



USE OF FLAXSEED (*Linum usitatissimum* L.) PROCESSING PRODUCTS AS A SOURCE OF DIETARY FIBER IN CHOCOLATE MILK POWDER

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ABSTRACT – This study evaluated the use of flaxseed-derived dietary fiber concentrates as a supplement in chocolate milk powder. Two types of concentrates were obtained: soluble and insoluble dietary fiber. The enriched formulations showed an approximately fourfold increase in fiber content compared to the control formulation. The results indicated that the addition of these concentrates allowed the product to be classified as a fiber source, meeting Brazilian regulations. The research highlights the potential of flaxseed processing fractions in the development of functional food products. Future studies should be conducted to assess the sensory and technological feasibility of these formulations.

RESUMO – Este estudo avaliou o uso de concentrados de fibra alimentar derivados da linhaça como suplemento em achocolatado em pó. Dois tipos de concentrados foram obtidos: fibra alimentar solúvel e insolúvel. As formulações enriquecidas apresentaram um aumento de aproximadamente quatro vezes no teor de fibra alimentar em relação à formulação controle. Os resultados indicaram que a adição dos concentrados permitiu classificar o produto como fonte de fibras, atendendo à legislação brasileira. A pesquisa destaca o potencial de frações do processamento da linhaça no desenvolvimento de produtos alimentícios funcionais. Estudos futuros deverão ser conduzidos para avaliar a viabilidade sensorial e tecnológica dessas formulações.

KEYWORDS: flaxseed gum, functional food, product development

PALAVRAS-CHAVE: goma de linhaça, alimento funcional, desenvolvimento de produto



1. INTRODUCTION

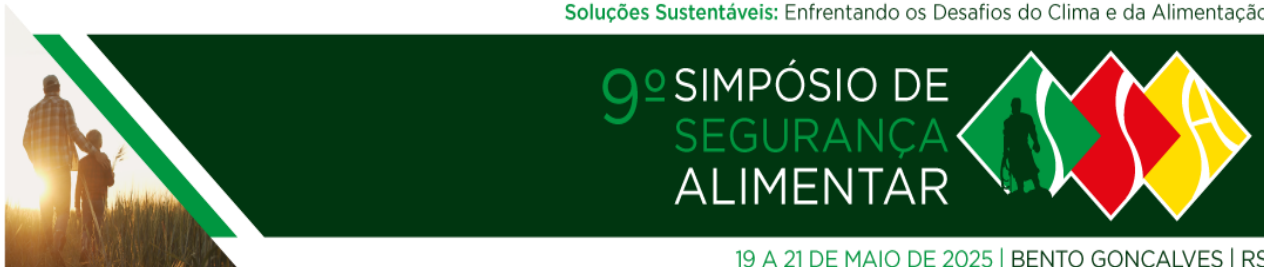
Flaxseed is a versatile oilseed that has been explored for various applications. The majority of global flaxseed production is directed toward oil extraction, primarily of interest to the chemical industry, as well as the pharmaceutical and food industries for both human and animal consumption. Additionally, flaxseed fibers are widely used in the textile industry (Rossetto, 2012). According to IBGE (2020), nearly 100% of Brazil's flaxseed production is concentrated in Rio Grande do Sul (RS). This crop serves as an important winter cultivation option for farmers in the region. Besides being a viable alternative for crop rotation with wheat – Rio Grande do Sul's main winter crop – it benefits the production system and contributes to income diversification in small-scale farms, predominantly based on family farming (Velho & Lúcio, 2021).

Currently, flaxseed oil is the primary industrial product derived from the seed. In conventional processing, the oil is extracted by pressing, yielding not only the oil but also flaxseed meal, which still contains a significant amount of dietary fiber. Optimizing this process enables the extraction of fractions rich in soluble and insoluble fiber, as well as protein, allowing the production of value-added concentrates within the flaxseed production chain. One example is seed degumming before oil extraction, a process aimed at obtaining flaxseed gum, which is particularly rich in soluble dietary fiber. Ziolkovska (2012) highlights that fractionating seed polysaccharides prior to oil extraction can enhance process efficiency and improve oil yield.

Chocolate milk powders represent promising matrices for studies involving specially flaxseed gum, considering both its role as a stabilizer and thickener – since these products require ingredients that influence viscosity and maintain desirable flow properties (Afoakwa, 2010) – and its potential functionality as a source of soluble fiber.

Studies report the use of flaxseed gum in concentrations ranging from 0.1% to 2.5% in food products, depending on its intended function and the food matrix in which it is incorporated (Soukoulis *et al.*, 2018). Kristensen (2012), for instance, compared the biological effects of consuming a flax fiber supplement in two different food matrices – a beverage and a baked product – and found that both reduced total cholesterol and LDL levels. However, the beverage demonstrated greater effectiveness, indicating that the food matrix and/or processing significantly influence metabolic effects.

This study aimed to analyze the nutritional composition of two fractions obtained from an optimized flaxseed processing system – an insoluble dietary fiber concentrate and a soluble dietary fiber concentrate – and to investigate their feasibility as dietary fiber supplements in chocolate milk powder.



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2. MATERIAL AND METHODS

Soluble dietary fiber concentrate (SDFC) and insoluble dietary fiber concentrate (IDFC) were obtained and provided by the Aquaculture Laboratory of the Department of Animal Science at the Federal University of Santa Maria, following the method described by Adorian *et al.* (2022), with modifications involving the exclusive use of water as a solvent in the degumming process of flaxseed. The SDFC underwent spray drying to obtain a powdered form, while the IDFC was ground using a ball mill at 400 rpm for 2 minutes and then sieved through a 0.212 mm mesh.

Chocolate milk powder formulations were produced on a laboratory scale at the facilities of the Department of Food Science and Technology at the Federal University of Santa Maria. The control formulation (Control) was prepared using 13 g of skimmed milk powder, 10 g of granulated sugar, and 2 g of cocoa powder (for dilution in 100 mL of water). Based on this formulation, two variations (F70:30 and F80:20) were developed by incorporating blends of SDFC and IDFC in calculated amounts to achieve approximately 1.25% dietary fiber in the final product (after dilution in water). Formulation F70:30 was prepared with an expected insoluble-to-soluble fiber ratio of 70:30 (2.62 g of IDFC and 0.76 g of SDFC), while F80:20 had a ratio of 80:20 (3 g of IDFC and 0.36 of SDFC).

The proximate composition analyses included the determination of moisture, ash, protein, fat, and dietary fiber content. Dry matter was measured by water evaporation at 105°C, while ash content was determined by organic matter elimination at 550°C (AOAC, 1995). The protein percentage was analyzed using the micro-Kjeldahl method (AOAC, 1995), and fat content was determined via cold extraction (Bligh & Dyer, 1959). Total, soluble, and insoluble dietary fiber were quantified using the enzymatic-gravimetric method (AOAC, 1995). These results also enabled the estimation of the approximate carbohydrate content.

Data were collected from two batches of chocolate milk powder, with analyses performed in duplicate. Statistical analysis was conducted using a completely randomized design, with sample mean comparisons performed via Tukey's test at a 5% significance level, using the Statistica 10.0 software (StatSoft Inc., Tulsa, USA). Results were expressed as mean \pm standard deviation.

3. RESULTS AND DISCUSSION

The results of the nutritional composition analysis of SDFC and IDFC are presented in Table 1.



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Table 1 – Nutritional facts of flaxseed soluble dietary fiber concentrate (SDFC) and insoluble dietary fiber concentrate (IDFC). *Not detected.

Nutritional facts (%)	SDFC	IDFC
Dry mater	90.53 ± 0.12	95.76 ± 0.12
Ash	13.75 ± 0.02	2.92 ± 0.04
Protein	20.73 ± 1.39	37.68 ± 0.79
Fat	0.27 ± 0.18	7.27 ± 0.44
Dietary Fiber	35.06 ± 4.63	45.28 ± 2.21
Insoluble Dietary Fiber	ND*	33.35 ± 0.88
Soluble Dietary Fiber	35.06	11.93
Carbohydrates	20.72	2.62

As expected, dietary fiber was the predominant component in both analyzed samples, confirming the findings of previous studies on these fractions (Adorian *et al.*, 2022).

The results of the nutritional composition analysis of chocolate milk powder are presented in Table 2.

Table 2 – Nutritional facts of chocolate milk powder formulations prepared with flaxseed fiber at expected insoluble-to-soluble ratios of 70:30 (F70:30) and 80:20 (F80:20), compared to a control formulation without flaxseed fiber (Control).

Nutritional facts (%)	Control	F70:30	F80:20
Dry mater	96.31 ± 0,07 ^b	95.74 ± 0.08 ^a	95.93 ± 0.14 ^a
Ash	4.33 ± 0,01 ^a	4.71 ± 0.02 ^a	4.47 ± 0.11 ^a
Protein	18.92 ± 1,44 ^a	21.74 ± 1.32 ^a	21.15 ± 1.88 ^a
Fat	1.56 ± 0,14 ^b	2.00 ± 0.19 ^a	2.12 ± 0.08 ^a
Dietary Fiber	2.05 ± 0,61 ^b	7.87 ± 1.32 ^a	8.43 ± 0.50 ^a
Insoluble Dietary Fiber	1.23 ± 0,37 ^b	5.30 ± 0.68 ^a	6.21 ± 0.03 ^a
Soluble Dietary Fiber	0.82	2.57	2.22
Carbohydrates	67.40	51.00	51.88

Compared to the control formulation, the formulations enriched with fiber concentrates exhibited an approximately fourfold increase in dietary fiber content. Significant differences were



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observed between the control formulation and the fiber-enriched formulations regarding dry matter and fat content, although to a lesser extent.

It is important to highlight that, for functional claims in food products, Brazilian regulations allow such claims only if the ready-to-consume portion provides at least 2.5 g of dietary fiber (BRASIL, 2018). Given that chocolate milk powder is intended for beverage preparation and the recommended serving size is 200 mL, the diluted product exceeds the minimum required amount, ensuring its classification as a source of dietary fiber.

In this context, it is also noteworthy that, compared to other commercially available gums, flaxseed gum exhibits lower viscosity, which facilitates food fortification. This characteristic can enhance sensory attributes without causing excessive texturization, even when a significant fiber concentration is required to deliver health benefits (IBRÜGGER *et al.*, 2012).

When diluted in water, the formulations enriched with fiber concentrates displayed a visual appearance similar to the control formulation, a slightly higher viscosity, and minimal changes in flavor and aroma. However, at this stage, the sensory attributes have only been evaluated empirically.

4. CONCLUSIONS

The optimized processing of flaxseed proves to be a promising approach, as it enables the production of dietary fiber concentrates that add value to processing and can be incorporated as supplements in food products.

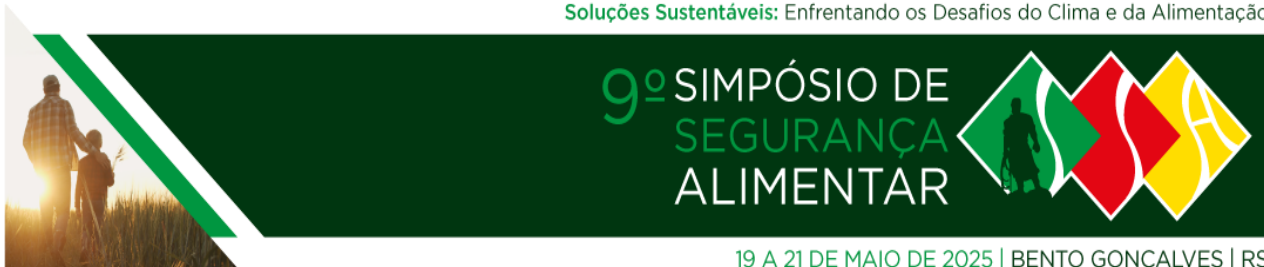
The addition of flaxseed dietary fiber concentrates to chocolate milk powder increased the fiber content by approximately four times compared to the control formulation. Moreover, it transformed a product that is conventionally not considered a source of dietary fiber into an option with this nutritional appeal.

Future studies, particularly those involving sensory analysis, will be essential to assess the technological feasibility of using these concentrates in chocolate milk powder.

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