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SENSORY AND PHYSICO-CHEMICAL CHARACTERISTICS OF MUFFINS OBTAINED FROM NON-CONVENTIONAL AGLUTENIC FLOURS

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Abstract

In this work we obtained and characterized gluten-free muffins from almond and coconut flour. Three distinct muffin recipes were designed with the two types of flour in different proportions: Var. 1 (100% almond flour), Var. 2 (50:50) almond flour: coconut flour and Var. 3 (80:20) almond flour: coconut flour. The muffins were analyzed from a sensory point of view (using the hedonic method) by a group of 25 consumers, evaluating: external appearance, appearance on the section, taste, smell, aroma, texture, color and consistency. Overall, the highest score was recorded in Var. 3, followed by Var. 1. The taste, color and aroma of the three variants were appreciated very well, but differences could be observed in the appearance on the section and texture. The level of acceptability by consumers was high for all muffin variants obtained. Moisture (34.8 ± 0.7 - 37.5 ± 0.51%), height/diameter ratio (0.4 ± 0.03 - 0.6 ± 0.026), porosity (68.2 ± 2.3 - 72.7 ± 1.8%) and elasticity (48.58 ± 1.4 - 54.9 ± 1.63%), polyphenol content (47.15 ± 2.21-128.4 ± 3.47 mg gallic acid/g) and the antiradical activity were evaluated (RSA: 68.2 ± 3.41 - 63.7 ± 2.6%).

Key words*: almond flour, coconut flour, muffins, physicochemical characteristics, sensorial evaluation.*

INTRODUCTION

Studies according to which gluten affects the digestive (Humbert et al., 2006; Biesiekierski et al., 2011; Herfarth et al., 2014) and neurological (Ford, 2009; Jackson et al., 2012) systems of consumers, the context in which the disease celiac disease is very widespread among humans (Viljamaa et al., 2005; Cosnes et al., 2008; Ford, 2009; Leonard et al. 2017), has led the flour products industry to develop new products by substituting wheat flour with gluten-free flours.

Moreover, the current consumer trend is to change the lifestyle, and implicitly the diet (Petcu C.D. et al., 2019). Thus, there are people who adopt the gluten-free diet, even if they do not have celiac disease, or the ketogenic diet (low carbs) even if they are not diabetic or overweight. In this context, the demand for dietary products is increasing, which is why a particular interest among researchers has been shown in replacing wheat flour with rye, sorghum, coconut, almond, pea, soy, rice, corn, chickpea, quinoa, amaranth (Man et al., 2014; Andersson, 2016; Javaria et al., 2017; Păucean et al., 2017; Stoin et al., 2018; Ghinea et al., 2019; Shatta et al., 2019; Ramya and Anitha, 2020; Roshiya et al., 2022; Hopkin et al., 2022) in obtaining bakery and pastry products.

Nucifera flours are an excellent alternative to wheat flour, with high fat and protein content, respectively lower carbohydrate content (Hopkin et al., 2022).

Due to its chemical composition (proteins: 14-18%, fats: 11-14%, carbohydrates: 60%), coconut flour is also suitable for the ketogenic diet (Hopkin et al., 2022), being very rich in fiber nutrition (double that of wheat bran, and 4 times that of oat bran). Coconut flour also contains globulin and 60 g of dietary fiber (hemicellulose, cellulose and lignin) (Kwon et al., 1996; Trinidad et al., 2006; Yalegama and Chavan, 2006; cited by Jiamjariyatam et al., 2021). According to the study carried out by Arancon (1999), cited by Ramya and Anitha, (2020), coconut flour presents benefits for consumers by contributing to the control of cholesterol and blood sugar levels, as well as to the prevention of colon cancer.

With a fat content of 35-40%, proteins 20-25% and carbohydrates 10-15%, almond flour being gluten-free, is an alternative to wheat flour. At the same time, it also has antioxidant activity conferred by polyphenolic compounds (Takemoto et al., 2001) (Yildiz and Gocmen, 2020).

Due to their wide popularity among consumers, classic muffins and those obtained from gluten-free flours have been the subject of numerous research studies. The total or partial replacement of wheat flour with gluten-free flours has led to very good results. Sensory, physicochemical and nutritional characteristics were studied (Ramya & Anitha, 2020; Stoin et al., 2018; Hopkin et al., 2022; Moss et al., 2022).

Thus, Stoin et al. (2018) reported that by substituting 20, 40 and 40% respectively of wheat flour with almond flour, the acceptability increased directly proportional to the degree of substitution, but the baking parameters (elasticity, porosity, diameter and height) of the muffins from almond flour were inferior to those of the control group. Hopkin et al. (2022) observed increases in the volume of muffins that had a higher content of almond flour compared to those that had a predominantly coconut flour content. Also, almond flour resulted in softer products and better acceptability (Ghinea et al., 2019; Hopkin et al., 2022).

The results of the studies carried out by Ramya & Anitha, (2020) showed that the addition of 25% coconut flour in the dough for muffins improved the sensory and physicochemical characteristics of the obtained samples and, increasing their nutritional value. Similar results were reported by Jiamjariyatam et al. (2021). The use of almond or coconut flour caused a substantial increase in the level of protein in these muffins compared to classic muffins and reduced hardness and fragility in the case of biscuits, but increased crunchiness (Jiamjariyatam et al., 2021). The water content and water absorption capacity of samples from coconut or almond flour is lower than that obtained from wheat flour (Ramya and Anitha, 2020; Stoin et al., 2018).

The polyphenol content of muffins made from almond flour was higher than that of muffins made from wheat flour. An improvement in the antioxidant activity of (Ghinea et al., 2019) was also observed.

Starting, on the one hand, the results reported by Jiamjariyatam et al. (2021), Makinde and Eyitayo, (2019) and Ghinea et al. (2019), who support the fact that bakery products made with coconut flour mixtures present benefits for obese, diabetic, cardiovascular or constipated people, and on the other hand, noting the precariousness of studies related to the use of almond flour in association with the coconut one, we decided to approach the present research in order to evaluate the sensory attributes, mechanical and chemical properties of muffins.

MATERIALS AND METHODS

Obtaining muffins

Three distinct muffin recipes were designed by combining almond flour (AF) with coconut flour in different proportions: Variant 1 (100% almond flour – AF 100), Variant 2 (50:50) almond flour: coconut flour coconut (AF50:CF50) and Variant 3 (80:20) almond flour: coconut flour (AF80:CF20). The ingredients used were: almond flour, coconut flour, eggs, maple syrup, almond milk, sunflower oil, baking powder, vanilla essence, salt.

Beat the eggs and maple syrup for 2-3 minutes until the mixture has doubled in volume. Added the oil, almond milk and vanilla essence. It was mixed again for complete homogenization. Separately sifted: almond flour, salt and baking powder, then mixed a little. This mixture was poured over the previously prepared composition and mixed. After the mixture was

homogeneous, it was poured into molds and placed in a preheated oven at 220°C for 13-15 minutes.

Table 1 Recipes for gluten-free muffins

Ingredients	Variant 1 (AF 100)	Variant 2 (AF50:CF50)	Variant 3 (AF80:CF20)
Almond flour, g	250	125	200
Coconut flour, g	-	125	50
Eggs, g	150	150	150
Maple syrup, g	200	200	200
Almond milk, g	70	70	70
Oil, g	100	100	100
Baked powder, g	7	7	7
Vanilla essence, g	0.5	0.5	0.5
Salt, g	3	3	3

Moisture determination

The moisture content of the muffins was determined by calculating the mass loss as a result of heating to 105°C.

Determination of the height/diameter ratio

Based on this report, the degree of development of the muffins taken for analysis can be appreciated. At values of this ratio of 0.4, it is considered that the muffins are well developed, above this value it is considered a superior product, and for lower values, the product is considered inadequate, and flattened. This indicator was determined immediately after cooling the muffins.

Porosity determination

Porosity (the volume of air voids in the product) was determined by measuring the diameter and height of a cylinder cut from the muffins, which was then weighed and calculated with the relation:

$$Porosity\ (\%) = \frac{V - \frac{m}{\rho}}{V} 100 \quad (1)$$

where:

V - the volume of the core cylinder [cm^3];

m - core cylinder mass [g];

ρ - flour density [g/cm^3],

$\rho_{almond\ flour}$ - 0.5 [g/cm^3],

$\rho_{cocos\ flour}$ - 0.5 [g/cm^3],

Determination of the elasticity of muffins

Muffin springiness was measured by pressing half a muffin for 1 minute and measuring its height at the highest point before and after pressing. Thus, half a muffin is placed on a flat surface and its height is measured. The other half of the muffin placed on the same flat surface is gently pressed with a plunger until it reaches half of the original height and the tension is maintained for 1 minute. The plunger is lifted and the muffin is left for another minute to return to its original shape. Measure the height again at the highest point and use the following relationship to calculate the elasticity:

$$Elasticity\ (\%) = \frac{H_2}{H_1} \times 100 \quad (2)$$

where:

H_1 - the height of the muffin before pressing [mm];

H_2 - the height of the muffin after pressing and its return to the initial position [mm].

Determination of polyphenol content

Total polyphenols content was determined using the Folin-Ciocalteu method (Apak et al., 2008). The results were expressed in mg gallic acid/g (Moldovan et al., 2022).

Determination of free radical scavenging activity

The free radical scavenging activity (RSA) was determined according to the method described by Hue et al., (2020), by the spectrophotometric method with ethanolic DPPH (1,1-diphenyl-2-picrylhydrazyl) 0.1 mM, reading the absorbances of the ethanolic extracts of muffins at 517 nm. For the RSA calculation, the relationship was used:

$$RSA\ (\%) = \frac{A_C - A_S}{A_C} 100 \quad (3)$$

where:

A_c - absorbance of control;

A_s - absorbance of the sample

Sensory evaluation

The evaluation of the sensory characteristics was carried out after baking the muffins. They were allowed to cool and then the external appearance, appearance on section, taste, smell, aroma, texture, color and consistency were evaluated. These characteristics were evaluated by the hedonic scoring method from 1-5. The sensory examination was carried out by a group of 25 consumers who rated these characteristics on the basis of a sensory sheet. The sensory analysis ensured that the muffins had a specific shape, the presence/absence of possible shape defects (deformations, flattening, crushing, cracks, etc.) was checked. As a color standard

for the surface of the muffins, the yellow-copper color was considered, without stains / traces of burns, soot, etc., and in the section golden color. The appearance in the section was evaluated, being properly appreciated the homogeneous, with uniform porosity, well baked. The smell was evaluated immediately after sectioning the muffins, it being characteristic, without foreign smells. Also, the specific taste of muffins was appreciated, pleasant, without unusual tastes (sour, rancid, bitter).

RESULTS AND DISCUSSIONS

The mechano-chemical characteristics of the muffins studied are presented in Table 2 and in Figure 1.

Table 2 Mechano-chemical characteristics of the muffins

Parameter	Variant 1 (AF 100)	Variant 2 (AF50:CF50)	Variant 3 (AF80:CF20)
Moisture, %	34.8±0.7	37.5±0.51	35.2±0.6
H/D ratio	0.6±0.04	0.4±0.05	0.52±0.04
Porosity, %	72.7±1.8	68.2±2.3	71.8±1.9
Elasticity, %	54.9±1.63	48.58±1.4	53.3±1.3

The humidity of the muffins varied between 34.8 ± 0.7 - 37.5 ± 0.51%. Muffins obtained exclusively from almond flour (AF 100) had a lower water content (34.8%) compared to those obtained from a mix (AF50: CF50) of almond flour and coconut flour in equal parts (37.5%). Hence the conclusion that the addition of coconut flour increases the humidity of the muffins. Similar results were reported by Hopkin et al., (2020), respectively Ramya and Anitha, (2020). It was also found that the water retention capacity increased with the increase in the amount of coconut flour in the dough (Ramya and Anitha, 2020). In contradiction to these results, Makinde & Adeyemi (2018) found higher moisture content in CF biscuits than in AF ones. In the case of partial substitution of rice flour with almond flour, a better water retention tendency was found, directly proportional to the degree of substitution (Stoin et al., 2018).

The best value of the height / diameter ratio was recorded for version 1 (muffins from AF 100) - 0.6, while for version 3 (AF80:CF20) the value of 0.4 was calculated, and for version 2 (AF80: CF20) - 0.52. Even with the 50% substitution of almond flour with coconut flour, the muffins developed well. The lower degree of substitution of AF with CF ranked the muffins obtained in the higher category.

The best porosity was recorded in Variant 1 (AF100) - 72.7 ± 1.8%, and the lowest in variant 2 (AF50: CF50) - 68.2 ± 2.3%. The addition of CF leads to an increase in the content of dietary fiber (Poonam and Tech, 2013, cited by Jiamjariyatam et al., 2021), and as a result, the density of the product increases, that is, the porosity is reduced. The presence of CF in muffins determined the reduction of their volume (Ramya & Anitha, 2020). These results also correlated with those reported by Stoin et al. (2018), who found in almond flour muffins porosity of 66.9%, but the increase in FA content (and the reduction of that of rice) was inversely correlated with porosity. The results of the study carried out by Gillespie & Ahlborn (2021) showed that the volume of bread obtained from almond flour was superior to other types of bread obtained from mixes with oat flour.

The experimental results show that the elasticity of the muffins was influenced by the ratio between AF and CF. By comparison with muffins obtained exclusively from AF, those with CF presented less elasticity. Thus, muffins with 100% AF had the highest elasticity (54.9%). The increase in the degree of substitution of FA varied inversely proportional to the elasticity of the muffins (Stoin et al., 2018). The decrease in the elasticity of muffins with CF was also reported by Hopkin et al., (2020).

The content of polyphenols and RSA of the muffins is presented in Figure 1. Muffins with exclusive AF had the highest content of polyphenols (128.4 mg gallic acid/g), while in version 2 of muffins it was substantially reduced (47.15 mg gallic acid/g). This fact is explained by the high content of polyphenols (625 mg/100 g) present in almond flour (Siqueira et al., 2015). The substitution of FA with CF determined the reduction of the content of polyphenols in direct correlation with the degree of substitution. Ghinea et al. (2019) reported that the substitution of wheat flour with almond flour led to increases in the total content of polyphenols in muffins.

Radical scavenging capacity was directly correlated with higher AF content. Thus, the highest RSA value (68.2%) was observed in

muffins with AF 100, while the lowest value (63.7%) was observed in muffins with the highest CF content. Considering that the value of 89.74 ± 0.8% for the DPPH radical scavenging activity found by (Naseer et al., 2021), for the almond cake, indicates its superior bioactive properties, it can be stated that the muffins from the present study have good antioxidant activity. Ghinea et al. (2019) observed that replacing wheat flour with FA resulted in an increase in antioxidant activity.

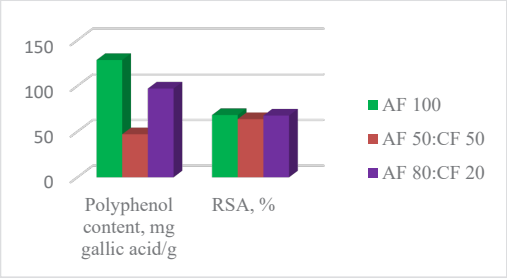

Figure 1. Polyphenol content and RSA

Following the evaluation of the sensory characteristics, the average of the recorded values is presented in Figures 2-4. In variant 1 (AF 100) of muffins, the taste, smell, aroma and color were appreciated very well, but the external appearance, the one on the section, the consistency and the texture were depreciated.
Muffin variant 2 (AF: CF - 50: 50) received high scores for colour, consistency, aroma, texture and taste, but was penalized for appearance and section. In the case of variant 3 (AF: CF - 80: 20), high scores were recorded for: colour, consistency, smell, aroma and texture. And in the case of variant 3, the appearance has been depunctated.

Figure 2. Muffins with AF and mix of AF with CF

According to the average of the assessed sensory characteristics, the highest score was recorded for variant 1, closely followed by variant 3.

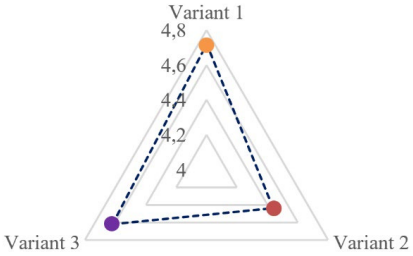

Figure 3. The mean of the sensory acceptability characteristics of the three types of muffins

If the taste, color and aroma of the three variants were appreciated close to the maximum, differences could be observed in the appearance per section and texture. Muffins made entirely from almond flour scored the highest for appearance per section, and those with equal mixes of almond flour and coconut scored the lowest.
In the specialized literature, Wilderjans et al. (2013) argue that the appearance of muffins obtained from almond flour is less appreciated once the proportion of almond flour increases, but Stoin et al. (2018) argue otherwise.
The texture of the muffins was improved by increasing the proportion of almond flour. This fact was correlated with the data from the specialized literature (Hopkin et al., 2022, cited by Moss et al., 2022).

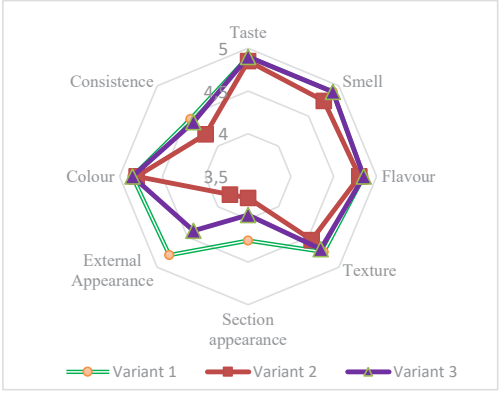

Figure 4. Sensory characteristics of the three types of muffins

The results of the study carried out by Stoin et al. (2018) show that the texture of muffins was detuned with increasing almond flour content.
The aroma and taste of the muffins were appreciated with very high scores. The taste and aroma conferred by almond flour, similar to that of walnut, was also appreciated in other specialist studies (Wilderjans et al., 2013).

CONCLUSIONS

The topic addressed led to the formulation of several conclusions.
The level of acceptability by consumers was high for all the variants of muffins obtained, the variants with a higher content of almond flour being rated better.
The substitution of almond flour with coconut flour led to an increase in the water content of the finished products.
Porosity and elasticity were influenced by the ratio of AF and CF.
Antioxidant activity (RSA) and polyphenol content was directly influenced by almond flour content.
The study is worth continuing to highlight other aspects regarding the optimal use of non-conventional flours in the bakery, pastry and confectionery industry.

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