Research, Society and Development, v. 9, n. 10, e8199109286, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i10.9286

The feasibility of use of sweet potato (*ipomoea potatoes l.*) flour in the preparation of bakery products

A viabilidade de uso da farinha de batata-doce (*ipomoea batatas l.*) na elaboração de produtos panificados

La factibilidad del uso de harina de patata dulce (*ipomoea potatoes l.*) en la preparación de productos de panadería

Received: 10/14/2020 | Reviewed: 10/14/2020 | Accept: 10/18/2020 | Published: 10/20/2020

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Abstract

Sweet potatoes are one of the most consumed vegetables in Brazil and in the world, as they are cheap, easy to buy and healthy food. The objective of this work was to prepare sweet potato flour, bread with the addition of sweet potato flour and evaluate its effect. Four bread formulations were prepared: P0% (standard) and the others added potato flour of 8% (P8%), 16% (P16%) and 24% (P24%). The microbiological, physical-chemical, sensory parameters and the color of flour and bread were evaluated. A statistical analysis was performed with the averages by the Tukey test at 5%. The result of the microbiological analysis was in accordance with the legislation. In potato flour, components such as carbohydrates and proteins stood out. Bread samples showed a significant difference (<0, 05) in relation to the physical-chemical parameters with the exception of moisture and crude fibers. All formulations showed good acceptance in all attributes, presenting scores higher than 6 and a good purchase intention with more than 50% of the products with the exception of the P24% sample.

Keywords: Nutritional quality; Microbiological quality; Sensory quality.

Resumo

A batata-doce é uma das hortaliças mais consumidas no Brasil e no mundo, por ser um alimento barato, de fácil aquisição e saudável. Objetivou-se neste trabalho elaborar a farinha de batata-doce, pães com adição da farinha de batata-doce e avaliar seu efeito. Foram elaboradas quatro formulações de pães: P0% (padrão) e as demais adicionadas farinha de batata de 8% (P8%), 16% (P16%) e 24% (P24%). Avaliou-se os parâmetros microbiológicos, físico-químicos, sensoriais e a cor, da farinha e dos pães. Foi realizada uma análise estatística com as médias pelo teste de Tukey a 5%. O resultado da analise microbiológica foi de acordo com a legislação. Em farinha de batata se destacou os componentes como carboidratos e proteínas. As amostras de pães apresentaram diferença significativa (<0,05) em relação aos parâmetros físico-químicos com exceção da umidade e fibras brutas. Todas as formulações apresentaram boa aceitação em todos os atributos apresentando notas maiores que 6 e uma boa intenção de compra com mais de 50% dos produtos com exceção da amostra P24%.

Palavras-chave: Qualidade nutricional; Qualidade microbiológica; Qualidade sensorial.

Resumen

La batata son una de las hortalizas más consumidas en Brasil y en el mundo, ya que son baratas, fáciles de comprar y alimentos saludables. El objetivo de este trabajo fue preparar harina de camote, pan con el agregado de harina de camote y evaluar su efecto. Se prepararon cuatro formulaciones de pan: P0% (estándar) y las demás agregaron harina de papa al 8% (P8%), 16% (P16%) y 24% (P24%). Se evaluaron los parámetros microbiológicos, físico-químicos, sensoriales y el color de la harina y el pan. Se realizó un análisis estadístico con los promedios por la prueba de Tukey al 5%. El resultado del análisis microbiológico fue conforme a la legislación. En la harina de patata destacaron componentes como carbohidratos y proteínas. Las muestras de pan mostraron una diferencia significativa (<0,05) en relación a los parámetros físico-químicos con excepción de la humedad y las fibras crudas. Todas las formulaciones mostraron buena aceptación en todos los atributos, presentando puntajes superiores a 6 y una buena intención de compra con más del 50% de los productos con excepción de la muestra P24%.

Palabras clave: Calidad nutricional, Calidad microbiológica, Calidad sensorial.

1. Introdution

Wheat flour is widely used in the manufacture of bakery products, due to its performance on some essential functional properties such as viscoelastic net and insolubility in water, which allows the greatest aggregation of all ingredients for proper formation of the pasta (Araújo et al 2010). These characteristics are attributed to the gliadin and glutenin proteins that make up gluten, which give the product water absorption capacity, cohesiveness, viscosity and elasticity (Vieira et al. 2015).

Bread is one of the most consumed foods by the Brazilian population and in the world. A traditional food made from wheat flour and easy to purchase. However, the high consumption of cereals such as bread has triggered an alert to health agencies, as the ingestion of wheat derivatives can compromise the quality of life of consumers genetically predisposed to the appearance of Celiac Disease (CD), an autoimmune disease triggered by eating cereals that contain glutem (Araujo et al. 2010). Thus the consumption of bread came to be seen not only to meet basic nutritional needs, but also to assist in maintaining health and in the process of preventing related ills (Teixeira et al. 2016). Reason why the search for new formulations has been growing by the bakery industries. The substitution or aggregation of ingredients has become possible with technological advances, seeking to provide quality and better development of breads.

The profile of the consumer market in recent years, which has become increasingly demanding in relation to quality, has provided an increase in the demand for healthy foods

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which, in addition to their basic function, can benefit health and prevent certain chronic diseases such as obesity, diabetes and diseases cardiovascular diseases (Ribeiro et al., 2018). Sweet potato is a tuber with great potential for application as a biofortifier in food. Due to its high content of functional nutrients such as the presence of β-carotene and vegetable protein source for vegetarians. Regular consumption of sweet potatoes can prevent and combat blindness in people deficient in vitamin A and fight obesity. In underprivileged populations, sweet potatoes are indicated as a food alternative to combat infant mortality caused by avitaminosis, mainly retinol (Oliveira do Nascimento et al. 2013).

Considering the growing demand from consumers, the present study aimed to study the effect of using mixed wheat and sweet potato flour in different proportions on the physicochemical and sensory characteristics of bread.

2. Material and Methods

The sweet potatoes were purchased at the organic market in the city of Bananeiras-Paraíba, from a rural producer. The sweet potatoes are Brazlândia of white cultivar. They were taken to the Federal University of Paraíba (UFPB Campus III) where the work was developed.

2.1 Process of obtaining sweet potato flour

For the preparation of the flour, healthy tubers were selected and disposal of deteriorated roots; then the washing was carried out, with the help of brushes with plastic bristles, to remove dirt from planting and harvesting, after which the roots were sanitized in 150 ppm chlorinated solution. After sanitizing, the roots were peeled and sliced with knives in a standardized thickness of 2 mm with the aid of a caliper. Then, to avoid enzymatic browning, the combined bleaching process, thermal at 80 °C and chemical with 1% citric acid, was applied. For drying, a Pratic Dryer dehydrator, Meloni brand, with a maximum power of 250 Watts, was used and for grinding a Willye knife mill, type Star FT-50/6, of the Fortinox series 24116.

2.2 Bread making formulation

Four formulations of bread enriched with 0%, 8%, 16%, and 24% sweet potato flour were prepared, partially replacing wheat flour, as shown in Table 1.

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Table 1. The different formulations for making bread.

Ingredients	Formulations			
	P0%	P8%	P16%	P24%
Wheat flour (g)	500	460	420	380
Sweet potato flour (g)	0	40	80	120
Salt (g)	8	8	8	8
Sugar (g)	90	90	90	90
Margarine (g)	50	50	50	50
Milk (ml)	150	150	150	150
Eggs (unit)	2	2	2	2
Yeast (g)	15	15	15	15

P0%: Formulation with 100% wheat flour; P8%: Formulation with substitution of 8% of wheat flour for sweet potato flour; P16%: Formulation with substitution of 16% of wheat flour for sweet potato flour and P24%: Formulation with substitution of 24% of wheat flour for sweet potato flour.
Source: Authors (2020).

To prepare the breads, after weighing the ingredients, the dry ingredients were initially mixed and the wet ingredients were added lately. Homogenization and kneading were carried out until the dough formed the gluten network. Then, the dough was cut into a standardized format of 50 g unit. Soon after, the cuts were modeled in the desired format and placed in the 28 °C oven for fermentation to take about two hours. They were taken to the preheated oven at a regulated temperature of 180 °C to bake, for approximately 25 minutes. After reaching the point, the breads were removed, cooled to room temperature, and packed in expanded polystyrene trays and covered with flexible PVC film and stored for later analysis.

2.3 Microbiological analysis

Microbiological analyzes were performed according to the requirements of Brazilian legislation, Resolution RDC nº 12 of January 2, 2001. The analyzes were performed according to the methodology described by the American Public Health Association (APHA, 2001). For elaborated flour, research of Coliforms, *Bacilus cereus* and Salmonella spp carried out and bread elaborated Coliforms, *Bacilus cereus, Estapfilococus Cogulase Positiva and Salmonella spp*. Petonated water and agar were used as culture medium in Petri dishes and test tubes. The incubation temperature was 27 °C and 45 °C for Coliforms.

2.4 Physicochemical analysis

The moisture was determined by drying method at 105 °C (AOAC, 2010). The ashes were determined by incineration at 550 °C (AOAC, 2010). The determination of lipids was made by the method proposed by Folch et al. (1957). Fibers, reducing sugars, total sugars and non-reducing sugars were determined using the AOAC method (2010). Proteins were determined using the Micro-Kjeldahl method. Water activity (Aw) was measured in Aqualab 4TE (Decagon Devices, USA) at 23 °C. The pH was measured using a pHmeter (PHS-3E, ION) at room temperature. Titratable acidity was determined by titration with NaOH correction factor 0.1 N. Carbohydrates were obtained by difference (100 -% moisture -% ash -% protein -% fat -% fiber). The determination of soluble solids (°Brix) was made using a digital refractometer with a scale from 0 to 92 °Brix.

- For flour, moisture, ash, soluble solids, pH, titratable acidity, proteins, lipids, carbohydrates, reducing sugars, total sugars, non-reducing sugars, crude fibers and yield were determined.

The following equation was used to calculate the yield (Y%) of sweet potato flour.

$$Y(\%/\text{Kg}) = \frac{FFW}{FPW} \times 100$$

Were:

Y = yield,

FFW = final flour weight,

FPW = fresh potato weight.

- For breads, moisture, ash, soluble solids, pH, titratable acidity, proteins, lipids, crude fibers, carbohydrates, reducing sugars, total sugars and non-reducing sugars were determined.

- The bread color was determined using a Delta Color d.8 colorimeter, model SN 7002000306. L*, a* and b* coordinates were determined, where L* indicates luminosity, positive a* indicates red and a* negative indicates green and, b* positive indicates yellow and b* negative refers to blue.

2.5 Sensory analysis

Sensory analysis of the loaves was performed with 70 untrained evaluators using a nine-point verbal hedonic scale. The evaluators received the samples of bread in individual cabin with water in the disposal. The evaluated parameters are Appearance, Texture, Flavor, Aroma, Color, Global impression and purchase intention. Sensory analysis was applied at two o'clock in the afternoon.

2.6 Statistical analysis

The experimental designer adopted for the experiment was a completely randomized design with 4 treatments and 3 repetitions. The data from the physical-chemical and color analyzes were examined using analysis of variance (ANOVA). The averages were evaluated using the Tukey test at 5% probability for comparison of significance with the use of the SAS® software, version 9.1.

3. Results and Discussion

3.1 Result of microbiological analysis of sweet potato flour

Table 2 shows the results of the microbiological evaluation of sweet potato flour. It is observed that the values found for total coliforms, *Bacillus cereus*, *Salmonella sp*. are within the standards established by Brazilian legislation. The current legislation recommends a tolerance of $3x10^3$ *UFC* /g for *B.cereus* and the value found was $1x10^3$ and for coliforms and *Salmonella spp* there was no growth. The microbiological qualities of a food guarantee its safety for consumption without compromising the health of consumers and for this it is necessary for good manufacturing practices. Raiol et al. (2016) also find results within the standards, with good practices as a fundamental factor for such result.

Table 2. microbiological result of sweet potato flour.

Microorganisms surveyed	Sweet potato flour	Brazilian Legislation
Coliforms 45 °C / g (NMP / g)	<3	10^2
Bacillus cereus/ g (UFC / g)	$1x10^3$	$3x10^3$
Salmonella spp.	Absent	Absence

Source: Authors (2020).

3.2 Results of the physical-chemical analysis of sweet potato flour

Table 3 shows the results of the physicochemical characterization of sweet potato flour. The yield was 35%, being economically good. This yield is due to peeling and great water loss during drying.

Regarding nutritional quality, potato flour has 88.18% of carbohydrates. Carbohydrates is the name used to designate a wide variety of chemical compounds that make up most of the dry matter in vegetables. Sugars, that is, monosaccharides are the basic units of carbohydrates that cannot be hydrolyzed, more soluble in water and are found in sweet potato flour (Fellows, 2018). Carbohydrates have several functions for the maintenance of the organism, they are primary sources of energy in the active organism and in the control of the blood glucose content (Johann et al., 2016). Franco et al. (2018) found 77.81% of carbohydrates in sweet potato flour.

The moisture content, water activity and pH are factors that contribute to food stability, factors that control microbial growth. The values found are 4.78%, 0.55% and 3.20 respectively, being low. Silva et al. (2020), also found low values of humidity and water activity in flour of different varieties of cassava. In low humidity and water activity, most pathogenic microorganisms are unable to develop, thus increasing food safety from a microbiological point of view. Temperature is a very important factor that can influence the moisture content and water activity of a food. Pagani and Santos (2017) found 2.73% moisture in sweet potato flour at a drying temperature of 65 °C while in this work the drying was at 60 °C. Microorganisms need water for their survival. For their growth and metabolism, microorganisms require the presence of water in an available form. Most of the other bacteria do not grow in a medium with low humidity and water activity below 0.91 (Damasceno et al., 2018). The pH is one of the main intrinsic factors capable of determining the growth, survival or destruction of microorganisms in it. Microorganisms have optimal and maximum pH values for their multiplication. Most microbial species have an optimal growth pH between 6.0 to 7.0, some like lactic acid bacteria reach pH 5.5 for their growth (Fellows, 2018). Pegani and Santos (2017) determined pH 3.20 in sweet potato flour, contributing to the high stability of the flour on the shelf, survival or destruction of the microorganisms in it.

Table3. Result of physical-chemical analyzes of sweet potato flour.

Parameters	Sweet potato flour
Moisture (%)	4.78 ± 0.14
Ashes (%)	1.30 ± 0.23
Soluble solids (°Brixo)	27.89 ± 0.00
pH	3.20 ± 0.00
Titratable acidity (%)	5.80 ± 0.01
Crude fiber (%)	1.55 ± 0.35
Lipids (%)	0.79 ± 0.16
Proteins (%)	3.40 ± 0.65
Reducing sugars (%)	14.56 ± 0.88
Non-reducing sugars (%)	3.14 ± 0.56
Total sugars (%)	17.70 ± 0.32
Carbohydrates (%)	88.18 ± 0.38
Water activity (Aw)	0.55 ± 0.00
Yield (%/kg)	35.29 ± 0.11

Source: Authors (2020).

In addition to carbohydrates, flour is rich in protein. Proteins are the most common organic compounds in an organism and perform various functions such as energetic, structural, catalytic among others. A good protein diet is necessary for muscle mass gain and weight loss (Rodrigues et al., 2015). In the present study, the protein value found in the flour was 3.40% while Lima et al. (2019) found 3.80% and Bezerra et al. (2015) found 4.38% protein in sweet potato flour, the values found corroborate the value found in this work. Some components such as lipids are found in lesser quantities, this makes potato flour a healthy food, less fat and less caloric for a good weight loss diet. The lipid content determined in this work was 0.779% while Franco et al. (2018) found 1.72%. Cardoso et al. (2020), also found a low lipid value in Jenipapo pulp flour. Low-lipid products are free from the oxidation problem avoiding health problems from free radicals. In Sorghum flour Correia et al. (2020) found 1.72% as the average lipid value.

3.3 Results of the microbiological analysis of the breads

The results of counts of microorganisms that are indicators of contamination in bread are shown in Table 4.

Table 4. Results of microbiological analysis of the breads made.

	Microorganisms surveyed			
Products	*Bacilus cereus* (UFC/g)	Coliforms at 45 ° C (NMP/g)	*Coagulase positive staphylococci* (UFC / g)	*Salmonella* spp.
P0%	$<1x10^2$	<3	$<1x10^2$	Absent
P8%	$<1x10^2$	<3	$<1x10^2$	Absent
P16%	$<1x10^2$	<3	$<1x10^2$	Absent
P24%	$<1x10^2$	<3	$<1x10^2$	Absent
Brazilian Legislation	$5x10^2$	$5x10^2$	$5x10^2$	Absence

P0%: Formulation with 100% wheat flour; P8%: Formulation with substitution of 8% of wheat flour for sweet potato flour; P16%: Formulation with substitution of 16% of wheat flour for sweet potato flour and P24%: Formulation with substitution of 24% of wheat flour for sweet potato flour.
Source: Authors (2020).

Due to the good manufacturing practices, strictly respected, the microbiological results of the breads were within the standards of the food safety code from a sanitary point of view. The consumption of products does not endanger the health of consumers. Feeding within satisfactory hygienic standards is one of the essential conditions for the promotion and maintenance of public health. In order to avoid food poisoning or infections, the guarantee of safe food is increasingly an issue of great interest in strategic decisions, being fundamental for the development of systems that maintain the population's health (Volcão et al., 2016).

3.4 Results of the physical-chemical analysis of the breads

Table 5 presents the results of the physical-chemical composition of the breads. It can be seen that the partial substitution of wheat flour for sweet potato flour significantly influenced ($p <0.05$) the physicochemical parameters determined, except for moisture content and fiber content. Sweet potato flour behaved low in fiber compared to wheat flour, this

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component being not compromised in breads by addition. According to Borges et al. (2011) there may be a fiber content in higher concentrations of added sweet potato flour.

Table 5. Results of the physical-chemical analysis of the breads.

Parameters	Formulations			
	P0%	P8%	P16%	P24%
Moisture (%)	24.82 ± 0.66[a]	25.44 ± 0.43[a]	24.09 ± 0.16[a]	25.18 ± 0.74[a]
Ashes (%)	1.83 ± 0.13[a]	1.87 ± 0.03[a]	1.43 ± 0.08[b]	1.42 ± 0.11[b]
Soluble solids (Brixo)	11.83 ± 0.17[c]	19.52 ± 0.43[b]	20.31 ± 0.44[b]	23.62± 0.44[a]
pH	6.08 ± 0.00[a]	5.84 ± 0.00[b]	6.05 ± 0.00[a]	5.94 ± 0.00[b]
Titratable acidity (%)	0.17 ± 0.03[b]	0.27 ± 0.01[a]	0.20 ± 0.01[b]	0.24 ± 0.01[a]
Crude fibers (%)	0.94 ± 0.14[a]	0.96 ± 0.00[a]	0.99 ± 0.00[a]	1.16 ± 0.00[a]
Lipids (%)	7.35 ± 0.15[b]	8.86 ± 0.12[a]	9.43 ± 0.23[a]	7.51 ± 0.31[b]
Proteins (%)	9.40 ± 0.19[b]	10.14 ± 0.36[b]	10.75 ± 0.11[b]	12.01 ± 0.06[a]
Carbohydrates (%)	55.39 ± 0.14[a]	52.72 ± 0.23[b]	53.31 ± 0.14[ab]	52.72 ± 0.30[b]
Reducing sugars (%)	7.29 ± 0.56[b]	11.95 ± 0.90[a]	12.08 ± 0.61[a]	13.30 ± 0.62[a]
Non-reducing sugars (%)	5.33 ± 0.11[a]	2.43 ± 0.46[b]	2.62 ± 0.07[b]	3.05 ± 0.55[b]
Total sugars (%)	12.62 ±0.66[b]	14.38 ± 0.43[b]	14.70 ± 0.54[ab]	16.36 ± 0.68[a]
L *	26.25[a]	23.86[c]	24.95[b]	23.68[c]
a*	1.59[a]	1.46[b]	1.40[b]	0.90[c]
b*	13.88[a]	12.84[b]	12.55[b]	13.63[a]

Means followed by the same lowercase letter on the same line do not differ significantly, at 5% probability, by the Turkey test. P0%: Formulation with 100% wheat flour; P8%: Formulation with substitution of 8% of wheat flour for sweet potato flour; P16%: Formulation with substitution of 16% of wheat flour by sweet potato flour and P24%: Formulation with substitution of 24% of wheat flour by sweet potato flour.
Source: Authors (2020).

Sweet potato flour is a hygroscopic product even at room temperature because its high starch content could have increased the moisture content in breads. The application of high temperature baking of the bread favored the loss of moisture to the point that there was no difference in the moisture content of the bread. Pereira et al. (2013) observed a variation in humidity when varying the concentrations of potato flour in different formulations. These authors reported, depending on the level of substitution of wheat flour for sweet potato flour, probably in higher concentrations it is possible that a variation in the moisture content of the final product may occur. The low humidity guarantees the product greater stability, controlling microbial growth, minimizing the risk to consumers' health.

Regarding the protein content, there was a significant difference ($p < 0.05$) between the different formulations. The P0% control formulation was the one with the lowest protein content and the P24% formulation with the highest protein content. This protein content has been increasing as the concentration of sweet potato flour in the formulations increases. It is important to know how much more you want breads with high protein content you need to increase the concentration of sweet potato flour in the formulations. According to Olatunde et al. (2015), some sweet potato cultivars are great sources of vegetable protein than others, this explains that in some cases a large substitution is not necessary to notice a significant difference in the protein content in breads. Pereira et al. (2013) observed the same effect in relation to the increase in protein, results that corroborate those found in this work.

For total, reducing and non-reducing sugars, the difference in formulations was significant ($p < 0.05$). The total sugar content increased due to the concentration of sweet potato flour and also to reducing sugars. The formulation P24% had a higher content (16.36%) of total sugars and P0% with a lower content (12.62%). For reducing sugars the sample P24% also had the highest value (13.30%) while for non-reducing sugars the formulation P0% showed the highest value (5.33%) expected result. The sweet potato, as its own name says, is rich in sugars (carbohydrates) that give it a sweet flavor, which is why it influenced the sugar content in breads. The values of total sugars and reducing sugars found by Alencar et al. (2019) in breads based on rice flour corroborate the values found in this work because rice also contains carbohydrate sugars.

The carbohydrate content was significantly influenced ($p < 0.05$). As the flour and sweet potato flour is a product very rich in carbohydrates, the effect of the substitution affected this component in breads a lot. The values of carbohydrates determined were higher than the values determined by Almeida and Szlapak (2015) in different formulations of potato breads due to the variation in the concentration of potato flour. Rigo et al. (2018) also obtained results that corroborate the results of this work.

As for ash content, the difference was significant ($p < 0.05$), while for Rigo et al. (2018) the difference was not significant. The control formulation (P0%) had the highest ash value and the formulation P24% had the lowest value. Higher ash content in foods represents greater inorganic residue present in this food, the fluctuation of ash content must be because wheat flour contains more inorganic materials than sweet potato flour and as wheat flour decreases. in the formulation of bread the content of inorganic matter in the final product also decreases. As the sweet potato flour used in this work was not obtained in an industrial way, it hypothetically explains the low presence of inorganic substances in breads. Martini et al. (2016) and Teixeira et al. (2016) found values close to ashes of the values determined in this work.

The addition of sweet potato flour in bread formulations promoted an increase in the content of soluble solids in relation to the standard formulation, showing a significant difference (p <0.05). It is observed that the content of soluble solids increases with an increase in the concentration of sweet potato flour, this result reinforces the work of Araújo (2015). The value of the P0% sample was lower while the P24% sample had a higher content of soluble solids. The values are close to those determined by Araújo (2015). There was a synergistic effect between wheat flour and sweet potato, increasing the soluble solids content.

The lipid values found in the present study showed a significant difference (p <0.05). Sweet potatoes are a low-fat food, even indicated for a weight loss diet. This lack of lipid in potatoes meant that the lipid content did not increase due to the concentration of the added sweet potato flour. In a study by Martini et al. (2016) where several French type breads were analyzed, observed that the substituting flour is low in fat and does not significantly influence the lipid content of the breads. In the work of Teixeira et al. (2018) with partial addition of eggplant peel flour in different formulations, increased the lipid content of breads, because eggplant peel has more lipids than wheat flour and sweet potato flour.

Sweet potato flour increased the acidity of the formulations that contain it and lowered the pH of these formulations. The increase in acidity was due to the type of bleaching of potatoes with citric acid before the preparation of the flour. The low pH increases the stability of the bread and also reduces the risk of food infections due to the majority of pathogenic bacteria not growing in an acidic medium (Fellows, 2018). In partial replacement of wheat flour with sweet potato flour, Araújo (2015) found a pH close to the values found in this work. The pH verified by Teixeira et al. (2016) in different breads also corroborate the values found. Neves, Gomes and Schiele found very low pH (3,75 e 3,95) in breads with added araticum.

Regarding the color, it was found that the values obtained for the luminosity (L*) of the color, the breads with the addition of sweet potato flour differed significantly in control (p <0.05). It was observed that the partial replacement of wheat flour contributed to the slight browning of the breads, with a decrease in luminosity. This phenomenon is due to the fact that wheat flour is whiter than sweet potato flour. Clarity decreases when adding potato flour.

Andrade et al. (2018), in the addition of green banana flour in bread making observed a decrease in luminosity, being a correlative factor.

For the parameter a* of the instrumental color analysis, there was a variation in the values found for the different formulations. The great variation was observed in breads with a higher concentration (sample P24%) of sweet potato flour with a tendency to green color (0.90). Even though the sweet potato flour appears to be white that dark, there is the presence of chlorophyll pigments and this in great concentration can interfere with the color of the breads. Pires et al. (2018) observed a variation of the parameter a* in breads with the addition of flours of different origins.

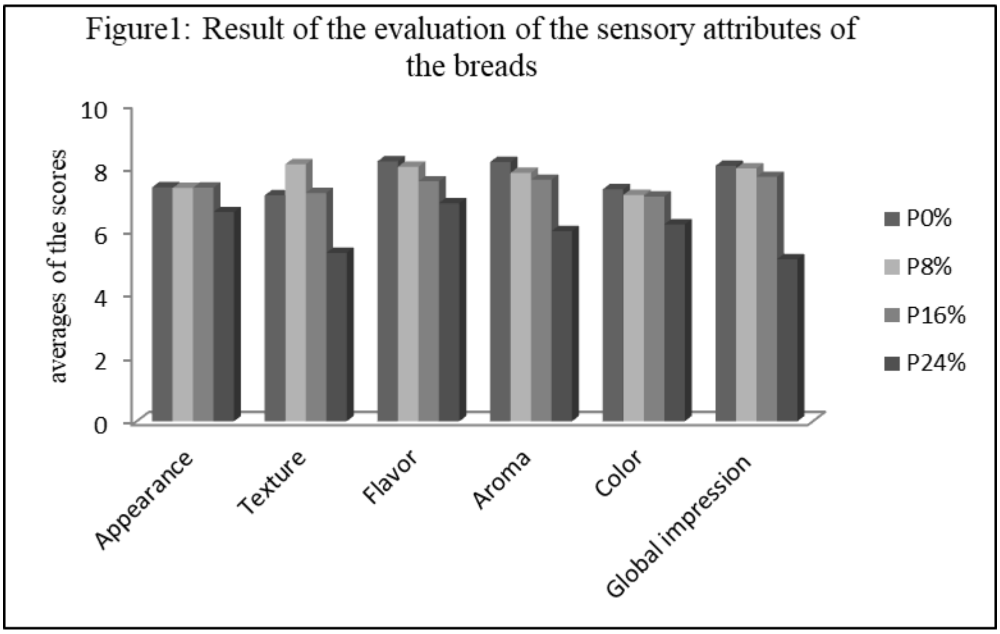
In the results of the color analysis, there was a significant difference ($p < 0.05$) between the different formulations in relation to the parameter b*. The addition of sweet potato flour showed that it does not contain any blue pigments when presenting b* positive, but there is a presence of yellow pigments. The presence of yellow pigments in breads may come from margarine added to the formulations or products of the Maillard reaction. With the addition of different sources of flour in the bread formulation, Andrade et al. (2018) observed a significant difference in the parameter b* being influenced by the color of the flour added depending on the concentration.

3.5 Results of sensory analysis of breads

Figure 1 shows the averages of the scores attributed by the tasters in relation to the evaluated sensory parameters.

Regarding the sensory parameters evaluated, all samples were well accepted with scores greater than 6 with the exception of the sample P24%, which had a score lower than 6 in texture and overall impression. With 24% substitution of wheat flour for sweet potato flour, the changes in sensory characteristics were totally perceptible, giving breads an unusual characteristic of bread. The P8% sample obtained a higher evaluation in relation to texture. This must have been due to the increase in protein added by sweet potato flour. The formation of gluten that contributes to the texture of bread is formed by proteins. According to Damasceno et al. (2018) the texture for baked goods is influenced by its formulation, the characteristic and the quantity of each added ingredient.

Color and appearance are among the first attributes that attract consumers' attention. Regarding the appearance and color attributes, the average grades attributed to all formulations were above 6, showing a good acceptance of these attributes. In breads with the addition of sugarcane bagasse flour, Rigor et al (2018) obtained good acceptance for appearance and color due to the bagasse fibers. The authors' results corroborate the values found.

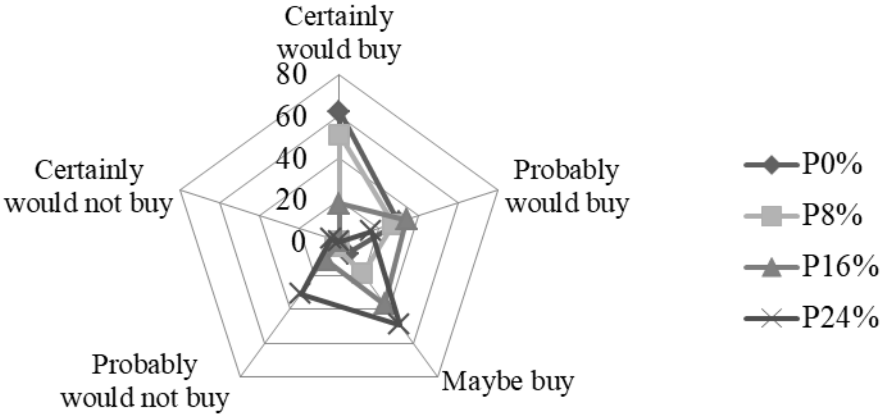


P0%: Formulation with 100% wheat flour; P8%: Formulation with substitution of 8% of wheat flour for sweet potato flour; P16%: Formulation with substitution of 16% of wheat flour for sweet potato flour and P24%: Formulation with substitution of 24% of wheat flour for sweet potato flour.
Source: Authors (2020).

The characteristics of the ingredients added to a bread formulation can determine its acceptance in terms of taste and aroma. In a study by Pereira et al. (2017) that evaluated the sensory acceptance of bread formulations based on sorghum flour, they did not obtain a good score for flavor and aroma attributes. It was obtained in this work for flavor, for aroma equal to or greater than equivalent, a good acceptance of these parameters. The P0% sample was more accepted in relation to aroma with 8.18 points and P24% was less accepted with 6.0 points. The evaluators liked the aroma of the P8% sample more, giving it a higher score. This aroma must be from Maillard's reaction with the reducing sugars and amino acids of sweet potato flour proteins. In the sensory research by Fretas et al. (2017) with green banana flour in bread making, observed that the notes attributed for aroma and flavor were of good acceptance due to banana flour did not cause a negative change in flavor and aroma as in the present work.

Figure 2 shows the results of the purchase intention of the different breads with partial substitution of wheat flour for sweet potato flour in relation to the standard.

Figure 2: Purchase intention of breads



P0%: Formulation with 100% wheat flour; P8%: Formulation with substitution of 8% of wheat flour for sweet potato flour; P16%: Formulation with substitution of 16% of wheat flour for sweet potato flour and P24%: Formulation with substitution of 24% of wheat flour for sweet potato flour.
Source: Authors (2020).

The P0%, P8% and P16% samples were those that obtained the highest positive purchase intention, with more than 50% of the evaluators who would certainly or likely buy the product, and the P24% sample with the highest negative purchase intention index (35%) in probably would not buy and certainly would not buy in relation to other formulations. The P8% sample came closer to the P0% sample in the intention of purchasing because it presented similar or even better sensory characteristics in some parameters such as texture and appearance than the control. The P8% sample with good nutritional characteristics would have the same market as the control.

It was observed that the P24% sample was maximally rejected because it had sensory characteristics totally different from the others. This result was already expected since the sweet potato flour is changing the original characteristics of the breads in relation to what consumers are used to. Araújo (2015) evaluating the intention to purchase breads with different proportions of sweet potato flour, there was a similar result.

4. Conclusion

The biofortification of bread by partially replacing wheat flour with sweet potato flour is a good alternative due to the likely improvements in the nutritional characteristics of bread. In addition to improvements in nutritional components, it is economically favorable to use sweet potato flour in bread formulations and also valuing rural producers. The microbiological characteristics attest that the flour can be used without risks for the production of safe food if good manufacturing practices have been respected. Therefore, the sensory analysis showed that there is a substitution limit for bread to have a market. Partial substitution of wheat flour for sweet potato flour is possible in bakery product formulations, in concentrations tested mainly in 8% to 16% substitution of preference.

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