

INVESTIGACION

Sensory evaluation of cakes prepared with orange-fleshed sweet potato flour (*Ipomoea batatas L.*)

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Carolina Netto Rangel¹; Erika Madeira Moreira da Silva²; Lorena Salvador³;
Renata Figueiredo³; Edson Watanabe³; João Bosco Carvalho da Silva⁴;
José Luiz Viana de Carvalho³; Marília Regini Nutti^{3*}

Abstract

Objective: to assess students' acceptability and preference for cakes prepared with orange-fleshed sweet potato flour (*Ipomoea batatas L.*). **Materials and methods:** the cakes were prepared with wheat flour (sample A) and a mixture where 40% of the wheat flour was replaced by orange-fleshed sweet potato flour (sample B). Questionnaires were applied to 100 students between 10 and 12 years old from a public school in the city of Rio de Janeiro; sensory acceptance and preference tests were also applied. **Results:** participants were on average 11,7 years old, 80% were 6th graders, 50% were female and 97% of the students reported liking the cakes. In this group, 14% reported consuming cakes less than once a month; 27%, 1-3 times per month; 37%, 1-4 times per week; 19%, 1-2 times a day; and only 2% reported never consuming them. Both cakes had high acceptability; with an average score of 9,27 (A) and 9,26 (B) out of a maximum of 10, without any significant differences in preference. Cake consumption was part of the children's eating habits. **Conclusions:** cakes prepared with 40% sweet potato flour were as well accepted as conventional cakes. Further, a portion of this cake (60 g) can contribute up to 22% of daily vitamin A needs.

¹ Universidade Federal Rural do Rio de Janeiro. Seropédica-Brazil.

² Universidade Federal do Espírito Santo, Centro de Ciências Agrárias (UFES). Alegre, ES-Brazil.

³ Embrapa Food Technology. Rio de Janeiro-Brazil.

⁴ Embrapa Vegetables. Gama-Brazil.

* mnutti@uninet.com.br.

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Key words: sweet potato (*Ipomoea batatas L.*), food fortified, food analysis, sensory evaluation, consumer satisfaction, food preferences.

Evaluación sensorial de pasteles con harina de camote (*Ipomoea batatas L.*)

Resumen

Objetivo: evaluar la aceptabilidad y preferencia de los estudiantes por los pasteles preparados con harina de camote (*Ipomoea batatas L.*). **Materiales y métodos:** los pasteles fueron preparados con harina de trigo (muestra A) y una mezcla donde se reemplazó el 40% de la harina de trigo por harina de camote (muestra B). Se aplicaron cuestionarios a 100 estudiantes entre 10 y 12 años de edad de una escuela pública en la ciudad de Río de Janeiro, a quienes se les aplicaron pruebas sensoriales de aceptación y preferencia. **Resultados:** los participantes tenían en promedio 11,7 años, 80% cursaban sexto grado, 50% eran mujeres y el 97% de los estudiantes reportaron gustarles los pasteles. En este grupo, 14% informó que consumían los pasteles menos de una vez al mes, 27%, 1-3 veces al mes, 37%, 1-4 veces por semana, 19%, 1-2 veces al día y sólo un 2% informó no consumirlos. Ambos pasteles tuvieron una alta aceptación, con puntuación media de 9,27 (A) y 9,26 (B) de un máximo de 10 sin diferencias significativas en la preferencia. El consumo de pasteles fue parte de los hábitos alimentarios de estos niños. **Conclusiones:** pasteles elaborados con 40% de harina de camote podría tener tan buena aceptación como los convencionales. Además, una porción de este pastel (60 g) puede alcanzar hasta 22% de las necesidades diarias de vitamina A.

Palabras clave: batata (*Ipomoea batatas L.*), alimentos fortificados, análisis de alimentos, evaluación sensorial, satisfacción de los consumidores, preferencias alimentarias.

INTRODUCTION

Vitamin A (VA) deficiency is considered one of the most important of the easily preventable public health problems in a number of countries, including Brazil (1). Vitamin A deficiency causes over 600.000 deaths per year, mostly of young children or pregnant women. In low-income countries, about 82% of the total VA intake is from carotenoids in plants (2).

The current estimates and indicate that 122 countries have vitamin A deficiency of public health significance based on the prevalence of night blindness or biochemical vitamin A deficiency (serum retinol concentration $<0,70 \mu\text{mol/l}$ or $<20 \mu\text{g/dl}$), respectively, in preschool-age children (3). At the same time,

there is also a need for the development of new field methods with which to assess vitamin A status that are cost effective and that can take into consideration the potential influences of infection (3).

In Brazil, the biochemical investigations available confirm that the deficiency of vitamin A is a public health problem in the states of São Paulo, Minas Gerais, Pernambuco, Paraíba, Ceará, Bahia and Amazonas. Especially in the Northeastern of Brazil, the prevalence of inadequate serum retinol levels in children between 2-8 years can reach almost 50% (1).

Since 1994, the Brazilian Health Ministry has been taking measures to provide targeted supplementation with megadose of vitamin A to eliminate the

deficiency of this nutrient in Brazil (4). The introduction of vitamin A precursors in the nourishment of populations at risk was added to this effort, given that vitamin A deficiency has become a public health problem in Brazil, as well as in much of Latin America (1).

The National School Meal Program (PNAE) covers about 45,6 million Brazilian students from the public elementary school network. The primary goal is to meet the nutritional needs of students during the regular classroom hours, thereby contributing to students' growth, development, learning rates, and school performance, as well as promoting the establishment of healthy eating habits (5). According to Belik and Souza (6), Brazil plays a prominent role in Latin America, providing a universal and decentralized School Meal Program, managed solely with Federal Government funds.

The introduction of foods in school meals should be careful, pursuant to Law No 11947, of 16/06/2009, focusing on Food and Nutrition Security guidelines, establishing healthy eating habits, and respecting local culture and traditions. This law also stipulates that at least 30% of the funds assigned to school meals must be used in the purchase of products directly from family farms in order to strengthen community economic development. Additionally, school menus are to be designed by a nutritionist and must include basic foodstuffs (7).

Considering the structure developed around the National School Meal Program, it is relevant to assess the feasibility of introducing foods in this program. Over the years, sweet potato (*Ipomoea batatas* L.) has been planted by families in rural Brazil, and it is usually eaten boiled, baked or fried, especially for breakfast. However, over the last five decades, the production of sweet potato has declined drastically, which is assumed to be caused by rural exodus and replacement by other foods that are more easily available (8). Nevertheless, technological advances

have increased productivity, reaching 548.000 tons in areas covering a total of 45,6 hectares (8).

Currently in Brazil, Embrapa Vegetables Research Center (Gama-DF) is selecting and assessing the viability of introducing clones of orange-fleshed sweet potato with high levels of pro vitamin A carotenoids, taking advantage of the strong correlation between color intensity and the concentration of these nutrients (9). The flour produced from these materials is especially rich in beta-carotene (about 84% of the total carotenoids content) and can be used to prepare cakes, breads and pastas (10).

The sweet potato could be considered as an excellent novel source of natural health-promoting compounds, such as β -carotene and anthocyanins, for the functional food market. Also, the high concentration of anthocyanin and β -carotene in sweet potato, combined with the high stability of the color extract make it a promising and healthier alternative to synthetic coloring agents in food systems. Starch and flour processing from sweet potato can create new economic and employment activities for farmers and rural households, and can add nutritional value to food systems (11). However, the introduction of foods is to be made with caution, and issues such as safety, acceptability and nutrient bioavailability need to be considered. In order to initiate this process, this study had the objective of evaluating the acceptance and preference of cakes prepared with orange-fleshed sweet potato flour by students from a public school in the municipality of Rio de Janeiro, in Rio de Janeiro state.

MATERIAL AND METHODS

Materials

This study was conducted in a public school, located in the city of Rio de Janeiro (Brazil) in the second semester of 2008. The school was chosen because of the recommendation of the Regional Education

Board and the school location. Students were chosen based on the premise that they could read and write and have more insight into food such, as the choices, tastes and preferences. Thus, only children between 10 and 12 years of age were selected. The orange-fleshed sweet potato flour was grown and provided by Embrapa Vegetables (Brasília, Brazil). The wheat flour was obtained from a local store (Rio de Janeiro, Brazil). The preparation of the cakes was carried out at Embrapa Food Technology (Rio de Janeiro, Brazil).

Orange-fleshed sweet potato flour preparation

Sweet potato flour was prepared from grated orange-fleshed sweet potato (*Ipomoea batatas*, L.) Gama, Brazil a Gama-Brazil. (OFSP). After grating, the material was dried in an oven with air circulation (approximately 60 °C) for 12 hours or until it reached 10% moisture. The dried sweet potato was removed and ground in a knife mill with a 2 mm sieve. This flour was prepared at Embrapa Vegetables (Gama, Brazil) under supervision of specialized researchers. The flour was kept inside black plastic bags under refrigeration (4 °C) until its use.

Particle size distribution

In order to characterize the raw materials used to prepare cakes, the two flours (wheat and OFSP) were submitted to a particle size analysis. The particle size distribution of each raw material was determined by sifting 100 g of flour per 10 minutes, through a plan sifter equipped with seven sieves with different opening sizes (0,425; 0,297; 0,249; 0,178; 0,150 and 0,105 mm).

Preparation of cakes

Two different cakes were prepared according to the recipes described in Table 1, one with 100% of wheat flour and the other with a mixture of wheat flour (60%) and sweet potato flour (40%).

Sensory analysis

Rio de Janeiro's Regional Education Board and the Ethics Committee of the Federal University of Rio de Janeiro approved the development of the study at a public school, in the city of Rio de Janeiro.

The study included 100 students between 10 and 12 years of age. All parents signed a Consent Form. The number of judges was proposed by Domínguez (12) and Minim (13). These authors pointed out that the required number of judges to participate in central location tests, such as in schools, can vary between 50 and 300.

Acceptability and preference analysis were assessed by providing 50 g of cake at room temperature to each student. The cakes were coded as "A" (conventional) and "B" (40% sweet potato flour) and served in disposable plastic containers, accompanied with mineral water, pencil with eraser and assessment sheets. The two samples were provided at the same time, coded with randomly chosen three-digit numbers, in the following order: AB (given to 50% of the judges) and BA (given to the remaining 50%). These analyses were carried out as proposed by Domínguez (12) and Minim (13).

Acceptability analysis was conducted using a 5-point structured hedonic scale from "strongly disliked (1)" to "liked very much (5)," using a mixed facial scale. In addition, the judges were asked to score each tested sample from 1 to 10. For preference analysis, the participant was asked to mark the best cake on the card provided (Figure 1). A questionnaire assessing cake eating frequency and age, gender, and school grade was also used.

Acceptability test results were analyzed with Student's t-test, while preference was analyzed by employing the binomial distribution test, considering P-value (0,05) (14). The statistical analyses were performed using *Statistica* software v.6 (15).

Table 1. Formulation of conventional cake (100% wheat flour, sample A) and cake with 40% sweet potato flour substitution (FBD, sample B)

Ingredients	Conventional		40% OFSP	
	g	%	g	%
Wheat flour	5.000	100	3.000	60
Sweet potato flour	0	0	2.000	40
Corn starch	250	5	250	5
Sugar	4.500	90	4.500	90
Salt	50	1	50	1
Whole milk	3.000	60	3.000	60
Hydrogenated vegetable shortening	1.250	25	1.250	25
Baking powder	150	3	150	3
Eggs*	2.500	50	2.500	50

* 50 g each.

RESULTS AND DISCUSSION

Particle size distribution

The particle size distribution of the raw material is known to have significant influence on the texture and palatability of the final product. So, cell structure of the raw material will be larger or smaller according to the milling process applied. The sieve analysis of the wheat flour and the orange-fleshed sweet potato flour (Table 2) demonstrated that 77,1% of the particles in the wheat flour fell within a particle size from 0,074 to 0,150 mm, while 62,7% of the particles in the orange-fleshed sweet potato flour fell within the particle size of 0,178 mm, indicating that this flour presents larger particles when compared to the wheat flour. This characteristic can influence the final product suggesting that the particle size as well as the kind of raw material can influence the water absorption of the mixture and the texture of the final product. These aspects, among others, can influence the judgment of the evaluated cakes. The particle size of the raw material is important in the preparation

of cakes and other products. Establishing a greater uniformity of particle size allows the elaboration of a final product with better sensory quality, especially texture, flavor and visual appearance resulting in a homogeneous mass of uniform cooking.

Sensory analysis

Average students' age was $11,7 \pm 1,0$ years, 50% were female, and 79,8 % were in 6th grade. The remaining students were from the 4th, 5th, or 7th grades (9,1%;9,1% and 3,0%, respectively).

Based on the cake eating frequency questionnaire, 27% of students reported eating cake 1 to 3 times a month and 14% less than once a month. 18% reported eating cake once a week and 19%, 2 to 4 times a week. 8% reported eating cake once a day and 11% reported eating cake twice a day. Only 2% reported never eating cake. To the question "Do you like cake?", 97% of the participants answered yes, and 3% abstained from answering. In a scale from 1 to 5, acceptability of cakes prepared with 40% sweet potato flour was $4,48 \pm 0,79$, which corresponds

Sensory evaluation of cakes prepared with sweet potato flour

Figure 1. Form filled out by school children for acceptability and preference tests

SENSORY EVALUATION OF SWEET POTATO FLOUR CAKES

Card: _____
 Code: _____
 Series: _____
 Date: _____

Please take a sip of water and rinse your mouth before starting.
 You have just received 2 (two) cake samples.
 Please try the two samples, starting from left to right.
 You can drink as much water as you like and you can also try the samples again,
 once you have tasted the two you received first.

Mark with an "X" the face that matches what you think about each cake.

<p>Sample #:</p> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <p style="font-size: 8px; text-align: center;">Strongly disliked Disliked Neither disliked nor liked Liked Strongly liked</p> <p style="font-size: 8px;">How did you like the cake? Provide a rating from 1 to 10: _____</p>	<p>Sample #:</p> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <p style="font-size: 8px; text-align: center;">Strongly disliked Disliked Neither disliked nor liked Liked Strongly liked</p> <p style="font-size: 8px;">How did you like the cake? Provide a rating from 1 to 10: _____</p>
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Now, please mark with an "X" the cake sample you liked best.

Would you like to add a comment?? Please write here:

THANK YOU FOR PARTICIPATING!!!!

Table 2. Particle size distribution of wheat flour and orange-fleshed sweet potato flour used to prepare 100% wheat flour cake and 40% sweet potato flour substituted cake

Mesh Tyler	Opening (mm)	Wheat flour (%)	Orange-fleshed sweet potato flour (%)
40	0,425	0,5	0,3
50	0,297	0,6	3,3
60	0,249	3,8	6,2
80	0,178	1,9	62,7
100	0,150	27,3	4,8
150	0,105	31,6	7,1
200	0,074	18,2	14,6

to the intermediate point between “like” and “liked very much.” No significant difference ($p>0,05$) was detected when compared with acceptability of the conventional cake ($4,57 \pm 0,63$). When prompted for a rating from 1 to 10, the average response was $9,26 \pm 1,23$ for the cakes with sweet potato flour, and $9,28 \pm 1,29$ for the conventional cakes, without significant differences between them ($p>0,05$). Similarly, there were no significant differences regarding cake preference ($p>0,05$). Nearly half of the students (50,5%) preferred the conventional cake (100% wheat flour) and 49,5% preferred the cake with 40% (OFSP) (sweet potato flour) (Table 3).

Cake is a processed food that allows the addition of various ingredients, such as diverse kinds of flour with different molecular structure (16). In this case, the use of orange-fleshed sweet potato flour helped reach a suitable condition for storing and transporting the sweet potato in the form of flour, thereby increasing shelf life from only a few days (fresh product) to several months suggesting that high levels of beta-carotene are preserved by the reduction of water activity in the flour, thus adding nutritional value to the final product.

As observed, cakes are part of school children’s eating habits; therefore, the inclusion of cakes as part of meals provided in the schools is highly likely, while fulfilling the regulations of the school meal program. Cakes are a type of food with good palatability, are relatively inexpensive and require no special

transport and storage conditions. Moreover, the formulation is based on high nutritional value staple foods and the quality of added fat can be adapted, excluding the use of trans fatty acids.

Recommendations for vitamin A and consumption of cakes

Sweet potatoes are a nutritious food, low in fat and protein, but rich in carbohydrate (17). Tubers and leaves are good sources of antioxidants (17), fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, and vitamin C (18). Because of their high carotenoid content and good yields, OFSP have also been used in several small-scale studies to increase VA status (19).

The amount of VA needed from the diet depends on age, sex, and presumably on genetics and lifestyle. Recommended daily intakes of VA for healthy individuals, called “dietary reference intakes,” for children 10 to 13 years old is $600 \mu\text{g RAE/day}$. Currently, carotenoid conversion in the body is estimated to be $6\text{-}\mu\text{g beta-carotene: } 1\text{-}\mu\text{g RAE}$ (21) or $12\text{-}\mu\text{g beta-carotene: } 1\text{-}\mu\text{g RAE}$ (20).

At Embrapa Food Technology (Rio de Janeiro, Brazil) a further study was conducted to analyze the content of total carotenoids and beta-carotene in cakes made with orange flesh sweet potato flour (OFSP). The preparation containing 40% OFSP had 2,061 mg of total carotenoids and 1,340 mg of beta carotene,

Table 3. Results from a sensory evaluation of cakes produced with 100% wheat flour or with 40% substitution by orange-fleshed sweet potato flour (n=100)

Evaluation	Conventional cake, Sample A	Orange-fleshed sweet potato cake, Sample B	p-value*
Acceptability (range 1-5), mean \pm SD	4,57 \pm 0,63	4,48 \pm 0,79	0,392
Scale (range 1-10), mean \pm SD	9,28 \pm 1,29	9,26 \pm 1,23	0,938
Preference, n (%)	49 (50,5)	48 (49,5)	0,505

* Student’s t-test for acceptability, scale and binomial distribution test for preference data.

Sensory evaluation of cakes prepared with sweet potato flour

both in 100 g of cake, considering the same recipe used in this study (22).

Considering that the daily recommendation of vitamin A to children between 10 and 13 years old (600 mcg / day) and RAE (retinol activity equivalents) (20) is 12:1 g (beta-carotene: VA), it can be concluded that a serving size of cake made with 40% OFSP (60 g - 1 slice, according to the Brazilian legislation (23-24)) can reach the daily need of 11,2% for the age group in question. On the other hand, when considering the conversion of beta-carotene to retinol, proposed by WHO and FAO (21), the same piece of cake for the same age group can reach 22,3% of the daily needs for vitamin A.

As cakes are consumed in smaller meals, such as breakfast and snacks, it is possible to suggest the intake of up to two servings per day, taking into account the needs of other nutrients and total caloric intake. Thus, it is important to define the type of conversion to be used in calculations of portioning and labeling, as well as other relevant factors such as gender, physical activity levels, interactions with other nutrients, anti-nutritional factors that may affect the bioavailability of vitamin A.

CONCLUSIONS AND IMPLICATIONS

The survey concluded that cakes prepared with 40% orange-fleshed sweet potato flour had high acceptability among elementary school students from a Brazilian public education system school. Furthermore, there was no significant difference regarding preference when compared to the conventional formulation. Almost all students reported liking the cake (97%), and 37% have a habit of eating cakes from 1 to 4 times a week. These data show that cakes have been incorporated into the dietary habits of the subjects and could be included as part of the school meals as an important alternative for nutrients supply, without compromising acceptability and fulfilling the regulations of the school meal program. Besides, a serving size of cake containing 40% OFSP can reach up to 22% of the daily needs of vitamin A to children between 10 and 13 years old.

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