PROCESSING AND EVALUATION OF PUMPKIN CAKE (*CUCURBITA MOSCHATA*)

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Pumpkin (*Cucurbita moschata*) is a vegetable traditionally consumed by the Brazilian population, especially in the Northeast region, serves as a significant vitamin A source. Then, the pumpkin has been used for the elaboration of new food products. The aim was to formulate cakes containing freeze-dried pumpkin flour (pulp and peel) and evaluate their sensory and chemical characteristics. Three cake formulations were prepared: F1 (without pumpkin flour), F2 (10% substitution of wheat flour with freeze-dried pumpkin flour), and F3 (20% substitution of wheat flour with freeze-dried pumpkin flour). Samples were evaluated microbiologically (total coliforms at 35 °C, thermotolerant coliforms at 45 °C and *salmonella* spp.), sensory-based on ranking for preference (ordering test), in terms of acceptance (hedonic scale) and consumers' purchase intentions by 80 untrained testers. Cakes' chemical characteristics (moisture, ash, protein, lipids, carbohydrates, and carotenoids) and color (by colorimetry) were evaluated. Formulations F2 and F3 had similar acceptance and purchase intentions. However, F3 was the most preferred formulation in terms of sensory attributes. The addition of freeze-dried pumpkin flour increased the ashes and carotenoids percentage, as well as intensified the color, making F2 and F3 more attractive. Pumpkin flour improved the sensory characteristics and nutritional value of the formulated cakes.

KEYWORDS: DEHYDRATION; FREEZE-DRYING; ACCEPTANCE; NUTRITIONAL COMPOSITION; CAROTENOIDS.

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INTRODUCTION

Pumpkin (*Cucurbita moschata*) is a vegetable traditionally consumed by the Brazilian population, especially in the Northeast region, and serves as an important vitamin A source. The appreciation for pumpkin has grown in recent years. Besides a significant option for farm diversification, it is a food that contributes to the nutrition and health of the population, considering its high antioxidant capacity, mainly represented by pro-vitamin A carotenoids (RODRIGUEZ-AMAYA, 1997; RODRIGUEZ-AMAYA; KIMURA; AMAYA-FARFAN, 2008).

Vitamin A has fundamental importance throughout life, acting in combination with its derivatives in several regulation processes related to vision, reproduction, embryogenesis, growth, cell differentiation, and immune system (WISEMAN; DADON; REIFEN, 2016). A deficiency of this vitamin, in turn, leads to numerous health disorders, which affect mainly children (RIVLIN, 2008). Vitamin A deficiency, around the world, is considered by the World Health Organization as a major public health problem (WORLD HEALTH ORGANIZATION, 2009). This same organization suggests that food fortification, adding one or more nutrients to increase the nutritional value of a given food (ENSMINGER et al., 1995), is one of the possible community interventions to reduce vitamin A deficiency (WORLD HEALTH ORGANIZATION, 2009).

Enrichment of different food products, especially bakery products, with carotenoids obtained from vegetable sources has been the object of study (OBRADOVIC et al., 2015; PONGJANTA et al., 2006), considering the capacity of these compounds to provide vitamin A to the organism (BENDER, 2006) and also because of other beneficial effects on health, such as its recognized antioxidant capacity (KIM et al., 2012). Pumpkin can be used as a source of pro-vitamin A in several formulations. However, its high moisture content (85.01 g/100 g on an organic basis), as reported by Monteiro et al. (2018), makes a pulp drying step indispensable to increase the carotenoids concentration. Consequently, the dilution effect resulting from mixing with other ingredients of the formulation is compensated. Given this, a drying technique such as freeze-drying is essential, in addition to its protective effect over the carotenoids than other techniques already demonstrated by Narwirska et al. (2009). Most studies on the enrichment of bakery products with pumpkin use its pulp *in natura*, cooked, or oven-dried (OBRADOVIC et al., 2015; MORAIS et al., 2017; PONGJANTA et al., 2006). One strategy to improve the nutritional quality and, consequently, reduce food waste is to take advantage of whole fruits (pulp and peel), either *in natura* or processed (CARVALHO et al., 2012). Because of the above, this study aimed to prepare and evaluate the formulation of cakes with partial substitution of wheat flour with freeze-dried pumpkin peel and pulp flours, aiming to improve the nutritional and sensory quality of this product as a strategy for consumers who want healthier food.

MATERIAL AND METHODS

ETHICS

This study was previously submitted to the Research Ethics Committee of the University of Sergipe, been approved on November 10^{th}, 2015, under the protocol n. 1315542.

OBTAINING THE PUMPKIN PEEL AND PULP FLOURS

Three mature pumpkin fruits were purchased at the local market in Aracaju-SE to obtain the pumpkin peel and pulp flours used in cake formulations. The fruits were carefully sanitized, according to Guimarães, Freitas e Silva (2010). Subsequently, the pulp was peeled and sliced into cubes of 3 cm edge. The peel was sliced into squares of 3 cm side. To dehydrate the samples (pulp and peel), L 101 Liotop equipment was used at -50° C at a pressure of 38 μm Hg for 72 hours. Then, the samples were ground in an industrial blender (Metvisa©, Lar 2, Brazil) to obtain the flour, which was packed in a glass bottle and protected from light by wrapping with aluminum foil. The material was stored in the freezer (Robert Bosch (Phy) Ltd. 2020, Intelligent Freezer 32, Brazil) at -18 ºC for up to seven days and then used to prepare the cakes.

FORMULATION AND ELABORATION OF CAKES

Initially, pre-tests were performed until the standard formulation was found (without freeze-dried pumpkin flour) to elaborate cakes with acceptable sensory characteristics, without the taster's participation.

Three cake formulations were prepared: Formulation 1 - F1 (standard formulation), Formulation 2 - F2 (10% substitution of wheat flour with 5% pumpkin peel flour + 5% pumpkin pulp flour), and Formulation 3 - F3 (20% substitution of wheat flour with 10% pumpkin peel flour + 10% pumpkin pulp flour). The following ingredients were used for the cupcake's formulation: egg, butter, refined sugar, wheat flour, baking powder, corn starch, and freeze-dried pumpkin peel and pulp flours. The basal formulation to approximately 100g is shown in Table 1.

TABLE 1 – THE PROPORTION OF INGREDIENTS FOR MAKING 100 GRAMS OF CUPCAKE OF THE FORMULATION 1, FORMULATION 2, AND FORMULATION 3

Ingredients	F1	F2	F3
Wheat flour	17g	15.3g	13.6g
Butter	10g	10g	10g
Sugar	15g	15g	15g
Eggs	50g	50g	50g
Starch	6g	6g	6g
Baking powder	2g	2g	2g
Pumpkin pulp flour	0	0.85g	1.7g
Pumpkin peel flour	0	0.85g	1.7g

F1 (Formulation 1): control without freeze-dried pumpkin peel and pulp flours. F2 (Formulation 2): 10% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one. F3 (Formulation 3): 20% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one.

PREPARATION OF CAKES

The ingredients were weighed on a semi-analytical scale (Ohaus Adventurer, ARC120, United States), except for eggs. In a mixer at speed one (Philips Walita, R1 7115, Brazil), the butter (room temperature) was mixed with the refined sugar for four minutes. The egg yolks were then sieved and added to the previous mix and homogenized again in the mixer (speed 1 for two minutes). Subsequently, wheat flour and corn starch were incorporated in the mixer at speed two for two minutes until a smooth and homogeneous dough was obtained. The dough was left to rest (approximately two minutes, at room temperature) until the egg whites and the baking powder were added to the dough, using slow and circular movements with the help of a spatula. Portions of 20g of the prepared dough were placed in paper bowls wrapped in aluminum foil, baked in a preheated oven (GE, De Luxe Timer, USA) at 180°C for thirty minutes. After baking, the cakes were cooled to room temperature (± 25°C) and kept in polyethylene bowls with a lid, for a maximum of twenty-four hours, until the sensory analysis.

MICROBIOLOGICAL ANALYSIS

Before the sensory analysis, 50g of each formulation was used for enumeration of total coliforms at 35 °C, thermotolerant coliforms at 45 °C, and *Salmonella* sp. at the DNUT Food Microbiology Laboratory (APHA, 1992; SILVA et al. al., 2010). The microbiological analysis aimed to verify if the microbiological characteristics of the proposed cake formulations were following the recommended by the Brazilian legislation on Microbiological Safety of Food, Board's Resolution n. 12 (BRAZIL, 2001).

SENSORY ANALYSIS

Sensory analysis was performed at the Technical Laboratory of the Department of Nutrition (DNUT) of the University of Sergipe, São Cristóvão *campus*. The tests were presented in a monadic and randomized manner, with eighty untested tasters randomly selected, aged between 18 and 50 years. Samples were assessed in a sensory evaluation room, individually, under white light illumination. Approximately 20g of each sample was served at 25 °C in cupcake molds coded with three-digit random numbers. Cake formulations (F1, F2, and F3) were evaluated for their preference (preference-ordering test), acceptance (hedonic scale), and purchase intentions. Acceptance was verified using a 9-point structured hedonic scale (1 = dislike extremely to 9 = like extremely) regarding the parameters: taste, texture, appearance, aroma, and overall impression. Purchase intentions scale ranged from one to five, as follows: 1 - definitely would not buy, 2 - probably would not buy, 3 –might buy, 4 – probably would buy, and 5 - definitely would buy (STONE; SIDEL, 1985, MINIM, 2013). The Acceptability Index (AI) was evaluated by the expression:

$$AI\ (\%) = \frac{A \times 100}{B}$$

A= average score obtained by the product and B= maximum score given to the product. An AI with good acceptance has been considered ≥ 70% (DUTCOSKY, 2011).

CHEMICAL COMPOSITION AND COLOR OF CAKES

The three cake formulations were analyzed at the Laboratory of Plant Ecophysiology - Embrapa Tabuleiros Costeiros. The samples were evaluated in triplicate, according to the following parameters: Moisture – oven-dried at 105 °C until constant weight; Crude protein - by the evaluation of the total nitrogen of the sample, using the classic Kjeldahl method. The nitrogen conversion factor for the protein of 6.25 was used; Total lipids - in a Soxhlet apparatus using petroleum ether as a solvent; Ash - by igniting in a muffle furnace at 550 ºC. All tests were performed as recommended by the analytical standards of the Adolfo Lutz Institute (2005). The total carbohydrate content was determined by theoretical calculation (by difference) using the results of each replicate, according to the formula: % Carbohydrates including fibers = 100 - (% protein + % lipids + % ash) (THOMAZ et al., 2012). The total carotenoids were determined according to the Rodriguez-Amaya (2001) methodology. For each 100g of cake, the caloric value was calculated using the following conversion factors: 4kcal/g for proteins and carbohydrates and 9kcal/g for lipids (DAMIANI et al., 2009). The color of cakes was measured on the top (crust) and inner parts (exposed by removing the crust) of the three formulations evaluated, using a colorimeter (Konica-Minolta, CR-10, Japan) in CIE L*C*h system. In that system, the “L*” indicates the lightness, and the chromatic coordinates “C” and “h” correspond to the Chroma and the hue angle, respectively, measured directly. The analysis was performed in triplicate (three cakes of each formulation), and each measurement was performed in the same location (MCGUIRE, 1992).

STATISTICAL ANALYSIS

With the help of IBM SPSS Statistics® software, version 21 (2012), the data from the sensory analysis and chemical composition were subjected to variance analysis (ANOVA) for repeated measures to verify the averages homogeneity. The homogeneous means ($p > 0.05$) were subjected to the Tukey parametric test. The variables that presented $p < 0.05$ were submitted to the Kruskal-Wallis non-parametric test to check contrasts between treatments. The p-values were considered significant when less than 0.05. However, in evaluating the color of the cupcakes, we used the analysis of variance (two-way ANOVA) for measurements and the Tukey test ($p \leq 0.05$) as post hoc analysis. These statistical tests were applied separately in the coordinate ‘L*’ and the parameter ‘C.’

RESULTS AND DISCUSSION

MICROBIOLOGICAL ANALYSIS

Regulation of the collegiate directory (RDC) number 12 of January 2nd, 2001 from the Ministry of Health (BRAZIL, 2001), which regulates the microbiological standards for food and beverages, establishes that ready-to-eat cakes must have up to 10 CFU/g coliforms counting at 45 °C/g and absence of *salmonella* sp. Because of the results obtained, cake formulations (F1, F2, and F3) showed no positive results for total coliforms and thermotolerant coliforms expressed in <3.0 MPN/g DP, the absence of *Salmonella* sp.

SENSORY ANALYSIS

Acceptance and purchase intention

Table 2 shows the acceptance and purchase intention results of the three cake formulations (F1, F2, and F3). The acceptance in all evaluated attributes, and the purchase intention, did not have significant differences ($p>0.05$) between F2 and F3. However, F1 had the lowest acceptance and purchase intention. This result indicates that, regardless of the inclusion level of pumpkin flour, the acceptability and purchase intention was similar among tasters. For liking and disliking perceptions, formulations F2 and F3 ranged between like moderately (7) and like very much (8), whereas F1 formulation ranged between 5 (neither like nor dislike) and 6 (like slightly). Regarding the purchase intention scale, the averages identified that tasters “might buy,” “probably would not buy,” and “probably would buy” F2 and F3 cakes, whereas they “probably would not” buy F1. Therefore, the pumpkin flour inclusion adds sensory value to the cake prepared using F2 and F3 formulations.

TABLE 2 – ACCEPTANCE AND PURCHASE INTENTION OF CUPCAKES

Sensory attributes	Formulations		
	F1*	**F2***	**F3***
Taste	$5.77^{c}\pm1.89$	$7.16^{ab}\pm1.5$	$7.62^{a}\pm1.20$
Texture	$5.02^{c}\pm2.12$	$7.36^{ab}\pm1.35$	$7.57^{a}\pm1.33$
Aroma	$6.11^{c}\pm1.50$	$7.28^{ab}\pm1.42$	$7.7^{a}\pm1.30$
Appearance	$5.32^{c}\pm1.95$	$7.44^{ab}\pm1.30$	$8.04^{a}\pm1.20$
Overall impression	$5.74^{c}\pm1.91$	$7.31^{ab}\pm1.28$	$7.77^{a}\pm1.24$
Purchase intention	$2.51^{c}\pm1.16$	$3.6^{ab}\pm0.95$	$4.01^{a}\pm0.93$

*Averages and standard deviation. Distinct letters in the row indicate significant differences according to Tukey's test or Kruskal-Wallis ($p<0.05$). F1 (Formulation 1): control without freeze-dried pumpkin peel and pulp flours. F2 (Formulation 2): 10% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one. F3 (Formulation 3): 20% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one.

The Acceptability Index (AI) obtained through the sensory attributes of F1, F2, and F3 cakes were between 59.1% and 67.9%, 79.6% and 82.7%, and 84.1% and 89.3%, respectively. Cake formulations 2 and 3 have considerable potential for consumption since the results, for the different attributes, were above 70% (DUTCOSKY, 2011). The same occurred for cakes with 7% watermelon rind flour (*Citrullus lanatus*), with AI>70% (GUIMARÃES; FREITAS; SILVA, 2010), and cereal bars added textured soy protein and camu-camu (*Myrciaria dubia*) with AI>70% (PEUCKERT et al., 2010).

According to these results, the pumpkin peel and pulp flours inclusion improved the cake's sensory characteristics. A similar response was obtained by Silva and Silva (2012), verifying good acceptability of cakes when pumpkin pulp (*in natura*) was added, in which 86%, 78%, 92%, 98%, and 92% of the tasters liked the taste, texture, aroma, color, and appearance, respectively. Relative to the preference of three cake formulations (F1, F2, and F3), approximately 64% of the tasters chose F3 as the most preferred cake.

CHEMICAL COMPOSITION OF CAKES

According to the data shown in Table 3, the inclusion of freeze-dried pumpkin flour in F2 and F3 formulations led to increases in total carotenoid, lipid, and ash contents compared to F1. The remaining constituents of the centesimal composition and the caloric value were not altered.

TABLE 3 – CHEMICAL COMPOSITION OF CUPCAKES

Evaluation*	Formulations		
	F1*	F2*	F3*
Moisture (%)	28.10^{a}±2.16	30.56^{a}±2.31	30.60^{a}±0.35
Lipids (g)	20.20^{b}±0.10	20.83^{a}±0.15	20.33^{ab}±0.26
Protein (g)	12.20^{a}±0.10	12.33^{a}±0.06	12.37^{a}±0.15
Ash (g)	2.73^{c}±0.06	2.93^{b}±0.06	3.20^{a}±0.0
Carotenoids (μg/g)	ND	33.20^{b}±1.99	62.90^{a}±1.81
Carbohydrates including fiber (g)	36.77^{a}±2.12	33.3 ^{a}±2.33	33.43^{a}±0.47
Caloric value (Kcal/100g)	377.57^{a}±9.26	370.07^{a}±8.97	366.56^{a}±1.27

*Averages and standard deviation. Distinct letters in the row indicate significant differences according to Tukey's test or Kruskal-Wallis ($p<0.05$). F1 (Formulation 1): control without freeze-dried pumpkin peel and pulp flours. F2 (Formulation 2): 10% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one. F3 (Formulation 3): 20% substitution of wheat flour with pumpkin peel and pulp flours, 50% of each one. ND = Not detectable.

The increase in carotenoid content confirmed the main expected improvement in the cake's nutritional quality, from a non-detectable level in F1 to an expressive value of 62.90 μg/g in F3. This value is higher than those listed by Rodriguez-Amaya et al. (2008) for fruits that are known sources of beta carotene, such as acerola (< 40.3 μg/g), mango (<25 μg/g), papaya (<58.7 μg/g) and even the Cinderella pumpkin variety (<47 μg/g). It is also above all beta carotene levels obtained by Pongjanta et al. (2006) in five different bakery products obtained by replacing wheat flour with "pumpkin powder," with substitution percentages of up to 50%. In addition to the increased carotenoid content, the increase in ash content is seen as a positive factor for new formulations. It represents an increase in the concentration of minerals that are essential nutrients to the organism (CAVALCANTE et al., 2016; CARMO, 2011; CHITARRA and CHITARRA, 1990). Similar results were obtained by Thomaz et al. (2012), who observed a similar increase in ash content in cracker biscuits added pumpkin peel flour.

COLOR ANALYSIS

The results of color determination on the top and inner part of cakes prepared with the three formulations (F1, F2, and F3) are shown in Table 4. These results show the differences between the enriched formulations (EF) and F1 (significant for all parameters except for L measured on the top) and also the distinction between the top and the inner part of cakes (notable not only for the L parameter of EFs).

TABLE 4 – COLOR ANALYSIS OF CUPCAKES FROM L COORDINATE AND CHROMA

		Color parameter								
		L			Chroma			h		
Location		**F1***	**F2***	**F3***	**F1***	**F2***	**F3***	**F1***	**F2***	**F3***
Top	M	61.8bA	61.9aA	63.7aA	42.6aC	55.8bB	67.0bA	70.3bC	73.8bB	76.2bA
	D.P.	0.5	0.6	1.3	0.2	1.2	1.1	0.9	0.5	1.5
IP	M	67.3aA	61.4aB	62.7aB	29.2bC	59.0aB	71.2aA	89.2aA	83.8aB	81.4aC
	D.P.	2.2	1.2	2.1	0.8	1.1	1.6	0.5	0.3	0.7

*Averages and standard deviation. Distinct uppercase letters indicate the statistical difference between rows, whereas different lowercase letters indicate the statistical difference between columns.

Regarding the tones of cakes, corresponding to the values of "h," they are positioned between the orange and the yellow in the color wheel illustrated by Konica Minolta (1998). Visually, these tones resemble brown and are due to the formation of Maillard reaction products and the presence of orange-yellow carotenoids. Maillard's reaction is typical in foods prepared using heat, producing brown compounds (LEBESI; TZIA, 2011; MARTINS; JONGEN; VAN BOEKEL, 2000). Carotenoids, in turn, are derived from ingredients used in the formulations. For F1, the source is exclusively the egg yolk, recognized by the presence of carotenoids in its composition (BLOUNT, HOUSTON, MOLLER, 2000). For F2 and F3, the principal source is the pumpkin flour, which conserves the fruit's typical pigments, as demonstrated by the analysis (SEREMET et al., 2016).

The combined evaluation of color, L*, and C parameters based on Minolta's classification (1998) allows us to describe as clear ($L > 50$; $c > 30$) both the top of cakes obtained from the three formulations evaluated as the inner part of cakes produced with pumpkin flour. The inner part of cakes produced using F1, on the other hand, is classified as pale ($L > 50$; $c < 30$). In addition to the findings obtained by the combined evaluation of the latter two parameters, the superiority of C values of EFs over F1 justifies the more orange color when pumpkin flour is added, as this parameter corresponds to the intensity of the color (PATHARE et al., 2013). Although color preference has not been tested in sensory evaluation, the greater acceptability of EFs is likely related to this characteristic since the color is considered one of the main determinants of consumer satisfaction and purchase decision (PATHARE et al., 2013; WU, SUN, 2013). Therefore, pumpkin flour can act as a natural dye, intensifying the color and making the cakes more sensorially attractive, and conferring the nutritional benefits already commented.

CONCLUSIONS

The substitution of wheat flour for lyophilized pumpkin flour (FAL) resulted in cakes with greater sensory acceptability and purchase intent, with the cake as the greatest addition of FAL, which was more preferred among the tasters. The greater the inclusion of FAL, the greater the carotenoid content and intensity of the cake color.

The preparations of cakes with lyophilized pumpkin flour proposed in this study are indicated for food industries that generally sell powder cake formulations, and can be used as a complement in domestic preparation by consumers.

Lyophilized pumpkin flour, due to the presence of carotenoids, can give greater oxidative stability to products that have it in its composition, since carotenoids have antioxidant activity.

Therefore, it is also important to evaluate the useful life of lyophilized pumpkin flour in terms of oxidative, microbiological, chemical and physical-chemical stability.

RESUMO

PROCESSAMENTO E AVALIAÇÃO DO BOLO DE ABÓBORA (MOSCHATA DE CUCURBITA)

A abóbora (Cucurbita moschata) é uma leguminosa tradicionalmente consumida pela população do Brasil, especialmente na região Nordeste, que serve como importante fonte de vitamina A. Depois, a abóbora tem sido utilizada para a elaboração de novos produtos alimentícios. O objetivo foi formular bolos contendo farinha de abóbora liofilizada (polpa e casca) e avaliar suas características sensoriais e químicas. Foram preparadas três formulações de bolo: F1 (sem farinha de abóbora), F2 (10% de substituição de farinha de trigo com farinha de abóbora liofilizada) e F3 (20% de substituição de farinha de trigo com farinha de abóbora liofilizada). As amostras foram avaliadas microbiologicamente (coliformes totais a 35 °C, coliformes termotolerantes a 45 °C e *Salmonella* spp.), sensorialmente com base na classificação de preferência (teste de ordenação), em termos de aceitação (escala hedônica) e intenções de compra de 80 consumidores não treinados. As características químicas dos bolos (umidade, cinza, proteína, lipídios, carboidratos e carotenoides) e cor (por colorimetria) foram avaliadas. As formulações F2 e F3 tiveram aceitação e intenção de compra semelhantes. No entanto, F3 foi a formulação mais preferida em termos de atributos sensoriais. A adição de farinha de abóbora liofilizada aumentou a porcentagem de cinzas e carotenoides, além de intensificar a cor, tornando F2 e F3 mais atrativos sensorialmente. A farinha de abóbora melhorou as características sensoriais e o valor nutricional dos bolos formulados.

PALAVRAS CHAVE: DESIDRATAÇÃO; LIOFILIZAÇÃO; ACEITAÇÃO; COMPOSIÇÃO NUTRICIONAL; CAROTENOIDES.

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