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Avaliação da composição físico-química e das propriedades hipoglicêmicas em biscoitos produzidos com farinhas de berinjela *(Solanum melongena L.)* e quiabo *(Abelmoschus esculentus L. Moench)*

Evaluation of the physical-chemical composition and hypoglycemic properties in biscuits produced with eggplant *(Solanum melongena L.)* and okra *(Abelmoschus esculentus L. Moench)*

Evaluación de la composición fisicoquímica y las propiedades hipoglucémicas en galletas producidas con harinas de berenjena *(Solanum melongena L.)* y okra *(Abelmoschus esculentus L. Moench)*

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Resumo

O objetivo deste estudo foi avaliar a composição físico-química e as propriedades hipoglicêmicas de farinhas de quiabo e berinjela. Inicialmente, os vegetais foram desidratados, triturados a ponto de farinha, acondicionados e armazenados até utilização. As farinhas foram submetidas a avaliação físico-química para determinação dos teores de umidade, lipídeos, proteínas, carboidratos e polifenóis e, em seguida, foi realizada a análise experimental. Esta se deu utilizando camundongos *Swiss*, distribuídos em 6 grupos (n=3), um saudável, dois controles diabéticos e três diabéticos tratados com rações comerciais contendo farinha de berinjela, quiabo e o *blend* das duas farinhas. A pesquisa durou 20 dias, com aferição diária da água e comida e, no intervalo de 5 dias, a glicemia e peso. A pesquisa foi aprovada pelo Comitê de Ética em Experimentação Animal da mesma instituição, sob nº de protocolo 157/16. A análise estatística foi realizada no STATISTICA Software versão 7.0. Os resultados demonstraram que as farinhas possuem importante composição nutricional, principalmente quanto ao teor de fibras. Em relação a atividade funcional, a farinha de quiabo conseguiu reduzir significativamente a glicemia dos camundongos quando comparado a farinha de berinjela, resultado equiparado ao de outros autores, que ressaltam a importância das fibras e dos compostos bioativos na obtenção deste resultado.Conclui-se que ambas as farinhas apresentaram boa composição nutricional, porém a de quiabo se mostrou mais eficiente na redução da glicemia dos camundongos diabéticos, podendo vir a ser uma alternativa no tratamento dietético desta patologia.

Palavras-chave: Berinjela; Quiabo; Farinhas; Bolacha; Hipoglicêmicos.

Abstract

This study aimed to evaluate the physical-chemical composition and hypoglycemic properties of okra and eggplant flours. Initially, the vegetables were dehydrated, crushed to the point of flour, conditioned and stored until use. The flours were subjected to physical-chemical evaluation to determine the moisture, lipids, proteins, carbohydrates and polyphenols contents and, then, the experimental analysis was carried out. This was done using Swiss mice, distributed in 6 groups (n = 3), one healthy, two diabetic controls and three diabetics treated with commercial diets containing eggplant flour, okra and the mixture of the two flours. The survey lasted 20 days, with daily measurement of water and food and, in the interval of 5 days, blood glucose and weight. The research was approved by the Animal Experimentation Ethics Committee of the same institution, under protocol number 157/16. Statistical analysis was performed using STATISTICA Software version 7.0. The results showed that the flours have an important nutritional composition, mainly in terms of fiber content. In relation to functional activity, okra flour was able to significantly reduce the glycemia of mice when compared to eggplant flour, a result comparable to that of other authors, who emphasize the importance of fibers and bioactive compounds in obtaining this result. both flours had a good nutritional composition, but the okra was more efficient in reducing the glycemia of diabetic mice, and may become an alternative in the dietary treatment of this pathology.

Keywords: Eggplant; Okra; Flours; Cookie; Hypoglycemics.

Resumen

El objetivo de este estudio fue evaluar la composición físico-química y las propiedades hipoglucémicas de las harinas de okra y berenjena. Inicialmente, las verduras fueron deshidratadas, trituradas hasta el punto de harina, acondicionadas y almacenadas hasta su uso. Las harinas se sometieron a evaluación físico-química para determinar el contenido de humedad, lípidos, proteínas, carbohidratos y polifenoles y, luego, se realizó el análisis experimental. Esto se realizó con ratones suizos, distribuidos en 6 grupos (n = 3), uno sano, dos controles para diabéticos y tres diabéticos tratados con dietas comerciales que contienen harina de berenjena, quimbombó y la mezcla de las dos harinas. La encuesta duró 20 días, con mediciones diarias de agua y alimentos y, en el intervalo de 5 días, glucosa en sangre y peso. La investigación fue aprobada por el Comité de Ética de Experimentación Animal de la misma institución, bajo el protocolo número 157/16. El análisis estadístico se realizó con el software STATISTICA versión 7.0. Los resultados mostraron que las harinas tienen una composición nutricional importante, principalmente en términos de contenido de fibra. Con respecto a la actividad funcional, la harina de okra fue capaz de reducir significativamente la glucemia de los ratones en comparación con la harina de berenjena, un resultado comparable al de otros autores, que enfatizan la importancia de las fibras y los compuestos bioactivos para obtener este resultado. Ambas harinas tenían una buena composición nutricional, pero la okra fue más eficiente en la reducción de la glucemia de los ratones diabéticos, y puede convertirse en una alternativa en el tratamiento dietético de esta patología.

Palabras clave: Berenjena; Okra; Harinas Galleta; Hipoglucemia.

1. Introduction

The term diabetes mellitus encompasses a group of metabolic diseases of different etiologies, characterized by chronic hyperglycemia, with metabolic defects of carbohydrates, fats and proteins that affect insulin secretion and/or activity (Rodrigues & Motta, 2012). In the world, about 387 million people are living with this pathology and it is estimated that by 2035 this number will rise to 592 million. Measures for Diabetes treatment include physical exercise, the use of medications and diet control (Carvalho et al., 2012).

Nutritional management in diabetes patients has proved to be an effective non-pharmacological measure for obtaining glycemic control and prevention of the acute and chronic complications of the disease. Several studies have shown that there is a variety of foods, including eggplant and the okra, that have beneficial substances that act in the control of diseases such as diabetes and its complications (Beretta, 2014; Carvalho et al., 2012, Zaparolli et al., 2013).

The eggplant (*Solanum melongena L.*) belongs to the Solanaceae family, as well as tomatoes, bell peppers, potatoes and scarlet eggplant (Oliveira et al., 2011; Queiroz et al., 2013). Since it contains substances with supposed therapeutic functions, the eggplant has been cited by several authors as one of the vegetables that can be classified as a functional food. Studies have reported its use in controlling high levels of, weight loss and diabetes treatment, as well as being a source of important vitamins and minerals (Carvalho & Lino, 2014; Zamariola et al., 2014).

The okra (*Abelmoschus Esculentus L. Moench*) is another vegetable with functional properties. It belongs to the Malvaceae family, with high nutritional value and good quantity of vitamins and minerals. Studies indicate that it may serve as a dietary therapy, decreasing glucose and cholesterol levels (Fan et al., 2014; Roy, Shrivastava & Mandal, 2014; Seyfried, 2014).

The vegetables abovementioned have good amounts of fiber, which are believed to be related to their properties (Gemede et al., 2015; Seyfried, 2014). Foods with high fiber content are considered functional foods that promote several physiological effects, including improvement of bowel movement, reduction of blood cholesterol and plasma levels of postprandial diabetic glucose (Lopes et al., 2015).

Considering the need for studies to elucidate the functional characteristics of eggplant (*Solanum melongena L.*) and okra (*Abelmoschus Esculentus L. Moench*) flours, this research aimed to evaluate the physical-chemical composition and hypoglycemic properties of these flours.

2. Material and Methods

2.1 Flour Production

The Eggplant and Okra flour were obtained according to Ferreira et al. (2015) with modifications. Fresh eggplant (*Solanum melongena L.*) and okra (*Abelmoschus esculentus L. Moench*) were purchased in the city of Picos – Piaui, Brazil. Approximately 15.7 kg of okra and 16.0 kg of eggplant were taken to the Food Technology Laboratory of the Federal University of Piauí, at Campus Senador Helvídio Nunes de Barros (Picos - PI), where the weighing, cleaning, sanitation (2% chlorinated solution for 10 minutes) and selection were performed. Then, they were submitted to the bleaching process in water at 60°C for 5 minutes and cooled in water at 2°C for 5 minutes. After the elapsed time, the vegetables were cut into thin slices of up to 2 mm, spread in nylon trays and taken to the "Pratic Dryer" food dehydrator for 12 hours at 65°C. Afterwards, the dried vegetables were crushed in a processor and then passed through a 1mm sieve. The flours were kept in metal packages at room temperature until use. The flours' final yield was calculated according to the equation R (%) = (Net weight/Gross weight) x 100.

2.2 Physical-chemical evaluation

The methodology used for the analysis of the cookies' moisture, lipids, ashes and proteins was described by the Association of Official Analytical Chemists - AOAC (2000). The carbohydrates were calculated by difference from the results obtained in the analysis and the caloric value of the products was calculated according to the system by multiplying the carbohydrates, proteins and lipids by their conversion factors, respectively 4 kcal/g, 4 kcal/g and 9 kcal/g, followed by the sum of the results (FAO, 2003). The total extractable polyphenols were determined spectrophotometrically using the methodology described by Larrauri, Rupérez and Saura-Calixto (1997), with results expressed as mg of gallic acid per 100g of flour.

2.3 Experimental Analysis

The hypoglycemic properties of the eggplant and okra flours that used for the preparation of the cookies was based on Sabitha, Ramachandran & Naveen (2011), Erukainure et al. (2013) and Harijono et al., (2013) with some modifications.

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2.4 Animals

Initially, 18 adult male Swiss mice, weighing on average 35g were selected from the UFPI animal house in Picos. The animals were kept in cages, with temperature between 21-25 C°, on ambient light in 12-hour cycles, with food and water *ad libitum*.

2.5 Induction of diabetes

Diabetes was induced in 15 mice through the injection of alloxan monohydrate (180 mg / kg) saline solution intraperitoneally, after a 12-hour fasting period. After 72h from the injection, animals that presented clinical signs similar to diabetes and glycemia above 200mg/dL were separated and those who did not develop such signs were submitted to another 150mg/kg alloxan injection (Erukainure et al., 2013, Sousa et al., 2015).

2.6 Experimental design

The mice were divided into 6 groups (n=3), 5 of which were composed of diabetic animals that received different treatments and one healthy control group (Table 1). The studied products were provided together with the standard commercial food (AIN-93), after being mixed in the proportion of 10% of the vegetables flour (Ossamulu et al., 2014). Metformin was used as a standard drug in the treatment of diabetes and was given orally through daily gavage of 600mg/kg/day, according to Sousa et al. (2015). All groups received 50g of the specific food daily and different amounts of water, with 340mL for diabetics and 250mL for others (Pereira et al., 2011).

Table 1 - Experimental groups, composition and treatments.

Groups (n=3)	Animals (mice)	Treatment
Group 01 (G01)	Not Diabetic	Commercial food
Group 02 (G02)	Diabetic	Commercial food
Group 03 (G03)	Diabetic	Commercial food + Metformin
Group 04 (G04)	Diabetic	Commercial food + 10% Eggplan Flour
Group 05 (G05)	Diabetic	Commercial food + 10% Okra Flour
Group 06 (G06)	Diabetic	Commercial food + 10% Blended Flour

Fonte: Própria (2016)

The experiment was carried out for 20 days with a daily verification of the levels of water and food intake. The weight and plasma glucose were verified with the mice fasting for 12 hours at the beginning of the experiment (T_i), then on the 5th (T_5), 10th (T_{10}), 15th (T_{15}) and 20th (T_f) days. The weight was obtained by weighing the mice on an analytical scale and the glucose values through a reagent strip test using the Accu-Check® Advantage II glycosometer. With the results of the animals' glycemia and weight, the variation percentages were calculated through the formula $(V_2-V_1) / V_1 \times 100$, where V_1 represents the initial value and V_2 the final measured value.

2.7 Ethical aspects

The research was approved by Animal Testing Ethics Committee of the Federal University of Piauí under nº 157/16.

2.8 Statistical analysis

The data collected in the analysis were submitted to statistical analysis with the application of analysis of variance (ANOVA) and Tukey's test to verify a significant difference between treatments at 5% significance. STATISTICA Software version 7.0 was used.

3. Results and Discussion

3.1 Flours

3.1.1 Yield and Chemical Composition

The eggplant and okra flours yielded 7.57% and 9.57%, respectively. These vegetables have a considerable amount of water in natura, which justifies the low yield after processing. These results are higher to the one found by Mauro, Silva & Freitas (2010), which yielded 5.4% and 3.8% from collard greens and spinach stalks, respectively. Regarding the centesimal composition, all the results presented by physicochemical analysis of the flour can be found in Table 2.

Table 2 - Chemical composition of eggplant and okra flour.

Components	Samples	
	EF	OF
Water content (g/100 g)	11.39±0.14[b]	13.38±0.11[a]
Ashes (g/100 g)	1.24±0.05[b]	7.58±0.12[a]
Proteins (g/100 g)	1.10±0.18[b]	13.38±0.11[a]
Lipids (g/100 g)	1.57±0.33[b]	2.07±0.09[a]
Crude Fiber (g/100 g)	0.45[a]	11.41[b]
Carbohydrates (g/100 g)*	84.25[a]	52.18[b]
Calorie content (Kcal)**	357.33	326.51
Polyphenols (mg 100 g^{-1})	278.05[a]	202.32[b]

The means followed by the same letter on the same line do not differ statistically from each other. Tukey test at 0.05;
* Calculated by difference; ** Calculation from the Conversion Factor: 9 (lipids), 4 (proteins and carbohydrates). EF: Eggplant Flour; OF: Okra Flour. Fonte: Própria (2016)

When comparing the physical-chemical analyzes of the two flours, it was verified that they are statistically different regarding water, ash, protein, fiber and lipid contents. The okra flour (OF) presented higher percentage of moisture, close to 12.9% found by Posseti & Lima Dutra (2011) for eggplant flour The variation in the moisture content from flours may occur due to several factors, such as the process, the product's drying period and the temperature used (Cristo et al., 2015). As for the mineral content, the okra flour presented higher levels when compared to the other samples, demonstrating significant mineral content, as described by Gemede et al. (2015).

As for protein and lipid content, the okra flour presented higher amount of both parameters, in comparison to the eggplant flour. He evaluation of chemical composition from flour made with okra seeds, Manal, Hassan & Hend (2015) obtained high levels of both lipids (19.12%) and proteins (23.87%), stating that the seeds contribute significantly to the results. This vegetable presents high quality protein content, especially in relation to essential amino acids and its seeds that are rich in unsaturated fatty acids, such as linoleic acid (Gemede et al., 2015). In relation to eggplant flour, Soares et al. (2012) found 0.45% of proteins and 4.10% of lipids, different from that obtained in this research.

The carbohydrates and fibers integrate the centesimal composition, showing significantly different results between the two flours. Other studies, reported variable quantities of fiber in the okra fruit, with 8.85% (Ogungbenle & Omosola, 2015) and 20.25% (Olaniyan & Omoleyomi, 2013) on dry basis. The latter study, stated that the seeds contribute significantly to the increased content, showing 26.4% of crude fiber in okra seed flour.

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As for the eggplant flour, the fiber content were different from that of Perez & Germani (2004), who obtained 44.12% of fiber from eggplant flour, also diverging from 13.5% found by San José et al. (2014). Vegetables are the only sources of dietary fiber because they are the main constituents of the plant cell wall, and their consumption is well known to reduce the risks of many disorders such as constipation, diabetes, cardiovascular diseases, diverticulitis and obesity (Kaczmarczyka, Miller & Freunda, 2012).

Regarding polyphenols, the eggplant flour showed better results than okra, with higher concentrations. Machado, Pereira & Marcon (2013) found that the fresh fruits possess lower phenolic concentration (85.08mg/100g) than those treated at 75ºC for 10min (116.93mg/100g). According to this same author, the increase in temperature also helps pigment extraction and its transfer from bark to pulp. As for the okra, Adetuyi & Ibrahim (2014) obtained 185mg/100g of phenolic compounds from its seeds, which is close to that found in this study.

3.2 Experimental analysis

The experimental flours were evaluated regarding their hypoglycemic capacity in mice with diabetes induced by alloxan (Table 3). It was observed that the diabetic control (G02) and the eggplant flour (G04) groups did not differ statistically from each other ($p > 0.05$), indicating that this flour did not significantly reduce the glycemia. When evaluating this same product, Soares et al. (2012) did not find a significant hypoglycemic effect either, differently from the result obtained by Madariaga, Ínsula & Milord (2015) using eggplant extract. Ossamulu et al. (2014) attributed the functional effect of eggplant to the synergism between nutrients, such as fiber and bioactive compounds, but emphasized that this nutritional composition can vary according to the way of cultivation or even the harvesting, storage and processing practices.

Table 3 - Glycemia means during the 20 days experiment

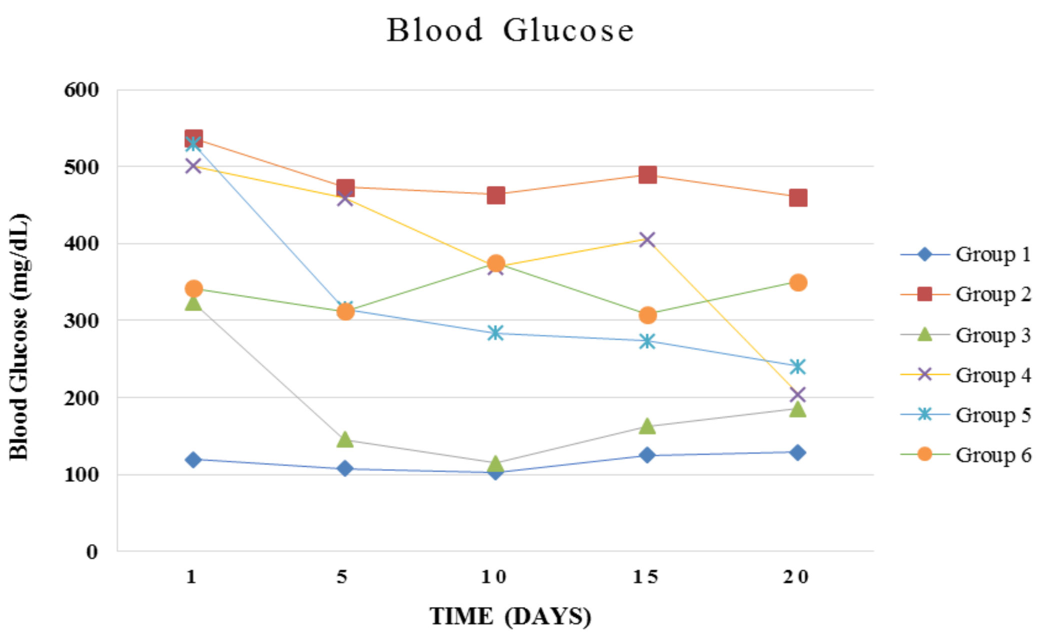
Group (n=3)	Glycemia (mg/dL)						
	1º day	5º day	10º day	15º day	20º day	Means*	% Variation
G01	119.33	107.33	102.67	125.33	128. 67	116.67±16.23	7.82
G02	536.67	473.00	464.00	490.00	460.33	484.80±59.67^{a}	-14.22
G03	323.33	145.33	114.67	162.33^{b}	185.33^{b}	186.20±83.67^{b}	-42.68
G04	501.00	458.67	369.00	405.67	204.66	387.80±132.38^{a}	-59.15
G05	528.67	315.33	283.33	273.67^{b}	240.67^{b}	328.33±145.81^{b}	-54.48
G06	341.67	311.67	375.00	308.00	350.67^{b}	337.40±111.67^{ab}	2.64

* Values expressed as means ± standard deviation (n = 3);
[a] Diabetic control group vs. Groups treated with flour; [b] Diabetic group treated with metformin vs. Groups treated with flour; values followed by the same letter, in the same column, did not differ by Tukey's test at 0.05.
G01: Not diabetic; G02: untreated diabetics; G03: diabetics treated with metformin; G04: diabetics treated with eggplant flour; G05: diabetics treated with okra flour; G06: diabetics treated with blended flour.
Variation: percentage of variation between days. Fonte: Própria (2016)

When the animals receiving the pharmacological treatment with metformin (G03) were compared to those treated with the experimental foods, the group that received the okra flour (G05) presented significant reduction of glycemia, with no differences to the metformin group. Other authors already emphasize the importance of this vegetable in the reduction of glycemia, but they mostly use extracts or seeds, but not the whole fruit. Sabitha et al. (2011) demonstrated this hypoglycemic potential by providing dried okra seeds to mice with induced diabetes, as well as Tian et al. (2015), Saha et al. (2015) that offered okra extracts that significantly reduced the glycemia.

Only the group treated with the flour blend presented reduced glycemia statistically similar to the two control groups. This result reflects what it was abovementioned, considering that it is the mixture of the two flours. In Figure 1, the glycemia variations are presented during the 20 days of treatment.

Figure 1- Blood glucose variation during 20 days of treatment.



Fonte: Própria (2016)

Considering the results of okra flour, it was verified that the hypoglycemic activity began on the fifteenth day of treatment, with glucose levels similar to the group treated with the drug (G03) ($p > 0.05$). On the last day of treatment, the group that received the flour blend produced the same results as those two.

Lima et al. (2012) observed that mice fed with food enriched with 10% *Passiflora nítida kunth* flour (*suspiro* passion fruit) demonstrated significant decreased glycemia levels after the twelfth day of the experiment, similar to the result obtained in thisstudy. This was different from the result obtained by Irondi, Oboh & Akindahunsi (2016) in the study with *Mangifera indica* seed flour, who found significant reduction in glycemia levels of animals already in the seventh day of treatment, with flour mixes at 10% and 20%.

In relation to chemical composition, both experimental samples analizy en the current study, proved to be important source of nutrient, particularly fibers. In this aspect, the okra flour was superior to eggplant, presenting higher fiber content, which may have had a positive influence on the animals' glycemic results. Fibers help to stabilize blood glucose by regulating the rate at which sugar is absorbed in the intestinal tract, contributing to diabetes treatment (Gemede et al., 2015). In a meta-analysis of randomized clinical data performed to evaluate the glycemia of patients with type 2 diabetes, it was found that high-fiber diets (up to 42.5 g/day) reduced glycated hemoglobin values by 0.55% and plasma glucose at 9.97 mg/dL, demonstrating that fiber intake can be used as an adjuvant treatment of type 2 diabetes (Silva et al., 2013).

Another study that demonstrates the hypoglycemic effect of fibers was developed by Sousa et al. (2015), who reported the decrease in glycemia through pectin administration of alloxan-induced diabetic mice. This same potential was observed in hyperglycemic animals when provided with high-fiber fruit cookies, emphasizing the importance of this nutrient in the dietary treatment of diabetes (Erukainure et al., 2013). According to Alam & Khan (2007), soluble fibers are present in large quantities in okra mucilage, with pectin, guar gum, carboxymethylcellulose, among others.

In addition to its fiber value, several authors report that okra is an important source of bioactive compounds, such as carotenoids, folic acid, thiamine, riboflavin, niacin, vitamin C and polyphenols such as quercetin (Roy et al., 2014). A study developed by Fan et al. (2014), showed that the ethanolic extract of okra and its main flavonoids, quercetin and isoquercitrin, reduced blood glucose and improved its tolerance in obese mice. Regarding the flour, Odom, Udensi & Ogbuji (2013) obtained positive results in the glycemia of animals by providing a blend of flours elaborated with fruits, attributing this fact to phytochemicals presented in the mixture.

More recent studies point to the antioxidant capacity of okra as one of its main functional attributes in the reduction of glycemia, since oxidative stress plays an important role in the etiology and pathogenesis of diabetes. Mishra, Kumar & Rizvi (2016) observed that okra was able to reduce alloxan oxidative stress by 75% and 22% in mice with induced diabetes, while the untreated group displayed an increase of about 153% to 290% in lipid Peroxidation and Advanced Protein Oxidation (AOPP), respectively.

In the study of Tian et al. (2015), blood glucose reduction was observed in mice with gestational diabetes induced by streptozotocin and treated with okra extract. The authors related this activity to the antioxidant property of the extract, which reduced the extent and level of glucose oxidation, and consequently, the formation of the superoxide anion radical, restoring the antioxidant enzymes. Peng et al. (2016) also found, in addition to the hypoglycemic effect, a reduction in the risk of diabetic nephropathy, attributing it to the presence of quercetin, the main antioxidant flavonoid of okra.

Epidemiological studies have suggested that consumption of flavonoid-rich foods could reduce the risk of cardiovascular disease, diabetes, obesity, hyperlipidemia, stroke and cancer, therefore suggesting that consumption of okra may be beneficial in metabolic diseases, as observed in this study (Xiao et al., 2011).

Okra has also been studied for having possible inhibitory activity on the hydrolases of starch, α-amylase and α-glucosidase. This activity would prolong the time of carbohydrate digestion and, consequently, reduce the rate of glucose absorption and avoid postprandial plasma hyperglycemia (Lu et al., 2016). Ahmed & Kumar (2016) showed in their *in vitro* study that okra efficiently inhibits α-amylase and α-glucosidase enzymes, with the aqueous extract displaying an inhibitory potential of 84.4%, while the ethanolic and methanolic displayed 88.6% and 92.3%, respectively. Although its action on glycaemia is widely discussed, the mechanism by which okra reduces it is not yet known, and further studies are necessary to clarify these activities (Sabitha et al., 2011).

The use of some foods that help the treatment of diseases must be accompanied by studies that prove their safety for consumption. Peron et al. (2008) demonstrated that eggplant juice in high amounts did not produce cytotoxic or clastogenic effects in Wistar mice. As for okra, Macedo et al. (2014) and Sabitha et al. (2011) evaluated, respectively, the extract and the flour of the seeds, and did not find any evidence of their toxicity.

The weight, water intake and food intake averages measured during the experiment are described in Table 4. From these results, a negative variation in the weight of diabetic animals was observed, which is justified by the metabolic changes caused by diabetes. Sousa et al. (2015) and Harijono et al. (2013), did not found evidence for such fact with the diabetic animals in their research.

Table 4 - Initial and final weight of the animals, followed by means of water and food intake during the 20 days of experiment.

Group (n=3)	Weight (g)			Means ± SD of daily intake (by animal)	
	Initial	Final	% Variation	Water (mL)	Food (g)
G01	33.0±4.36	36.3±4.44	13.64	12.46±4.75[b]	6.30±1.01[b]
G02	41.8±0.76	39.3±0.58	-5.98	29.28±17.33[a]	6.96±1.54[ab]
G03	40.0±2.65	38.0±1.73	-5	20.79±8.97[ab]	5.92±0.89[b]
G04	31.0±0.0	29.7±2.20	-4.09	37.44±16.52[a]	7.59±1.86[ab]
G05	35.7±4.73	32.0±7.00	-10.28	28.97±18.28[ab]	6.28±1.98[b]
G06	35.0±1.73	33.3±3.06	-4.76	36.15± 15.86[a]	8.57±2.44[a]

Values followed by the same letter, in the same column, did not differ by Tukey's test at 0.05.
G01: Not diabetic; G02: untreated diabetics; G03: diabetics treated with metformin; G04: diabetics treated with eggplant flour; G05: diabetics treated with okra flour; G06: diabetics treated with blended flour.
Variation: percentage of variation between days. Fonte: Própria (2016)

Regarding water intake, all diabetic groups showed no significant difference among water consumption; only the animals treated with metformin and okra presented results similar to the healthy group. Polydipsia is a characteristic symptom of diabetes and is linked to hyperglycemia. Thirst is caused by intracellular dehydration that occurs when blood glucose levels rise and water is withdrawn from body cells, including those located in the thirst center (Porth & Grossman, 2011).

Regarding food intake, the results show that the group treated with the flour blend (G06) ingested a larger amount of food, but statistically similar to the groups G02 and G04. The amount consumed by the healthy animals treated with metformin and okra flour was similar, however, the first group also resembled the groups that were untreated and treated with eggplant flour. Sousa et al. (2015) obtained a different result from this research, verifying an increase in water and food intake by the groups treated with pectin extracted from *Passiflora glandulosa Cav*.

4. Conclusion

Experimental flours made from eggplant (*Solanum melongena L.*) and okra (*Abelmoschus esculentus L. Moench*) presented significant amounts of minerals, proteins, lipids, carbohydrates and fiber, which are important to their functional attributes. In relation to the hypoglycemic activity, the okra flour was more efficient in the reduction of glycemia from diabetes-induced mice when compared to the eggplant flour. This result reflects the fiber content and bioactive compounds presented in the vegetable, similar to other authors who worked with the same. However, the researched literature involves studies of okra seeds or extracts, making the need for further studies with the whole vegetable flour. As for the eggplant, research still shows inconclusive results regarding its hypoglycemic effect; and finally, the blend of the two flours presented great research potential, since it provided a reduction of glycemia.

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Conflict of interest

The authors declare that they have no conflict of interest.

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