ASSESSMENT OF HYGIENE CONDITIONS IN HOTEL'S RESTAURANT AND MICROBIAL CHANGES OF PREPARED GROUND BEEF SAUCE DURING COLD STORAGE

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ABSTRACT

This study evaluates the quality management system, sanitary conditions, and microbial changes in food prepared at hotels's restaurant. The food safety management system is assessed based on criteria related to the layout, equipment and utensils, sanitation programs, practices, and the knowledge of food safety among the kitchen staff at the hotel's restaurant. Additionally, sanitary conditions are evaluated through microbial indicators of food-contact surfaces, water samples, and ice. A typical product of the preparation and cold storage process in the restaurant is ground beef sauce. Ground beef sauce samples were collected at various time points (0, 1, 2, 3, 4, and 5 days) during refrigerated and frozen storage. Microbiological analysis determined the total plate count (TPC), pathogenic bacteria (*Salmonella* spp*., Staphylococcus aureus, Listeria monocytogenes, Clostridium perfringens*), indicator microorganisms (*Coliforms, Escherichia coli*), and spoilage microorganisms (*Pseudomonas* spp*., yeasts and molds*). Data were statistically processed to evaluate the relationship between sanitary conditions, the quality management system, and microbial changes in the food. The results help verify the food safety conditions in the restaurant and hotel and optimize the process of storing prepared food in hotel's restaurants.

Keywords: Restaurant, hotel, food safety assurance, microorganisms, ground beef sauce, cold storage

1. INTRODUCTION

Food safety plays an essential and pivotal role in safeguarding public health and fostering sustainable societal development. Food and beverages are fundamental human needs and, as such, must be handled hygienically at every stage—from raw material sourcing to preparation, storage, and service. Failure to maintain proper food safety controls may lead to foodborne illnesses, which are a significant public health concern. According to the World Health Organization (WHO), there are 31 recognized agents, including bacteria, viruses, parasites, toxins, and chemicals, that can cause such illnesses. Annually, approximately 600 million individuals are affected by foodborne diseases, resulting in over 420,000 fatalities, with 125,000 of these being children under the age of five [1]. Common pathogens, such as *Escherichia. coli* and *Staphylococcus* spp., are primary causes of diarrheal diseases and several severe foodborne outbreaks. For instance, the 2007 outbreak in the United States, which involved ground beef contaminated with *E. coli* O157:H7, and the 2020 incident linked to *Pseudomonas* spp., highlight the critical importance of ensuring food safety at all stages of

food production and distribution.

In Vietnam, the General Statistics Office reported a robust recovery of the tourism sector in the first quarter of 2024, which has subsequently driven rapid growth in the restaurant and hotel industries. As a result, the volume of food requiring preparation, storage, and service has significantly increased, further emphasizing the need for stringent food safety practices. In industrial kitchens, particularly in large-scale food establishments, ensuring optimal hygiene conditions and controlling food safety is paramount in preventing cross-contamination and the growth of harmful microorganisms.

Spaghetti with minced beef sauce is a widely popular dish in many restaurant and hotel menus. However, given the large-scale preparation and extended storage time, this product is particularly susceptible to microbial contamination if temperature and storage time are not meticulously controlled. Research conducted by the U.S. Food Safety and Inspection Service (FSIS) has shown that even under refrigerated conditions, processed foods can still provide an environment conducive to the growth of spoilage microorganisms, such as *Pseudomonas* spp., *lactic acid bacteria (LAB)*, *Clostridium* spp., as well as hygiene indicator microorganisms like coliforms and *E. coli*, as evidenced in studies by FSIS [2]. Additionally, a study by Erwan Adi Saputro [3] regarding the design of HACCP systems for Rendang Padang further underscores the risk of microbial growth if critical control points during cooking, cooling, and storage are not rigorously controlled. Moreover, research by Kim et al. [4] demonstrated that *L. monocytogenes* and *LAB* strains are capable of growing in cooked meat stored at temperatures as low as 10 °C, thereby increasing the risk of foodborne illness if proper storage conditions are not maintained.

This study aims to bridge the gap between hygiene condition assessment and its actual implications for food microbial safety. By evaluating environmental hygiene indicators and observing microbial dynamics in a representative prepared food product, the research seeks to validate how hygiene status correlates with microbial risks in post-processing stages.

Given these considerations, the aim of this study is to evaluate “Assessment of hygiene conditions in hotel’s restaurant and microbial changes of prepared ground beef sauce during cold storage”.

2. MATERIALS AND METHODS

2.1. Food service establishments and food preparation:

The study was caried out from August 2023 to April 2025 in Food Exchange restaurant at Novotel Suites Hanoi including: Kitchen areas within the restaurant, 28 staff members directly involved in the operation at the restaurant and hotel were surveyed and cold-stored ground beef tomato sauce product

2.2. Sample collection

The sampling method for prepared food samples, food-contact surfaces, and water used in food processing was conducted following the guidelines outlined in Circular No. 14/2011/TT-BYT [5] and QCVN 01:2009/BYT issued by the Ministry of Health (MOH).

2.2.1. Cook-served food

Evaluation of the hygiene of samples of cook - served food were collected from different kitchen areas depending on the menu being served and the availability of dishes. Total of 8

cook-served food samples were collected from hotel's restaurant. Approximately 350 g of each sample was carefully collected from cooked food placed into pre-sterilized food-grade bags, and stored in insulated containers with ice packs to maintain low temperatures during transport. Samples were delivered to the laboratory within 3–4 hours for microbiological analysis. Additionally, all samples were refrigerated at 0–4 °C and analyzed within 24 hours to ensure accuracy and representativeness of the results. These samples were collected annually as part of the facility's internal hygiene surveillance program.

2.2.2. Food contact surfaces

To assess hygiene levels, samples were collected from food contact surfaces. The evaluation of surface hygiene occurred following the completion of routine cleaning and sanitation procedures. Surface samples were collected from key food-contact surfaces including knives, cutting boards, countertops, and buffet utensils using sterile swabs over an area of 25 cm^2, following ISO 18593:2018. In the case of kitchen surfaces, the process required employing two sterilized cotton balls soaked in physiological saline solution to swab an area of approximately 100 cm2, encompassing cutting boards, knives, staff hands, slicing machine, and plates. Hand swab samples were taken from food handlers' palms and fingertips using moistened swabs prior to handling ready-to-eat food. Equipment samples included inner surfaces of slicing machines, blenders, and storage containers. The samples were then placed in insulated containers with ice packs to maintain temperatures at ≤4 °C during transport to the laboratory, ensuring that the time from collection to analysis did not exceed 3–4 hours. In the laboratory, water samples were refrigerated at 0–4 °C and analyzed microbiologically within 24 hours to ensure result validity and accuracy. These samples were collected annually as part of the facility's internal hygiene surveillance program.

2.2.3. Water source hygiene

The hygiene assessment of water used in food processing was also conducted in accordance with Circular No. 14/2011/TT-BYT [5]. Water samples were taken directly from usage points in the processing line (e.g., raw material preparation areas, cooking areas, utensil washing stations). Approximately 500 mL of water was carefully collected in pre-sterilized sampling bottles, avoiding direct contact with the sampler's hands or surrounding surfaces. The samples were then placed in insulated containers with ice packs to maintain temperatures at ≤4 °C during transport to the laboratory, ensuring that the time from collection to analysis did not exceed 3–4 hours. In the laboratory, water samples were refrigerated at 0–4 °C and analyzed microbiologically within 24 hours to ensure result validity and accuracy. Water sampling was performed on a monthly basis.

2.2.4. Practical applications of food safety and hygiene conditions

Evaluation of compliance with food safety and hygiene conditions:
A data collection form was developed for the study covering aspects such as personal hygiene awareness, compliance with food safety regulations, good hygiene practices, and critical control points (CCPs). Prior to the official survey, a pilot investigation was conducted to refine the survey form. Following this, training for the data collectors was carried out. The data collection was then conducted using a combination of observation, evaluation, document and record review, as well as interviews and surveys with food handlers at the hotel's restaurant. All information was recorded in checklists constructed based on the inspection guidelines outlined in Circular 48/2015/TT-BYT [6] and other relevant legal documents.

2.2.5. Microbial changes of prepared ground beef sauce during storage

A total of 40 samples were packaged in stainless steel containers (350 g/container), sealed with PE film, and then divided into three groups for storage under different temperature conditions: Room temperature (25 ± 1 °C), cold storage (5 ± 1 °C), freezing (-18 ± 1 °C). Samples of cooked ground beef sauce were collected daily over a 5-day period. The microbial indicators were monitored and quantitatively analyzed at different time intervals during storage, focusing on the following parameters: TPC, *P. spp*., Yeasts and, *L. monocytogenes.*

Investigation of Microbial Growth: To study the growth of total aerobic microorganisms, spoilage microorganisms (*Pseudomonas* spp.), *L. monocytogenes*, and yeasts and molds in the ground beef tomato sauce product during cold storage, samples were taken in accordance with the guidelines set forth in Circular 14:2011/TT-BYT on food sampling procedures. The ground beef tomato sauce was prepared and portioned into stainless steel containers (350 g per container), which were then sealed with thin, pre-sanitized PE film. The samples were subsequently stored under three different temperature conditions: 5 ± 1 °C, 25 ± 1 °C, and – 18 ± 1 °C. For microbiological analysis, the containers were placed into insulated boxes with ice packs to maintain a low temperature and transported to the laboratory within 3–4 hours. All samples were refrigerated at 0–4 °C upon arrival and were analyzed within 24 hours to ensure microbiological accuracy and result validity.

2.3. Microbiological analysis

The identification and quantification methods were performed according to the relevant international and national standards, including: ISO 4833-1:2013/Amd1:2022 [7], ISO 11290-2:2017 [8], TCVN 8275-2:2010 (ISO 21527-2:2008) [9], TCVN 7138:2013 (ISO 13720:2010) [10], TCVN 6848:2007 (ISO 4832:2006) [11], ISO 6579-1:2017/Amd1:2020 [12], AOAC 975.55 [13], TCVN 4991:2005 (ISO 7937:2004) [14], TCVN 7924-2:2008 (ISO 16649-2:2001) [15], TS-KT-PCR-01:2022 [16], TCVN 6492:2011 [17], TCVN 6185:2015 [18], TCVN 1240-1:2020 [19], TCVN 6625-3:2011 [20], SMEWW 3114B:2023 [21], TCVN 6187-1:2019 (ISO 9308-1:2014) [22].

2.4. Statistical analysis

The experiment was repeated three times independently. The data were compiled and analyzed using Microsoft Excel. The experimental results were then analyzed using the Two-Way ANOVA method and Turkey's test on SPSS 20 software, with a significance level set at $\alpha = 0.05$. The final objective was to compare the mean values and identify statistically significant differences.

3. DISCUSSION

3.1. The prevalence and conformity of microbiological aspects in cook-served food

To assess the microbiological safety of cook-served food, samples of prepared dishes were collected and analyzed in accordance with national food hygiene standards. This analysis focused on detecting common microbiological indicators such as total aerobic bacteria, coliforms, *E. coli*, and *S. aureus*,... The aim was to evaluate the prevalence of contamination and determine the level of conformity with current food safety regulations.

The microbiological test results for selected cook-served food at the hotel's restaurant (Table 1) indicate that the majority of samples met the food safety standards for

microbiological quality, as defined by QCVN 8-3:2012/BYT – National Technical Regulation on Microbiological Limits in Food. These dishes represent various types of food preparation, including cold dishes (salads), grilled items, soups, and custard-based desserts. All tested samples showed no detection of major pathogenic bacteria such as *E. coli*, *Staphylococus* spp., *L. monocytogenes*, *Bacillus cereus*, and enterotoxigenic *S. aureus*. These microorganisms are critical indicators directly associated with foodborne illnesses and are particularly concerning in hotel's restaurant environments serving large numbers of guests.

However, among the nine samples tested, four showed the presence of total aerobic microbial count (TPC), including: traditional Caesar salad (5.2×10^4 CFU/g), grilled Norwegian salmon (4.6×10^4 CFU/g), cream cake (2.2×10^4 CFU/g), and pastry filling (80 CFU/g). According to QCVN 8-3:2012/BYT, the maximum permissible limit for total aerobic microorganisms in ready-to-eat products such as salads, pastries, and prepared foods ranges from 10^5 to 10^6 CFU/g, depending on the product type. Thus, although TPC was present in these samples, all levels remained within acceptable limits, posing no direct risk to consumer health. The presence of low-level TPC may reflect factors such as storage duration, suboptimal cooling processes, or the potential for cross-contamination during preparation, especially for cold salads or cream-based desserts with fresh, microbiologically sensitive components.

Table 1. Microbiological test results for selected cook-served food at the Hotel's Restaurant

Dishes	TPC	*E. coli*	*B. cereus*	*Coagulase Positive Staphylococci*	*Staph.* spp.	*L. monocytogenes*
Traditional Caesar Salad	5.2 x 10^4 CFU/g	ND	<10 CFU/g	<10 CFU/g	ND	ND
Cream of Mushroom Soup	<10 CFU/g	ND	<10 CFU/g	<10 CFU/g	ND	ND
Cake	2.2 x 10^4 CFU/g	ND	<10 CFU/g	<10 CFU/g	ND	ND
Grilled Norwegian Salmon	4.6 x 10^4 CFU/g	ND	<10 CFU/g	<10 CFU/g	ND	ND
Steamed Rice			<10 CFU/g		ND	ND
Honey-Glazed Grilled Ribs	ND	ND	ND	ND	ND	ND
Creme bulee Cake	ND	ND	ND	ND	ND	ND
Crab and Asparagus Soup	ND	ND	ND	ND	ND	ND

The facility's complete control over pathogenic microorganisms, combined with maintaining TPC at safe levels, provides evidence that its food processing and storage practices are effectively managed. The implementation of a Hazard Analysis and Critical

Control Points (HACCP) food safety management system, with 12 critical control points (CCPs) spanning raw material reception, processing, cooling, storage, and service, has contributed to proactively controlling microbiological hazards. This underscores the positive impact of enhanced sanitation practices, improved personal hygiene, and strengthened internal monitoring measures implemented during the study period.

According to the study by Pham Hong Thang et al. [23] at urban food service establishments, total aerobic microbial counts in salad and cold-prepared foods ranged from 10^4–10^5 CFU/g, while poorly controlled facilities showed levels exceeding 10^6 CFU/g, posing a significant risk of foodborne illness. Similarly, research by Nyati [24] on chilled sous vide meat products reported a rapid increase in TPC from $<10^2$ to over 10^4 CFU/g within just five days when storage temperatures exceeded 5 °C. In a survey of 4–5-star hotel systems in Korea, Kim et al. also found that cold dishes such as salads and sashimi commonly had TPC levels ranging from 10^3–10^4 CFU/g, due to direct air exposure and the potential for cross-contamination during service [4]. The results from the surveyed facility in the present study, with TPC levels in affected samples ranging from 2.2×10^4 to 5.2×10^4 CFU/g, are notably lower than the average levels reported in these previous studies. This further confirms the effectiveness of the restaurant–hotel's hygiene control measures in its food preparation and service processes.

3.2. Hygienic conditions of food contact surfaces

The microbiological test results on selected food-contact surfaces at the hotel's restaurant (Table 2) indicate that the cleanliness of the food preparation environment is relatively well-controlled. Of the 6 samples tested, none showed the presence of *E. coli* – a microbiological indicator for personal hygiene and fecal contamination, commonly used to assess cross-contamination risks in food preparation areas.

Table 2. Microbiological test results on selected food-contact surfaces at the Hotel's Restaurant

Food-Contact Surface	TPC	*E. coli*
Pastry Staff Hands	80 CFU/g	ND
Cutting Board	<10 CFU/g	ND
Slicing Machine	40 CFU/g	ND
Knife	50 CFU/g	ND
Sushi Staff Hands	4.8 x 10^1 CFU/g	ND
Plate in the Buffet Area	1.5 x 10^1 CFU/g	ND

The total aerobic microbial count (TPC), which reflects the overall microbial contamination level, was recorded at low levels, ranging from <10 CFU/g to 80 CFU/g, significantly below the alert threshold set by QCVN 12-1:2011/BYT and HACCP guidelines for food processing equipment, where the recommended TPC limit on food-contact surfaces is typically ≤100 CFU/cm² (US FDA [25], 2004; CAC [26]/RCP 1-1969 Rev. 2020) .

Samples such as pastry staff hands (80 CFU/g), slicing machine (40 CFU/g), knife (50 CFU/g), and cutting board (<10 CFU/g) showed low levels of microbial contamination, especially on tools that frequently come into contact with raw ingredients and processed foods. Samples from sushi staff hands and plates in the buffet area – representing direct service surfaces – showed TPC values of 4.8×10^1 CFU/g and 1.5×10^1 CFU/g, respectively, both of which were low. This indicates that enhanced sanitation measures for equipment and personnel

have been effective and reflects adherence to cleaning, disinfection, and equipment management protocols at the facility.

Compared to the study by Pham Hong Thang et al. (2014) [23] in urban kitchens, TPC values on surfaces such as knives, cutting boards, and food handler hands typically ranged from 1.0×10^2 to 10^3 CFU/g, and could even exceed 10^4 CFU/g if not cleaned properly. The results from the facility surveyed in this study are at least 2-3 times lower than the average levels reported in the previous study, confirming the effectiveness of implementing the HACCP system and regular cleaning and disinfection procedures. Furthermore, the absence of *E. coli* on all surfaces demonstrates that the risk of fecal contamination or cross-contamination from improperly sanitized hands or equipment is very low, proving the effectiveness of measures such as hand hygiene checks, glove usage, separate preparation areas, and regular equipment maintenance.

3.3. Hygienic conditions of water source

Regarding water source conditions, the results of periodic surveys and inspections demonstrate that the facility fully complies with current regulations on hygiene and the safety of water used in food processing. Specifically, water samples analyzed periodically in accordance with Circular 15/2012/TT-BYT [27] show that all physicochemical and microbiological parameters are within permissible limits.

Table 3. Water quality test results

No.	pH	Colorimetric Value	Taste and Odor	Turbidity	Residual Chlorine	Asen	*E. coli*	Coliform	*Legionella*
1	7.02	<6 Pt-Co	No Odor or Unusual Taste	<1 NTU	0.230 mg/L	<0.005 mg/L	0 CFU/ 100 mL	0 CFU/ 100 mL	
2	7.02	<6 Pt-Co	No Odor or Unusual Taste	<1 NTU	0.355 mg/L	<0.005 mg/L	0 CFU/ 100 mL	0 CFU/ 100 mL	
3	7.11	<6 Pt-Co	No Odor or Unusual Taste	<1 NTU	0.425 mg/L	ND	0	0	ND

The measured pH value of 7.11; 7.02 indicates a stable neutral character; sensory parameters such as color (<6), turbidity (<1), and taste/odor (no odor, no unusual taste) all meet established standards. The residual chlorine concentration was recorded at 0.425 mg/L; 0.355 mg/L; 0.230 mg/L ensuring effective disinfection without negatively affecting the sensory quality of food. Notably, high-risk microbiological indicators such as *E. coli,* coliforms, and *Legionella* were not detected (ND), while heavy metal indicators such as arsenic did not exceed threshold levels. These findings not only confirm that the facility's water supply meets quality standards but also reflect its strong capacity to maintain hygiene, including the implementation of measures to prevent dust, insects, and contamination during water storage and use. Furthermore, the hotel's restaurant ensures an adequate supply of clean water and sanitary ice for food preparation, processing, and service activities. Compared to the study by Kieu Thiet Thu (2015) [28], in which only 92% of facilities met clean water

standards, the results from the surveyed facility in this study demonstrate superior compliance. Strict control of water quality, identified as a critical control point (CCP) within the HACCP system, serves as a key foundation for ensuring food safety throughout the entire hotel's restaurant processing and service chain.

3.4. Assessment of the practical application of food safety and hygiene conditions

The primary responsibility for ensuring food safety in hotel's restaurant lies with the head of the establishment. This responsibility is demonstrated through full compliance with current legal regulations concerning food safety in the food service industry. These regulations include requirements related to administrative procedures (legal documents, relevant paperwork), personnel conditions, infrastructure, equipment, and tools used for food preparation and storage. Administrative procedures for restaurant within hotels mainly include: registering for a certificate of food safety compliance (or a commitment to ensuring food safety in cases where the establishment is exempted from certification according to regulations), confirming food safety knowledge for staff directly involved in food preparation and service, organizing regular health checks for employees, and maintaining records of raw material origins and food production and storage processes.

Moreover, after the establishment has submitted the food safety commitment, the hotel's restaurant must continue to strictly adhere to legal requirements, such as confirming food safety knowledge for employees, organizing regular health checks, establishing hygiene plans for food preparation and storage areas, equipment, and tools, and conducting regular food quality testing to maintain and improve the effectiveness of food safety management.

Survey results from the hotel's restaurant indicated that the establishment was evaluated to meet food safety conditions at a relatively high level.

Among these, the administrative procedure group showed a very high compliance rate, with the establishment possessing all required documents, including the business registration certificate, food safety compliance certificate or food safety commitment statement, sample retention records, three-step inspection logs, and documentation proving the origin of raw materials. However, some limitations were observed, particularly in the incomplete provision of regular health check-up certificates and food safety knowledge confirmation for food handlers, primarily among newly recruited staff and seasonal workers. The establishment surveyed is currently applying the food safety management system (HACCP), which effectively controls the physical conditions and operational processes related to food. The establishment’s implementation of Critical Control Points (CCPs), continuous monitoring, and corrective actions helps prevent food safety risks, standardize processes, and ensure traceability and compliance during internal inspections or regulatory audits. HACCP also improves food preparation hygiene and staff awareness, while supporting compliance with legal requirements. The HACCP system is implemented with 12 CCPs throughout the food preparation process: (1) Purchasing food; (2) Receiving food; (3) Storing food; (4) Thawing food; (5) Preparing food; (6) Cooking food; (7) Cooling hot food; (8) Reheating food; (9) Keeping food hot; (10) Plating and garnishing food; (11) Washing cooking and eating utensils; (12) Room service – Transport. The identification of these CCPs helps minimize the risk of microbial contamination and standardize food safety procedures. Continuous monitoring at each CCP has allowed the hotel to tightly control bacterial contamination, physical, and chemical contamination risks while standardizing corrective procedures for deviations. This system not only enhances the effectiveness of preventing food safety incidents but also helps the establishment easily trace the origin of products and demonstrate compliance during internal and regulatory inspections. Observations in practice indicate that the food preparation environment is maintained in good hygiene, and staff show greater awareness and active

practice of food safety, enabling the hotel's restaurant to exceed the regulatory requirements regarding administrative procedures and infrastructure conditions.

In terms of infrastructure, most critical components met the required standards, achieving a 100% compliance rate. These include location and surrounding environment, one-way kitchen layout, clean water system, sanitation of food preparation and processing areas, dining area, storage rooms, changing rooms, and restrooms. These findings are consistent with those of Pham Hong Thang et al. (2014) [23], who emphasized the importance of adequate investment in food service facilities in urban settings. However, several shortcomings were observed regarding structural quality and sanitation within the food preparation area. Specifically, issues such as peeling paint on walls, the presence of cracks and broken tiles in hidden corners, dislodged floor tiles caused by impact during operations, and uncovered waste bins were documented. These deficiencies not only compromise aesthetic standards but also pose potential risks for cross-contamination and poor hygiene. Moreover, they hinder cleaning efforts and increase the likelihood of occupational accidents. These problems are mainly attributed to the facility's long operational history and the lack of regular maintenance, indicating the urgent need for repair and infrastructural upgrades.

Survey results on equipment and utensils revealed that most criteria achieved high compliance rates. Several key items—including handwashing stations, food sample retention equipment, personal protective equipment, and tools for separating raw and cooked food—met 100% of requirements. However, some essential criteria were not fully implemented, such as food tongs and appropriate food-grade containers. The inconsistency or deterioration of these tools can compromise hygiene effectiveness and pose significant risks in food safety control. The absence or degradation of certain equipment and utensils at the facility may negatively impact on the efficiency of food safety management. For example, the lack of food tongs may compel staff to use their hands during service or food preparation, increasing the risk of cross-contamination if proper hand hygiene is not strictly maintained. Damaged food containers—such as those with cracks, residual old labels, or those not meeting hygiene standards—can serve as harborage sites for microorganisms and promote food contamination. Similarly, inadequate or substandard waste containers may lead to reverse contamination into food processing areas. Such deficiencies may contribute to elevated microbiological indicators, such as total aerobic plate count or the presence of *E. coli* on food contact surfaces, both of which are indicative of poor sanitation during food processing. Therefore, ensuring the availability, quality maintenance, and proper usage of equipment and utensils in food preparation and storage is a critical factor for sustaining a high level of food safety in hotel's restaurant. Furthermore, many of the devices in use have been operated continuously for over seven years without a replacement policy, resulting in rusting, chipping, or mechanical instability—issues that affect both production efficiency and the facility's professional image. As such, it is imperative for the establishment to implement a comprehensive equipment lifecycle management system. This should include regular inspections, timely disposal of damaged, rusted, or non-compliant utensils, and investment in the replacement of outdated tools with new, food safety-compliant equipment. This requirement is essential for maintaining a clean processing environment, preventing cross-contamination, and meeting food safety inspection standards set by regulatory authorities. Such measures are also consistent with the provisions of Decision No. 1246/QĐ-BYT (2017) [29] on food safety conditions in collective kitchens.

In the domain of human-related conditions, the findings indicate that Awareness and practices related to food Personal hygiene of food handlers at the surveyed establishment were generally at a fairly good level. Most employees had received training in food safety knowledge. However, several limitations remain that require corrective action. The consistent use of personal protective equipment (PPE) was not strictly observed across all departments.

Some employees were still found wearing watches, bracelets, or having untied hair while working in food preparation areas. The primary reasons identified include a lack of awareness regarding the importance of personal hygiene in preventing food contamination, unadjusted personal habits, and insufficient supervision and enforcement by the management. Additionally, some temporary or probationary staff had not undergone regular health checks or received adequate food safety training, resulting in non-compliance with food safety regulations. These findings are less favorable compared to studies conducted in other localities, such as those by Trinh Bao Ngoc et al. (2019) [30] and Hoang Thi Hoa (2022) [31], highlighting the urgent need to strengthen human resource management capacity and internal awareness of food hygiene and safety (FHS).

Additionally, sample retention, the three-step inspection records, documentation of ingredient traceability, and legal records are all properly maintained at the facility, demonstrating compliance with the requirements of Decision 1246/QD-BYT (2017) [29]. This legal framework is crucial for traceability and proactive food safety control, especially in the event of an incident.

Overall, the results of the study suggest that the hotel's restaurant has made significant efforts to ensure food safety, particularly in aspects related to facilities, legal documentation, and equipment systems. However, there are still certain factors that could potentially impact food safety, particularly human factors and equipment maintenance. Therefore, to enhance food safety management effectiveness, it is necessary to strengthen monitoring efforts, improve staff awareness, and establish a regular equipment maintenance and replacement process to ensure the system operates stably, consistently, and meets long-term standards.

3.5. Microbial changes in cooked beef sauce during cold storage

This section presents the microbial changes observed in cooked beef sauce stored under cold conditions over a defined period. The analysis aimed to monitor the growth of key microorganisms during storage to evaluate the product's microbiological stability and shelf-life. Regular sampling and microbiological testing were conducted to assess how storage time affects food safety and quality.

Table 4. Microbial groups in cooked minced beef sauce

No	Indicators		Compliant	Non-compliant
1	Microbiology	TPC	1.6 x 10^2 CFU/g	
2		*E. coli*	ND	
3		*Coliforms*	ND	
4		*C. perfringens*	ND	
5		*C. botulinum*	ND	
6		*Staphylococcus* spp.	ND	
7		*L.monoocytogenes*	ND	
8		*S. aureus*	ND	

The test results (Table 4) show that all microbiological indicators of the cooked ground beef sauce are within the safety limits: the total number of aerobic bacteria measured is 1.6×10^2 CFU/g, and no *E. coli, Staphylococcus* spp., *L. monocytogenes*, or *C. botulinum*, dangerous

pathogens, were detected. This indicates that the cooking process and post-cooking hygiene control were carried out effectively, ensuring consumer safety, in accordance with HACCP standards and the regulations of the Ministry of Health. The absence of *Clostridium* and *Listeria*, both of which have the ability to produce toxins and persist in food, further confirms that the processing environment and post-cooking storage conditions were rigorously maintained. Additionally, the results reflect strict adherence to the principles of hazard analysis and critical control point (HACCP) control throughout the entire production process.

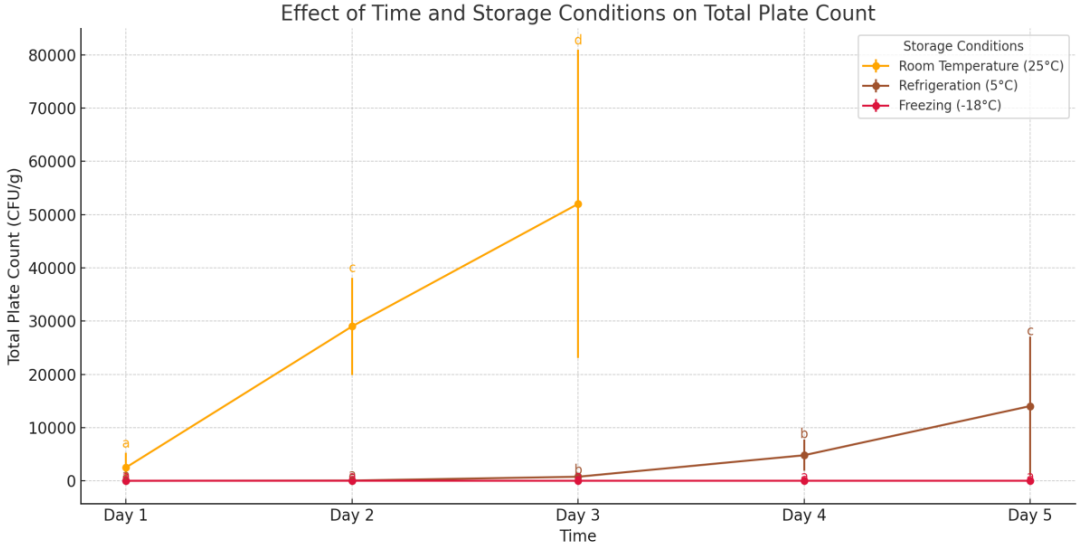

Figure 1. Changes in TPC density of cooked ground beef sauce over time during storage at stable temperatures of -18 ± 1 °C, 5 ± 1 °C, and 25 ± 1 °C.

The results of the study show that under normal storage conditions (room temperature), the Aerobic Plate Count (TPC) increased rapidly, reaching a peak on day 3 with an average of 52,000 CFU/g. After this point, microbial growth stabilized but remained at a very high level, exceeding the safety limits set by many international regulations. Under refrigerated storage conditions (<5 °C), the microbial count increased from 0 on day 1 to 52 CFU/g on day 2, and reached 14,033 CFU/g on day 5, indicating a slow yet noticeable growth after the lag phase. Under freezing conditions (<-18 °C), TPC remained unchanged throughout the 5-day period, maintaining at 0 CFU/g. The Total Plate Count (TPC) is an important indicator of the overall microbial status of food. Statistical analysis (ANOVA) confirmed that both time, storage conditions, and their interaction significantly affected the changes in TPC ($p < 0.05$). The time × storage condition interaction showed that the degree of microbial growth was dependent on the interaction between time and storage environment. These findings reflect a favorable initial sanitary condition: the starting TPC was only 1.6×10^2 CFU/g, which is considerably lower than commonly reported in comparable food environments. This observation aligns with the surface hygiene results (Section 3.2), where TPC values on knives, cutting boards, and staff hands were all well below 100 CFU/cm². Furthermore, the absence of *E. coli* on all tested surfaces and in water samples (Sections 3.2 and 3.3) reinforces the conclusion of a low initial microbial load. Consequently, the slow microbial growth observed in the cold-stored sauce can be attributed to this hygienic baseline, which effectively limited contamination during food handling and packaging. These results are consistent with the study by Nyati (2000) [24], where the total aerobic bacteria in sous-vide cooked pork stored at 3 °C remained below 3 log CFU/g after 5 weeks, while at 8 °C, it exceeded the safety threshold. Similarly, the study by

Djenane et al. (2001) [32] also recorded a rapid increase in TPC in ground beef stored under refrigeration, particularly when exceeding 4 °C. This further emphasizes the decisive role of temperature in controlling the growth of aerobic microorganisms.

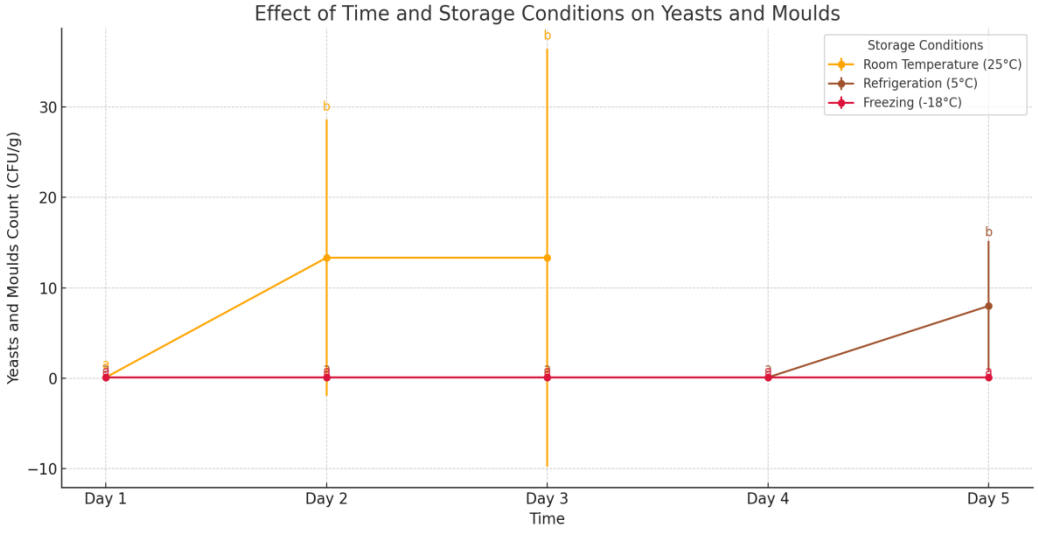

Figure 2. Changes in the density of Yeasts & Molds in ground beef sauce over storage time at stable temperatures of -18 ± 1°C, 5 ± 1°C, and 25 ± 1°C

The research findings indicate that under ambient conditions, molds began to appear on day 2 with a density of approximately 13.3 CFU/g and remained at a similar level through day 3. Under refrigerated conditions, no molds were detected during the first four days; however, on day 5, yeasts and molds began to emerge with a density of 8 CFU/g, suggesting an adaptive response following a latent period. Under frozen conditions, no fungal growth was observed throughout the 5-day storage period.

Yeasts and molds are groups of microorganisms capable of growing in dry environments, those rich in carbohydrates, and even under mildly cold conditions. They are commonly associated with food spoilage, sensory quality degradation, and the production of mycotoxins. ANOVA analysis revealed that storage condition was the only factor with a statistically significant effect ($p = 0.033$), whereas time and the interaction between time and condition were not significant. This confirms that temperature is the primary factor controlling mold development in cooked foods. Yeasts and molds are often associated with airborne contamination, unclean storage containers, and high-humidity environments. However, the very late onset and low fungal counts indicate strong environmental and equipment hygiene. Section 3.3 confirmed that the facility's water was free from *E. coli,* coliforms, and *Legionella*, and Section 3.4 noted effective sanitation of storage utensils and limited structural defects. Additionally, proper cleaning of buffet plates and separation of raw-cooked food zones likely contributed to reducing fungal spores' survival. These factors collectively explain the delayed and limited appearance of fungi in the stored sauce. In comparison with the study by Wang et al. (2004) [33], yeasts were found in high numbers in cooked chicken wings stored for seven weeks at 2°C, while no yeasts were detected in traditionally cooked samples. This suggests that yeasts and molds possess mild heat resistance and can grow slowly under cold storage, particularly over extended periods. In the present study, which spanned five days, lower fungal levels were recorded, indicating that microbial development was still limited during the early phase of storage.

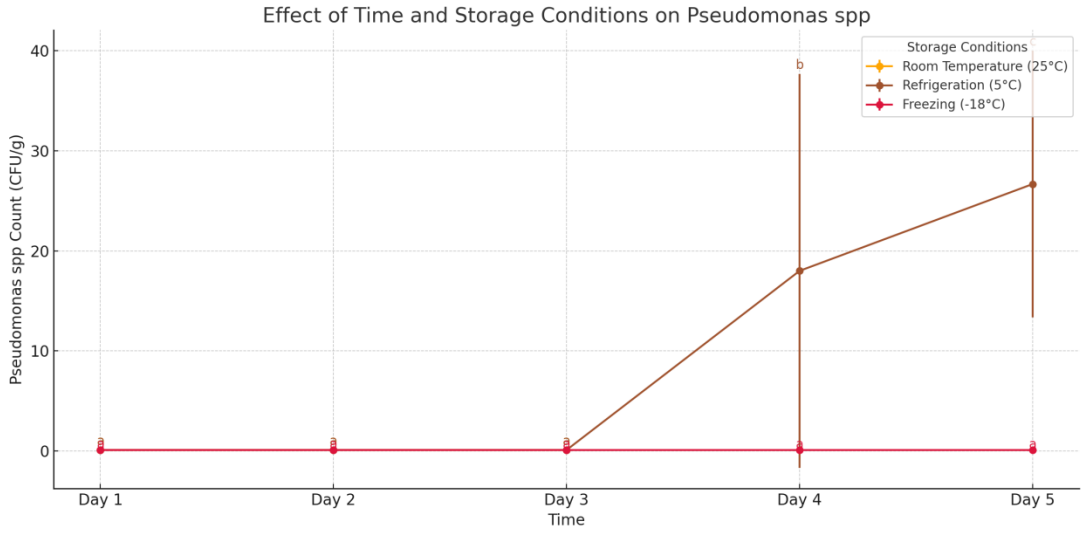

Figure 3. Changes in *Pseudomonas.* spp density in minced beef sauce during storage over time at stable Temperatures of -18 ± 1 °C, 5 ± 1 °C, and 25 ± 1 °C

The research results showed that *Pseudomonas* spp. were not detected under any storage condition during the first three days. From day 4 onward, the bacteria appeared in samples stored under refrigerated conditions, with an average density of 18 CFU/g, increasing to 26.67 CFU/g by day 5. No growth of *Pseudomonas* spp. was observed in samples stored under ambient or frozen conditions throughout the study period.

Pseudomonas are common psychrotrophic bacteria capable of growing at low temperatures and are recognized as primary spoilage agents in refrigerated food storage. Statistical analysis confirmed that time, storage condition, and the interaction between time and condition all had significant effects ($p < 0.05$). Notably, refrigerated conditions, generally considered safe, were shown to facilitate the growth of *Pseudomonas* following a latent period. *Pseudomonas* are psychrotrophic bacteria capable of growing at low temperatures and are a common cause of spoilage in refrigerated foods. Their delayed appearance suggests a very low initial presence, likely due to strict sanitation of slicing equipment and hand hygiene, as shown in Section 3.2. Tools like the slicing machine and cutting board recorded microbial levels below 50 CFU/g, and no *E. coli* was found. Additionally, staff hygiene (Section 3.4) showed overall good compliance despite minor limitations. These conditions created an environment where *Pseudomonas* could not proliferate until the end of the storage period, highlighting how good sanitation can delay spoilage onset. These findings are consistent with those of Díaz et al. (2008) [34], who reported the emergence of *Pseudomonas* after a latent phase in cooked pork products stored at 2–4 °C. Similarly, Nyati (2000) [24] found that *Pseudomonas.* reached levels as high as 6 log CFU/g when the storage temperature increased from 3°C to 8°C. These studies support the observation that *Pseudomonas* can proliferate slowly but significantly under cold storage, especially after several days.

Listeria monocytogenes

L. monocytogenes is a Gram-positive bacterium capable of causing serious foodborne illness, particularly in pregnant women, the elderly, and immunocompromised individuals. It is well known for its ability to grow under refrigerated conditions, making it a major concern in the ready-to-eat food industry.

Section 3.4 outlined that the facility adheres to a HACCP system with 12 well-monitored critical control points (CCPs), including cooking, cooling, packaging, and cold chain maintenance. The absence of structural defects in key food preparation zones, verified in Section 3.1, further minimizes the chance of post-cooking contamination. Moreover, the result supports literature indicating that *L. monocytogenes* typically requires longer periods and more favorable conditions to regrow, particularly when initial contamination is absent or minimal. However, during the entire 5-day study period and across all three storage conditions (ambient, refrigerated, and frozen), *L. monocytogenes* was not detected in any of the food samples. This result aligns with the findings of Schoder et al. (2015) [35], who reported no detection of *L. monocytogenes* in ready-to-eat products stored under refrigeration for a short period post-heat treatment. Similarly, the study by Sant'Ana et al. (2012) [36] showed that noticeable growth of this bacterium only occurred after 7–10 days of storage at 4 °C, particularly in foods with high water activity and favorable pH.

It is possible that the food in the present study had undergone sufficient thermal processing and maintained hygienic handling and packaging practices, eliminating any surviving cells of *L. monocytogenes*. Moreover, the relatively short storage duration (5 days) may not have been long enough to observe bacterial recovery or regrowth, if any injured cells were present. While *L. monocytogenes* can grow in cold environments, it typically requires longer time periods and suitable conditions of pH, moisture, or substrates to proliferate.

Based on the microbial data collected across storage conditions, the microbiological safety of prepared ground beef sauce is shown to be strongly dependent on both temperature and storage duration. At room temperature (25 ± 1 °C), the Total Plate Count (TPC) exceeded the safety threshold (52,000 CFU/g) by day 3, indicating that the product is microbiologically unsafe after 2 days of storage under these conditions. Under refrigeration (5 ± 1 °C), although the TPC remained within the acceptable limit of QCVN 8-3:2012/BYT (14,033 CFU/g on day 5), the emergence of spoilage microorganisms such as *Pseudomonas* and molds on day 5 suggests that the safe shelf-life should not exceed 4 days to maintain both safety and sensory quality. In contrast, freezing at –18 ± 1 °C effectively inhibited microbial growth throughout the 5-day storage period, demonstrating that this method ensures microbiological safety during the studied timeframe

4. CONCLUSION

The study provides a comprehensive overview of food safety conditions at the hotel's restaurant facility and thoroughly analyzes the changes in microorganisms on a ready-to-eat product (minced beef sauce) during cold storage. The survey results indicate that the facility has complied well with food safety regulations, particularly in terms of legal aspects, infrastructure, equipment systems, water supply control, and traceability documentation. The water quality test results show that all physicochemical and microbiological indicators meet the standards, including neutral pH, acceptable turbidity, color, residual chlorine, and the absence of *E. coli, Coliform*, and *Legionella* – confirming that the clean water supply system is safe for food preparation.

The microbiological test results on food samples indicate that most of the processed food samples met the required standards, with no detection of key pathogenic bacteria such as *Samonella.*, *L. monocytogenes*, *B. cereus*, and *E. coli.* Some samples showed a low total aerobic microbial count (TPC) within the acceptable range, reflecting good control over microbiological hazards in food preparation and storage. Similarly, microbiological tests on food-contact surfaces also revealed low TPC, with no detection of *E. coli,* further confirming the effectiveness of sanitation measures for tools and personal hygiene in preventing cross-contamination from the preparation environment. However, some limitations were noted

regarding the structural quality of the facility, deteriorating equipment, and inconsistent personal hygiene practices, particularly among new and temporary staff.

From a microbiological perspective, the study shows that cold storage conditions (<5 °C) are effective in slowing the growth of total aerobic bacteria, yeasts, molds, and *Pseudomonas* although some strains still have the potential to grow after the lag phase. Notably, deep freezing (< -18 °C) proved to be exceptionally effective, as all surveyed microorganisms, including total aerobic bacteria, molds, and *Pseudomonas* did not grow throughout the study period. This confirms that deep freezing is a key factor in completely inhibiting microbial activity on processed food, thus extending shelf life and ensuring optimal microbiological safety. Additionally, *L. monocytogenes* was not detected in any samples, indicating that the initial processing and packaging procedures were effective in ensuring hygiene and safety

The findings suggest that the safe storage duration for prepared ground beef sauce varies significantly with temperature: ≤2 days at room temperature, ≤4 days under refrigeration, and ≥5 days under freezing conditions. This emphasizes the importance of temperature control in ensuring product safety, particularly in large-scale food service operations.

The study demonstrates that initial hygiene conditions such as TPC on hands and equipment, and water quality have a direct influence on microbial risk profiles during food storage. This confirms the value of regular hygiene audits not only for compliance but also for predicting food safety risks under realistic storage scenarios

Based on these findings, the study recommends that food service establishment continue to maintain and strengthen food hygiene and safety practices, with particular focus on raising worker awareness, investing in regular equipment maintenance, and rigorously controlling the post-processing storage environment. Furthermore, the application of frozen storage should be more widely adopted for ready-to-eat foods as an effective measure to minimize the growth of spoilage-causing microorganisms. Long-term studies are also necessary to assess the potential for microbial recovery and growth under refrigerated conditions, which still pose hidden risks if not continuously monitored.

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TÓM TẮT

ĐÁNH GIÁ ĐIỀU KIỆN VỆ SINH TẠI NHÀ HÀNG KHÁCH SẠN VÀ SỰ BIẾN ĐỔI VI SINH VẬT TRÊN XỐT BÒ BĂM ĐÃ QUA CHẾ BIẾN TRONG QUÁ TRÌNH BẢO QUẢN LẠNH

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Nghiên cứu này nhằm đánh giá hệ thống quản lý chất lượng, điều kiện vệ sinh và sự biến đổi vi sinh vật trên thực phẩm tại nhà hàng khách sạn. Hệ thống bảo đảm an toàn thực phẩm

được đánh giá dựa trên các tiêu chí như bố trí khu bếp, thiết bị dụng cụ, chương trình vệ sinh, thực hành chế biến và kiến thức của nhân viên. Đồng thời, điều kiện vệ sinh được khảo sát thông qua các chỉ tiêu vi sinh trên thực phẩm đã chế biến, bề mặt tiếp xúc thực phẩm và nước. Sản phẩm điển hình được theo dõi là xốt bò băm đã qua chế biến, được bảo quản ở ba điều kiện: nhiệt độ phòng (<25°C), làm mát (<5°C) và cấp đông (<-18°C) trong 5 ngày. Các chỉ tiêu vi sinh được theo dõi gồm tổng số vi khuẩn hiếu khí (TPC), *Pseudomonas spp.,* nấm men, nấm mốc và *Listeria monocytogenes*. Phần lớn các mẫu thực phẩm chế biến và bề mặt tiếp xúc đạt yêu cầu vi sinh, không phát hiện các vi khuẩn gây bệnh chính (E. *coli, S. spp., L. monocytogenes, C. botulinum*...). Mức TPC trong thực phẩm và trên bề mặt đều dưới ngưỡng cho phép. Ở 25 °C, vi sinh vật phát triển nhanh và vượt ngưỡng an toàn sau 3 ngày. Ở 5 °C, vi sinh vật tăng chậm, *Pseudomonas spp.* và nấm men, nấm mốc bắt đầu xuất hiện sau ngày thứ 4–5. Ở -18 °C, không phát hiện sự phát triển vi sinh trong suốt 5 ngày. Ngoài ra, hệ thống HACCP được triển khai với 12 điểm kiểm soát tới hạn (CCP) góp phần kiểm soát nguy cơ vi sinh hiệu quả. Tuy nhiên, một số bất cập vẫn tồn tại như trang thiết bị xuống cấp, vệ sinh cá nhân chưa đồng đều ở nhân viên mới/thời vụ. Nghiên cứu khẳng định rằng điều kiện vệ sinh ban đầu (tay, dụng cụ, nước sạch) có ảnh hưởng trực tiếp đến rủi ro vi sinh trong bảo quản thực phẩm. Việc kiểm soát nhiệt độ và thời gian bảo quản là yếu tố quyết định bảo đảm an toàn thực phẩm trong nhà hàng khách sạn. Cấp đông là phương pháp bảo quản hiệu quả nhất để kéo dài thời gian sử dụng và ngăn ngừa hư hỏng vi sinh.

Keywords: Nhà hàng, khách sạn, đảm bảo an toàn thực phẩm, vi sinh vật, bảo quản lạnh.