European Journal of Food Science and Technology, 13 (1), 62-72, 2025
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Panela-Type Cheese Enriched with Canola Oil and Almonds: Design and Market Study

Jesús Hernández-Ruiz, Karla Mireya Martínez-Castro, Ávila-García Lorenzo Jarumi Aguilar-Guggembuhl
Ingeniería Industrial, Tecnológico de Estudios Superiores de Chalco. Carretera México Cuautla s/n. La Candelaria Tlapala, Chalco Estado de México. C.P. 56640.

doi: https://doi.org/10.37745/ejfst.2013/vol13n16272 Published September 19, 2025

Citation: Hernández-Ruiz J., Martínez-Castro K.M., Aguilar-Guggembuhl.A.L.J (2025) Panela-Type Cheese Enriched with Canola Oil and Almonds: Design and Market Study, *European Journal of Food Science and Technology*, 13 (1), 62-72

Abstract: *In this study, panela-type cheese was enriched, and a market study was carried out by incorporating ground almonds and canola oil in order to produce a functional food and commercialize it. Raw milk was obtained from the region, pasteurized, and when it reached 45 °C, a commercial rennet was added. The curd was separated and divided into four portions. Curd portion 1 was salted, mixed, placed in a mold, and compacted. The same process was applied to the other three portions: portion 2 received 5% ground almonds (relative to weight), portion 3 received 5% canola oil, and portion 4 received both 5% ground almonds and 5% canola oil. After 24 hours, a consumer acceptance sensory evaluation was carried out using untrained judges. A semi-structured hedonic survey was used (scale 0 = negative to 10 = maximum acceptance), evaluating color, odor, creaminess, graininess, softness, and overall acceptance. Data were analyzed using ANOVA and Duncan's multiple range test at p = 0.05. For the market study, the CANVAS methodology was followed. The sensory evaluation showed no significant differences in color and odor indicators, which positively impacted acceptance since the enrichment with almonds and/or canola oil was not a rejection factor for consumers. Regarding creaminess and graininess, significant differences were observed ($p < 0.03$ and $p < 0.02$, respectively). The sample enriched with both canola oil and almonds achieved the highest creaminess rating, followed by the sample enriched only with canola oil, while the most grainy sample was the one enriched only with almonds—though these were highlighted as desirable attributes. The softness and overall acceptance indicators were highly significant: the softest cheese was the one enriched with oil, and the highest overall acceptance was for the cheese enriched with both canola oil and almonds. Therefore, the product was considered suitable for commercialization, which the CANVAS study confirmed as viable.*

Keywords: Functional foods, value added products, food innovation.

European Journal of Food Science and Technology, 13 (1), 62-72, 2025
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

INTRODUCTION

Panela-type cheese is a traditional Mexican food widely accepted and consumed, mainly due to its mild flavor, low fat content, and culinary versatility (González-Tenorio et al., 2020). Recently, and as a result of health problems associated with food consumption, there has been a growing interest in functional foods with added nutritional value. Consequently, the dairy industry faces the challenge of developing innovative products that contribute to a balanced and healthy diet (FAO, 2021). In this context, the incorporation of functional ingredients such as canola oil and almonds represents a viable strategy to improve the nutritional profile of panela cheese. Canola oil is a rich source of monounsaturated fatty acids and omega-3, known for their cardioprotective effects and their role in preventing non-communicable chronic diseases (Jones, P. J., et al., 2020). On the other hand, almonds provide plant-based proteins, dietary fiber, antioxidants, and essential minerals, making them an ideal complement to enrich dairy products (Chen et al., 2021).

The development of a panela-type cheese enriched with these ingredients aims not only to improve the nutritional content of the final product, but also to respond to new market demands for healthier and more functional foods. This article presents the design of such a product, as well as a market study aimed at understanding consumer acceptance, preferences, and willingness to pay for a cheese enriched with additional health benefits.

THEORETICAL FRAMEWORK:

Consumption of Fresh Cheeses in Mexico

The consumption of fresh cheeses in Mexico is significant, with panela cheese, along with other fresh cheeses such as Oaxaca and doble crema, being the most consumed due to their mild flavor, low fat content, and culinary versatility (González-Tenorio et al., 2020). The national cheese consumption in Mexico exceeds 400,000 tons annually, which translates into an approximate per capita consumption of 4 kilograms per year. Although this figure has shown growth, it remains low compared to European countries such as the Netherlands, where consumption exceeds 18 kilograms per person per year (Agroberichtenbuitenland, 2021; BmEditores, 2023).

Mexico is positioned as one of the main cheese producers in Latin America, ranking third in the region and tenth worldwide, with an estimated annual production of around 250,000 tons, predominantly fresh cheese varieties (The Food Tech, 2023). The states with the highest cheese production are Jalisco, Guanajuato, Chihuahua, and Chiapas (The Food Tech, 2023). Cheese consumption represents approximately 9% to 10% of the food budget in Mexican households, allocating about 24% of that expenditure specifically to cheese products (Voz de las Empresas, 2023).

Panela cheese is a fresh dairy product of Mexican origin, made from pasteurized cow's milk, without maturation and with low fat content (NOM-223-SSA1-2018). Its high acceptance in the Mexican market is due to various attributes such as economic accessibility, mild flavor, culinary versatility, and its nutritional contribution (INEGI, 2021). This type of cheese contains proteins of high biological value, calcium, phosphorus, and B-complex vitamins, in addition to a moderate fat content, making it an appropriate food within healthy diets (Secretaría de Salud, 2019).

Functional foods and their importance

Functional foods are those that, in addition to providing basic nutrients for nourishment, contain bioactive components that offer additional health benefits and can help prevent diseases or improve certain physiological functions (Granato et al., 2020). This concept has evolved from the growing consumer demand for products that not only nourish but also contribute to overall well-being and the prevention of chronic conditions such as cardiovascular diseases, diabetes, obesity, and inflammatory disorders (Hasler, 2002). Currently, there is a trend in the food industry focused on the development of functional foods. In this context, the fortification of traditional products with functional ingredients such as nuts or vegetable oils rich in bioactive compounds has gained scientific and commercial relevance (Granato et al., 2020).

Almonds and Canola Oil as Functional Ingredients

Almonds (Prunus dulcis) are recognized for their favorable nutritional profile. They are an excellent source of monounsaturated fatty acids, proteins, dietary fiber, vitamin E, magnesium, and phenolic compounds with antioxidant properties (USDA, 2023). Various studies have shown that their consumption is associated with reduced LDL cholesterol and metabolic benefits including improved cardiovascular health (Chen et al., 2019). The incorporation of almonds into dairy matrices has demonstrated improvements in nutritional profile, texture, and sensory acceptance (Mashayekh et al., 2008).

On the other hand, canola oil stands out for its high content of oleic acid (omega-9), linoleic acid (omega-6), and alpha-linolenic acid (omega-3), as well as its low level of saturated fats, making it one of the healthiest plant lipid sources (Aljuhaimi et al., 2021). Its inclusion in dairy products such as cheese can enrich the lipid profile of the food without compromising sensory or technological stability (Rabetafika et al., 2014).

METHODOLOGY

Type of Study

This work was carried out as a quasi-experimental applied study, with a quantitative approach and a completely randomized design.

European Journal of Food Science and Technology, 13 (1), 62-72, 2025
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Product Elaboration

Raw milk was acquired from the region (Cuautzingo, State of Mexico) and subjected to a pasteurization process. When the milk reached a temperature of 45°C, commercial rennet was added to induce coagulation. Once the curd was separated, it was divided into four portions:

- Portion 1 (T1 – Control): Salted, mixed, molded, and compacted without the addition of functional ingredients.
- Portion 2 (T2): Mixed with 5% ground almonds (based on the weight of the curd), then molded and compacted.
- Portion 3 (T3): Mixed with 5% canola oil, then molded and compacted.
- Portion 4 (T4): Mixed with 5% ground almonds and 5% canola oil, then molded and compacted.

Samples were stored under refrigeration (4°C) for 24 hours prior to analysis.

Sensory Evaluation

A sensory acceptance test was conducted 24 hours after elaboration using a panel of untrained judges (n = 30), selected by convenience, all of whom were regular consumers of fresh dairy products. A semi-structured hedonic survey was applied using a scale from 0 to 10, where 0 indicated a negative perception and 10 indicated maximum acceptance. The evaluated attributes were: color, odor, creaminess, lumpiness, smoothness, and overall acceptance.

Physicochemical and Statistical Analysis

A simulation based on nutritional tables was performed on the samples to determine their basic parameters: moisture, fat, protein, pH and energy content, as recommended by the AOAC (2019). For the sensory data, an analysis of variance (ANOVA) was performed together with Duncan's multiple range test, with a significance level of $p = 0.05$, to identify significant differences between treatments.

Market Study

Additionally, a market study was carried out using the CANVAS methodology, aiming to identify commercialization opportunities, consumer profile, distribution channels, value proposition, and economic feasibility of the developed functional cheese.

RESULTS AND DISCUSSIONS

Four cheese samples were obtained, with desirable appearance and consistency. The sensory evaluation showed no significant differences in color and odor indicators, which positively impacted acceptance since the enrichment with almonds and/or canola oil was not a rejection factor for consumers. Regarding creaminess and graininess, significant differences were observed ($p < 0.03$ and $p < 0.02$, respectively). The sample enriched with both canola oil and almonds achieved the highest creaminess rating, followed by the sample enriched only with

canola oil, while the most grainy sample was the one enriched only with almonds—though these were highlighted as desirable attributes. The softness and overall acceptance indicators were highly significant: the softest cheese was the one enriched with oil, and the highest overall acceptance was for the cheese enriched with both canola oil and almonds. Table 1 shows the sensory evacuation values.

Table 1. Sensory evaluation

	T1. Control Media±desvest	T2. Almonds Media±desvest	T3. Canola oil Media±desvest	T4. Almonds + canola oil Media±desvest	p=
Color	6.2 ± 0.3^{a}	6.3 ± 0.2^{a}	6.6 ± 0.2^{a}	6.6 ± 0.3^{a}	0.4
Odor	5.1 ± 1.3^{a}	4.8 ± 2.1^{a}	5.5 ± 1.1^{a}	5.7 ± 1.9^{a}	0.3
Creaminess	4.2 ± 1.6^{b}	3.8 ± 2.1^{b}	8.6 ± 1.4^{a}	9.4 ± 1.8^{a}	0.03
Graininess	3.8 ± 0.6^{b}	7.8 ± 0.8^{a}	3.2 ± 0.6^{b}	7.2 ± 1.1^{a}	0.02
Softness	4.3 ± 1.3^{a}	6.3 ± 1.1^{b}	8.7 ± 0.6^{c}	7.2 ± 0.9^{c}	0.01
Overall acceptance	4.8 ± 1.3^{a}	5.3 ± 1.1^{a}	8.1 ± 0.5^{b}	9.5 ± 0.9^{c}	0.01

[a] Different literals in the same row indicate significant differences ($p<0.05$)

The simulated values of the physical chemical analysis are shown in Table 2. Simulation of physical chemical analysis

Table 2. Simulation of physical chemical analysis

	Humidity (%)	Fat (%)	Protein (%)	pH	Acidity (% lactic acid)
T1. Control	55.2	19.5	16.3	6.3	0.21
T2. Almonds	54.8	20.7	17.2	6.2	0.24
T3. Canola oil	55.0	22.1	15.9	6.1	0.22
T4. Almonds + canola oil	54.3	23.0	16.7	6.0	0.25

Estimates based on 100 g of dry matter

The pH remained slightly acidic in all samples, consistent with fresh cheeses, and showed no significant alterations after the addition of functional ingredients. Regarding moisture and dry extract, the incorporation of solids (almonds) and lipids (oil) decreased moisture content and increased dry matter, which is expected. Fat content increased notably in the samples with canola oil due to its high lipid concentration. T4 presented the highest value. Protein

content slightly increased in the almond-enriched sample, as almonds provide plant-based proteins. Ash content also increased slightly due to the mineral content of almonds. The fat-to-protein ratio, a useful indicator of relative lipid richness, showed that Q3 and Q4 had a more lipid-rich profile.

The CANVAS Business Model Applied to Panela-Type Cheese Enriched with Almonds and Canola Oil

1. Value Proposition

The product offers an innovative alternative to traditional fresh cheeses by incorporating functional ingredients (almonds and canola oil) that enhance the nutritional profile. This panela-type cheese provides cardiovascular health benefits, antioxidants, healthy fatty acids, and high protein content without compromising flavor or texture. Its differential value lies in being a functional food that contributes to a balanced diet.

2. Customer Segments

Targeted primarily at health-conscious consumers:

- Young and older adults concerned about their health.
- People interested in functional nutrition or balanced diets.
- Consumers of low-fat dairy products with added value.
- Health food stores and gourmet markets.

3. Distribution Channels

- Direct sales at local fairs and organic markets.
- Health food stores and supermarkets with specialized sections.
- Online sales through social media or artisan product platforms.
- Potential agreements with health-conscious restaurants and cafés.

4. Customer Relationships

- In-store tastings to promote the product.
- Social media engagement with educational content on nutritional benefits.
- Customer satisfaction surveys and ongoing feedback.
- Promotions or special formats (functional packs).

5. Revenue Streams

- Direct sales of the functional cheese in different formats.
- Partnerships with local distributors or food companies.
- Future expansion potential into other functional dairy products.

6. Key Resources

- Raw materials: local raw milk, high-quality almonds, and canola oil.
- Equipment for production and refrigeration.

- Trained personnel for production and quality control.
- Marketing strategies and distribution networks.

7. Key Activities

- Production and standardization of the enriched cheese.
- Physicochemical and sensory quality control.
- Marketing, brand positioning, and consumer education.
- Distribution logistics and point-of-sale management.

8. Key Partners

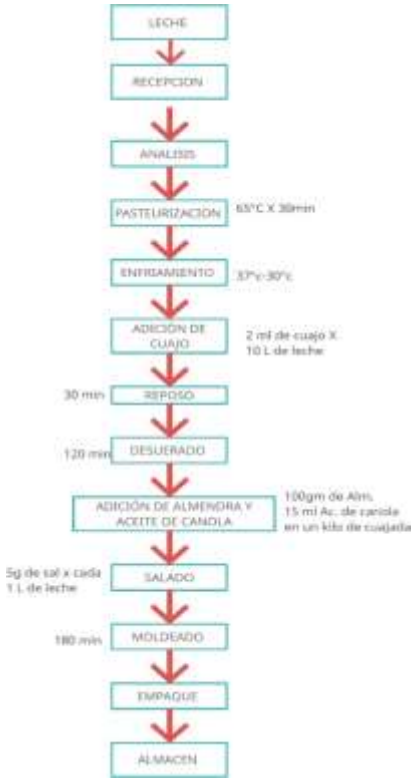
- Local producers of milk and almonds.
- Suppliers of food-grade ingredients.
- Academic or health institutions interested in promoting functional foods.
- Physical and digital distribution channels.

9. Cost Structure

- Costs of raw materials (milk, almonds, canola oil).
- Production expenses (energy, packaging, supplies, refrigeration).
- Marketing and logistics costs.
- Investment in promotion and brand development.

Flow diagram of the panela production process.

European Journal of Food Science and Technology, 13 (1), 62-72, 2025
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK



Costs and expenses, for one month's production, were considered, costs of raw materials, labor and indirect manufacturing costs, in table 1.

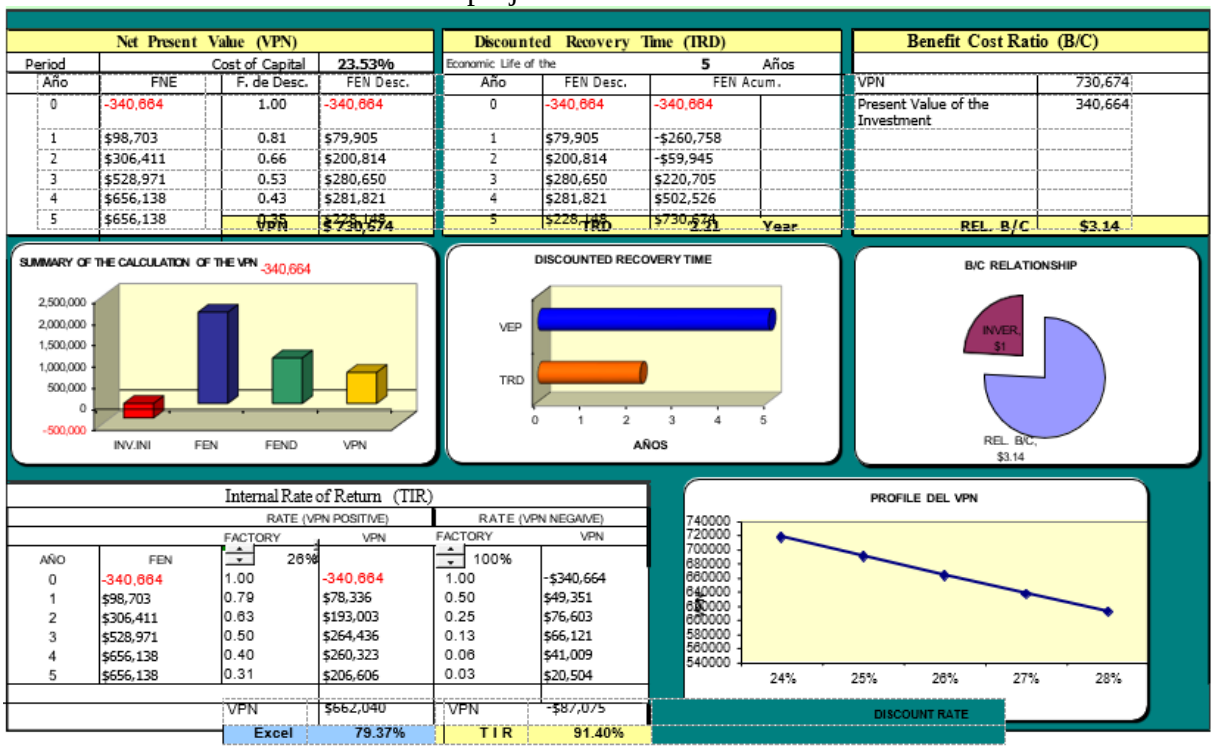
Table 1. Costs and expenses

COST CONCENTRATE 1ST MONTH	
VARIABLE	
COST OF RAW MATERIALS	**$123,221**
FIXED	
DIRECT LABOR	**$24,300**
INDIRECT MANUFACTURING EXPENSES	**$1,500**
	$149,021
Variable expenses	**$123,221**
Total	**$170,171**

EXPENSE CONCENTRATE 1ST MONTH	
FIXED	
ADMINISTRATION EXPENSES	**$21,150**
SALES EXPENSES	**$0**
	$21,150

European Journal of Food Science and Technology, 13 (1), 62-72, 2025
Print ISSN: ISSN 2056-5798(Print)
Online ISSN: ISSN 2056-5801(online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Table 2. Financial evaluation of the project



CONCLUSIONS

The results of the sensory evaluation indicate that the incorporation of ground almonds and canola oil into panela-type cheese did not negatively affect the perception of color or odor, suggesting good acceptance by consumers. The significant differences observed in creaminess and graininess attributes ($p < 0.03$ and $p < 0.02$, respectively) show that the addition of functional ingredients can positively modify the product's texture. In particular, the sample enriched with both ingredients received the highest creaminess rating, while the sample with only almonds was the grainiest—an attribute perceived as desirable. Additionally, highly significant differences were found in softness and overall acceptance, highlighting the canola oil-enriched cheese as the softest and the sample with both ingredients as the most accepted overall. These findings support the sensory and commercial viability of the developed product, which was confirmed by the CANVAS model analysis, demonstrating its potential for market insertion as an innovative functional food.

REFERENCES

Agroberichtenbuitenland. (2021). Cheese market in the Netherlands. Ministerio de Agricultura, Naturaleza y Calidad Alimentaria de los Países Bajos.

https://www.agroberichtenbuitenland.nl/

Aljuhaimi, F., Ghafoor, K., Özcan, M. M., Babiker, E. E., & Koca, I. (2021). Effect of cold pressing on oil yield and fatty acid composition of some canola cultivars grown in Saudi Arabia. Journal of Oleo Science, 70(1), 59–65. https://doi.org/10.5650/jos.ess20245

BmEditores. (2023). Panorama del consumo de queso en México. https://www.bmeditores.mx/

Chen, C. Y., Milbury, P. E., Lapsley, K., & Blumberg, J. B. (2019). Almond consumption and cardiovascular risk factors in healthy adults. Journal of Nutrition, 139(7), 1226–1231. https://doi.org/10.3945/jn.108.103564

Chen, G. C., Tong, X., Xu, J. Y., Han, S. F., Zhang, Z. L., Wei, Y. D., & Qin, L. Q. (2021). Nuts consumption and risk of cardiovascular disease: A meta-analysis. Nutrition, Metabolism and Cardiovascular Diseases, 31(8), 2224–2233. https://doi.org/10.1016/j.numecd.2021.02.025

FAO. (2021). The state of food and agriculture 2021 – Making agrifood systems more resilient to shocks and stresses. Food and Agriculture Organization of the United Nations. https://www.fao.org/documents/card/en/c/cb4476en/

Granato, D., Barba, F. J., Bursać Kovačević, D., Lorenzo, J. M., Cruz, A. G., & Putnik, P. (2020). Functional foods: Product development, technological trends, efficacy testing, and safety. Annual Review of Food Science and Technology, 11, 93–118. https://doi.org/10.1146/annurev-food-032519-051708

González-Tenorio, R., Hernández-Melchor, D. J., & Pérez-González, J. (2020). Panela cheese production and its nutritional and technological value: A Mexican tradition. Revista Mexicana de Ciencias Pecuarias, 11(3), 789–803. https://doi.org/10.22319/rmcp.v11i3.5194

Hasler, C. M. (2002). Functional foods: Benefits, concerns and challenges—A position paper from the American Council on Science and Health. Journal of Nutrition, 132(12), 3772–3781. https://doi.org/10.1093/jn/132.12.3772

Instituto Nacional de Estadística y Geografía (INEGI). (2021). Estadísticas a propósito del Día Mundial de la Leche. https://www.inegi.org.mx

Jones, P. J., Senanayake, V. K., Pu, S., & Jenkins, D. J. (2020). Cardiovascular health benefits of oils rich in omega-3 fatty acids. Nutrition Reviews, 78(8), 595–605. https://doi.org/10.1093/nutrit/nuz088

Mashayekh, M., Rezaei, K., & Alemzadeh, I. (2008). Effect of fortification of ultrafiltered cheese with walnut and almond nuts on chemical, rheological and sensory properties. International Journal of Dairy Technology, 61(3), 205–211. https://doi.org/10.1111/j.1471-0307.2008.00302.x

NOM-223-SSA1-2018. (2018). Productos y servicios. Quesos. Especificaciones sanitarias. Diario Oficial de la Federación. https://www.dof.gob.mx

Rabetafika, H. N., Bchir, B., Blecker, C., & Richel, A. (2014). Fractionation of almond (Prunus dulcis) oil and proteins: A review. Biotechnology, Agronomy, Society and Environment, 18(3), 387–397. https://popups.uliege.be/1780-4507/index.php?id=11155

Secretaría de Salud. (2019). Guía de orientación alimentaria para la población mexicana. Gobierno de México. https://www.gob.mx/salud

The Food Tech. (2023). Panorama de la producción de quesos en México. https://thefoodtech.com/

United States Department of Agriculture (USDA). (2023). FoodData Central. https://fdc.nal.usda.gov/

Voz de las Empresas. (2023). Consumo y gasto de lácteos en los hogares mexicanos. https://www.vozdelasempresas.org/

ACKNOWLEDGEMENTS

To all the participants who answered the survey and to the academic authorities who supported its dissemination.