

ORIGINAL ARTICLE

Muffin with pumpkin flour: technological, sensory and nutritional quality

Muffin com farinha de abóbora: qualidade tecnológica, sensorial e nutricional

Michele Scarton¹ , Gustavo Costa Nascimento¹ , Mária Herminia Ferrari Felisberto^{1,2} ,
Thaís de Menezes Alves Moro^{1,3} , Jorge Herman Behrens⁴ , Douglas Fernandes Barbin⁵ ,
Maria Teresa Pedrosa Silva Clerici^{1*} 

¹Universidade Estadual de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos, Departamento de Ciência dos Alimentos e Nutrição, Campinas/SP - Brasil

²Universidade Federal de Viçosa (UFV), Departamento de Tecnologia de Alimentos (DTA), Viçosa/MG - Brasil

³Universidade Santa Úrsula (USU), Faculdade de Nutrição, Rio de Janeiro/RJ - Brasil

⁴Universidade Estadual de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos, Departamento de Ciência dos Alimentos e Nutrição, Campinas/SP - Brasil

⁵Universidade Estadual de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos, Departamento de Engenharia e Tecnologia de Alimentos, Campinas/SP - Brasil

*Corresponding Author: Maria Teresa Pedrosa Silva Clerici, Universidade Estadual de Campinas (UNICAMP), Faculdade de Engenharia de Alimentos, Departamento de Ciência dos Alimentos e Nutrição, Rua Monteiro Lobato, 80, CEP: 13083-862, Campinas/SP - Brasil, e-mail: mclerici@unicamp.br

Cite as: Scarton, M., Nascimento, G. C., Felisberto, M. H. F., Moro, T. M. A., Behrens, J. H., Barbin, D. F., & Clerici, M. T. P. S. (2021). Muffin with pumpkin flour: technological, sensory and nutritional quality. *Brazilian Journal of Food Technology*, 24, e2020229. <https://doi.org/10.1590/1981-6723.22920>

Abstract

Pumpkin is a yellow or orange-colored vegetable with a mild flavor that stands out as a fiber and nutrient source. However, the products with pumpkins are still little explored in Brazil, due to high perishability *in natura* and to the lack of eating habits of regional baked goods. This study aimed to produce and characterize a pumpkin flour to be used as an ingredient in muffins, evaluate the technological, and sensory characteristics of these cakes, and select the most sensorially accepted muffin for nutritional composition evaluation. Three muffins were produced as following: one control (M0); and two containing 5 (M1) and 10 (M2) g/100 g of partial substitution of wheat flour by pumpkin flour, thus maintaining the other ingredients common to cakes. The technological characteristics of firmness, volume and color were evaluated. Sensory acceptance was assessed using an affective test on an unstructured 9-point hedonic scale. There were no significant differences in the firmness and image analysis (distribution, size, and pore area of the crumb) among the three muffins, however, M1 and M2 presented darker crust color, more orange crumb, and a lower volume compared to M0. The sensory acceptability of the muffins was considered as a criterion for selection for nutritional composition analysis. The muffins' acceptance of M1 was better than M0, but without differences to M2. The consumers' opinions were also considered, and M1 was selected for having greater acceptance. Nutritionally, M0 and M1 presented similar levels of proteins, digestible carbohydrates, and lipids, however, M1 showed a higher content of ash and total dietary fibers: 2.01 ± 0.03 and 1.57 g/100 g (dry basis), respectively. Thus, the pumpkin flour could be produced and used as a regional, enriched, and natural-colored ingredient for muffins or other bakery products, and therefore they had a socially positive impact on family farming.

Keywords: Sustainability; Healthiness; Bakery; Fiber; Cake; Family farming.



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Resumo

A abóbora é um vegetal de cor amarela ou laranja, de sabor suave, que se destaca como fonte de fibra e nutrientes. Porém, os produtos com abóboras ainda são pouco explorados no Brasil, devido à sua alta perecibilidade *in natura* e à falta de hábitos alimentares dos produtos de panificação regionais. O objetivo deste estudo foi produzir e caracterizar uma farinha de abóbora para ser utilizada como ingrediente em muffins, além de avaliar as características tecnológicas e sensoriais desses bolos, e selecionar o muffin com maior aceitação sensorial para avaliação de sua composição nutricional. Foram produzidos três muffins: um controle (M0) e dois contendo de 5 (M1) e 10 (M2) g/100 g de substituição parcial da farinha de trigo pela farinha de abóbora, mantendo-se os demais ingredientes comuns aos bolos. Foram avaliadas as características tecnológicas de firmeza, volume e cor. A aceitação sensorial foi avaliada utilizando um teste afetivo em escala hedônica não estruturada de nove pontos. Não houve diferenças significativas na firmeza e na análise de imagem (distribuição, tamanho e área dos poros do miolo) entre os três muffins, porém M1 e M2 apresentaram cor da crosta mais escura, miolo mais laranja e menor volume em relação ao M0. Foi considerada a aceitabilidade sensorial dos muffins como critério de seleção para análise da composição nutricional. A aceitação dos muffins M1 foi melhor do que a aceitação de M0, mas sem diferenças em relação a M2. A opinião dos consumidores também foi considerada e M1 foi selecionado por ter maior aceitação. Nutricionalmente, M0 e M1 apresentaram teores semelhantes de proteínas, carboidratos digestíveis e lipídios, mas M1 apresentou um maior teor de cinzas e fibras totais: $2,01 \pm 0,03$ e $1,57$ g/100 g (base seca), respectivamente. Assim, a farinha de abóbora poderá ser produzida e usada como ingrediente regional, enriquecido e de cor natural para muffins ou outros produtos de panificação e, dessa forma, ter um impacto socialmente positivo para os pequenos agricultores.

Palavras-chave: Sustentabilidade; Saudabilidade; Panificação; Fibras; Bolo; Agricultura familiar.

1 Introduction

In Brazil, pumpkins (*Cucurbita sp.*) are grown mainly by family farming and locally commercialized due to its high perishability and low-profit margin (Resende et al., 2013). It is well-known that pumpkins are a high energy food source and possess a considerable amount of total dietary fiber: 1.1 g/100 g in the cooked pulp, without peel and seeds (United States Department of Agriculture, 2019). The dietary fibers are very important for health, specifically for the prevention of cardiometabolic diseases due to its roles in satiety, glucose control, maintenance of gastrointestinal regular function and microbiota (Lie et al., 2018).

In addition to the pulp, its peel is also an edible source of fiber, i.e., frequently discarded and considered as a food waste (Staichok et al., 2016). As vegetable flour, the peel of pumpkins could be largely used, besides the advantage of the extended shelf-life, thus increasing its possibilities of use and the nutritional enhancement of products such as soups, creams, bread, or cakes. Baked goods have been targets for fortification and nutritional improvement due to their daily role in the diets of consumers (Zhou et al., 2014).

Notably, there is a demand for healthier formulations of baked goods that traditionally present a high content of sugar and fats – like biscuits and muffins, for instance. The muffins are sweet cakes with a round shape, consisting of a Wheat Flour (WF) base, which are consumed in a meal or snack since they are ready-to-eat products available in small portions (Soong et al., 2015). In addition to the nutritional purpose, these vegetable flours, such as pumpkin flour, could be beneficial for the partial replacement of WF in bakery products, and appreciation of local agriculture, particularly for countries that have a dependency on wheat import. The use of locally produced food products could also be a nutritious and alternative source of dietary fiber in pandemic times, such as Coronavirus Disease 2019 (COVID-19), where the circulation of products and people is limited (He & Harris, 2020).

Thus, to stimulate a production chain of a new vegetable flour, this research aimed to produce and characterize pumpkin flour (made with the pulp and peel of pumpkins) for chemical and technological characteristics. The addition of pumpkin flour in muffin formulations was also evaluated, through

technological and sensory characteristics, in addition to selecting the most sensorially accepted muffin for evaluating nutritional composition.

2 Material and methods

2.1 Material sourcing

Pumpkins (*Cucurbita maxima* Duch.) were purchased at the *Central de Abastecimento SA*. (CEASA), located in Campinas, SP, Brazil. The WF used was donated by *Moinho Anaconda Industrial e Agrícola de Cereais S.A.* (Jaguarié, São Paulo, Brazil). The rheological properties of the WF were: Water Absorption = 58.20%; Dough Development Time (DDT) = 15.33 ± 0.25 min; Mixing Tolerance Index (MTI) = 24.67 ± 2.89 Brabender Units; and Dough Stability (DS) = 23.07 ± 0.76 min, characterizing it as a strong flour (Pylar & Gorton, 2009).

All the other ingredients (eggs, sugar, soybean oil, baking soda, salt, and soybean lecithin) were purchased in retail trade stores of Campinas city (São Paulo, Brazil), making sure that they were from the same lot.

2.2 Production of pumpkin flour

The ripe pumpkins (commercial point of maturation) were received, washed, and sanitized by immersion in chlorine solution at 200 mg/L for 15 min. The pumpkins were cut in half, the seeds removed and each portion of the pumpkin reduced to smaller pieces (cubes, 6 cm³), which were then subjected to the bleaching process (4 min at 95 °C). Then, the pumpkins were dried with forced air circulation at a rate of 2.5 m/s and 50 °C until the moisture content was less than 12 g/100 g (approximately 7 hours).

To obtain the Pumpkin Flour (PF), the dehydrated pumpkin was ground and sieved to 0.5 mm. The PF was packaged hermetically and stored under refrigeration at 8 °C until its use. The yield of flour production was calculated by the difference in the weight of the pumpkins (without the seeds, fibrous pulp, and rotten parts).

2.3 Physicochemical characterization of pumpkin flour

2.3.1 Chemical composition

The chemical composition was evaluated by the following methods from the Association of Official Analytical Chemists (2006): n° 926.12, for moisture; n° 945.18, for protein; n° 900.02, for ash; n° 920.39, for lipid in the ethereal extract. The digestible carbohydrate content was calculated by difference: [100 - (moisture + ethereal extract + protein + ash + dietary fiber)].

The total, soluble and insoluble, dietary fiber was evaluated by an enzymatic-gravimetric method, using a Megazyme K-TDFR 05/12 kit (Megazyme, Wicklow, Ireland), based on methods n° 985.29 (Association of Official Analytical Chemists, 2006) and n° 32-21.01 (American Association of Cereal Chemists, 2010). The total titratable acidity and reducing sugars were performed according to methodologies of Instituto Adolfo Lutz (2008) n° 310/IV and 176/IV, respectively.

2.3.2 Technological properties

Water Absorption Index (WAI) and Water Solubility Index (WSI) were performed by methodology proposed for Anderson et al. (1970), and pH was evaluated according to method n° 02-52.01 (American Association of Cereal Chemists, 2010) using a potentiometric meter model 300 M (Analyzer, São Paulo, SP, Brazil), in triplicate.

2.3.3 Instrumental color

Color parameters were evaluated by a Mini ScanXE HunterLab colorimeter (Reston MINOLTA, Virginia, USA, 1994), with illuminant D 65 and 10° angle. The CIELab color space method was used, determining the parameters L*, a*, and b*.

2.4 Preparation of muffins

The muffins were made with partial replacement of WF by PF at three levels: M0 (control), M1, and M2, corresponding to 5 g and 10 g of substitution in 100 g of WF, respectively. The formulations and proportions of the other ingredients are described in Table 1.

For the preparation of the muffins, the oil and sugar were mixed for 3 min using a Kitchen Aid (St. Joseph, Michigan, USA), and then the eggs were added and mixed for 3 min. The remaining ingredients were added, and mixed for about 2 min. A fixed amount (55 g) of muffin batter was distributed in paper liners (5 cm diameter, and 4 cm height), and baked in a Technipan oven (Prática Equipamentos, Pouso Alegre, Brazil) at 190 °C for 13 min, cooled at room temperature for 60 min and then stored in polystyrene packages.

Table 1. Formulations of the control muffins (M0) and with pumpkin flour (M1 and M2).

Ingredients	Formulation of muffins		
	M0	M1	M2
Wheat Flour (WF)	100	95	90
Pumpkin Flour (FP)	0	5	10
Flour Basis	100	100	100
Sugar ⁽¹⁾	59	59	59
Whole egg ⁽¹⁾	40	40	40
Soybean oil ⁽¹⁾	35	35	35
Baking soda ⁽¹⁾	2.30	2.30	2.30
Salt ⁽¹⁾	1.20	1.20	1.20
Soybean lecithin ⁽¹⁾	0.90	0.90	0.90
Water ⁽¹⁾	15	20	25

⁽¹⁾Quantities in g/100 g of flour basis (Wheat Flour (WF), or Wheat Flour (WF) and Pumpkin Flour (PF) mixture).

2.5 Technological characterization of muffins

2.5.1 Specific volume

The specific volume was determined after 24 hours of storage, by the Rapeseed Displacement method n° 10-05.01 (American Association of Cereal Chemists, 2010).

2.5.2 Thickness of the crust and instrumental texture of crumb

The muffins were cut in half, and the thickness of the crust was measured using a digital electronic caliper (in mm). Firmness of the crumb was determined using a TA-XT2i Stable Micro Systems Texturometer (Surrey, England), with a 25 kg load cell and cylindrical probe P/36R, according to parameters described in method n° 74-09.01 (American Association of Cereal Chemists, 2010). The results were obtained in the Texture Expert software for Windows.

2.5.3 Instrumental color parameters

The instrumental color parameters for the crust and the crumb of the muffins were evaluated by the methodology described in item 2.3.3.

2.5.4 Image analysis

For the image analysis, the muffins were cut in half and the images were acquired in triplicate, using the HP Scanjet G2710 scanner equipment (Hewlett-Packard Enterprises, Brazil). Image analysis was performed in ImageJ software (National Institutes of Health, 2017).

For the total number of pores and total area of pores (in mm²) quantification, the Otsu Thresholding algorithm (Otsu, 1979) was used, combined with the Median filter with a value of 1.5 pixels to allow the contrast between the pores and the continuous part of the images (Turabi et al., 2008).

2.5.5 Consumer testing of muffins and selection

The sensory analysis was previously approved by the Research Ethics Committee of Unicamp (CAAE 54667116.9.0000.5404), to apply an acceptance test to 119 consumers, according to the Meilgaard et al. (2000) methodology. The consumers were asked to evaluate the samples appearance, aroma, texture and overall liking of the muffins using an unstructured 9-point hedonic scale (9 cm, labelled in the lower extreme as “disliked it extremely” and in the upper extreme, as “liked it extremely”). The best sensory-evaluated muffin containing the PF was selected for the nutritional characterization.

2.5.6 Nutritional characterization of the selected muffin

For the nutritional evaluation, the selected muffin was characterized by its proximate composition with the same methodology described in item 2.3.1. The total dietary fiber was calculated considering only the refined WF and the PF as a source of this food component.

2.6 Statistical analysis

The obtained data from technological and sensory evaluations were analyzed by Analysis of Variance (ANOVA), and the difference between the means evaluated by Tukey's test, using the software SISVAR, version 5.6 (Ferreira, 2000). For the nutritional composition of muffins, the data were analyzed by ANOVA followed by F-test using the Excel software (Microsoft Office Mondo 2016 version, Redmond, Washington, EUA).

3 Results and discussion

3.1 Physicochemical characterization of pumpkin flour

3.1.1 Chemical composition

After the processing of the PF, we observed an acceptable yield of 3.85 g/100 g, considering that pumpkins have only 5 g of dry matter/100 g of fresh pulp (United States Department of Agriculture, 2019).

The results of the physicochemical characteristics of the PF are described in Table 2. Regarding moisture content of PF, similar results were observed by Ambrósio et al. (2006), for dehydrated pumpkin flakes. This low content contributes to its microbial stability and nutrient conservation. The protein and lipids content of PF was like those found by Guiné et al. (2011) for its dehydrated pumpkin samples. The ash content of the dehydrated pumpkin of the mentioned study was higher when compared to our PF, which could be due to harvest variations, such as soil type stage of maturation. A higher total dietary fiber content was found for PF when compared to the one reported by Guiné et al. (2011), probably due to the utilization of the peel of the pumpkin in the production of the flour in our study, and it is also related to a lower total digestible carbohydrate content. During the pumpkin processing, the discard of edible parts is significant and bulky, and the use of pumpkin peel contributes as a source of dietary fiber and reduces food waste (Staichok et al., 2016).

The reducing sugars content in PF was close to those reported by Guiné et al. (2011), who also evaluate *C. maxima* pumpkin dehydrated at two different temperatures (30 °C and 70 °C). While reducing sugars are mostly glucose and fructose, they contribute as a sweetener and for the color of the bakery products toward both caramelization and *Maillard* reaction, leading to the color and flavor formation (Purlis, 2010).

Table 2. Physicochemical and technological characteristics of the pumpkin flour⁽¹⁾.

Chemical composition (g/100 g)	Values
Protein	12.09 ± 0.07
Lipids	03.73 ± 0.27
Ash	06.09 ± 0.07
Total dietary fiber	35.33 ± 3.49
<i>Insoluble fiber</i>	26.97 ± 1.13
<i>Soluble fiber</i>	08.35 ± 3.35
Carbohydrate – Digestible ⁽²⁾	42.76
<i>Reducing sugars</i>	19.8 ± 0.65
Technological parameters	
Water Absorption Index (WAI)	09.20 ± 0.15
Water Solubility Index (WSI) (%)	16.40 ± 0.46
pH	05.98 ± 0.01
Total titratable acidity (mg of acid malic)	01.09 ± 0.03
Color parameters	
L*	69.35 ± 0.07
a*	24.63 ± 0.07
b*	64.21 ± 0.53

⁽¹⁾Results presented as mean ± Standard Deviation (SD) (triplicate), in dry basis (the moisture content was 7.17 ± 0.09). ⁽²⁾Calculated by difference: = 100 - (etheral extract + protein + ash + total dietary fiber).

3.1.2 Technological properties

The technological properties of the PF were described in Table 2. Regarding the WAI and WSI, the results were probably due to the bleaching process of the pumpkins and their subsequent drying, which could be related to the cold hydration of a pregelatinized starch fraction, which occurs during treatments with heat (Poliszko et al., 2019). Thus, the PF is a highly recommended ingredient to be used in pre-mix formulations of cakes, and several other baked goods that require a shorter preparation process and a rapid hydration period.

We observed pH value close to 6 in the PF, which was like the one found by Tamer et al. (2010) for pulp from *C. maxima* pumpkin (5.80 ± 0.15). Due to its pH, the pumpkins are classified as a food with low acidity, which associated to its high moisture content - 95 g/100 g of fresh pulp (United States Department of Agriculture, 2019) – then favoring the growth of microorganisms that causes deterioration. Thus, the reduction of the water activity by the dehydration process for the production of the PF could contribute to an increase of the shelf life of pumpkins (Staichok et al., 2016).

The transformation of the pumpkin into a flour also favors its commercialization for a longer period and not only during its production. Regarding the titratable acidity, which is a parameter related to the flavor, it was also reported that the pumpkins have low content, and among the organic acids found in these vegetables, malic acid is highlighted (Nawirska-Olszańska et al., 2014).

3.1.3 Instrumental color

Regarding the parameters of the color of PF (Table 2), the orange color was predominant. In the study of Guiné et al. (2011) with dry pumpkin pulp at 70 °C, the authors observed L*, a*, and b* values of 63.38, 28.01, and 57.26, respectively, i.e., very close to those found in the present study. The orange color of the

pumpkins is due to the presence of carotenoids, mainly lutein, lycopene and β -carotene, which is a natural colorant that has effects on human health, associated with anti-inflammatory, antioxidant properties as well as a provitamin A function (Rodriguez-Amaya, 2016). Processing factors, such as temperature, as well as the characteristics of the food (moisture content, composition and thickness) can affect the rate of loss of these carotenoids, leading to a reduction of the visual orange color intensity. Thus, it is important the control and use of mild heating in the drying process (Sojak et al., 2014). In studies with carrots, convective drying conditions between 45-55 °C for 8 hours were recommended to obtain greater β -carotene retention (Demiray & Tulek, 2017). In study with convective drying methods for pumpkins (*C. maxima*), temperatures below 60 °C were well suitable for better retention of carotenoids after storage (Sojak et al., 2014). These conditions were similar to those used in our study.

3.2 Technological characterization of muffins

3.2.1 Specific volume

The results for this parameter are presented in Table 3. The specific volume is mainly related to softness and maintenance of an aerated structure after baking, not only due to the gluten network, but also by the denaturation of egg proteins and starch gelatinization after baking (Zhou et al., 2014). The M1 and M2 presented a lower specific volume than M0, probably owing to the fiber content of the PF. According to Aydogdu et al. (2018), the vegetal fiber could reduce the volume in cakes due to its physical interference in gas retention capacity of the starch-gluten matrix. However, in cakes, the weakening of the gluten network is desirable, especially with wheat flours that have greater gluten strength (Gutkoski et al., 2011), where the PF can replace the use of commercial starches or gluten-free flours used for this purpose, also promoting the regionalization of the baked goods.

Table 3. Technological and color parameters of the control muffins (M0) and with pumpkin flour (M1 and M2)⁽¹⁾.

Parameters	Muffins ⁽²⁾				
	M0	M1	M2		
Specific volume (mL/g)	02.40 ± 0.01 ^a	02.28 ± 0.07 ^b	02.25 ± 0.02 ^b		
Firmness (N)	14.95 ± 0.88 ^a	12.18 ± 0.93 ^b	15.40 ± 1.88 ^a		
Crumb	Color	L*	81.05 ± 0.29 ^a	76.70 ± 0.47 ^b	73.48 ± 0.50 ^c
		a*	01.98 ± 0.05 ^c	09.07 ± 0.19 ^b	13.34 ± 0.10 ^a
		b*	28.71 ± 0.26 ^c	56.03 ± 0.68 ^b	65.59 ± 0.60 ^a
Crust	Color	L*	55.59 ± 1.34 ^a	47.86 ± 2.41 ^b	36.17 ± 0.21 ^c
		a*	18.01 ± 0.26 ^{ab}	19.09 ± 0.82 ^a	17.61 ± 0.36 ^b
		b*	39.82 ± 1.40 ^a	44.69 ± 2.09 ^a	30.65 ± 2.80 ^c

⁽¹⁾Flour basis of M0: 100 g Wheat Flour (WF) and 0 g Pumpkin Flour (PF); M1 95 g WF and 5 g PF; and M2 (90 g WF and 10 g PF).

⁽²⁾Results as mean ± Standard Deviation (SD), and different lowercase letters in the same line differ from each other by the Tukey's test ($p \leq 0.05$) and ns = non-significant difference.

3.2.2 Thickness of the crust and instrumental texture of crumb

The thickness of the crust of muffins were 2.62 ± 0.00 , 2.66 ± 0.00 and 2.68 ± 0.00 for M0, M1 and M2, respectively. There were no significative differences for this parameter, which could indicate a homogeneous baking of the surface of the muffins. For the firmness, the M1 (5 g of PF/100 g of WF) showed a softer crumb statistically different from the M0 and M2, as could be observed in Table 3. According to Zhou et al. (2014), a softer crumb in cakes is an important quality parameter for consumers. Thus, the quantity of 5 g of PF could bring a technological benefit for cakes.

3.2.3 Instrumental color parameters

PF addition affected color parameters L^* , a^* , and b^* of the crumb, and all the muffins with PF differed significantly when compared to M0, as could be observed in Table 3. There was a decrease in the value of luminosity (L^*), and an increase in values for parameters a^* and b^* , visually interpreted as “yellow” and “red”, respectively. That modification was caused due to the intense orange color from the β -carotene present in the pumpkin and that remained in the flour, even after processing (Figure 1).

Regarding crust color, the muffins containing the PF (M1 and M2) presented a darker (lower L^*) and orange (higher a^* and b^* values) color when compared to M0 (Table 3). The crust color is important for the acceptability of the muffins due to the consumer demand, who want a crust with the characteristic golden color (Zhou et al., 2014). So, the use of PF may be beneficial for use as a natural ingredient of color for muffins. Thus, the substitution of the WF by PF, or other natural colored vegetable flour could provide new characteristics and so, can contribute for a new flavor and visual appealing bakery product with enhancement of its nutritional composition.

3.2.4 Image analysis of muffins

The pore evaluations of the muffins are presented in Table 4, and the images of the crumb surface, analyzed area, and binary image are shown in Figure 1. There was no significant difference between the muffins considering the total number of the pores and total area of pores, indicating that PF did not interfere in these parameters. All the muffins presented more than 65% of pores smaller than 0.5 mm^2 of area, values like those found by Sozer et al. (2011) for chocolate cakes, which had most of the pores measuring between 0.2 and 0.6 mm^2 . Small and uniform distributed pores, as observed in the present work, are important for a soft crumb, and appreciated by consumers (Zhou et al., 2014).

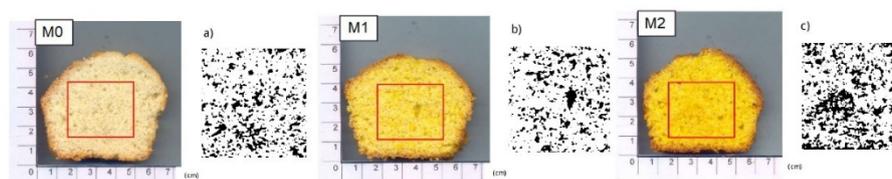


Figure 1. Images of muffin's crumb to M0 (flour basis: 100 g Wheat Flour -WF, and 0 g Pumpkin Flour – PF), M1 (95 g WF and 5 g PF), and M2 (90 g WF and 10 g PF) and a, b and c are correspondent binary images with Otsu Threshold algorithm and median filter with a value of 1.5 pixels (the red lines highlight the region of the collected binary image).

Table 4. Results of the image analysis of the control muffins (M0) and with pumpkin flour (M1 and M2)⁽¹⁾.

Pore size (mm^2)	Number of pores of the muffins ⁽²⁾		
	M0	M1	M2
< 0.5	228.00 \pm 27.09 (69.30) ^{ns}	177.00 \pm 37.50 (66.88) ^{ns}	205.00 \pm 11.86 (65.22) ^{ns}
0.5-1.0	44.33 \pm 3.40 (13.48) ^{ns}	31.00 \pm 5.66 (11.71) ^{ns}	43.33 \pm 6.02 (13.79) ^{ns}
1.0-5.0	49.67 \pm 9.39 (15.10) ^{ns}	46.67 \pm 0.94 (17.63) ^{ns}	55.00 \pm 5.89 (17.50) ^{ns}
5.0-10.0	4.67 \pm 1.25 (1.42) ^{ns}	7.67 \pm 3.86 (2.90) ^{ns}	7.67 \pm 1.89 (2.44) ^{ns}
10.0-15.0	2.33 \pm 0.47 (0.71) ^{ns}	2.33 \pm 2.62 (0.88) ^{ns}	3.33 \pm 0.47 (1.06) ^{ns}
Total pores	329.00 \pm 29.06 ^{ns}	264.67 \pm 37.28 ^{ns}	314.33 \pm 21.75 ^{ns}
Total area (mm^2)	231.32 \pm 21.10 ^{ns}	240.62 \pm 62.12 ^{ns}	266.26 \pm 12.97 ^{ns}

⁽¹⁾Flour basis of M0: 100 g Wheat Flour (WF) and 0 g Pumpkin Flour (PF); M1 95 g WF and 5 g PF; and M2 (90 g WF and 10 g PF).

⁽²⁾Results as mean \pm Standard Deviation (SD) (triplicate) and values in parenthesis correspond to the mean percentage in relation to the means of total number of pores and ^{ns} = non-significant difference by the Tukey's test ($p \leq 0.05$).

3.2.5 Consumer testing of muffins

The sensory analysis data is shown in Table 5, and in the radar-chart in Figure S2 (Supplementary material). All the muffin formulations obtained fairly high mean ratings around 6-7 in the 9-point hedonic

scale, and according to Meilgaard et al. (2000) products with acceptance mean ratings around 7 could be considered sensorially optimized. M1 presented the best scores in comparison to M0 and M2, indicating that the consumer accepted the inclusion of PF in the muffin.

For the selection of the best proportion of pumpkin flour substitution, optional comments were also considered, since they were a source of information on consumer perception. It was observed that 12 out of 119 consumers provided in the comments (optional) information related to negative M2 sensory experience, such as “pumpkin flavor too strong”, “color too yellow”, and “texture too dry”. Thus, we opted for the selection of the M1, and the results for the nutritional characterization. In other studies, with the addition of new ingredients that are a regional source of fibers and natural coloring in cakes, the acceptance mean rates were impaired, as observed by Micheletti et al. (2018), for instance, with the addition of jaboticaba peel flour in muffins. Thus, the sensory acceptance of the PF in muffins by the consumers highlighted the possibilities of using this ingredient.

Table 5. Acceptability in the consumer test of the control muffins (M0) and with pumpkin flour (M1 and M2)⁽¹⁾ (N = 119)⁽²⁾.

Muffins	Acceptance attributes ⁽³⁾				
	Appearance	Aroma	Flavor	Texture	Overall liking
M0	6.31 ± 1.94 ^b	6.37 ± 1.94 ^{ns}	6.21 ± 1.95 ^b	5.97 ± 2.16 ^b	6.28 ± 1.84 ^b
M1	7.06 ± 1.72 ^a	6.92 ± 1.86 ^{ns}	6.83 ± 1.88 ^a	6.77 ± 1.88 ^a	6.91 ± 1.72 ^a
M2	6.73 ± 1.87 ^{ab}	6.56 ± 1.84 ^{ns}	6.31 ± 1.96 ^{ab}	6.27 ± 1.94 ^{ab}	6.50 ± 1.78 ^{ab}
Tukey's test HSD ⁽⁴⁾	0.56	-	0.59	0.61	0.54

⁽¹⁾Flour basis of M0: 100 g Wheat Flour (WF) and 0 g Pumpkin Flour (PF); M1 95 g WF and 5 g PF; and M2 (90 g WF and 10 g PF). ⁽²⁾N = quantity of assessors. ⁽³⁾Analytical results correspond to the mean ± Standard Deviation (SD); different lowercase letters in the same column differ from each other by the Tukey's test ($p \leq 0.05$), and where ns = non-significant difference. Values in regarding a 9-point hedonic scale (9-cm non-structured). ⁽⁴⁾HSD = Honestly Significant Difference.

3.2.6 Nutritional characterization of the selected muffin

The results of the chemical composition (Table 6) of M1 were compared to the M0, and it was observed that the composition of protein and lipids did not differ significantly. But, the ash, and total dietary fiber contents were higher for M1, with a proportional reduction of the digestible carbohydrates, what could be especially due to the ash and fiber composition of the PF, even in substitution of 5 g of PF/100 g of WF. According to Brazilian regulation (Brasil, 2012), the food products should have a minimum of 2.5 g of total fiber by portion to be classified as a “source of fiber”. However, we could consider that the muffins are a part of a daily food intake, and not a usual dietary fiber source.

Table 6. Nutritional composition of control muffins (M0) and with pumpkin flour (M1).

Nutritional composition (g/100 g)	Muffins ⁽¹⁾⁽²⁾	
	M0	M1
Proteins	12.12 ± 0.06 ^{ns}	11.94 ± 0.40 ^{ns}
Lipids	23.77 ± 0.19 ^{ns}	24.31 ± 0.13 ^{ns}
Ash	1.39 ± 0.65 ^{*(5)}	2.01 ± 0.03 ^{*(5)}
Total dietary fiber ⁽³⁾	0.86	1.57
Digestible carbohydrates ⁽⁴⁾	61.86	60.17

⁽¹⁾Flour basis of M0: 100g Wheat Flour (WF) and 0 g Pumpkin Flour (PF) and M1 95 g WF and 5 g PF. ⁽²⁾Results presented as mean ± Standard Deviation (SD) (triplicate), in dry basis (the moisture content was 15.05 ± 0.46, and 16.21 ± 0.06 for M0 and M1, respectively).

⁽³⁾Calculated considering only the fiber content of WF (1 g/100 g) and of PF (35.33 g/100 g) and the quantities of these ingredients in formulation of each muffin. ⁽⁴⁾Calculated by difference = 100 - (lipids + protein + ash + mean of total dietary fiber). ⁽⁵⁾* = significative difference by F-test, and ns = non-significant difference.

4 Conclusions

From this study, it was possible to obtain a pumpkin flour using its pulp and peel with the characteristic of attractive coloring and high fiber content, besides reducing sugar content. It is also possible to use the PF as an ingredient in muffins formulations, replacing WF in 5 g/100 g, without prejudice to sensory acceptance. Furthermore, PF contributed mainly as a dietary fiber source in this product. Thus, the PF could be an ingredient for family farming during the off-season, and a way to offer pumpkins for use in bakery products.

Acknowledgements

The authors are grateful to the following funding agencies: *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* program (grant number 001), for the maintenance of the Postgraduate Program; *Conselho Nacional de Desenvolvimento Científico e Tecnológico* - CNPq for scholarship to Michele Scarton (140791/2017-5) and to Maria Teresa Pedrosa Silva Clerici (312786/2020-4); PIBIC/Unicamp for the scientific initiation scholarship to Gustavo Costa do Nascimento; *FAEPEX/UNICAMP* for research funding. They also thank the *Moinho Anaconda Industrial S.A* (São Paulo, SP) for donating the wheat flour.

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Funding: Conselho Nacional de Desenvolvimento Científico e Tecnológico (140791/2017-5, 312786/2020-4)/ Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (001) / Fundo de Apoio ao Ensino, à Pesquisa e Extensão, Universidade Estadual de Campinas - PIBIC/Unicamp.

Received: Sept. 13, 2020; Accepted: June 22, 2021

Supplementary Material

Supplementary material accompanies this paper.

Figure S2 - Radar-chart for the sensory acceptance mean scores of muffins (flour basis: 100 g wheat flour -WF, and 0 g pumpkin flour – PF), M1 (95 g WF and 5 g PF), and M2 (90 g WF and 10 g PF).

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