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ORIGINAL ARTICLE

Methodology for preparing and evaluating frozen meals from the cold area at Havana Catering Base Business Unit

Metodología para la elaboración y evaluación de comidas congeladas del área fría en la Unidad Empresarial de Base Catering Habana

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Abstract The study's objective was to develop a methodology for preparing and evaluating frozen meals from the cold area at the Havana Catering Base Business Unit. Services with adequate conditions for freezing storage and subsequent commercialization were selected. Freezing did not yield positive results due to the defrosting time of the juice. Among the five dishes suitable for freezing were a snack, a cold dish, a cold cuts appetizer, a sandwich, and a vegetable appetizer. The sensory evaluation of the products was carried out by a sensory evaluation committee composed of the center's staff. The cold dish underwent rapid freezing and microbiological and sensory quality assessments. The stability of the dish was maintained for 30 days, as determined by the deterioration of its sensory quality. A methodology integrated the procedures for preparing and evaluating frozen meals from the cold area, including storage conditions, sampling time, number of samples, microbiological analysis, sensory evaluation methodology, and defrosting conditions.

Keywords frozen food, sensory evaluation, microbiological quality, stability, methodology.

Resumen El objetivo del trabajo fue desarrollar una metodología para la elaboración y evaluación de comidas congeladas del área fría en la U.E.B. Catering Habana. Se seleccionaron los servicios que tenían las condiciones adecuadas para el almacenamiento en congelación y su posterior comercialización. La congelación no ofreció resultados positivos a causa del tiempo de descongelación del jugo. De los cinco platos con condiciones para resistir a la congelación: un bocadito, un plato frío, un entrante de embutidos, un sándwich y un entrante de vegetales. La evaluación sensorial de los productos se realizó por una comisión de evaluación sensorial integrada por trabajadores del centro. El plato frío fue sometido a una congelación rápida, luego se evaluó su calidad microbiológica y sensorial. La estabilidad del plato se mantuvo por 30 días, el tiempo estuvo determinado por el deterioro de su calidad sensorial. Se desarrolló una metodología que integró los procedimientos de la elaboración y evaluación de comidas congeladas del área fría, las condiciones de almacenamiento, tiempo de muestreo, número de muestras, análisis microbiológicos, metodología de evaluación sensorial y condiciones de descongelación.

Palabras clave comida congelada, evaluación sensorial, calidad microbiológica, estabilidad, metodología.

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PUBLIS EDITORIAL

Introduction

Onboard catering services are essential for air travel. Airlines provide food and beverages to passengers during flights, offering various options depending on the flight class, distance, and type of service (Mortensen et al., 2022). This sector faces significant challenges, such as the growing demand for quality services alongside the economic constraints imposed by many airlines, driving innovation in products and processes (Castillo-Reina & Cruz, 2022).

Dish simplification, food safety, and the attainment of certifications like ISO 22000 have become fundamental pillars for airline catering companies, including those in emerging markets like Cuba. Despite being the only catering company in the country, Cubacatering S.A. has implemented strategies to improve its products, diversify its offerings, and ensure food safety by incorporating innovative technologies such as producing frozen meals.

Since 2002, Cubacatering S.A. has utilized freezing processes for producing hot lunches and dinners, ensuring microbiological and organoleptic quality during storage for up to 30 days. These reserves are essential for meeting urgent requests or periods of high demand, such as in 2014, when regular requests for frozen meals for delayed flights were recorded by the Havana Gastronomy Basic Unit of Cubacatering S.A., with a frequency of up to twice a week.

However, the production flow faces interruptions as it relies exclusively on frozen reserves of hot meals, leaving other options, such as salads or cold snacks, unaddressed. This challenge is exacerbated by the higher demand for breakfasts and cold snacks compared to hot services in regular and emergency operations.

In line with the Recommended International Code of Practice for the Processing and Handling of Quick-Frozen Foods (CAC/RCP 8-1976, 2008), which emphasizes the need to validate freezing processes to ensure food safety, this study developed a comprehensive methodology for the production and evaluation of frozen meals from the cold section at the Havana Catering Base Business Unit. This methodology included storage criteria, production planning, microbiological analyses, and sensory evaluations to enhance the competitiveness and sustainability of the services provided.

Methodology

The research was conducted at the Havana Catering Base Business Unit and involved selecting, preparing, and freezing dishes to evaluate their resistance to freezing. Samples of the selected dishes were prepared and refrigerated before being placed in a freezing chamber at -18 to -21 °C. Subsequently, they were stored in freezers at -18 to -20 °C. The meals were packaged in box lunches to facilitate preservation and handling. They were kept frozen for three days to analyze their initial stability.

Thawing was performed in transit refrigerators at 5 to 8 °C before sensory analysis. An evaluation committee, composed of trained judges following international standards (NC-ISO 8586-1, 2004), identified and discarded dishes with difficulties, selecting the most suitable ones. The judges, recruited internally, conducted sensory and discriminatory tests to familiarize themselves with the dishes' attributes and detect defects in texture and other parameters affected by freezing.

Microbiological evaluations were conducted at the Food Industry Research Institute (IIIA), including analyses of microorganisms, coliforms, molds, yeasts, and pathogens. Additionally, descriptive and quantitative sensory analyses were performed on specific storage days (1, 15, 30, 45, and 60). The data obtained were processed using statistical tools (Statistica and Excel) to identify significant differences between the samples. This approach enabled the assessment of the impact of freezing on the sensory and microbiological quality of the stored dishes.

Results and discussion

A dinner set and two snacks were selected, dishes contracted by Cubana de Aviacion, the company's main client. The composition of the dishes allowed them to be used as cold breakfasts, categorizing them as versatile options for both services. The meals consisted of industrially processed foods and freshly prepared dishes. Table 1 presents the thawing times for the assembled meals and the individually analyzed dishes.

Table 1. Thawing time of the selected dishes

Dish	Thawing time (h)
Dinner set	4
Snack 1	6
Snack 2	6
Prepared sandwich	3
Cold dish	3
Appetizer	3

The snack services exhibited the most extended thawing times in the study, an expected result due to the larger number of components. In contrast, the juice was the last to thaw, likely because of its Tetra Brick packaging. Rahman & Vélez (2007) and Machado-Velasco and Vélez-Ruiz (2008) suggested using microwaves to reduce thawing times to between one and ten minutes for various foods. However, this method was not feasible in the present study due to the incompatibility of the service's plastic materials with microwaves.

The increased thawing time associated with the number of services led to the exclusion of assembled services, as the

production flow time could not be reduced. An alternative of freezing services without the juice and adding it later was considered but rejected, as it involved double handling, disrupted the service standard, and increased the crew's workload.

A frozen reserve of prepared products was created as a solution, leaving the industrial components ready for assembly in the preparation area, thereby reducing time spent in the cold area. The individually analyzed dishes had shorter thawing times, although issues related to moisture content were observed. Zaritzky (2008) noted that water released during thawing tends to diffuse and partially return to the food, though not to its original location.

Finally, it was determined that the thawing process for sensory evaluations should include three hours in a maintenance refrigerator and at least two hours in a climate-controlled room simulating onboard consumption conditions. According to Machado-Velasco and Vélez-Ruiz (2008), the parameters of time and temperature during freezing, storage, and thawing significantly influence the final product quality, especially for foods that will not undergo further cooking, as in this case.

After removing the assembled services from the study and considering the aforementioned factors, the composition and arrangement of the dishes were adjusted, and two new dishes were included to expand the final offering. The selection focused on dishes that retained their sensory characteristics after three days of frozen storage (Table 2).

Due to the availability of resources, laboratory capacity, and the sensory panel's ability, it was decided not to conduct the research with all five selected dishes simultaneously. The study began with the Cold Dish, as its raw materials represented the majority of the ingredients in the other dishes, and the results obtained were limited to this dish.

The sensory panel consisted of 20 internally selected individuals, following the recommendations of Duarte et al. (2008) to ensure stability and confidentiality. The group included 11 women and 9 men from various areas of the organization, forming a heterogeneous team. The initial sensory test included basic flavors and olive flavor, which was key to the study. Some participants had difficulty identifying the bitter taste and differentiating between salty and sour. In contrast, others struggled to correctly identify aromas such as diacetyl (butter) and butyric acid (cheese), resulting in their elimination for not reaching 80% correct responses.

Of the 17 candidates evaluated, 13 passed the initial tests, showing a 75% success rate. These candidates achieved satisfactory results in additional tests of visual acuity and texture. The theoretical and practical training, based on the recommendations of Espinosa (2014), allowed the judges to improve their skills and understand the importance of sensory evaluation. Six judges completed the process during the training, which included 46% of the raw materials from all the dishes, showing consistent progress. However, four judges did not achieve significant improvements and were eliminated.

Table 2. Cold-section dishes with the potential to be included in the frozen meal offering

Dish	Raw material	Quantity
Prepared sandwich	Milk bread 25 g	1 U
	Gouda cheese	10 g
	Cooked ham	10 g
	Butter	3 g
Cold dish	Gouda cheese	40 g
	Cooked ham	40 g
	Vela chorizo	10 g
	Montero chorizo	10 g
	Olive	1 U
Cold cuts appetizer	Gouda cheese	40 g
	Cooked ham	40 g
	Chorizo	10 g
Sandwich	Hot dog bun 80g	1 U
	Gouda cheese	40 g
	Cooked ham	40 g
	Smoked loin	40 g
	Vela chorizo	20 g
	Butter	15 g
Vegetable appetizer	Corn kernels	30 g
	Julienned carrot	30 g
	Peas	20 g
	Olive pits	7 g

In the first nine practical training sessions (Figure 1), a general improvement was observed among the judges, with some reaching the acceptance zone quickly and others showing less initial precision. Finally, the results indicated satisfactory progress in training the sensory panel to evaluate the cold dish.

The training stage in scaling tests was conducted with the six candidates who completed the differentiation tests using the raw materials from the Cold Dish. The results showed no significant differences between the judges' responses ($p \leq 0.05$), confirming the homogeneity of the group. The Sensory Evaluation Commission was composed of three women and three men from the unit's production, operations, and management subdirectorates. Additionally, an extra member was added, in compliance with the NC-ISO 8586-1 (2004) standard, to ensure continuous operation in rotating shifts.

In the descriptive test training, 49 initial descriptors were generated for the four characteristics analyzed, following the pre-list method. Subsequently, redundant, hedonic, and irrelevant terms were removed according to the NC-ISO 11035 (2008) standard, resulting in a final selection of significant

attributes (Table 3). A complete product description was obtained using the

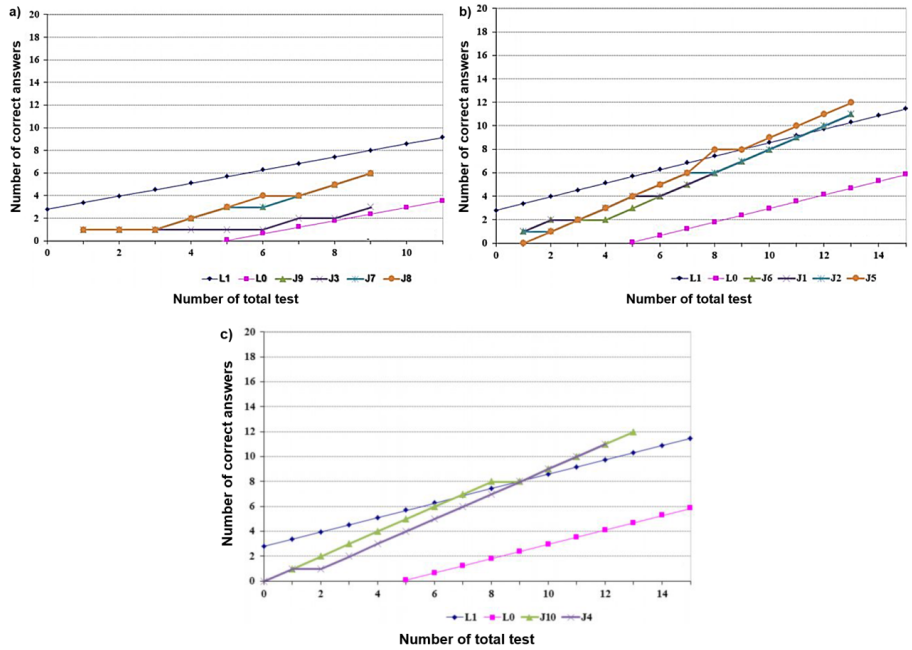

Figure 1. Results of the sequential analysis of the judges' training in differentiation tests. a) Judges 3, 7, 8, and 9; b) Judges 1, 2, 5, and 6; c) Judges 4 and 10.

Table 3. Descriptors generated during the descriptive quantitative analysis

Characteristic	Generated descriptor	
Appearance (15)	Surface	Presence of stains
	Uniform surface	Coating
	Surface free of wrinkles	Distribution of components
	Shine	Presentation
	Opaque	Presence of water
	Products without pores	Heterogeneous color
	Color	Presence of fat clots
	Homogeneous color	
Smell (8)	Characteristic smell	Bad smell
	Rancid smell	Putrid smell
	Intensity	Acidic smell
	Typical smell	Free from strange odors
Taste (10)	Characteristic taste	Salty
	Rancid taste	Bitter
	Typical taste	Fatty taste
	Putrid taste	Intensity
	Taste of lack of cold	Unaltered taste
Texture (16)	Softness	Chewiness
	Moisture	Plasticity
	Firmness	Elasticity
	Chewability	Soft texture
	Good texture	Smoothness
	Adequate texture	Hardness
	Graininess-free	Dry
	Cohesiveness	Sliminess

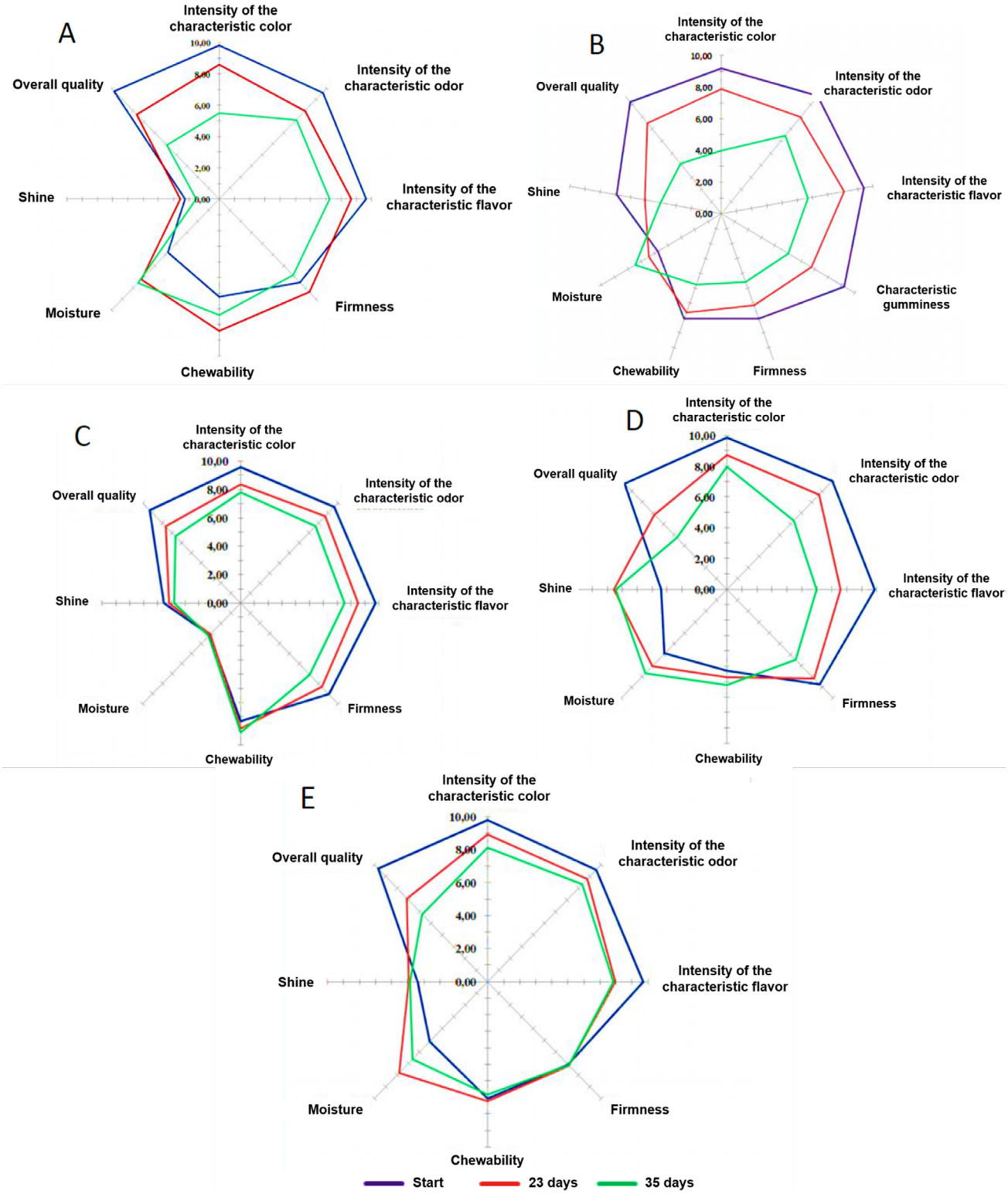

Figure 2. Quantitative descriptive profiles of cold dishes during storage: a) ham, b) cheese, c) Vela chorizo, d) olive, e) Montero chorizo.

consensus method after four sessions. In the early sessions, discrepancies were observed among the judges, which, according to Stone & Sidel (1998), is normal due to the difficulty of establishing a common language, especially with a panel in training. Fifteen descriptors were generated for appearance, with "uniform surface" and "wrinkle-free" highlighted as indicators of surface properties. Some terms, such as "pore-free product" and "opaque," were modified or eliminated because they were considered redundant, irrelevant, or defective. The final descriptors included "homogeneous color" and "presence of stains."

For odor, redundant, hedonic, or defect-related terms were removed from the eight initial descriptors. For flavor, out of the 10 descriptors generated, terms like "rancid flavor" or "salty flavor" were discarded as defects or irrelevant. In texture, redundant and hedonic terms were removed, leaving attributes like firmness and moisture. Defects such as "slimy" were discarded.

A 10 cm structured scale and a product description form were used to evaluate the samples, together with a checklist of potential defects. All judges correctly described more than 70% of the samples, meeting the NC 8586-1 (2004) standards, and were accepted in this phase.

The sensory and microbiological characteristics of the cold dish stored at -18 °C were evaluated at 0, 15, 23, 30, and 35 days. The microbiological analyses did not coincide with the sensory evaluations, as temperature fluctuations during freezing affected the product's structural characteristics. Monitoring intervals were adjusted to assess these alterations. The defrosting time was set at three hours, with water droplets observed, disappearing after two additional hours. The use of microwaves was discarded due to logistical limitations and potential alterations to sensitive ingredients like cheese.

The quantitative descriptive profiles in Figure 2 showed changes in the dish at the beginning, 23, and 35 days of storage. Due to their similar behavior, the profiles did not include attributes such as "surface" and "strange odor". The most noticeable alterations were observed in ingredients like olives.

Gouda cheese showed the most remarkable variations, significantly impacting the overall quality of the dish. During freezing, changes in texture were attributed to structural damage caused by cell rupture due to the phase change of water. Previous studies (Singleton & Pattee, 1993; Graiver et al., 2004) indicated that this process alters the protein structure and cellular microstructure, affecting the viscoelastic properties. After 15 days of storage, the cheese showed notable differences in texture, color, shine, and firmness, although these attributes remained acceptable until 35 days.

The olive, with a high water content, suffered more pronounced structural damage, especially in flavor and surface. The color deterioration was gradual, with significant differences only at 35 days. In contrast, the ham showed minimal variations, with slight color and overall quality deterioration.

Vela and Montero chorizo, with lower moisture content, showed more sensory stability, maintaining their properties almost intact, with slight variations in moisture and overall quality. On the other hand, due to its high water activity, the cooked ham experienced sensory deterioration, particularly in its characteristic odor, possibly due to interactions between aromatic substances in the dish's ingredients.

Packaging with stretch film helped reduce moisture loss and minimize temperature fluctuations, preventing the negative effects observed in frozen products without sealing, as noted by Campañone et al. (2001) and Machado-Velasco & Vélez-Ruiz (2008). Figure 3 reflects the general behavior of the dish's quality during storage.

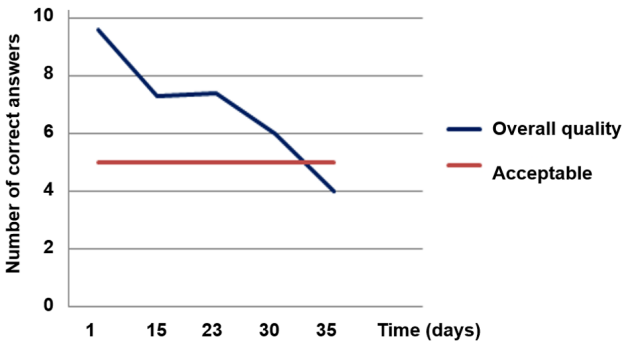

Figure 3. Overall quality behavior of the dish.

A significant decrease ($p \leq 0.05$) in the overall quality of the dish was recorded over time. The most considerable variation occurred between the initial samples and those evaluated after 15 days, after which the parameter stabilized until day 23. New significant differences ($p \leq 0.05$) were observed on day 30, and the dish was rejected on day 35, although the Chorizo Vela and Montero maintained acceptable characteristics. It was concluded that the cold dish prepared at the Havana Catering Base Business Unit preserves its optimal sensory characteristics during storage for up to 30 days.

The proposal begins with the request for raw materials, omitting details regarding warehouse handling, as the integrated management system ensures the quality of the inputs entering the production area.

1. Raw material processing: Raw materials must be requested and processed in the pre-elaboration area on the

same day the dishes are assembled in the plating area. This procedure follows the standard flow of the cold area, ensuring that materials are extracted from storage on the day of preparation.

2. Dish assembly: The dishes must be assembled in the cold plating area, adhering to the established temperature and time specifications.

3. Dish registration: Register the dishes with batch number, production date, specifications, quantity, and responsible handler, using the PEC.09.10 (2002) model applied to hot meals.

4. Quick freezing: The dishes will be rapidly frozen at -18 ºC, with a 0.7-2 cm/h rate.

5. Storage: Frozen dishes will be stored in the freezing chamber at -18 ºC, with rotation control according to CCP No. 2 (PEC 32.1, 2009). Their durability will be 30 days, marking them as "Non-compliant" for those exceeding this period, per the general procedure (PG 13, 2001). Defrosted dishes cannot be re-incorporated into the process.

6. Pre-consumption defrosting:

a) For flights: Dishes must be extracted from storage at least 5 hours before consumption. They defrost and assemble in 1 hour and are then stored in the transit fridge for at least 2 hours.

b) For ground services: Dishes are placed directly in the transit fridge, where they must remain for at least 4 hours before consumption.

Consumption begins when dishes are removed from storage, with rapid transfer to the assembly area and subsequent storage in the transit fridge. Service to the aircraft takes between 1 and 2 hours, and the dishes can be consumed up to 12 hours after defrosting, ensuring a minimum of 5 hours from storage extraction to consumption. On the ground, dishes are moved directly from the storage fridge to the transit fridge, considering at least 1 hour from dispatch to consumption, including distribution through the Havana Gastronomy Basic Unit of CubaCatering S.A.

Proposed procedure for the preparation and evaluation of frozen dishes:

1. Preparation and initial freezing: Prepare and freeze 10 dish samples following the established procedures.

2. Freezing storage: Store the samples for 3-5 days in the freezing fridge without affecting microbiological stability but observing sensory changes.

3. Defrosting: Defrost by placing the samples for 3 hours in a maintenance fridge and 2 hours in a climate-controlled room.

4. Preliminary sensory evaluation: Evaluate the dish's ability to withstand freezing and defrosting.

5. Freezing of samples: Prepare and freeze 60 samples on three dates. Use five daily samples for microbiological and sensory evaluations.

6. Storage and monitoring: Store the samples in the freezing fridge and continuously monitor the temperature.

7. Microbiological analysis: Perform analyses according to NC 585 (2015) standards on specific storage days (1, 15, 30, 45, 50, and 60).

8. Sensory evaluations: After obtaining satisfactory microbiological results following the same defrosting procedure, perform sensory evaluations.

9. Descriptive profile: Create a descriptive profile to analyze sensory behavior during storage.

10. Stability definition: Determine when the dish maintains microbiological and sensory stability.

The dishes were selected by analyzing the prepared services, including hot and cold dishes, such as appetizers and salads. The most suitable dishes for freezing storage were chosen, considering factors such as the target market, the feasibility of preparation and commercialization, and their suitability for freezing and subsequent sale.

The sensory panel at the center was trained to evaluate the dishes, ensuring panelists could identify defects in the raw materials and distinguish between these and degradation during the processes evaluated. This training also enabled the creation of descriptive sheets and sensory evaluation forms.

The dishes were prepared according to the proposed procedure, and the stability of each one was evaluated. The methodology applied can be used in any unit of Cubacatering S.A. and, with the necessary modifications, in hot dish preparation and defrosting processes.

Conclusions

The freezing of complete meals was ineffective due to the time required to defrost the juices, reducing the benefits of frozen meals. Five dishes suitable for freezing were selected: a snack, a cold dish, a cold cuts appetizer, a sandwich, and a vegetable appetizer, which were part of Cubana de Aviación's services, offering options for cold breakfast and snacks. To evaluate the dishes, a Sensory Evaluation Commission was created at the Havana Catering Base Business Unit, consisting of six workers with verified sensory skills. The cold dish maintained its quality for 30 days at -18 ºC, the time determined by its sensory deterioration. Furthermore, a methodology was proposed covering procedures for preparing and evaluating frozen meals, including production flow, storage, sampling, microbiological analysis, sensory evaluation, and defrosting.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on 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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