Research, Society and Development, v. 11, n. 17, e190111739085, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i17.39085

Jatobá (Hymenaea sp.) as a wheat substitute in plant-based cookies to improve its nutritional quality

Jatobá (Hymenaea sp.) como substituto do trigo em biscoitos veganos para melhorar sua qualidade nutricional

Jatobá (Hymenaea sp.) como sustituto del trigo en galletas vegetales para mejorar su calidad nutricional

Received: 12/07/2022 | Revised: 12/20/2022 | Accepted: 12/21/2022 | Published: 12/24/2022

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Abstract

Jatoba (*Hymenaea* sp.) is a Brazilian savanna fruit with low lipid content, high amounts of dietary fiber, protein and minerals like calcium, iron, and zinc. Despite the lack of studies, due to jatoba nutritional characteristics, it could be used to replace wheat on plant-based cookies, improving their nutritional quality. Therefore, this study aimed to evaluate the use of jatoba flour to replace wheat flour in plant-based cookies regarding chemical composition and physical characteristics. Cookies were prepared with 25%, 50%, 75% and 100% of jatoba flour replacing wheat flour and, subsequently, physical parameters (cooking factor, diameter, thickness and spread rate) and chemical composition were evaluated. Regarding the cooking factor, there was no significant difference between the samples, the cookies' diameters were smaller in the samples 25%, 50% and 75% compared to the control sample and 100%.I In the thickness parameter the control sample showed a smaller value compared to the preparations made with jatoba and the spreading rate showed a significant difference from the control sample to the others, however the samples 25%, 50%, 75% and 100% did not differ from each other. Plant-based cookies with jatoba flour were higher in fiber, calcium, magnesium, iron, zinc content than the control sample (100% based on wheat flour). Jatobá flour is a good alternative to improve the nutritional quality of plant-based cookies.

Keywords: Jatobá flour; Cookies; Chemical composition; Physical characteristics; Vegan.

Resumo

O jatobá (Hymenaea sp.) é uma fruta do cerrado brasileiro, com baixo teor de lipídios, alto teor de fibras alimentares, proteínas e minerais como cálcio, ferro e zinco. Apesar da escassez de estudos, devido às características nutricionais do jatobá, ele poderia ser utilizado para substituir o trigo em biscoitos vegetais, melhorando sua qualidade nutricional. Portanto, este estudo teve como objetivo avaliar a utilização da farinha de jatobá em substituição à farinha de trigo em biscoitos veganos quanto à composição química e características físicas. Biscoitos foram preparados com 25%, 50%, 75% e 100% de farinha de jatobá em substituição à farinha de trigo e, posteriormente, foram avaliados parâmetros físicos (fator de cocção, diâmetro, espessura e taxa de espalhamento) e composição química. Com relação ao fator de cocção, não houve diferença significativa entre as amostras, o diâmetro dos biscoitos foi menor nas amostras 25%, 50% e 75% em relação à amostra controle e 100%, enquanto no parâmetro espessura a amostra controle apresentou um valor menor em relação às preparações feitas com jatobá. A taxa de espalhamento apresentou diferença significativa da amostra controle para as demais, porém as amostras 25%, 50%, 75% e 100% não diferiram entre si. Biscoitos à base de plantas com farinha de jatobá foram mais ricos em fibras, cálcio, magnésio, ferro, zinco do que a amostra controle (100% à base de farinha de trigo). A farinha de Jatobá é uma boa alternativa para melhorar a qualidade nutricional dos biscoitos veganos.

Palavras-chave: Farinha de jatobá; Biscoito; Composição química; Características físicas; Vegano.

Resumen
La jatoba (Hymenaea sp.) es una fruta de la sabana brasileña, con bajo contenido de lípidos, altas cantidades de fibra dietética, proteína y minerales como calcio, hierro y zinc. Apesar de la falta de estudios, debido a las características nutricionales de la jatoba, podría usarse para reemplazar el trigo en las galletas de origen vegetal, mejorando su calidad nutricional. Por lo tanto, este estudio tuvo como objetivo evaluar el uso de harina de jatoba para reemplazar la harina de trigo en galletas de origen vegetal con respecto a la composición química y las características físicas. Se prepararon galletas con 25%, 50%, 75% y 100% de harina de jatoba en sustitución de harina de trigo y, posteriormente, se evaluaron parámetros físicos (factor de cocción, diámetro, espesor y tasa de esparcimiento) y composición química. En cuanto al factor de cocción, no hubo diferencia significativa entre las muestras, el diámetro de las galletas fue menor en las muestras 25%, 50% y 75% en comparación con la muestra control y 100%, mientras que en el parámetro espesor el la muestra control mostró un valor menor en comparación con las preparaciones hechas con jatoba y la tasa de aplicación mostró una diferencia significativa de la muestra control a las demás, sin embargo las muestras 25%, 50%, 75% y 100% no difirieron entre sí. Las galletas a base de plantas con harina de jatoba tenían un contenido más alto de fibra, calcio, magnesio, hierro y zinc que la muestra de control (100 % a base de harina de trigo). La harina de j'atobá es una buena alternativa para mejorar la calidad nutricional de las galletas de origen vegetal.
Palabras clave: Harina de jatobá; Galletas; Composición química; Características físicas; Vegano.

1. Introduction

Jatoba (*Hymenaea* sp.) is a fruit from the Brazilian savanna, the second-largest Brazilian biome (Brasil, 2011). This fruit stands out for presenting low lipid content (2.12% - 4%), high amounts of soluble dietary fiber (12.6g / 100g) and insoluble (36.4g / 100g), high amount of protein (5.83 mg / 100g) and minerals like calcium (73.9 mg / 100g), iron (2.0mg / 100g), zinc (1.2mg / 100g) (Almeida, 2012; Marin, 2006; Silva et al., 1999), phosphorus (92.1mg / 100g), and magnesium (48.5 - 194.8 / 100g) (Marin, 2006). The *jatobá* nutritional characteristics, mainly on protein and sodium content, higher than traditional fruits (Nepa, 2011) make this fruit interesting to compose a vegetarian diet that may lack these nutrients (Abonizio, 2013). *Jatobá* has a pale-yellow farinaceous pulp, with a very distinctive sweet flavor and aroma (Almeida, 1987b), mainly used in Brazilian regional culinary, in products such as bread, cakes, and cookies (Brasil, 2015). Besides the nutritional and sensory characteristics, regional fruits can also strengthen local sustainability (Figueiredo Melo Villas Boas et al., 2021; Ginani et al., 2020). However, knowledge gaps regarding the potential use of this endemic fruit result in its underutilization (Ribeiro and Walter, 1998). Thus, it is necessary to search for food application alternatives exploring the use of this fruit with potential environmental and health benefits to consumers (Ribeiro & Walter, 2013).

Among the main products that *jatobá* can be applied to improve nutritional quality, cookies are characterized as low-protein and high-fat content products, well-accepted and worldwide consumed baked goods. Its market is estimated at USD 30.62 billion in 2018, and its consumption is expected to substantially increase in developed and emerging countries (Grand View Research, 2019). Therefore, given its high acceptability, the development of healthier cookies might be an effective strategy to take advantage of the potential health benefits of *jatobá* and reducing fat and improving protein, fiber, and calcium content (Silva et al., 2001a). Therefore, this study aimed to evaluate the *jatobá* flour replacing plant-based cookies' wheat flour on its chemical composition and technological characteristics. We hypothesize that the *jatobá* could replace wheat on plant-based cookies, improving their nutritional quality with no significant differences in physical quality.

2. Methodology

2.1 Ingredients and formulation

To produce plant-based cookies samples, the following ingredients were used: wheat flour, jatoba flour (retrieved from a certified organic products reseller), sugar, brown sugar, corn starch, vanilla extract, soybean oil, oat vegetable extract, sea salt, sodium bicarbonate, milk-free chocolate (Table 1). The ingredients were purchased from local supermarkets in Federal

District/Brazil, except for the jatoba flour (purchased from an association of organic products in the Federal District/Brazil). A control formulation (100% wheat flour) and four others were prepared to replace wheat flour with 25%, 50%, 75% and 100% jatoba flour (Table 1).

Table 1 - Original plant-based cookie formulation and those with the addition of jatoba flour.

Ingredients		**Original**	**25%**	**50%**	**75%**	**100%**
Flour basis (g)	Wheat flour (g)	100	75	50	25	0
	Jatobá flour (g)	0	25	50	75	100
Sodium bicarbonate (g/100g of flour)		2.04	2.04	2.04	2.04	2.04
Salt (g/100g of flour)		0.14	0.14	0.14	0.14	0.14
Sugar (g/100g of flour)		47.62	47.62	47.62	47.62	47.62
Brown sugar (g/100g of flour)		34.28	34.28	34.28	34.28	34.28
Cornstarch (g/100g of flour)		14.28	14.28	14.28	14.28	14.28
Oat milk (g/100g of flour)		30	30	30	50.47	57.14
Soy oil (g/100g of flour)		34.28	34.28	34.28	34.28	34.28
Vanilla extract (g/100g of flour)		0.95	0.95	0.95	0.95	0.95
Milk-free chocolate (g/100g of flour)		57.14	57.14	57.14	57.14	57.14

Source: Authors.

For the dough preparation, sugars, corn starch, oat milk, vanilla extract, soy oil flour basis, sodium bicarbonate, sea salt were mixed by hand until the dough was homogenous. After, drops of milk-free chocolate were incorporated into the dough. The dough was modeled and fractionated into cookies of an average of 32g, placed in a rectangular aluminum pan, keeping approximately 5 cm between them and stored under refrigeration (4 °C) for 30 minutes. The dough was baked for 12 minutes (160 °C). After baking, the cookies were maintained at room temperature (27 °C) until physical analysis occurred on the same day of the preparation of the cookie.

2.2 *Physical analysis*

The doughs and cookies samples were weighed using a digital scale of capacity from 1g to 10kg *(Tomate-SF400, Brazil)*. The cooking factor for each cookie sample was determined using the formula shown in equation 1 (W. Araújo et al., 2014).

$$\text{Cooking Factor} = \frac{\text{Baked bread (g)}}{\text{Bread dough}}$$

The diameter (D) was calculated using the method proposed by the American Association of Cereal Chemists (Aacc, 2000). The diameter of four cookies from the same sample was measured using a ruler (1mm – 30 cm). The cookies were rotated at 90 ° angles and the diameter was measured again in another position. Then, the average diameter measures were calculated in triplicate for each cookie and recorded in centimeters (cm).

The cookies' thickness (T) was evaluated according to the AYO method (Ayo et al., 2007) using a manual caliper *(Starrett, EUA)* with an accuracy of 0.01 mm. The thickness analysis was performed in triplicate and recorded in millimeters (mm). The cookies' spreading ratio (SR) was calculated according to the formula presented in equation 2 (Nasir et al., 2010).

$$\text{Spreading ratio} = \frac{\text{diameter (cm)}}{\text{tickness (cm) x CF}} \text{ x } 10$$

* Where CF = correction factor, at constant atmospheric pressure (1.0 in the present study).

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2.3 Chemical composition analysis

The two main Brazilian nutritional composition tables were used to obtain chemical composition data of the cookies: the Brazilian Food Composition Table (Nepa, 2011) and the Nutritional Composition Table of Food Consumed in Brazil (Ibge, 2011). The Chemical composition of jatobá flour was obtained from a Brazilian study (Marin, 2006b). The nutrients evaluated were carbohydrates, proteins, lipids, fiber, calcium, magnesium, and zinc, and we also evaluated total energetic value.

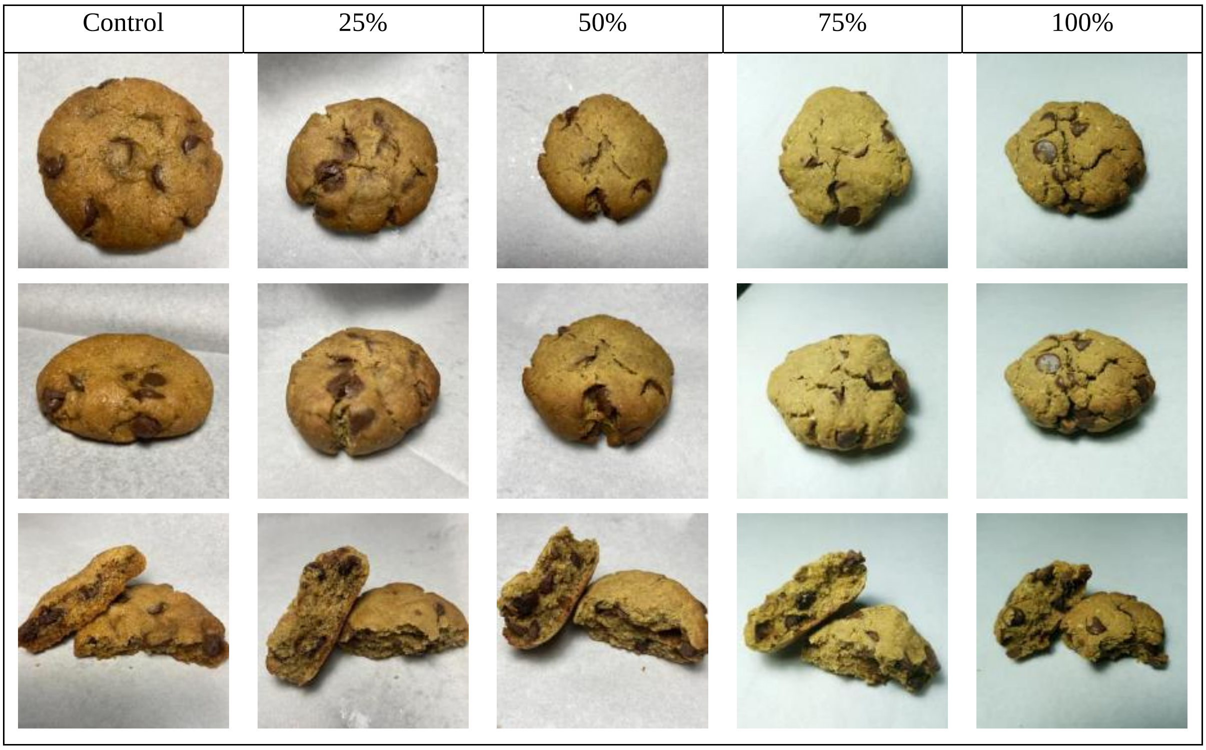
2.4 Statistical analysis

The physical analysis data were subjected to analysis of variance of repeated samples (ANOVA) with posthoc Fisher's HSD test, both with a 95% confidence level ($p < 0.05$).

3. Results and Discussion

Figure 1 presents the images of the control sample and cookies prepared with different concentrations of jatobá flour (25%, 50%, 75% and 100%). It was not possible to perform the sensory test of the products due to the COVID-19 pandemic. However, it is possible to verify that the 75% and 100% samples were drier, less shiny and thicker, probably due to the higher amount of fiber from jatoba flour. The 25% and 50% samples were softer than the other samples with jatoba flour, the first brighter than the second.

Figure 1 - Cookies samples with different concentrations of jatoba flour.



Source: Authors.

Table 2 - Physical characteristics of plant-based cookies.

Sample	Cooking factor	Diameter (cm)	Thickness (cm)	Spreading ratio
Control	0.91 ± 0.01^{a}	6.33 ±0.19^{a}	1.50 ±0 ^{c}	41.38 ±1.27 ^{a}
25%	0.92 ±0.04^{a}	5.34 ±0.07^{c}	1.90 ±0.33^{ab}	28.69 ±5.91^{b}
50%	0.95 ±0.01^{a}	5.45 ±0.17 ^{bc}	1.86 ±0.11^{b}	29.28 ±1.49^{b}
75%	0.92 ±0.01^{a}	5.25 ±0^{c}	2.16 ±0.05 ^{a}	24.24 ±0.65^{b}
100%	0.93 ±0.01^{a}	5.95 ±0.58^{ab}	2.03 ±0.05^{ab}	29.33 ±3.50^{b}

Values presented as mean ± standard deviation. Mean values presented in the same column with the same superscript letters did not show significant differences after ANOVA and Fisher's HSD test (95%, p <0.05). Source: Authors.

The cooking factor expresses the dough's ability to retain the water added to it (W. Araújo et al., 2014). Regarding the cooking factor, there was no significant difference (p <0.05) between the formulations, including the original preparation, that is, the addition of jatobá flour does not interfere with the yield of the preparation, as well as the removal (partial or total) of the wheat flour also does not change this parameter. Once the cooking factor expresses the dough's ability to retain the water added to it (W. Araújo et al., 2014), this result was expected once it was necessary the addition of more oat milk when increasing the amount of jatoba flour due to its high amount of fiber, also increasing the amount of water. Comparing the cooking factors of plant-based cookies with jatoba replacing wheat flour (0.92-0.95) with a cookie prepared with oats partially replacing wheat flour in which CF was 0.86 (Costa, 2017), the jatoba might be better to retain water in cookies than oats, improving the product final weight. Besides the cooking factor, the physical parameters of diameter, thickness, and rate of spread of cookies have been used to predict their quality (Silva De Moraes et al., 2010).

There were no statistical differences between control and 100% cookies' samples. However, the control sample spreading ratio was higher than the 100% sample, probably due to the higher dough growth (both height and width) in the sample with 100% jatoba flour, influencing the spread ratio calculation. This dough growth may have occurred due to the higher water content (resulting from oat milk) necessary for preparing this mass, which, when heated, forms water vapor, favoring the dough growth (W. Araújo et al., 2014).

Differences were found among samples that used both types of flour and the ones that used only one flour type (Table 2). The samples 25%, 50% and 75% did not differ from each other. Probably, the interaction between the two flours and the other ingredients of the cookies influenced this parameter. The gluten protein in wheat flour plays a vital role in forming a web-like structure during dough heating, and this structure is important for its expansion (Leon et al., 2012). On the other hand, Jatoba flour increases water absorption according to the amount of fiber present, the dough's development time, and the mixture's tolerance index (Araújo et al., 2009). Thus, the partial substitution of wheat flour for jatobá flour resulted in less gluten and an increase in the fiber amount caused a decrease in the dough's viscosity, which contributed to the smaller diameter of the 25%, 50 % and 75% cookies.

The thickness of the cookies ranged from 1.50 to 2.16 cm. The control sample had lower thickness value (1.5 cm) compared to samples with the addition of jatobá flour, probably due to the amount of fiber added to the dough. The samples 50% and 75% of jatoba flour differed, possibly due to the greater use of water and fibers in the second (Ikumola et al., 2017).

The spreading ratio, which is the ratio of diameter to thickness (Durante et al., 2011) showed a significant difference (p <0.05) from the control biscuit to the other biscuits with jatobá flour, whereas the modified samples (25%, 50%, 75% and 100%) did not differ between them. In this sense, the results showed that the spreading ratio of cookies showed a decreasing trend with jatoba flour addition. The spreading rate of cookies is affected by competition between jatoba flour and any other ingredients for the water available during the dough mixing, thus resulting in a lower spreading rate (Araújo et al., 2015).

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Table 3 presents the chemical compositions of cookies (original, 25%, 50%, 75% and 100%) produced from the mixture of wheat flour and jatoba flour.

Table 3 - Chemical compositions of cookies prepared with wheat flour and jatoba flour (100g).

Sample	Energy	Protein (g)	Lipid (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Magnesium (mg)	Iron (mg)	Zinc (mg)
Control	410.53	4.71	16.69	60.80	1.41	70.29	30.24	1.65	0.74
25%	438.62	4.51	16.82	57.35	4.35	88.04	43.04	1.73	0.77
50%	423.85	4.37	16.92	53.89	7.29	105.81	55.84	1.81	0.80
75%	465.94	3.96	16.09	48.04	9.63	123.37	62.00	1.77	0.77
100%	483.69	3.73	15.93	44.20	12.16	139.61	74.75	1.81	0.79

Source: Authors.

Cookies with jatoba flour have a higher content of fiber, calcium, magnesium, iron and zinc compared to the control one. The total energetic value was 3% to 18% higher than the original sample. Therefore, there was an increase in the values according to an increase in the addition of jatoba flour. Despite the high energy value found in our samples, this is a characteristic of this type of food given the need for high amounts of sugar and fat in its composition (Silva De Moraes et al., 2010).

Regarding proteins, it is noted that the standard formulation made only with wheat flour has a higher value than the formulations made with jatoba flour. The values show a decrease of 4% to 21% in the preparations with jatobá compared to the control sample. It might be linked to wheat flour's higher protein content than jatoba flour (H. M. C. Araújo et al., 2010). The protein content decreased as the amount of wheat flour in the preparations decreased and the amount of jatobá flour increased, since the first flour has 10g / 100g in its protein composition and, the second, 5.83g / 100g. This decrease in protein values when replacing wheat flour is quite common, representing a great challenge to obtain alternative bakery products, requiring the introduction and combination of other ingredients to achieve a good bakery product (Vieira et al., 2015).

Concerning the lipid content, the control formulation showed a lower lipid value than the samples 25% and 50% (which varied between 0.77% and 1.37%, respectively). Samples 75% and 100% presented the percentage of lipids 4% and 5% less than the original sample. It possibly justifies this decrease in the lipid content of the samples 75% and 100%, was the need to add oat milk for handling the dough and modeling the cookies, increasing the water content in the product and reducing the concentration of lipids.

The carbohydrates of jatoba cookies presented a reduction between 6% to 27% compared to the original sample, that is, the more jatoba flour was added, the lower the amount of carbohydrates in the sample. The higher amount of fiber can explain this effect and less starch in the jatoba flour than the wheat flour (Mariani, 2010).

The jatoba cookies had a fiber content of 208% to 762% more than the control one. According to ANVISA Resolution RDC No. 54/2012 (ANVISA, 2012), the jatoba cookies can be classified as a fiber source in the case of samples 25% and 50% and high fiber content 75% and 100%. Dietary fibers play a regulatory and remissive role in gastrointestinal disorders and chronic non-communicable diseases (Moraes et al., 2012), they act to decrease intestinal transit, increase fecal volume, reduce blood cholesterol and LDL levels, slow down the carbohydrate absorption process and reduce postprandial blood glucose levels (W. Araújo et al., 2014).

The control sample had the lowest calcium value, the other samples showed a range of 25% to 98%. This nutrient is frequently low in plant-based cookies to the absence of dairy products. Calcium is fundamental for bone health, acting in the metabolism of protein hormones and releasing or activating cellular enzymes (Miranda et al., 2013). The increase in calcium in biscuits with jatoba flour enhances the interest in this product for vegans since this group tends to present bone density 4% lower than omnivores, thus presenting a greater risk of osteoporosis (Slywitch, 2012).

Another important nutrient for the protection and maintenance of bone mass is magnesium (Krey et al., 2018), which presented an increase of 42% to 147% in the composition of the cookies 25%, 50%, 75% and 100% compared to the control sample.

The iron content increased 5% to 10% compared to the control biscuit, and the samples 50% and 100% presented the same value of iron 10%. Iron is an essential mineral for health and acts to the production of red blood cells and the transport of oxygen to all body cells, the electron transport chain, and enzyme production (Andrade, 2018). Due to the lower bioavailability of iron in the vegetarian diet, the recommended intake of this group is 1.8 times higher than for non-vegetarians. (Ada, 2009), therefore, cookies based on jatoba flour can help vegetarians have a higher iron intake.

Regarding zinc values, the control sample has lower content than jatoba cookies, with samples 25% and 75% showing the same percentage of 4% increase and cookies 50% and 100 %, a variation of 8% and 7%, respectively. This nutrient requires special attention regarding its intake. The vegetarian diet usually has a moderate absorption content of this mineral (Siqueira et al., 2016). Given the above, jatoba cookies are good alternatives for zinc intake for vegetarians.

4. Conclusion

Regarding the physical properties, the jatoba cookies did not change the cooking factor compared to the original sample, but significant differences in the other parameters. The diameter and the rate of propagation decreased with jatoba flour, and the thickness increased significantly.

Cookies made with jatoba flour have a higher energy value and higher fiber, calcium, magnesium, iron, and zinc levels compared to the control sample. According to Brazilian legislation, jatoba cookies can be declared as a fiber source (in the samples 25% and 50%) and high fiber content (75% and 100% samples), in addition to micronutrients such as calcium, magnesium that contribute to make these cookies a good alternative to plant-based nutritious cookies.

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