

ORIGINAL ARTICLE

Behavior of the parameters of the quality of ground beef lasagna stored at freezing conditions

Comportamiento de los parámetros de calidad de una lasaña de carne de res molida almacenada en condiciones de congelación

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Received: 08 October 2025 / Accepted: 19 December 2025 / Published online: 23 January 2026

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Abstract The production of filled pasta dishes like lasagna at UEB Catering Habana is considered viable due to access to raw materials available on the domestic market, allowing the product to be offered at competitive prices to both airlines and airport food service providers. Post-production freezing offers an operational advantage by ensuring a longer shelf life and enabling faster service to consumers; however, this process can affect certain product quality parameters. In this context, the objective of this study was to evaluate the behavior of quality parameters in ground beef lasagna during frozen storage at -18 °C. To this end, physicochemical, microbiological, and sensory indicators of the finished product were analyzed throughout the storage period. The results showed that, in general, the lasagna met the established quality standards, with only variations in texture and an increase in pH observed after 15 days of storage. These changes did not lead to a loss of product acceptability.

Keywords lasagna, quality, freezing, stability, unacceptability.

Resumen La elaboración de pastas típicas en la UEB Catering Habana se considera viable, ya que brinda acceso a las materias primas disponibles en el mercado nacional, lo que permite ofrecer el producto a precios competitivos tanto para aerolíneas como para servicios gastronómicos en instalaciones aeroportuarias. La congelación posterior a su preparación constituye una ventaja operativa, ya que garantiza una mayor vida útil y facilita un servicio rápido al consumidor; sin embargo, este proceso puede afectar ciertos parámetros de calidad del producto. En este contexto, el propósito del estudio es evaluar el comportamiento de los parámetros de temperatura de una carne res-molida durante la congelación a -18 °C. Para ello, se analizan los indicadores físicos, microbiológicos y sensoriales del producto al final del período de procesamiento. Los resultados muestran que, en general, la lasaña cumple con los estándares de calidad establecidos; solo se observó, a partir de los 15 días de procesamiento, una variación en la textura y un aumento del pH, aunque estas modificaciones conllevan la pérdida de aceptabilidad del producto.

Palabras clave lasaña, calidad, congelación, estabilidad, objetabilidad.

How to cite

Díaz, Y., & Feito, A. (2026). Behavior of the parameters of the quality of ground beef lasagna stored at freezing conditions. *Journal of Food Science and Gastronomy*, 4(1), 17-22. <https://doi.org/10.5281/zenodo.18294174>

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Introduction

In recent decades, the service sector has experienced remarkable expansion across various modes of transport, integrating significant management into the field of commercial aviation through the development of airline catering, a strategic service in constant growth. In this sector, the demands are particularly high, and airline catering companies must guarantee compliance with strict standards of quality, operational efficiency, and food safety, while simultaneously adapting to the specific requirements of each aircraft (Kanwal et al., 2025).

Air transport has become a necessity in the context of globalization, driven by the growing economic and social dynamics that demand reduced travel times and distances between countries and continents (Wandelt et al., 2024). This scenario has increased the volume of operations and competition among airlines; bus cargo can vary due to the optimization of travel time, the frequency of visits, and the improvement of onboard comfort, among which the food offering plays a key role. In this regard, one of the main challenges on a global scale remains the production and distribution of safe, high-quality food (Hussain et al., 2025), especially under restrictive consumption conditions such as those in aviation (FAO, 2017).

Onboard electrical supply is a key concern for airlines, and today's consumers demand products that meet rigorous sensory, nutritional, and health requirements. Food safety is therefore an essential attribute, ensuring that food served onboard does not pose a risk to passenger health or become contaminated due to inadequate handling, microbiological contamination, or the presence of potentially adverse ingredients—situations that can arise under emergency health conditions during flight (McMullan et al., 2007, EFSA Scientific Committee et al., 2021; ICAO, 2022).

In Cuba, airline catering was developed by Cuba Catering, SA, which has established a tray service sector associated with the quality and prestige of the Basic Business Units (UEBs) distributed throughout the country. The Havana Plant UEB is responsible for providing these services in the capital and offering, among other products, ground beef preserved through freezing. The pasta available represents a high-quality option requested by airport food service users; however, currently only one company produces a variety of flavors, ranging from very mild meats to spices.

While freezer storage is an effective way to extend the shelf life of these products, it can alter their physical, microbiological, and sensory characteristics, potentially leading to economic implications for the facility and consumer health protection. This situation requires special consideration in the context of air transport, as any adverse event could escalate into a public health emergency. Therefore, the key is to conduct stability studies to assess, with a reasonable de-

gree of confidence, the behavior of these products throughout their development and ensure their suitability for human consumption (James et al., 2006; Fellows, 2022).

The quality and safety of ready-to-eat and convenience foods, such as ground beef lasagna, are strongly influenced by processing and storage conditions, particularly freezing, which is widely used to extend shelf life and maintain product stability. However, despite its technological advantages, freezing may induce physicochemical and sensory changes that affect consumer acceptance and nutritional value. In this context, Gallardo and García (2024) report that the growing consumption of junk food and similar ultra-processed products is driven not only by convenience but also by social perception, often overlooking potential quality and health risks. Therefore, evaluating the behavior of key quality parameters in frozen ground beef lasagna is essential to ensure product integrity, inform better processing practices, and contribute to a more critical understanding of the quality attributes of widely consumed convenience foods. The present study aimed to evaluate the physical, microbiological, and sensory stability of remoldable meat produced at the UEB Habana Plant during freezing at -18°C , to ensure temperature and safety in airline catering services.

Methodology

The study was conducted at the UEB Catering Habana, operated by Cuba Catering S.A., in collaboration with the Laboratories of the Institute of Research for the Food Industry. Before product development, the hygienic and sanitary conditions of the facility were evaluated using an inspection guide based on the Manual for Sanitary Inspection and the European Union's Guide for Self-Assessment of Hygienic Quality in Agri-food Facilities.

Frozen meat lasagnas are prepared taking into account the package size, the ingredient formula, and the final destination of the product. The lasagna sheets are made with flour, water, egg, oil, and salt. The ingredients are mixed until a smooth dough is formed, which is then rolled out to the desired thickness. The dishes, consisting of béchamel sauce and minced beef, are made with the usual ingredients of the traditional recipe: milk, butter, wheat flour, seasonings, tomato puree, ground beef, and Gouda cheese.

The lasagnas are assembled in the hot zone of the UEB (Basic Business Unit) on pre-conditioned aluminum strips. Each unit consists of three alternating layers of pasta, béchamel sauce, minced beef, and Gouda cheese. The lasagnas are heated to 170°C for approximately 20 minutes, cooled to 60°C , and then rapidly chilled in a cooling tunnel. Each piece is divided into 250 g portions, placed in aluminum containers with metal lids, and frozen at -18°C for evaluation (Figure

1).

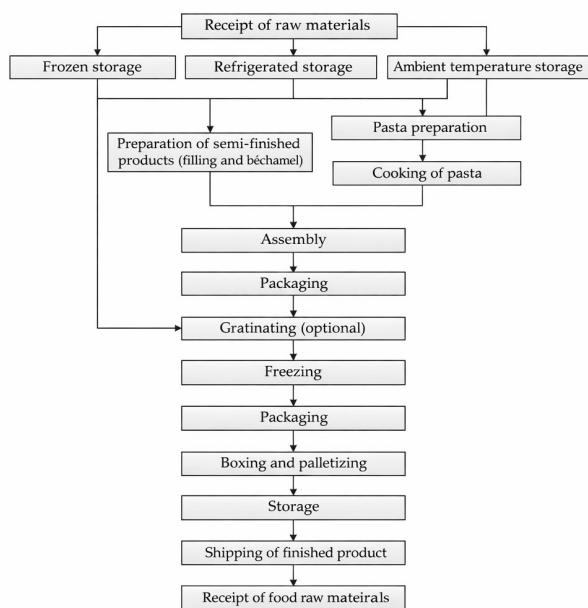


Figure 1. Technological flow of the preparation of ground beef lasagna.

The program will be carried out randomly over at least 15 days, with a total of 30 days of storage. In each case, we will evaluate physical (pH and total acidity index), microbiological, sensory, and instrumental textural parameters. For sensory and textural determinations, the products are thawed in microwave ovens, while for microbiological and chemical analyses, they are thawed without refrigeration.

Total acidity was determined according to standard NC-79-06 (1981), and pH was measured using a potentiometer conforming to standard NC-ISO 1842 (2001). Texture was evaluated using a compression-shear-extrusion test with a Kramer cell (Figure 2) combined with a TA.HD Plus texture analyzer, determining the maximum shear compression force. Microbiological analyses included the detection of aerobiomes, total and fecal coliforms, molds and yeasts, coagulase-positive *Staphylococcus*, and *Salmonella* spp., by the Cuban and ISO standards.

Sensory evaluation was conducted using a panel of daily training sites, employing a descriptive test combined with a five-point scale, under controlled conditions in the cat's enclosure, according to NC ISO 8589 (2010). Product acceptability was determined by considering changes in color, oil content, and texture, as well as the presence of visible signs of deterioration, applying rejection criteria based on a binomial distribution.

The data obtained were analyzed using analysis of variance (anova) and Duncan's multiple range analysis, using the statistica program version 6.0, with a significance level of $p \leq 0.05$.

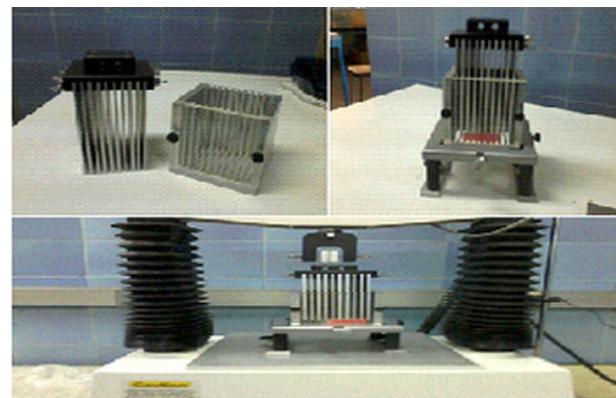


Figure 2. Kramer cell with ten parallel metal plates, each 2 mm thick.

Results and discussion

The application of the inspection guide, based on the Manual for Sanitary Inspection and the Self-Assessment Guide for the Hygienic Quality of Agro-Food Facilities of the European Union, yielded an overall score of 97 points, demonstrating compliance with the criteria established by these standards, whose minimum acceptable threshold is above 80 points.

It is important to note that the facility has a systematic plan for conducting sanitary inspections. These inspections are carried out regularly both internally, every week by the management of Cuba Catering S.A. and the plant's executive staff, and externally, through monthly inspections conducted by CNICA. This approach contributes to the continuous monitoring of the hygienic and sanitary conditions of the facility.

As shown in Table 1, the main deficiencies were identified in the section related to exterior areas, specifically in indicator one, which is associated with the presence of locations where water accumulation may occur during rainfall events. Nevertheless, this situation does not represent a significant environmental risk, as it does not involve wastewater.

Table 1. Physicochemical characterization of the lasagna

Determination	Time (days)		
	0	15	30
pH	6.2	6.9	7.0
Acidity (% lactic acid)	0.18	0.11	0.09

These variations can be explained by the fact that the mincing process distributes microorganisms throughout the entire meat matrix that were initially confined to the external surface, thereby favoring spoilage processes. In addition,

cutting increases the surface area of the meat, which enhances the opportunities for microbial colonization and proliferation; consequently, the commercial shelf life of minced meat is significantly shorter compared with that of whole meat. Although this product undergoes a high-temperature cooking process that may reduce the risk of contamination by pathogenic microorganisms, it should be noted that some species of the genus *Clostridium* are spore-forming bacteria that are highly resistant to heat, capable of surviving thermal treatment and growing at refrigeration temperatures. Such growth can lead to deterioration of product quality by altering its physicochemical parameters and promoting the formation of undesirable compounds, such as amines (Doyle, 1997).

The observed decrease in the Kramer shear compression force (Figure 3) could be due to the freezing method used during processing. Slow freezing is characterized by the formation of large ice crystals capable of causing significant damage to the food's cellular structure, with direct repercussions on the aforementioned textural properties. The integrity of the cell membrane, responsible for regulating the exchange of substances between intracellular and extracellular environments, can be compromised by the mechanical forces associated with water expansion during cell formation, as well as by alterations in membrane lipoproteins. These effects reduce water retention capacity, promote exudate loss during thawing, and give the product a flaxseed-like appearance, according to Díaz (2009).

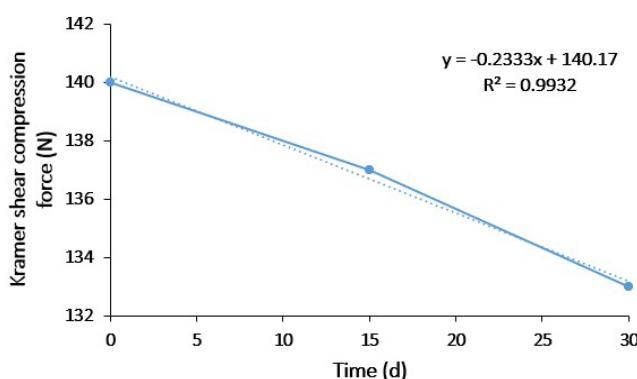


Figure 3. Force variation of the ground beef lasagna stored at freezing conditions.

Furthermore, the lasagnas are placed in a freezer for operational use at the plant, which implies potential exposure to temperature fluctuations resulting from the frequent opening and operation of the equipment. These temperature variations can induce recrystallization processes, characterized by changes in the temperature of ice crystals during storage, contributing to the increased exudate observed during thawing. This window of opportunity can also be amplified during the transport of samples to the laboratories of the

Food Industry Research Institute, as weighing them using the applied control methods can produce temperature oscillations that promote recrystallization.

Lasagna is a product whose preparation requires a high degree of handling, so the probability of microbiological contamination is high. However, as can be seen in Table 2, both at the beginning and end of the study, the tests performed yielded negative results for the presence of microorganisms such as *E. coli* and *Salmonella*, reported for the remaining cases containing less than 10 CFU/g.

Table 2. Microbiological determinations carried out while the product was finished as long as its processing lasted

Determinations	Counts (UFC/g)
Count of aerobes mesophiles	< 10
Count of coliforms totals	< 10
Count of fungi and yeasts	< 10
Staphylococcus coagulase-positive	< 10
Presence of <i>E. coli</i>	Negative
Presence of <i>Salmonella</i> spp.	Negative

These results are primarily due to the positive influence that the facility's hygienic and sanitary conditions have on the microbiological quality of the finished product, a fact corroborated by the results obtained during the sanitary inspection. Furthermore, the plant continues to implement the HACCP system across all its production lines, enabling rigorous control of process parameters, especially at critical points related to safety. This translates into the systematic application of good manufacturing practices and the effectiveness of inhibiting food processing by freezing it at -18°C to prevent microbial growth—factors that, together, contribute to minimizing contamination.

Due to the influence of temperature in the microbial environment, the predominant microbiota in this type of product is composed of probiotic bacteria, yeasts, and bacteria capable of surviving in extreme conditions (Díaz, 2009). However, the determinations carried out during processing showed very low counts, which significantly reduced the probability of product spoilage associated with the activity of these microorganisms.

Overall, the problem is not due to the results of any of the three evaluations performed ($p \leq 0.05$). As shown in Table 3, texture is the attribute most affected by storage time, consistent with the results of the instrumental evaluation, where a more pasty consistency was observed in the container, making it difficult to find. In contrast, the oil and salt content remained stable, with no significant variations during storage.

Table 3. Sensory evaluation has the different point in time of sampling

First assessment (t=0)	Second assessment (15 days)	Third assessment (30 days)
<u>External appearance:</u> The product resembles the container it's in, with cheese and ground meat visible on the surface.	Accepted	Accepted
<u>Internal appearance:</u> It can be easily cut and retains its shape.		
<u>Smell:</u> Like pizza (a mixture of tomato sauce and cheese).		
<u>Taste:</u> It doesn't have the typical lasagna flavor; there's a strong taste of flour.		
<u>Texture:</u> Firm.		
Impression general of quality: good		

Conclusions

The Havana Catering Business Unit (UEB) presents adequate hygienic and sanitary conditions, complying with the requirements established in national and European Union inspection guidelines, which is reflected in the high rating obtained during the evaluation. The freezing process significantly influences the physical and chemical parameters of the lasagna; however, these variations are subject to acceptable ranges. The product maintained its sensory acceptability in the study, although the texture and attributes were more affected, without causing rejection. As a result, the lasagna maintained microbiological stability and complied with current standards for the microorganisms evaluated. Overall, the results show that the ground beef lasagna can be considered a stable and safe product under the evaluated freezing processing conditions.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Author contributions

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Statement on the use of AI

The authors acknowledge the use of generative AI and AI-assisted technologies to improve the readability and clarity of the article.

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