated the samples for flavor, texture, aroma and overall impression using a structured hedonic scale of 9 (nine) points, with value 1 being defined as 'highly disliked' and value 9 as 'highly liked'. The purchase intention test was also carried out through a structured scale of 5 (five) points, ranging from 1 = I certainly would not buy to 5 = I would certainly buy (STONE & SIDEL, 2004). The obtained scores were analyzed statistically by means of analysis of variance (ANOVA) and Tukey's test, considering the level of significance of 5% using SensoMaker Software version 1.9 (NUNES & PINHEIRO, 2014).

2.2.10 Statistical analysis

The experiment was conducted in a completely randomized design with four treatments and four replications. The data were submitted to analysis of variance (ANOVA) using the statistical program Sisvar version 5.6 (FERREIRA, 2014), performing a mean test (Tukey) when necessary at the 5% significance level for chemical composition, color and texture of the cookies. In the sensorial analysis, SensoMaker Software version 1.9 was employed.

3 RESULTS AND DISCUSSION

3.1 PROXIMATE COMPOSITION OF CHIA SEEDS AND MUCILAGE

The yield was 6.44 g of freeze-dried chia mucilage/100 g of chia seeds. Table 2 shows the average values of the proximate composition of the chia seeds and the freeze-dried chia mucilage.

Table 1. Proximate composition of the chia seeds and of the freeze-dried chia mucilage.

Component	Chia seeds* (g/100g)	Freeze-dried chia mucilage* (g/100g)
moisture	7.66 ± 0.05	2.41 ± 0.32
lipids	30.38 ± 1.29	1.03 ± 0.12
protein	18.77 ± 0.82	8.21 ± 0.19
crude fiber	9.42 ± 0.18	14.33 ± 0.06
ash	4.15 ± 0.09	6.86 ± 0.03
carbohydrates	37.28 ± 0.62	69.57 ± 0.13

Mean ± standard deviation. *Values expressed in dry matter, except moisture.

Chia seeds presented high values of lipids and proteins, their being an important source of oil and its use is interesting in the formulation of foods destined to celiac people. Similar values were found by other authors (BUSHWAY, BELYEA, & BUSHWAY, 1981; AYERZA & COATES, 2011; COELHO & SALLAS-MELADO, 2014a; SEGURA-CAMPOS et al., 2014a, TIMILSENA et al., 2016b). The amount of lipids in the chia mucilage was very low (1.03%), probably due to the low solubility of lipids in water, which makes its use as an ingredient in low fat foods interesting. Similar results of lipids, proteins, crude fiber and ashes in chia mucilage were obtained by Capitani et al. (2015).

3.2 PHYSICOCHEMICAL PROPERTIES OF CHIA MUCILAGE

3.2.1 Solubility

The solubility of the chia mucilage dispersions at 1% w/v at the temperature of 30 ° C and pH of 6.49 in this work was of 79.49% ± 1.50. High water solubility values of chia mucilage near room temperature indicate its promising application in food. High solubility for the use of mucilage as texture and viscosity modifiers and to stabilize emulsions or dispersions is desirable (TIMILSENA et al., 2016a). This value found corroborates with values of solubility obtained by Capitani et al. (2013) for chia mucilage at different temperatures (25-80 °C), which presented percentages of solubility ranging from 66 to 87%.

3.2.2 Water holding capacity (WHC) and oil holding capacity (OHC)

The water holding capacity (WHC) of chia mucilage was of 97.12 ± 0.08 g water/g mucilage. That high value of WHC is desirable for the modification of the physical properties of food products and for the stabilization of emulsions (TIMILSENA et al., 2016a).

In this work, the WHC of the mucilage of chia was similar to that obtained by Segura-Campos et al. (2014a) of 100 g water/g chia mucilage, higher than that verified by Timilsena et al. (2016a) (23 g/g) and by Felisberto et al. (2015) (57.33 g/g) for chia mucilage and higher than that found in guar gum (25 g/g) (TIMILSENA et al., 2016a).

Due to the capacity of mucilage to hold water, when added to foods, it may contribute to increased satiety, decrease nutrient absorption time and in the control of blood sugar levels (VÁZQUEZ-OVANDO et al., 2009; COELHO & SALLAS-MELADO, 2014b).

Oil holding capacity (OHC) is attributed to the physical entrapment of oil by molecules such as lipids and proteins (SEGURA-CAMPOS et al., 2014a). The chia mucilage showed a OHC of 7.38 ± 0.20 g oil/g mucilage, value similar to that of gum arabic (8-9 g oil/g sample) and higher than that found in guar gum, xanthan gum (4-6 g/g) and in fraction of fiber-rich chia (2.02 g/g) (VÁZQUEZ-OVANDO et al., 2009). Low OHC (7.38 g/g) of mucilage was found when compared with that found by Felisberto et al. (2015) (12.97 g/g) and Segura-Campos et al. (2014b) (11.67 g/g). Due to its low OHC, chia mucilage can be utilized in fried products for providing a non-greasy feeling in foods (VÁZQUEZ-OVANDO et al., 2009).

3.2.3 Emulsifying activity

The emulsifying activity (EA) of chia mucilage was of 94.06% ± 1.32. That value indicates that chia mucilage contributed in the process of emulsion formation by the reduction of surface tension on the interface of the immiscible phases oil and water, which suggests its use in food products. The high value of emulsifying activity of fibers indicates an important beneficial physiological effect due to the ability to adsorb bile acids, providing probable increase of the excretion of them and consequently limiting the reabsorption process of these acids in the small intestine, thus reducing blood cholesterol levels (VÁZQUEZ-OVANDO et al., 2009).

Koocheki et al. (2009) investigated the influence of gum of *Alyssum homolocarpum* in oil/water emulsions and found values of EA of about 96%, similar to that found in the chia emulsions in this study.

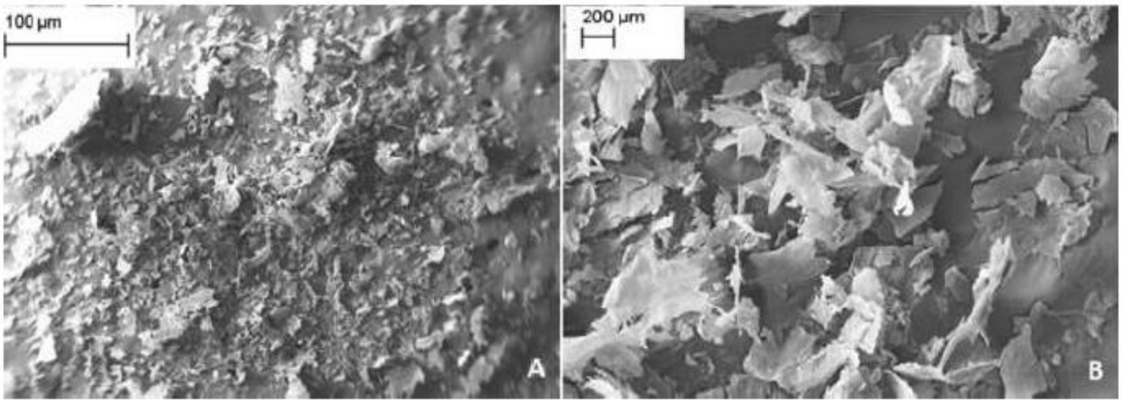
3.3 INSTRUMENTAL COLOR

The values of instrumental color of chia for L*, a* and b* were of 74.28 ±0.64, 1.99 ± 0.06 and 14.58 ± 0.15. The chia mucilage presented coloration with a tendency to yellow and visually color closer to beige.

3.4 SCANNING ELECTRON MICROSCOPY

As to scanning electron microscopy (SEM), the images of the freeze-dried chia mucilage were found in Figure 1. It can be viewed that the freeze-dried mucilage presents appearance of overlapped leaves, with a brittle aspect and little uniformity, as also viewed by Capitani et al. (2013).

Figure 1. Images obtained by SEM of the freeze-dried chia mucilage: (A) 19x and (B) 167x.



Source: own author.

3.5 PROXIMATE COMPOSITION OF THE COOKIES

The average values of the proximate composition of the cookies manufactured by replacing fat, i.e., butter by chia mucilage, are described in Table 3.

The moisture (Table 3) of the cookies ranged from 8.65% to 10.75%. The lipid content of the cookies decreased significantly ($P<0.05$) with the increase of their replacement by chia mucilage, being the lower fat content obtained in the CIII treatment, however, this did not differ significantly from CII treatment. The protein content was not altered, however, significant differences ($P<0.05$) in the crude fiber contents were found, with a higher value found for CIII treatment and a significant increase in the ash amount was observed from treatment CII. The energy value of CC treatment (without the fat substitution) was of the order of 422.07 kcal /100g and for CIII treatment (with 30% fat substitution) was of 397.7 kcal/100g, occurring reduction of the energy value by about 6%.

Table 3. Proximate composition and energy value of cooks with fat replacement by chia mucilage.

Determination	Proximate composition (g/100g)			
	CC	CI	CII	CIII
moisture	8.65 ± 0.17 [c]	10.75 ± 0.09 [a]	9.88 ± 0.09 [b]	10.70 ± 0.06 [a]
lipids	12.55 ± 0.14 [a]	11.25 ± 0.52 [b]	10.13 ± 0.39 [c]	9.63 ± 0.09 [c]
crude protein	8.05 ± 0.17 [a]	8.19 ± 0.04 [a]	8.15 ± 0.12 [a]	8.19± 0.11 [a]
crude fiber	0.30 ± 0.03 [b]	0.33 ± 0.03 [b]	0.37 ± 0.05 [b]	0.47 ± 0.02 [a]
ashes	1.22 ± 0.04 [b]	1.19 ± 0.02 [b]	1.38 ± 0.02 [a]	1.44 ± 0.03 [a]
carbohydrates	69.23 ± 0.37 [a]	68.29 ± 0.60 [b]	70.09 0.44 [a]	69.57 0.20 [a]
	Energy value (kcal/100g)			
Energia	422.07	407.17	404.13	397.71

CC: control cookie, CI, CII and CIII: cookies with replacement of 10, 20 and 30% of the fatty ingredient (butter) by chia mucilage, respectively. Means ± standard deviation followed by same small letters in the row do not differ from one another by the Tukey test at the significance level of 0.05.

3.6 PHYSICAL PROPERTIES OF THE COOKIES

Color is one of the characteristics that contribute to the consumer's preference in relation to the product. Table 4 shows the values for the L*, a* and b* coloration parameters and texture parameters evaluated in the cookies.

The cookies presented reduction of lightness as the amount of chia mucilage increased. Changes in the coloration parameter L* of the cookies were observed with the addition of chia mucilage, this was expected, since the freeze-dried chia mucilage showed beige coloration. With increasing mucilage concentration in the cookies, the L* values decreased significantly and, consequently, a darker coloration became more pronounced, being more intense in CIII treatment, due to its increased concentration of mucilage. Nevertheless, CII and CIII treatments did not present significant differences among each other (P> 0.05) for the L* values, as observed in Table 4.

Table 4. Coloration and texture parameters of the cookies with replacement of fat by chia mucilage.

	Coloration parameters			Texture
Treatments	L*	a *	b*	Strength (N)
CC	70.10 ± 1.01 [a]	3.54 ± 0.36 [a]	27.55 ± 0.35 [a]	47.46 ± 0.19[b]
CI	66.62 ± 1.47 [b]	3.19 ± 0.25 [a]	23.34 ± 0.84 [b]	38.74 ± 1.02[b]
CII	63.27 ± 0.72 [c]	3.83 ± 0.81 [a]	21.42 ± 1.59 [bc]	67.46 ± 1.75 [a]
CIII	62.17 ± 0.88 [c]	4.23 ± 0.24 [a]	21.01 ± 0.53 [c]	73.55 ± 0.72[a]

CC: Control cookie, CI, CII and CIII: cookies with replacement of 10, 20 and 30% of butter by chia mucilage, respectively. Means ± standard deviation followed by the same small letters in the column do no differ from one another by the Tukey test at the significance level of 0.05.

No significant statistical differences (P>0.05) were observed for the parameter a* among the cookie formulations. The parameter b* presented reduction in the values with increasing incorporation of chia mucilage (Table 4). The CC treatment showed the highest value of b*, while the CIII treatment had the lowest average value, which presented significant differences (P<0.05). Positive value for parameter b* is related to yellow coloration, the greater the value of b* the more intense the yellow coloration. It can be observed that the biscuits of the CC treatment showed a greater tendency to yellow coloration, which may be related to the higher concentration of fat in the formulation. Reduction in the values of L* and b* with addition of chia mucilage was reported by Felisberto et al. (2015).

The texture of the cookies presented significant statistical differences (P<0.05). The cookies with no fat replacement (CC) and with 10% of replacement of butter by chia mucilage (CI) did not show any significant differences (P>0.05), with means of 47.46 N and 38.74 N. Nevertheless, when the fat ingredient (butter) of the cookies was replaced at the levels of 20% and 30% by chia mucilage

(CII and CIII, respectively) the cookies became harder, with means of 67.46 N and 73, 55 N, respectively, with significant differences (P<0.05) in relation to CC and CI treatments. However, the cookies of the CII and CIII treatments did not present significant differences (P>0.05) among them.

In cookies and dough, fat generally works as a softening agent (MORETTO & FETT, 1999). Felisberto et al. (2015) observed greater firmness in cakes manufactured with fat reduction by chia mucilage in the replacement of 50% and 75% of fat. Santiago-García et al. (2017) replaced the biscuit fat by *Agave angustifolia* fructans (soluble fibers) and found an increase in the hardness of the cookies at the concentrations of 20 and 30 g/100g of fat replacement.

3.7 SENSORIAL ANALYSIS

The sensory evaluation scores and the results of the analysis of variance of the cookies are presented in Table 5.

Table 5. Average values of sensory acceptance and purchase intention of the cookies with fat reduction by chia mucilage.

Treatments	Scores of the sensorial analysis				
	Apperance*	Flavor*	Texture*	Overall Impression*	Purchase intention**
CC	7.48 ± 1.14 [a]	7.21 ± 1.32 [a]	7.05 ± 1.51 [a]	7.23 ± 1.20 [a]	4.02 ± 0.98 [a]
CI	6.76 ± 1.24 [b]	6.65 ± 1.25 [b]	6.22 ± 1.55 [b]	6.57 ± 1.16 [b]	3.45 ± 1.02 [b]
CII	6.56 ± 1.48 [b]	6.64 ± 1.57 [b]	6.08 ± 1.77 [b]	6.52 ± 1.56 [b]	3.39 ± 1.16 [b]
CIII	5.82 ± 1.79 [c]	5.91 ± 1.63 [c]	5.45 ± 1.72 [c]	5.68 ± 1.49 [c]	2.67 ± 1.09 [c]

CC: Control cookie, CI, CII and CIII: cookies with replacement of 10, 20 and 30% of butter by chia mucilage, respectively. Means ± standard deviation followed by the same small letters in the column do no differ from one another by the Tukey test at the significance level of 0.05.*Scores ranging from 1 (I disliked it extremely) to 9 (I liked it extremely).** Scores ranging from 1 (I surely would not buy it) to 5 (I would surely buy it).

Although the CI and CII treatments presented significant differences (P<0.05) in relation to the control (CC) for all evaluated attributes, these two treatments presented high sensory acceptance scores that ranged from 'I liked it slightly' to 'I liked it moderately' in the hedonic scale, while the CC treatment presented scores between 'I liked it moderately' and 'I liked it very much'. Regarding the score obtained in the intention to buy test, the CC treatment presented score of 'I would probably buy it ' and the CI and CII treatments obtained scores between 'I do not know' and 'I would probably buy it'. Changes in the color, flavor, texture and overall impression of ice creams made with chia mucilage were also observed by Campos et al. (2016). Laguna et al. (2014) found that the use of 30% of the HPMC fat replacer showed significant differences both in the appearance and color of the cookies compared to the treatments with no fat replacer with15% inulin and 15% HPMC, presenting the lowest sensory scores.

4 CONCLUSIONS

Chia mucilage displayed high values of solubility and water holding capacity which is desirable for the modification of the physical properties of food products and for the stabilization of emulsions and dispersions. In addition, it contributed to the emulsion formation process by reducing the surface tension between water and oil, presenting good emulsifying activity.

Regarding the sensorial acceptance of the cookies made with fat reduction by the use of chia mucilage, maintenance of the sensory acceptance scores for the treatments with 10% and 20% of replacement of fat, whose scores ranged from 'I liked it slightly' to 'I liked it moderately' and for the purchase intention, scores between 'I do not know' to 'I would probably buy it' were found.

The use of chia mucilage as a fat substitute is a promising alternative to be used as a technological innovation by the food industry in the process of cookie manufacturing.

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