

FLAXSEED FLOUR ADDITION ON FATTY ACID PROFILE AND SENSORY PROPERTIES OF BRAZILIAN CHEESE ROLL

Adição de farinha de linhaça no perfil de ácidos graxos e nas propriedades sensoriais do pão de queijo brasileiro

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ABSTRACT

In recent decades, studies on human nutrition have emphasized the importance of omega-3 and 6 intake. Since flaxseed is a good source for such fatty acids, the aim of this study was to develop a Brazilian cheese roll enriched with flaxseed flour. Three formulations were produced to determine the intensity of some sensory attributes and to set the best composition for conducting a consumer acceptance test. In the selected formulation, it was determined the Brazilian cheese roll's expansion rate, its physico-chemical characteristics, fatty acid composition and acceptance rate. Regarding its flavor and general characteristics, the results showed a good acceptance of the cheese roll enriched with flaxseed flour. The product also presented an omega-6/omega-3 ratio of 7.32:1.0, which is within the recommended one. Therefore, the cheese roll enriched with flaxseed presents as a good alternative for the traditional one, specially concerning the omega-3 and omega-6 content, which aggregates nutritional and functional benefits to the product.

Index terms: Sensory evaluation, food analysis, food composition, omega-3, functional food.

RESUMO

Nas últimas décadas, estudos sobre nutrição humana têm enfatizado a importância da ingestão de ômega 3 e 6. Considerando que a linhaça é uma boa fonte desses ácidos graxos, neste estudo, objetivou-se desenvolver um pão de queijo enriquecido com farinha de linhaça. Foram produzidas três formulações para determinar a intensidade de alguns atributos sensoriais e para definir a melhor composição para a realização do teste de aceitação com consumidores. Na formulação selecionada, foram determinadas a taxa de expansão do pão de queijo, suas características físico-químicas, perfil de ácidos graxos e o índices de aceitação. Em relação ao sabor e às características gerais, os resultados mostraram que o pão de queijo enriquecido com farinha de linhaça foi bem aceito pelos consumidores. O produto apresentou também uma razão de ômega 6/ômega 3 de 7,32:1,0, que está dentro do recomendado. Portanto, o pão de queijo enriquecido com linhaça parece ser uma boa alternativa ao pão de queijo tradicional, especialmente no que concerne ao seu conteúdo de ômega-3 e ômega-6, que agrega benefícios nutricionais e funcionais para o produto.

Termos para indexação: Análise sensorial, análise de alimentos, composição de alimentos, ômega-3, alimentos funcionais.

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INTRODUCTION

The Brazilian cheese roll is a kind of cheese bread, a Brazilian specialty. Its historical origin is still inaccurate, but there is evidence of its emergence in Minas Gerais (a Brazilian state) as a result of slaves' creativity in the use of leftover ingredients from the colonial kitchen (ABDALA, 2006). Until the 80s, the production of Brazilian cheese roll was entirely handmade (PEREIRA, 1998). However, there was a strong growth in its production due to the introduction of a process to freeze the product, which led to increased supply and lower price, consequently expanding its trade to other Brazilian states and abroad (PEREIRA et al., 2004).

Being a widely accepted product among Brazilians, the cheese roll is consumed by people of all

ages and from every social class (OLIVEIRA; MORAES, 2009). In Brazil, pre-prepared cheese roll can be found in the market in two main forms: the ready-mix, to which it is necessary the addition of liquid ingredients, before rolling and baking, and the frozen ready cheese roll, which just need baking. Despite the absence of a standardized technology, the manufacturing method adopted by the great majority of cheese roll producers uses cassava starch and/or sour cassava starch, cheese, oil and eggs as basic ingredients (PEREIRA et al., 2004). The cheese roll provides a great source of energy because of its high level of carbohydrates and, as it is known as gluten free, it can be consumed by people with celiac disease (PEREIRA et al., 2004). Hence they are often mentioned as a product with a little or no nutritional value, receiving the designation of "empty

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calories” (PUTNAM; ALLSHOUSE; KANTOR, 2002). In that perspective, the development of a Brazilian cheese roll with a better nutritional value seems to be an alternative to improve the quality of a product which is part of most Brazilian’s consumption habits. It also brings the possibility of including nutrients that the population generally lacks.

Currently has been observed that the foods with functional quality have received special attention from both researchers and consumers (LALOR et al., 2011), representing a fast growing segment in the food industry. In this context, flaxseed (*Linum usitatissimum* L.) attracted interest in the scientific field due to its great potential as functional food. It is a seed with large potential for human nutrition, which has both soluble and insoluble fibers, is rich in essential fatty acids and presents a high level of lipids (32 to 38%), among which 50 to 55% are from the unsaturated fatty acid α -linolenic acid (18:3n-3), belonging to the omega-3 family. It also contains linoleic acid (from the ω -6 family) and monounsaturated and saturated fatty acids (MARQUES et al., 2011). Therefore, considering the present tendency of using ingredients with functional properties, this aim of this study was to develop an enriched with flaxseed flour cheese roll and evaluate the sensory characteristics and fatty acid composition of the product.

MATERIAL AND METHODS

Production of cheese roll enriched with flaxseed flour

The golden flaxseeds, purchased in the local market in Blumenau (Santa Catarina, Brazil), were washed under tap water, left soaking in a 5ppm sodium hypochlorite solution for 15 minutes and rinsed out again under tap water. After that, they were dried up in a semi-industrial oven (PRP-400 model, Progás, Caxias do Sul, Rio Grande do Sul, Brazil) at 100° C for 20 minutes and ground in a blender (Metvisa, Brusque, Santa Catarina, Brazil) until obtaining a fine flour.

Three formulations of cheese roll (F1, F2 and F3) were initially produced by adding 1.0, 5.0 and 10.0 g of flaxseed flour to 100g of the basic formulation presented in table 1. Afterwards, for the acceptance test and all the other analysis, a new formulation was produced by adding 2.5g of flaxseed flour to 100 g of the basic formulation. This was done due to the high aroma and flavor of flaxseed presented in formulations F2 and F3 reported by the trained panel.

Table 1 – Basic formulation of the cheese roll used in this study.

Ingredients	Quantity (g)
Cassava starch	28.07
Sour cassava starch	16.84
Minas Frescal cheese ^a	8.43
Parmesan cheese	5.61
Soybean oil	5.41
Water	30.87
Salt	0.84
Margarine	1.68
Cheese flavor	2.25
TOTAL	100

^a Minas Frescal cheese: type-cheese originally made in the state of Minas Gerais, Brazil.

The production steps of the cheese roll enriched with flaxseed flour is presented in figure 1. The first step was to scald cassava starch and sour cassava starch. The scalding was done through mixing those ingredients with soybean oil and margarine in boiling water. Then the mixture was agglutinated to the other ingredients in a semi-industrial mixer (BP-12SL model, Lieme, Caxias do Sul, Rio Grande do Sul, Brazil). The cheese roll units were manually shaped (20 g each unit) and packed in low density polyethylene bags. Since the aim of this study was to develop a formulation that could be sold frozen in markets, the cheese roll units had been frozen in a freezer (310 model, Consul, Joinville, Santa Catarina, Brazil) for at least two days. Just prior to each analysis, the frozen units were baked at 170° C for 30 minutes, in a semi-industrial oven (PRP-400 model, Progás, Caxias do Sul, Rio Grande do Sul, Brazil).

Sensory Evaluation

The sensory evaluation performed in this research was approved by the Research Ethics Committee of the Regional University of Blumenau (*Universidade Regional de Blumenau - FURB*, Blumenau, Santa Catarina, Brazil), filed under n° 099/09, according to the resolution 196/96 from the National Council of Health, in accordance with the Declaration of Helsinki of 1995. The tests were performed at room temperature, under white light, between 9:00 a.m. and 11:00 a.m. and between 2:00 p.m. and 5:00 p.m. (MEILAGAARD; CIVILLE; CARR, 2007).

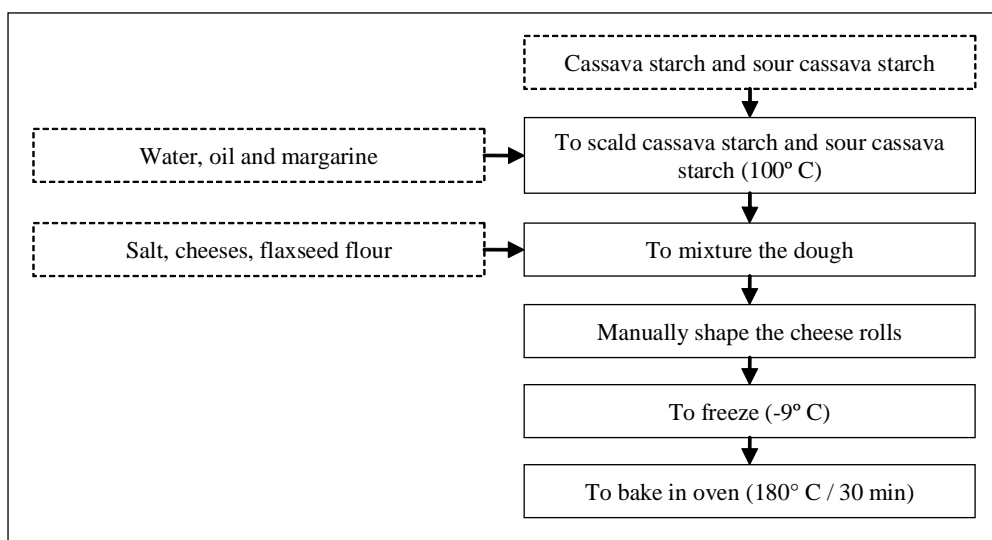


Figure 1 – Production steps of the Brazilian cheese roll enriched with flaxseed flour.

In order to verify the intensity of the attributes - cheese flavor, flaxseed flavor, acid taste, salty taste, flaxseed smell, cheese smell, crispness of the crust and elasticity of the dough - among samples from the three formulations (F1, F2 and F3), it was used a ranking test based on a structured 7-point scale, using five trained panelists (MEILAGAARD; CIVILLE; CARR, 2007). The cheese roll units (20 g) were placed in dishes coded with three digits and between the tasting, water was offered to the panel. The presentation order was randomized for each session and the tests were performed in triplicate.

The acceptability was evaluated using sensory affective tests in cheese roll containing 2.5 g of flaxseed flour. The acceptance test was performed using a structured 9-point hedonic scale, with verbal terms at the ends and midpoint (STONE; SIDEL, 1993), varying from 1:disliked extremely to 9:liked extremely. One hundred consumers, of both genders, who were randomly chosen at FURB, took part in the acceptance test. It was also asked to the panel to mention the characteristics they liked more and less in the sample tasted, and the intention to purchase the product according to a 3-point scale, varying from 1:definitively would not buy to 9:definitively would buy. Data from acceptance test were analyzed through descriptive statistic (mean and standard deviation) and the acceptance rate (AR) was calculated as the ratio between the mean value of the test (M) by the highest value (H), as follows: $AR(\%) = (M \cdot 100) / H$ (TEIXEIRA; MEINERT; BARBETTA, 1987). Products are considered accepted when the average score is greater than 7 ± 0.5

according to Stone and Sidel (1993) and if the acceptance rate is greater than 70% (TEIXEIRA; MEINERT; BARBETTA, 1987).

Physico-chemical characterization

The analysis of moisture content and pH were performed according to the Association of Official Analytical Chemists-AOAC methods 925.10 (2000) and 935.39 (2000), respectively. Water activity (a_w) was performed using the water activity meter (AquaLab, Decagon) with direct reading of the samples. All the tests were performed in triplicate in the cheese roll units and in the flaxseed flour. For comparative purposes, two commercial brands of traditional Brazilian cheese roll (without flaxseed flour) were also analyzed under the same conditions.

Determination of cheese roll's expansion rate

In order to determine if the enrichment with flaxseed flour had influence on the expansion rate of cheese roll, it was also performed a test for comparative purposes with products from two commercial brands. The expansion rate (Exp) was calculated by the ratio between $K1$ (baked cheese roll diameter + baked cheese roll height / 2) and $K2$ (diameter of shaped dough + shaped dough height / 2), $Exp = K1/K2$, according to Pereira et al. (2004), and the tests were also performed in triplicate.

Gas chromatographic analysis of fatty acids

The fatty acids composition, from C8 to C24, were determined through gas chromatography (GC), according

to the AOAC method 996.06 (2000). The values were expressed in grams of fatty acids per 100 grams of product. The chromatographic analysis was performed in the Laboratory of Analysis at Federal University of Santa Catarina (*Laboratório de Análises, Universidade Federal de Santa Catarina - UFSC, Florianópolis-SC/Brazil*) in a Agilent 6890N GC instrument (Agilent Technologies) equipped with a Quadrex capillary column (60 m x 0.25 mm, 0.25 μ m) (Quadrex) and a flame ionization detector. The column started at 60° C and the temperature was increased by 5° C/min and maintained at 225° C isothermal form. Hydrogen was used as the carrier gas, with a linear velocity of 1.6 m/min; injection volume was 1 μ L, with a split ratio of 1:100.

Statistical analysis

The results were statistically analyzed by variance analysis (ANOVA), using the software Statistica 7.0 (StatSoft, Inc. Tulsa, OK, EUA). Statistical differences at p-values under 0.05 were considered significant and subsequently compared using Tukey's test.

RESULTS AND DISCUSSION

Sensory evaluation of the cheese roll enriched with flaxseed flour

The statistical results of the scores assigned by the trained panelist for each attribute, and for each formulation of the cheese roll enriched with flaxseed flour are presented in table 2. The results showed that there was a remarkable

difference ($p < 0.05$) between at least two samples, for all the evaluated attributes, except for the crispness of the crust.

The sensory profile of the formulations is graphically shown in figure 2, where the mean value assigned by the trained panel to each attribute is scored on the corresponding axis. The center of the figure corresponds to the zero point on the scale used in the evaluation, while the intensity increases from the center to the periphery.

It was observed that the formulation F3 has differed from the others by having a remarkable flaxseed flavor, due to the increase in the amount of flaxseed flour. This sample also presented a higher flaxseed smell, however it has not differed from formulation F2. On the other hand, the sample F1 presented the highest intensity regarding both flavor and aroma of cheese, due to the lower flaxseed flour content of this sample. The formulation F3 also presented a saltier taste, which may be associated with the higher flaxseed flour concentration. The flaxseed presents a high potassium content, 869mg/100g (NÚCLEO DE ESTUDOS E PESQUISAS EM ALIMENTAÇÃO-NEPA, 2011), and it is usually found as potassium chloride, which has a salty taste similar to sodium chloride.

Regarding elasticity, the higher the amount of flaxseed flour, the smaller the amount of water available in the dough. If a large amount of water is added, it gets softer and stickier, while a water scarcity makes it harder and with no adherence (PEREIRA et al., 2004). In addition, sour cassava starch produces lighter and more elastic dough with higher volume and more porous texture

Table 2 – Mean of values assigned by the trained panel to each attribute for the enriched cheese roll's formulations (F1, F2 and F3).

Attributes	Formulations		
	F1	F2	F3
Cheese flavor	4.4 \pm 1.8 ^a	3.0 \pm 1.2 ^{ab}	2.6 \pm 1.5 ^b
Cheese smell	3.0 \pm 1.5 ^a	1.2 \pm 0.4 ^b	1.8 \pm 1.0 ^{ab}
Sour flavor	1.6 \pm 1.3 ^a	1.8 \pm 1.0 ^{ab}	3.6 \pm 1.8 ^b
Flaxseed smell	2.6 \pm 2.0 ^a	4.2 \pm 1.6 ^{ab}	5.8 \pm 1.6 ^b
Flaxseed flavor	2.0 \pm 1.4 ^a	3.6 \pm 1.6 ^a	6.6 \pm 0.8 ^b
Salty taste	3.0 \pm 1.4 ^a	3.4 \pm 1.1 ^a	5.8 \pm 1.0 ^b
Elasticity of the dough	5.0 \pm 0.7 ^{ab}	5.6 \pm 1.6 ^a	4.0 \pm 1.2 ^b
Crispness of the crust	4.6 \pm 0.8 ^a	5.4 \pm 1.1 ^a	5.8 \pm 1.0 ^a

Data are expressed as means and standard deviation (SD) ($n=3$). Means \pm SD followed by the same letter, within a line, do not statistically differ by Tukey's test at 5% of confidence level.

(PEREIRA, 1998). These factors suggest the reduced elasticity of dough in the cheese roll produced with a higher concentration of flaxseed flour.

Although cheese contributes to the typical aroma and flavor of cheese roll and to some technological parameters (PEREIRA et al., 2004), it increases the saturated fat and cholesterol levels. The use of artificial cheese flavoring reduces the need of increasing the quantity of cheese in the formulation. However, even with its use, there was a remarkable difference in the sensory characteristics of the cheese roll containing the highest (10.0 g) and the lowest (1.0 g) concentration of flaxseed flour tested in this study. Moreover, although the formulations F1 and F2 have shown statistically the same values for most of the attributes, the trained panel highlighted that the sample F2 still presented high aroma and flavor of flaxseed and low aroma and flavor of cheese, which could compromise the product acceptance.

Thus, in order to perform the acceptance test and further analysis, an intermediate concentration (2.5 g) of flaxseed flour was used. Concerning the acceptance test, the new formulation (with 2.5 g of flaxseed flour) was well accepted, receiving an average score of 7.2 ± 0.88 within a 9-point scale, and an acceptance rate of 79.5%.

Determination of physico-chemical characteristics and expansion rate of the cheese roll enriched with flaxseed flour

When observing table 3, it is possible to notice that the cheese roll containing 2.5 g of flaxseed flour does not statistically differed from the commercial brands of Brazilian cheese roll.

According to table 3, the value of pH for the cheese roll enriched with flaxseed flour is similar to those for commercial brands. Pereira et al. (2005) also studied three different commercial brands of frozen cheese roll and found

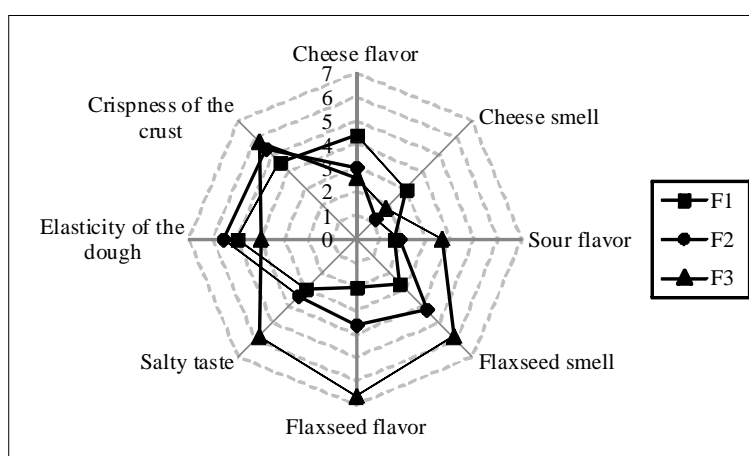


Figure 2 – Sensory profile of the enriched cheese roll's formulations (F1, F2 and F3).

Table 3 – Values of pH, moisture content, water activity (a_w) and expansion rate of flaxseed flour and of the cheese roll's samples (samples containing 2.5 g of flaxseed flour and commercial samples from brands 1 and 2).

Parameter	Flaxseed flour	<i>Brazilian cheese roll</i>		
		With flaxseed flour	Commercial brand 1	Commercial brand 2
pH	6.69 ± 0.9	6.07 ± 0.8^a	6.43 ± 0.5^a	6.05 ± 0.7^a
Moisture (%)	6.20 ± 1.1	39.00 ± 1.9^a	39.00 ± 1.3^a	40.00 ± 0.8^a
a_w	0.610 ± 0.3	0.964 ± 0.6^a	0.979 ± 0.2^a	0.978 ± 0.9^a
Expansion rate	-	1.17 ± 1.5^a	1.32 ± 1.0^a	1.46 ± 2.2^a

Data are expressed as means and standard deviation (SD) ($n=3$). Means \pm SD followed by the same letter, within a line, do not statistically differ by Tukey's test at 5% of confidence level.

average values of pH of 5.83 for the baked dough. Silva et al. (2009) found that the pH of cheese roll presented a small decrease in the values found until 120 days of freezing storage, varying from 5.54 to 5.08.

The moisture content values found in this study are close to those reported by Pereira et al. (2005), who found values near from 40% of moisture for the frozen dough and 30% for the baked dough. The water activity is related to the moisture level. Park and Antonio (2006) highlight that the quantification of water content in food products is important for its conservation. Water in a food matrix can have different functions, depending on its availability and the other components of the product. In addition, it influences food transformation reactions, which can be microbiological, physical or chemical. The water activity in the cheese roll enriched with flaxseed flour showed no significant difference in comparison to the ones in the commercial samples.

Regarding the cheese roll expansion rate in a study developed by Pereira et al. (2004), when evaluating the function of ingredients in the dough consistence and in the visual characteristics of cheese roll, the expansion rate of the dough containing cassava starch, milk, oil, salt, egg and cheese was 3.27. The same study also evaluated a type of dough containing all those ingredients except eggs and obtained 1.56 for it, a value similar to the one found in this study for the cheese roll enriched with flaxseed flour (1.17). This last composition had no eggs either. Moreover, the expansion rate of the enriched cheese roll was also similar to the commercial ones.

Fatty acid profile of the cheese roll enriched with flaxseed flour

For the International Society for the Study of Fatty Acids and Lipids-ISSFAL (2004), the intake of omega-3 is 2.2 g/day and the intake of omega-6 for adults is 4.4 g/day. According to the Food and Nutrition Board of the Institute of Medicine (2002), the recommendations for daily intake

for adults ranges from 5 to 10% and from 0.6 to 1.2% of the total amount of energy for fatty acids omega-6 and omega-3, respectively. The fatty acids composition of the cheese roll enriched with 2.5 g of flaxseed flour is presented in table 4. The obtained results show that every 100g of this cheese roll has respectively 0.5g and 3.66g in relation to the levels of omega-3 (C18:3n3c and C20:5n3) and omega-6 (C18:2n6c). The enriched cheese roll does not satisfy the recommended daily intake for these fatty acids, but it contributes with it.

It is known that the convergence trend of the ratio between omega-6 and omega-3 fatty acids (n-6/n-3), in the diet should be within the interval of 4:1 to 10:1 (HEALTH AND WELFARE CANADA, 1990; FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS-FAO; WORLD HEALTH ORGANIZATION-WHO, 1993). Ratios from 2:1 to 3:1 have been recommended by some authors, by allowing a higher alpha-linolenic acid conversion into docosahexaenoic acid (DAH), which reaches its maximum values around 2.3:1, as demonstrated by Masters (1996). On the other hand, diets based in ratios inferior to 1:1 are not recommended, as long as they inhibit the conversion of linolenic acid into polyunsaturated fatty acids of very long chain (AGPI-CML) (MARTIN et al., 2006).

According to Martin et al. (2006), in several countries the average intake of fatty acids results in a n-6/n-3 relation within a proportion of 10:1 and 20:1, despite the fact that there are records of relations reaching 50:1. The omega-6 excess, which increases the relation n-6/n-3, is found in Western diets today, promoting the pathogenesis of several illnesses, including cancer, cardiovascular illnesses, inflammatory and autoimmune diseases. A lower proportion of n-6/n-3 fatty acids is more desirable to reduce the risk of chronic diseases of high prevalence in Western societies, as well as in developing countries (SIMOPOULOS, 2004). Therefore, considering that the flaxseed-enriched cheese roll presented an omega-

Table 4 – Fatty acid profile of the cheese roll enriched with 2.5 g of flaxseed flour, in grams per 100g of the product.

Composition (g/100g)	0.05	0.10	0.01	0.20	0.52	0.04	0.05	2.65	0.08	0.04	0.01	0.98	4.36	3.66	0.05	0.43	0.01	0.05	0.02	0.01	0.07	0.03	0.01	0.07
Fatty acids	C8:0	C10:0	C11:0	C12:0	C14:0	C14:1	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1-c9	C18:2n6c	C18:2n6t	C18:3n3c	C18:3n3t	C20:0	C20:1	C20:2n6	C20:5n3	C22:0	C22:2	C24:0

6/omega-3 ratio of 7.32:1.0, it is possible to verify that it remained within the parameter mentioned for the n-6/n-3 polyunsaturated fatty acids ration.

CONCLUSIONS

The cheese flavor decreased the need for cheese addition and it may contribute to a lower content of saturated fat and cholesterol in the cheese roll. However, the addition of flaxseed flour in a more meaningful quantity still compromises the sensorial acceptance of cheese roll. Moreover, it is suggested that the addition of flaxseed flour affects negatively the cheese roll elasticity.

This research showed that the cheese roll enriched with 2.5 g of flaxseed flour is a product appreciated by the consumers, regarding general aspects and flavor. This cheese roll enriched with flaxseed flour presents advantages when compared to the conventional ones, as it contains omega-3 and omega-6 fatty acids, which add nutritional and functional benefits to the product. This product does not satisfy the recommended daily intake for those fatty acids, but it contributes with it.

Therefore, it is suggested to the related food industry, the possibility of offering a cheese roll with both energetic and functional properties, considering the existing market. However it must be highlighted that the flaxseed flour must be added in a low amount due to the possible changes it may cause in the typical sensory characteristics of the Brazilian cheese roll.

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