Muffin preparation using chickpea flour with the addition of walnuts: physicochemical analysis of the flour and nutritional quality of the muffins

Elaboração de *muffin* utilizando farinha de grão-de-bico com adição de nozes: análises físico-químicas da farinha e qualidade nutricional dos *muffins*

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1 INTRODUCTION

Chickpeas (*Cicer arietinum* L.) are a legume of the Fabaceae family, native to Asia Minor, from where they spread to several continents in ancient times. The grain ranks third in world production among the most important pulses (legumes with edible dry seeds) in the world, along with beans and peas (FAO, 2017).

The Brazilian population suffers from protein and mineral deficiencies. Chickpeas are a source of protein, carbohydrates, minerals, vitamins and fiber. The development of baked products with this legume can decrease the protein and mineral deficiencies by increasing and diversifying its consumption. The addition of walnuts (*Juglans regia*, L.) in these baked products is interesting because they have considerable amounts of protein, lipids, minerals, and fiber. Fiber is important to help regulate the intestine, reduce plasma cholesterol, control blood glucose, and help prevent and treat obesity (PERES; GOUVEIA, 2017).

Chickpeas are considered a good source of energy, protein, minerals, fiber, and contain phytochemicals potentially beneficial to health (JACOMELLI, 2021). It differs from other legumes for its digestibility, low content of antinutritional substances, and it also has good iron availability (SHUBERT, 2017). It has a good source of carbohydrates, mainly long-chain (poly and oligosaccharides) with slower metabolization in the body, besides simple sugars (glucose and sucrose) in smaller proportion (TRINDADE, 2019). It is also a rich source of unsaturated lipids, such as linoleic acid and oleic acid, good source of phytosterols, such as beta sitosterol, campesterol and stigmasterol, besides being a great source of mineral elements, vitamins (mainly vitamin E and those of the B complex) and dietary fiber (FERREIRA; BRAZACA; ARTHUR, 2006). Nutritionally, this legume has great potential to be explored in order to minimize protein and mineral deficiencies of the population, since it is a grain that is configured as a good source of minerals (P, Mg, Fe, K, Co, Mn) (CARNEIRO *et al*., 2017).

The practice of using chickpeas with cereals results in balanced, nutritious, and healthy diets. In addition, this legume helps to combat obesity and chronic diseases (e.g., diabetes and cardiovascular problems), caused mainly by excessive consumption of animal foods (FAO, 2019).

Chickpea flour is considered nutritionally superior compared to refined wheat flour, showing as an abundant source of protein of approximately (24.4% - 25.4%) corresponding to twice that found in wheat flour (9.3% - 14.3%). It is known to be rich in lysine, but limited in sulfur-containing amino acids, mainly methionine, tryptophan, and cysteine. This property makes chickpea flour an excellent protein quality enhancer when mixed with other cereal flours (DANDACHY; MAWLAWI; OBEID, 2019).

Walnuts are an abundant source of unsaturated fatty acids, proteins, vitamins, and secondary metabolites of nutritional interest (POLMANN *et al*., 2018). They have considerable amounts of lipids and proteins, so they are good sources of energy. The chemical composition of this oilseed, from a nutritional point of view is of primary importance to highlight this nut in food, as well as in its applications (PERES; GOUVEIA, 2017). The intention when adding nuts to *muffins* made with chickpea flour is to increase its nutritional value, since the nut in 100 g of fresh weight has 13.20 g of protein, 3.50 g of fiber and 65.20 g of total lipids (PERES; GOUVEIA, 2017).

2 OBJECTIVE

This work aimed to study the nutritional quality of *muffins* made with chickpea flour, with the addition of nuts, in order to improve the nutritional characteristics of this product, giving more visibility to this legume so that it can be more cultivated and consumed in Brazil.

3 METHODOLOGY

This work was developed in the Center of Agricultural Sciences and Engineering of the Federal University of Espírito Santo (CCAE/UFES). It was used chickpeas (*Cicer arietinum* L.), walnut (*Juglans regia* L.), wheat flour, milk, sugar, eggs, margarine, baking powder and salt, acquired in the local commerce in the city of Alegre-ES.

The flour was obtained by milling the grains, using a knife mill (Solab® SL-31) with a 0.50 mm mesh sieve, to obtain a flour of adequate granulometry.

The granulometry of the chickpea flour was determined according to methodology No. 66-20 adapted from AACC (2000), for 100 g of sample, using a set of sieves with mesh sizes of (30, 40, 50 and 60) mesh, equivalent to (0.595; 0.420; 0.297 and 0.250) mm, submitted to vibratory action for a period of 10 minutes.

The chemical characterization of the chickpea flour was performed for the content of water, ash, protein and lipids according to the methodologies of the Institute Adolfo Lutz (IAL, 2005). The dietary fiber analyzed was Acid Detergent Fiber (FDA) (AOAC, 1998). The carbohydrates were determined by the difference method (SOUCI; FACHMAN; KRAUT, 2000).

To determine the pH, a solution was prepared with 5 g of flour sample in 50 mL of distilled water, which was stirred for 10 minutes in a magnetic stirrer. Then, the pH of the supernatant liquid was read directly using a digital pH meter (IAL, 2005). After determining the pH the same solution was used to determine the titratable acidity by adding 2 to 4 drops of phenolphthalein solution and titrating with 0.1 M sodium hydroxide solution until it turned pink (IAL, 2005).

The color of the flour was measured by the CIEL*a*b* system, in a colorimeter (Konica- Minolta CM-5). The coordinates analyzed were: L* or brightness (black-0/white-100), a* (green -/red +) and b* (blue -/yellow +) (HUNTERLAB, 2013).

To make the *muffins*, chickpea flour was used in the proportions of 0%, 10%, 20%, 30%, and 40% to replace wheat flour, in addition to nuts, eggs, sugar, butter, milk, baking powder, and salt.

The determination of the water content (method 012/IV), protein (method 037/IV), lipids (method 032/IV) and ash (method 018/IV) were performed in the *muffins* ready for consumption, according to the methodology proposed by the Instituto Adolfo Lutz (IAL, 2005). The carbohydrates were determined by the difference method (SOUCI; FACHMAN; KRAUT, 2000).

Weight was measured on an analytical balance immediately after the *muffins* reached room temperature. The volume was determined by displacing millet seeds one hour after baking the *muffins*. The specific volume was calculated by dividing the volume found for the muffin (cm^3) by its weight (g) (EL DASH; CAMARGO; DIAZ, 1982).

The color of the *muffins* was determined by the CIEL*a*b* system, in a colorimeter (Konica - Minolta CM-5). The coordinates analyzed were: L* or luminosity (black-0/white-100), a* (green -/red +) and b* (blue -/yellow +) (HUNTERLAB, 2013). The overall color difference between the *muffins of* each of the formulations was calculated, compared to the standard *muffin* (100% wheat flour) by the parameter ΔE*, according to equation (1):

$$\Delta E^* = [(\Delta a^*)^2 + (\Delta b^*)^2 + (\Delta L^*)]^{20,5} \quad (1)$$

The texture profile of the *muffins* was obtained by the TPA (Texture Profile Analysis) method on the same day of baking. The instrumental texture of the crumb was determined using a Brookfield® texturometer (Texture Analyser model CT3) and a 36 mm cylindrical probe (P36/R), based on the standard method of AACC 74-09 (AACC, 2000). The parameters measured were: hardness (N), elasticity (mm), cohesiveness, gumminess (N) and chewiness ($N.mm^{-1}$).

To determine the physicochemical characteristics of chickpea flour, the results were analyzed by descriptive statistics, obtaining the mean and standard deviation for each analysis. To compare the effect of different levels of chickpea flour in relation to the physical and physicochemical characteristics of *muffins*, the experiment was conducted in an entirely randomized design, with five levels of chickpea flour concentration (0%, 10%, 20%, 30% and 40%) and three repetitions, and the results were analyzed by analysis of variance (ANOVA) and the means were compared by the Tukey test, adopting a significance level of 5%.

The statistical analyses were performed with the help of the GENES program (CRUZ, 2006).

4 DEVELOPMENT

The results obtained in relation to the physicochemical composition and characteristics of chickpea flour are presented in Tables 1 and 2. It is observed in Table 1 that the particles of the flour showed a percentage of 89% of particles with particle size between 0.60 and 0.30 mm in diameter, being considered a coarse flour.

Table 1 - Granulometry of chickpea flour.

	Sieve aperture (mm)				
	0,600	0,425	0,300	0,250	< 0,250
%	58,90	16,24	14,23	6,86	0,87

Source: Authors' own production (2022).

According to the IN No. 08 of June 3, 2005 from MAPA, 95% of wheat flour must pass through the sieve of 0.250 mm (BRASIL, 2005). However, ANVISA's RDC No. 711 of July 1, 2022 does not determine any specific granulometry for flours in general (BRASIL, 2022).

The results of the physicochemical analyses of the chickpea flour are presented in Table 2.

Table 2 - Centesimal composition and physical-chemical characteristics of chickpea flour

Parameters	**Average ± standard deviation***	
	bu**	**bs****
Water content (g/100)	**11,62 ± 0,04**	--------
Proteins (g/100)	**22,89 ± 0,06**	**25,90 ± 0,07**
Lipids (g/100)	**10,15 ± 0,71**	**11,49 ± 0,80**
Ash (g/100)	**3,04 ± 0,03**	**3,44 ± 0,03**
Fiber (g/100)	**35,16 ± 3,56**	**39,79 ± 4,02**
Carbohydrates (g/100)	**23,52 ± 4,37**	**20,38 ± 3,92**
pH***	**6,43 ± 0,01**	
Acidity (mL NaOH/100 g)	**8,25 ± 0,67**	
L*	**87,16 ± 0,17**	
a*	**2,01 ± 0,13**	
b*	**20,14 ± 0,37**	

*Average of three repetitions; **bu = wet basis; bs = dry basis; ***pH = dimensionless. Source: Authors' own production (2022).

Based on the current legislation in Brazil for flours, cereal starch, whole grains and bran, RDC No. 711/2022 (BRASIL, 2022), the maximum moisture content allowed for flours is 15%. The chickpea flour analyzed had an average water content of 11.62, within the specific legislation.

The average protein content of chickpea flour was 25.90 g/100 g on a dry basis. Ferreira, Brazaca and Arthur (2006) and Jacomelli (2021) found in raw chickpea seeds, protein contents of 25.73 g/100 g (bs) and 25.79 g/100 g (bs) respectively, very close to the value obtained in this work.

The average value of lipids found was 11.49 g/100 g (bs). When chemically characterizing raw chickpea seeds, Ferreira, Brazaca and Arthur (2006) found a lipid content of 4.71 g/100 g (bs), a value much lower than that found in this study. On the other hand, Jacomelli (2021) obtained a lipid content in chickpea flour of 17.55 g/100 g (bs), higher than that of the flour analyzed in this work. The average ash content found in the chickpea flour was 3.44 g/100 g (bs), being close to the values found by Ferreira, Brazaca and Arthur (2006) of 3.74 g/100 g (bs) and by Jacomelli (2021) of 3.33 g/100 g (bs).

In this study, a value of 39.79 g/100 g of fiber (bs) was found. Ferreira, Brazaca and Arthur (2006) and Jacomelli (2021) obtained contents of 20.42 g/100 g (bs) and 30.99 g/100 g (bs) respectively. The carbohydrate content was 20.38 g/100 g (bs). Ferreira, Brazaca and Arthur (2006) found a value of 45.37 g/100 g (bs) for carbohydrates in raw chickpeas, being a very high value compared to this study, while Jacomelli (2021) obtained a value of 22.39 g/ 100 g (bs), closer to that observed in this work.

The average pH value of chickpea flour was 6.43. Ladjal and Chibane (2015) obtained a pH value of 6.41 in their study, which was almost identical value in both studies. The acidity found was 8.25. Ladjal and Chibane (2015) found an acidity value of 4.17, a lower value than that found in this work.

The flour in this study was submitted to instrumental color measurements, presenting average values of L* (luminosity) of 87.16, a* of 2.01 and b* 20.14, indicating it to be a light-toned flour and coloration tending toward yellow (b*) slightly reddish (NASCIMENTO, 2020).

The results of the chemical analyses of the *muffins* are presented in Table 3. It was observed that there was a significant difference ($p \leq 0.05$) between the mean values of the treatments for all parameters analyzed.

Table 3 - Results of chemical analysis of *muffins* on a dry basis (g.100 g^{-1}).

Treatments	**Content of Water (bu)**	**Proteins (bs)**	**Lipids (bs)**	**Ash (bs)**	**Carbohydrates (bs)**
F0	25,69 **ab**	12,61 **b**	38,82 **b**	2,86 **a**	45,71 **a**
F10	25,45 **b**	14.27 **ab**	38,70 **b**	2,87 **a**	44,16 **a**
F20	29.30 **ab**	15,80 **a**	50,47 **a**	2,72 **a**	31,01 **b**
F30	25,28 **b**	13.22 **ab**	44.00 **ab**	2,19 **b**	40.59 **ab**
F40	30,94 **a**	15,66 **a**	51,21 **a**	2,99 **a**	30,14 **b**

Means followed by the same letter in the columns do not differ statistically from each other by Tukey's test, at 5% significance level ($p > 0.05$).
bu = wet basis; bs = dry basis.

Source: Authors' own production (2022).

It is observed that the water content of formulation F40 differed statistically ($p \leq 0.05$) from formulations F10 and F30, ranging from 25.28% (F30) to 30.94% (F40).

It can be seen that there was a significant difference ($p \leq 0.05$) in the protein content of the *muffins* only for treatments F20 and F40 compared to treatment F0, ranging from 12.61% for formulation F0 to 15.80% for formulation F20. It was expected to obtain increasing values of the protein content of the *muffins* with increasing amount of chickpea flour in the formulations, since chickpea flour has a higher protein content than wheat flour as found for formulations F20 and F40.

For lipid content it is observed that there was significant difference by Tukey's test ($p \leq 0.05$) between treatments F20 and F40 compared to treatments F0 and F10, ranging from 38.70% (F10) to 51.21% (F40). Similarly to the protein content, it was expected to obtain increasing values of the lipid content of the *muffins* with increasing amount of chickpea flour in the formulations, since chickpea flour presents higher lipid content than wheat flour, as verified for formulations F20 and F40.

Regarding ash only the mean value of treatment F30 differed statistically ($p \leq 0.05$) from the other treatments, ranging from 2.19% (F30) to 2.99% (F40).

As for the carbohydrate content, calculated by difference, there was also a significant difference ($p \leq 0.05$) between the means of treatments F0 and F10 compared to treatments F20 and F40, ranging from 30.14% (F40) to 45.71% (F0), since the protein and lipid contents were higher for these two formulations.

The results of the specific volume and color analyses of the *muffins* are presented in Table 4.

Table 4 - Results of the analyses of the specific volume and instrumental color parameters of the *muffins.*

Treatments	Vol. spec. (cm^3 /g)	L* *muffins*	a* *muffins*	b* *muffins*	ΔE *muffins*	L* core	a* core	b* core	ΔE core
F0	2,09 **a**	60,54 **a**	11,29 **a**	37,27 **a**	-----	67,00 **a**	4,68 **c**	33,48 **a**	-----
F10	2,13 **a**	53,75 **a**	14,21 **a**	36,60 **a**	8,03 **a**	59,49 **b**	6.79 **ab**	34,35 **a**	7,94 **a**
F20	2.03 **ab**	56,48 **a**	7,46 **a**	31,44 **b**	9,15 **a**	62.70 **ab**	4,95 **c**	32,74 **a**	4,67 **a**
F30	1,64 **b**	57,90 **a**	10,65 **a**	36,38 **a**	6,25 **a**	60,79 **b**	6,98 **a**	34,42 **a**	6,83 **a**
F40	2,14 **a**	61,31 **a**	9,50 **a**	37,51 **a**	6,49 **a**	63.73 **ab**	5,96 **b**	35,02 **a**	3,92 **a**

Means followed by the same letter in the columns do not differ statistically from each other by Tukey's test, at 5% significance level ($p > 0.05$).

Source: Authors' own production (2022).

It was observed that there was a significant difference ($p \leq 0.05$) between the mean values of the treatments for the specific volume, for the b* color parameter of the *muffins,* and for the L* and a* color parameters of the *muffin* crumb.

Only formulation F30 differed statistically ($p \leq 0.05$) from the other *muffin* formulations regarding the specific volume, ranging from 2.14 cm^3 /g (F40) to 1.64 cm^3 /g (F30). This result may have been influenced by the fact that treatment F30 was baked in different baking sheets than the other treatments.

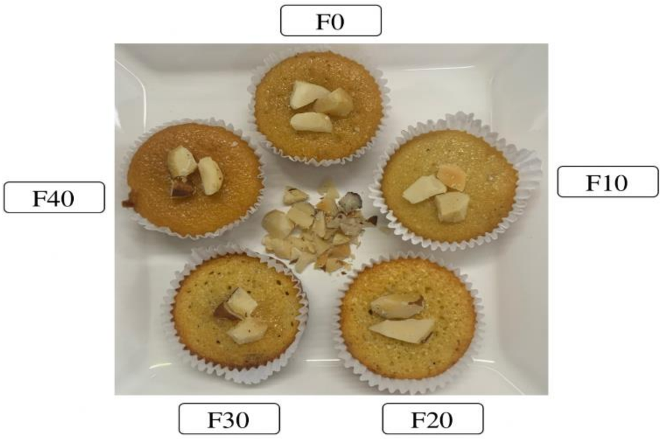
According to the color parameters, the *muffins* presented a dark coloration (L*) tending to a reddish yellow, i.e., a brownish coloration. Only for the b* parameter the F20 formulation differed statistically ($p \leq 0.05$) from the other formulations.

The crumb of the *muffins* showed a slightly lighter color (L*) tending to a yellow (b*) less reddish color (a*). Only formulations F0 and F20 differed statistically ($p \leq 0,05$) from the other formulations only in relation to the a* parameter.

Marques (2022) observed in the colorimetry of breads made with rice flour and chickpea flour that the increase in the proportion of chickpea flour caused decrease in the brightness L* ranging from 55.20 to 68.67, increase in the value of a* ranging from -9.04 to -1.63 and there was no significant effect for the parameter b* ranging from 15.69 to 19.44. When analyzing the crumb, the author found that the L* and a* values decreased considerably, L* ranging from 71.18 to 63.76 and a* from -2.75 to -1.53 and the b* parameter increased from 15.69 to 19.44 leaving the crumb of bread with a higher percentage of chickpea flour more yellowish. Thus, the results of Marques (2022) were close in relation to the values of L*, but distant from the results observed for the parameters a* and b* in relation to baked *muffins* and their crumb.

The overall color difference (ΔE) determines how much a sample differs from the standard sample in relation to the overall impression of color, i.e., how much this difference is perceived by human eyes (RAMOS; GOMIDE, 2007). According to the classification presented by Konica Minolta, a color difference (ΔE) ranging from 3 to 6 indicates a difference easily distinguishable by consumers (EVANGELISTA *et* *al*., 2011). It is observed in Table 4 that the *muffin* samples, as well as, their cores presented ΔE values above 3, indicating that the addition of chickpea flour influenced the visual perception of color compared to the standard sample (F0), as also observed in Figure 1. However, the overall color difference did not differ statistically (p>0.05) between the formulations.

Figure 01 - Image of the *muffins* prepared with different percentages of substitution of wheat flour by chickpea flour.



Source: Authors' own production (2022).

The results of the texture analysis of the *muffins* are presented in Table 5. It was observed that there was no significant difference ($p > 0.05$) between the mean values of the treatments for all parameters analyzed.

Table 5 - Results of the texture analysis of the *muffins*.

Treatments	Hardness N	Cohesivity	Gumminess N	Chew. N.mm^{-1}	Elasticity mm
F0	37,04 **a**	0,30 **a**	10,83 **a**	72,07 **a**	6,68 **a**
F10	60,56 **a**	0,30 **a**	18,50 **a**	144,40 **a**	7,85 **a**
F20	30,74 **a**	0,28 **a**	8,67 **a**	60,70 **a**	7,09 **a**
F40	68,44 **a**	0,20 **a**	14,06 **a**	115,53 **a**	8,22 **a**

Means followed by the same letter in the columns do not differ statistically from each other by Tukey's test, at 5% significance level ($p > 0.05$).

Source: Authors' own production (2022).

Therefore, these results indicate that the addition of up to 40% chickpea flour in the formulations, in replacement of wheat flour, did not influence the instrumental texture characteristics of the *muffins*.

Schubert (2017) analyzed the hardness and elasticity of gluten-free breads made with chickpea flour and found that hardness increased and elasticity decreased as the percentage of chickpea flour in the formulations increased, different from the results obtained in this work for the *muffins*.

5 CONCLUDING REMARKS

The characterization of chickpea flour showed that this grain has high levels of protein, lipids and fiber, constituting, therefore, a product of good nutritional quality. The color parameters showed that this flour has a light shade tending to yellow.

The chemical analyses of the *muffins* showed increased values of proteins and lipids and decreased carbohydrates among the formulations with a higher percentage of chickpea flour, providing better nutritional quality.

The increase in the percentage of chickpea flour did not significantly alter the results of color and instrumental texture parameters, as well as the specific volume of the *muffins*, except for F30. Therefore, these results indicate that the addition of up to 40% chickpea flour in the formulations, replacing wheat flour, did not influence the main physical characteristics of the *muffins*.

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