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### ANALYSIS OF THE CHEMICAL COMPOSITION AND ENERGY VALUE OF PISTACHIO, CARDAMOM AND CHOCOLATE MUFFINS

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**Abstract:** The present paper aims at the development and physicochemical characterization of an innovative pastry product - pistachio, cardamom and chocolate muffins (own production) - analyzing the impact of functional ingredients on the final quality. The technological process followed the classic manufacturing stages, including the separate preparation of the dry mixture (flour, sugar, loosening agent) and the liquid mixture (eggs, milk, butter), followed by rapid homogenization to prevent the excessive development of the gluten network. The aromatic notes were provided by the addition of cardamom, while pistachios and chocolate contributed to both the sensory profile and the nutritional density of the product. Baking was carried out under controlled conditions at temperatures of 180-200°C for about 25-30 minutes, optimal parameters for ensuring the coloring kinetics of the shell and the porous texture of the core. The analysis of the quality indicators for the own production sample revealed a balanced profile, with a humidity of 32.926%, a value that ensures optimal freshness and is comparable to the reference standards for muffins baked at high temperatures. The use of pistachios resulted in a fat content of 11.338%, representing a significant reduction compared to standard variants (14%), confirming the potential for replacing saturated fats with oilseed pastes. The level of protein (6.366%) and total ash (1.2%) exceeded the values of the control muffins (5.30% protein and 0.89% ash), indicating an improvement in biological value and mineral content. The product had a pH of 6.11 and an energy intake of 302.71 kcal/100 g, falling into the category of gourmet pastries with an optimized nutritional profile. The results demonstrate that pistachio, cardamom and chocolate muffins are a viable alternative to conventional products, offering a balance between premium sensory qualities and superior physicochemical indicators.

**Keywords:** muffins, pistachios, cardamom, physico-chemical indicators, technological process, energy value.

#### • Introduction

Muffins are popular pastries due to their versatility and sensory appeal, but conventional variants have a high content of sugars and saturated fats, with low nutritional value [1], [4]. The incorporation of functional ingredients such as pistachio paste, cardamom powder and chocolate chips allows the nutritional profile to be improved, through the intake of proteins, unsaturated fats, antioxidants, vitamins and essential minerals. Pistachios, in particular, stands out for its rich content of monounsaturated fatty acids, phytochemicals and polyphenols, helping to reduce cardiovascular risk and optimize the lipid composition of bakery products [5], [6]. Cardamom adds distinct aromatic notes and bioactive properties similar to other spices used in functional products, while chocolate enhances sensory acceptability without compromising nutritional density [1]. The present paper aims at the development and physicochemical characterization of pistachio, cardamom and chocolate muffins from our own production, analyzing the impact of these ingredients on the chemical composition and energy value. This approach responds to the growing consumer demand for healthy foods with improved sensory characteristics, addressing the challenge of reducing the caloric value in pastries that are traditionally based on carbohydrates and fats [7]. The analysis of macronutrient composition, typically calculated using comprehensive food composition tables [8], alongside sensory evaluations employing hedonic scales [9], provides a robust methodology for assessing the nutritional quality and consumer acceptance of such innovative baked goods. The current investigation extends beyond mere nutritional profiling to incorporate a detailed assessment of the impact of these functional ingredients on the rheological properties of the dough and the textural attributes of the final product, crucial for industrial scale-up and consistent quality. This study therefore aims to systematically evaluate the chemical composition and energy value of pistachio, cardamom, and chocolate muffins, providing insights into their potential as functional bakery products. This involves a meticulous analysis of their proximate composition, including moisture, protein, fat, ash, and carbohydrate content, alongside their caloric density, to ascertain their nutritional contributions. Furthermore, a comprehensive understanding of the volatile compounds and textural profiles of these muffins is critical, as these parameters significantly influence consumer perception and product shelf-life [3]. Therefore, this research will focus on quantifying the specific macro- and micronutrients contributed by the pistachio, cardamom, and chocolate, and correlating these with the overall energy content and potential health benefits. This detailed characterization will delineate the specific improvements in nutritional quality and functional attributes achieved through the strategic incorporation of these ingredients, thereby establishing a scientific basis for their utilization in health-conscious bakery formulations. [4], [10]

#### • Material and method

The materials utilized in this study included commercially sourced all-purpose wheat flour, granulated sugar, fresh pistachios, ground cardamom, and dark chocolate chips. Additional ingredients comprised pasteurized whole eggs, unsalted butter, baking powder, and fresh milk, all acquired from local markets to ensure typical commercial availability and quality for standard muffin preparation. All raw materials underwent preliminary inspection for consistency and quality parameters, such as moisture content and sensory attributes, prior to their incorporation into the muffin formulations to ensure standardized experimental conditions. Muffins were prepared according to a standardized recipe, with precise measurements of each ingredient to maintain uniformity across batches. This meticulous control over ingredient ratios is critical for accurately assessing the isolated impact of pistachio, cardamom, and chocolate on the overall chemical composition and energy value of the final product [11]. The baking process was standardized by preheating the oven to 180°C and baking the muffins for 15 minutes, followed by cooling to room temperature and packaging in polypropylene pouches to preserve their freshness for subsequent analysis [12], [13]. Subsequently, the prepared muffin samples were subjected to a battery of analytical tests to determine their proximate composition, including moisture, ash, crude protein, fat, and carbohydrate content, using established methodologies [1]. Energy value was calculated using established Atwater factors [14].

#### • Results and discussions

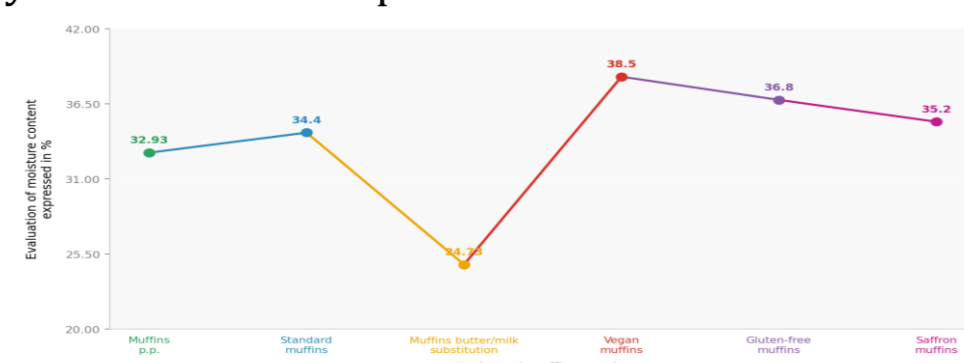
The following table shows the values regarding the chemical composition and energy value of the muffins of own production (p.p.), compared with other types of muffins in the literature.

**Table 1. Values obtained from physicochemical analyses for Muffins with pistachios, cardamom and chocolate p.p. and values taken from the literature for other types of muffins**

Crt. no.	Evaluated muffin samples	Humidity (%)	Fat content (%)	Total protein (%)	pH	Total ash (%)	Energy value (kcal/100 g)
1	Pistachio, cardamom and chocolate muffins p.p.	32.926	11.338	6.366	6.11	1.2	302.71
2	Standard Muffins [15], [16]	34.40	14.00	5.30	6.20	0.89	326.60
3	Muffins with butter/milk substitution [2], [17]	24.73	11.98	8.01	6.30	1.19	313.26
4	Vegan Muffins (No Eggs/Milk/Butter) [5]	38.50	10.55	7.80	6.45	1.05	271.40
5	Gluten-free muffins [6]	36.80	12.10	9.20	6.15	1.35	298.90
6	Muffins with saffron powder [11]	35.20	13.06	6.52	6.25	1.10	328.42
	P.P. – own production						

#### Evaluation of the moisture content (%) of the muffin samples.

Figure 1 shows the variation in humidity in the muffin samples evaluated.

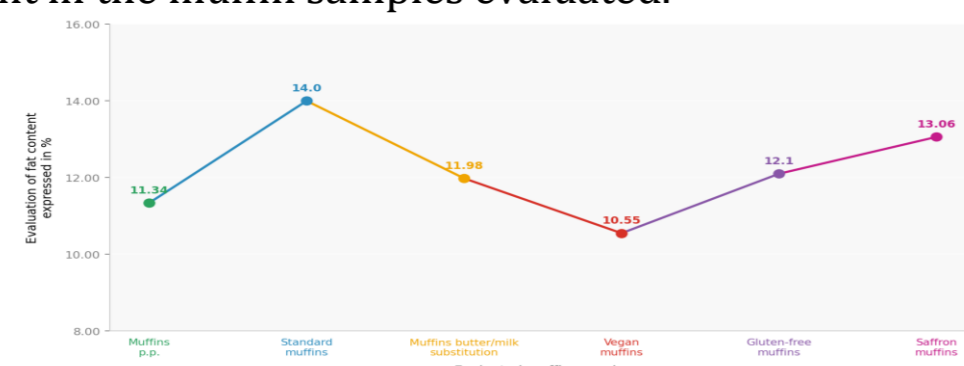


**Figure 1. Humidity variation in muffin samples evaluated**

Muffins with pistachios, cardamom and chocolate p.p. showed a humidity of 32.93%, lower than that recorded for standard muffins (34.40%), vegan muffins (38.50%), gluten-free (36.80%) and saffron powder (35.20%), but higher than the variant with butter and milk substitution (24.73%). This intermediate value suggests that the addition of pistachios and chocolate contributes to a rearrangement of the solid phase, favoring water retention to a moderate extent, but without leading to an excessively moist structure. Compared to standard muffins, the analyzed product has a slightly more compact texture, but more stable than in the case of the substitute version, where low humidity can induce a feeling of dryness.

#### Evaluation of the fat content (%) of the muffin samples.

Figure 2 shows the variation in fat content in the muffin samples evaluated.

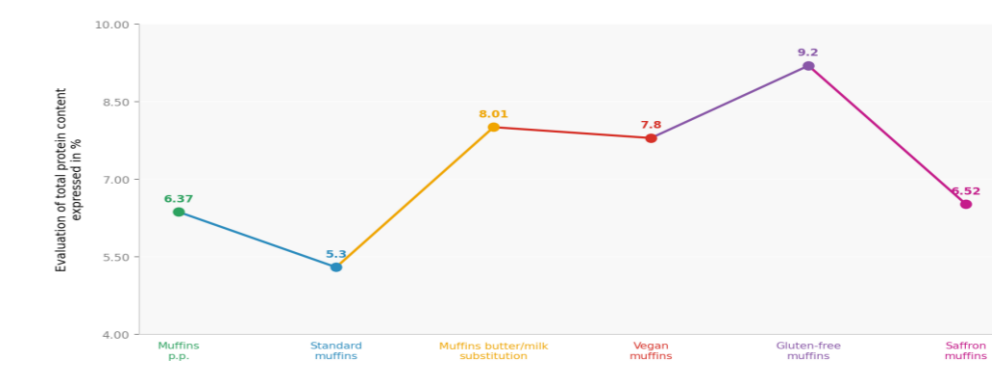


**Figure 2. Variation in fat content in muffin samples evaluated**

The fat content of pistachio, cardamom and chocolate muffins was 11.34%, lower than that of standard muffins (14.00%) and saffron powder muffins (13.06%), but comparable to muffins with butter and milk substitution (11.98%) and higher than the vegan variant (10.55%). This reduction in fat compared to standard muffins indicates a more balanced lipid profile, which can be attributed to the partial replacement of classic fats with plant-based lipids from pistachios. From a nutritional point of view, this aspect is favorable, as it allows obtaining a product with controlled energy density, without significantly affecting the sensory properties.

#### Evaluation of the total protein content (%) of muffin samples.

Figure 3 shows the variation in total protein content in the muffin samples evaluated.

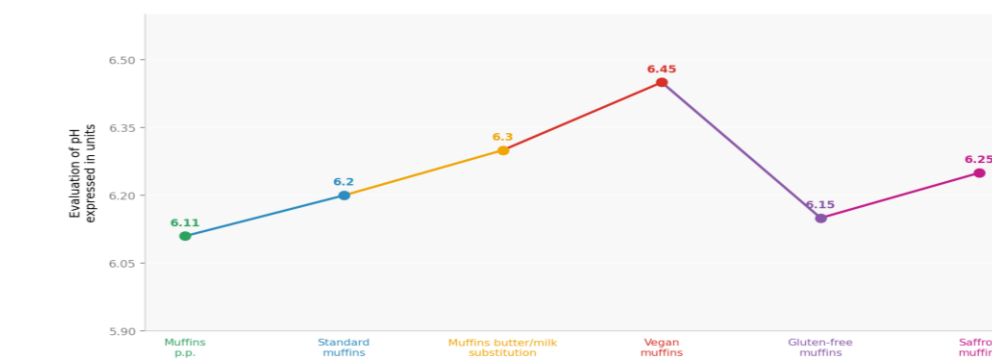


**Figure 3. Variation in total protein content in muffin samples evaluated**

The value of the total protein content for pistachio, cardamom and chocolate muffins was 6.37%, exceeding the level recorded for standard muffins (5.30%) and being close to that of muffins with saffron powder (6.52%). However, it remains lower than vegan (7.80%), butter and milk substitution (8.01%) and gluten-free (9.20%) variants. The increase in protein content compared to standard muffins highlights the protein intake of pistachios, demonstrating the role of functional ingredients in improving nutritional value. At the same time, the moderate values obtained indicate that a balance between the protein and energy components is maintained, suitable for a pastry intended for mass consumption.

#### Evaluation of the pH of muffin samples.

Figure 4 shows the pH variation in the muffin samples evaluated.

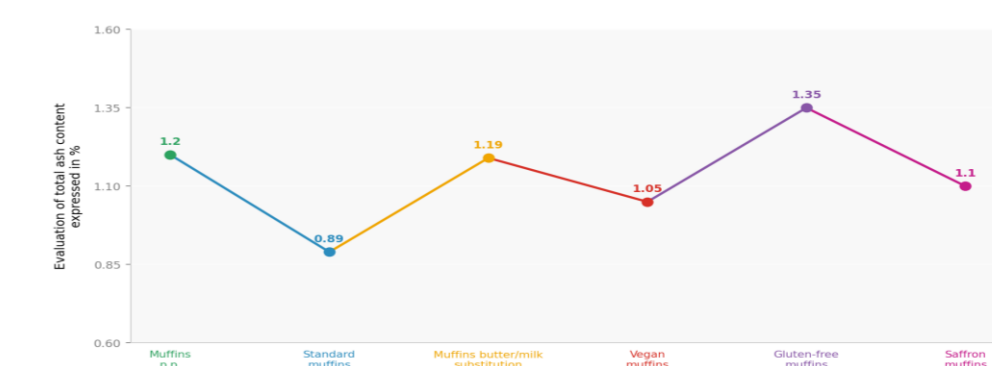


**Figure 4. pH variation in muffin samples evaluated**

Pistachio, cardamom and chocolate muffins recorded a pH of 6.11, slightly lower than that of standard muffins (6.20), but close to gluten-free muffins (6.15). Compared to the vegan (6.45), butter and milk substitution (6.30) and saffron powder (6.25) variants, the analyzed product shows a slight tendency towards acidity. The low pH differences indicate that the added ingredients do not significantly influence the acidity reactions of the dough, keeping the product in the optimal range for microbiological stability and sensory quality.

#### Evaluation of the total ash content (%) of the muffin samples.

Figure 5 shows the variation in total ash content in the muffin samples evaluated.

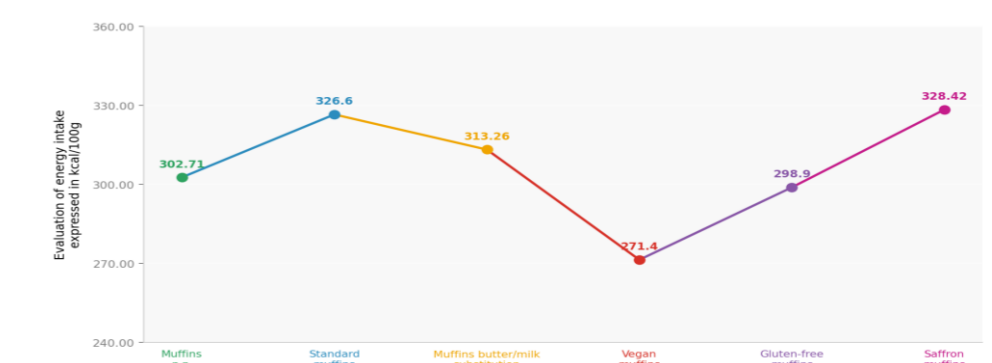


**Figure 5. Variation in total ash content in muffin samples evaluated**

The total ash content of pistachio, cardamom and chocolate muffins was 1.20%, clearly exceeding the value determined for standard muffins (0.89%) and being comparable to the butter and milk substitute variant (1.19%). At the same time, this level is slightly lower than gluten-free muffins (1.35%), but higher than vegan muffins (1.05%) and saffron muffins (1.10%). The increased level of ash reflects a higher mineral content, due to the intake of pistachios and spices, which positively differentiates these muffins from the standard variant from a nutritional point of view.

#### Evaluation of the energy intake (kcal/100 g) of the muffin samples.

Figure 6 shows the energy intake of the muffin samples evaluated.



**Figure 6. The energy intake of the muffin samples evaluated**

The energy intake of pistachios, cardamom and chocolate muffins was 302.71 kcal/100 g, lower than that of standard muffins (326.60 kcal/100 g) and saffron powder muffins (328.42 kcal/100 g). On the other hand, it is higher than that of vegan muffins (271.40 kcal/100 g) and comparable to gluten-free variants (298.90 kcal/100 g) and butter and milk substitution (313.26 kcal/100 g). The reduction in energy intake compared to standard muffins highlights a more balanced caloric profile, the result of decreasing fat content and using ingredients with added nutritional value, without compromising the quality of the product.

#### Conclusions

The present paper analyzed the chemical composition and energy value of pistachio, cardamom and chocolate muffins (own production), comparing the results obtained with the data reported in the literature for different variants of muffins. Based on the physico-chemical determinations performed, the following conclusions can be formulated: The humidity of the muffins p.p. was 32.93%, an intermediate value compared to the other variants analyzed (24.73%–38.50%), which ensures an optimal texture and adequate freshness of the product. This value falls within the range reported for standard muffins in the literature, confirming the technological quality of the manufacturing process. The fat content of 11.34% is significantly lower than standard muffins (14.00%), which demonstrates that the incorporation of pistachio paste allows the reduction of saturated fats in the classic recipe, without compromising the sensory quality of the product. The more balanced lipid profile, with the predominance of monounsaturated fatty acids in pistachios, gives the product a nutritional advantage over conventional variants. The total protein content of 6.37% exceeds the values of standard muffins (5.30%), confirming the protein intake of pistachios as a functional ingredient. This reflects an appropriate balance between the protein and energy component specific to mass consumption pastries. The pH value of 6.11 is within the optimal range for pastries (6.0–6.8), indicating adequate microbiological stability and the absence of technological defects. The slight tendency towards acidity compared to standard muffins (pH 6.20) does not negatively influence the sensory quality or durability of the product. The total ash content of 1.20% clearly exceeds the values of standard muffins (0.89%), reflecting a higher mineral content due to the intake of pistachios and spices (cardamom). Pistachios are a recognized source of magnesium, potassium, phosphorus and iron, which is a significant nutritional advantage of the product. The energy intake of 302.71 kcal/100 g is lower than standard muffins (326.60 kcal/100 g), demonstrating that the use of functional ingredients allows an optimized caloric profile to be achieved without compromising product quality. In conclusion, pistachio, cardamom and chocolate muffins are an innovative pastry product with a superior nutritional profile compared to conventional variants, offering an increased protein and mineral content, reduced fat and an optimized energy value, maintaining the sensory qualities specific to a gourmet product. The results confirm the potential of pistachios, cardamom and chocolate as valuable functional ingredients in the pastry industry, opening up prospects for the development of new formulas with added nutritional value.