e-ISSN:2706-6800

Analysis in municipal markets for the evaluation of the hygienic quality of beef

Análisis en Mercados municipales para la evaluación de la calidad higiénica de la carne bovina

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Published
Instituto Tecnológico Superior Edwards Deming. Quito – Ecuador

Periodicity
January-March
Vol. 1, Num. 21, 2024
pp. 25-39
http://centrosuragraria.com/index.php/revista

Dates of receipt
Received: December 08, 2023
Approved: February 02, 2024

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Abstract: The objective of this study was to evaluate the presence of E. coli/Coliforms in beef marketed in the Municipal Markets of Northeastern Guayaquil in order to determine the microbiological quality of meat products. The research work was carried out in the laboratory, with descriptive, exploratory and non-experimental knowledge. Using the Petrifilm plate culture system, a total of 84 beef samples obtained from 5 municipal markets with a total of 42 stalls dedicated to the sale of meat products were evaluated during two weeks. The results determined that 96% of the samples showed CFU of E. coli and Coliforms and 4% showed the presence of CFU of Coliforms and E. coli. Coli, resulting in a total value of 94% (79) of samples unfit for human consumption and a lower percentage of fit samples represented by 6% (5). In turn, these results could be related to the application of Good Manufacturing Practices where it was established that none of the stalls complied with the regulations; therefore, better control by the corresponding authorities is recommended in order to maintain food safety for the population.

Keywords: Coli, GMP, Beef, Coliforms, CFU

Resumen: El presente estudio tuvo como objetivo evaluar la presencia de E.Coli/Coliformes en carnes bovinas comercializadas en los Mercados Municipales del Noreste de Guayaquil para determinar la calidad microbiológica de los productos cárnicos. El trabajo de investigación se ejecutó en laboratorio, con conocimientos descriptivos, exploratorios y no experimentales. Mediante el sistema de cultivo en Placas Petrifilm se pudieron evaluar durante dos semanas un total de 84 muestras de carne bovina, obtenidas de 5 mercados municipales con un total de 42 puestos dedicados a la venta de productos cárnicos. Los resultados determinaron que el 96% de las muestras presentaron UFC de E. Coli y Coliformes y el 4% presencia de UFC de Coliformes y E. Coli, dando como resultado un valor total de 94% (79) de muestras no aptas para el consumo humano y un porcentaje menor de muestras aptas representada con el 6% (5). A su vez, estos resultados podrían estar relacionados con la aplicación de Buenas Prácticas de Manufactura donde se estableció que ninguno de

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los puestos cumplía con la normativa, por lo que se recomienda un mejor control por parte de las autoridades correspondientes para mantener la inocuidad alimentaria de la población.

Palabras clave: Coli, BPM, carne bovina, Coliformes, UFC

Introduction

From 1973 to 1987 in the United States, 48% of the outbreaks identified as pathogens were related to specific foods such as beef, eggs, pork, poultry, fish and shellfish, carcasses and crustaceans. or dairy products. (Pardo Baron, 2020). This finding highlights the critical importance of implementing Good Manufacturing Practices. These methods include a series of processes used in both food preparation and processing stages, whose main objective is to ensure food safety.

(Hidalgo & Yahaira, 2019) They point out that beef plays an important role in human nutrition, providing essential nutrients such as iron, zinc and selenium, as well as antioxidants and bioactive compounds that help promote bone health and mental health. In Ecuador, the meat industry shows an evolving structure that can improve efficiency through modernization. Domestic livestock density is 1.48 animals/ha, lower than international standards and can reach 5 animals/ha. Globally, the cattle industry has demonstrated its resilience and beef production is expected to increase by 1% in 2022 compared to the previous year.

In recent decades, the agricultural sector has been positively affected by innovation and increasing technological density, which can be observed in many other areas of activity. At the same time, the global structure of this activity has changed significantly, making the increased demand for meat a great opportunity for livestock farmers, mainly domestic. Although compliance with hygiene standards during the production, processing and sale of meat products is unpredictable. (FAO, 2019).

According to, Vélez (Diagnosis Of The Slaughtering Process And The Microbiological Quality Of Bovine Meat In The Camal Del Gad Municipal Del Cantón Bolívar, 2019). Meat is one of the most perishable foods due to its high water and nutrient content, which creates the conditions for microorganisms to grow. Microbial multiplication is the main cause of the poor quality of beef, causing a gradual deterioration of the organoleptic properties of the meat, therefore it is important to determine the type and quantity of microorganisms present because they are factors that shorten the shelf life of the meat. (AND19).

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Meat in general is very susceptible to the presence of many different types of microorganisms, which is why most bacteria are capable of multiplying and rapidly decomposing meat products (Costa, 2019). Fresh meat shrinks, loses weight and is rapidly exposed to bacteria from the air, hands, cleaning products and vehicles. Because bacterial growth increases as temperature and humidity increase, the greatest danger occurs in the tropics; for this reason, when refrigeration is not available, meat is generally retailed within 12 hours after slaughter, even if there is a risk of loss due to shrinkage, wastage and spoilage.

The presence of a large amount of bacteria in food products is a clear indication of poor manufacturing practices, leading to high microbial loads. This situation, in turn, leads to a significant increase in morbidity and mortality from foodborne diseases. (Ministry of Public Health, 2021).. It is important to increase compliance with good manufacturing practices and good agricultural practices at all stages of the food chain, from production to processing and distribution of food. Effective implementation of these measures helps to reduce public health risks and also improves food quality and consumer confidence.

Implementing different methods to determine food quality is an excellent strategy to improve control of the wholesomeness of the final product. Continuously educating food manufacturers, processors and handlers about the importance of these practices is key to preventing contamination and ensuring food safety. The immediate identification of microbial populations is of great importance in the fight against outbreaks of foodborne disease (FOD), 50% of which are caused by the consumption of meat with a high microbial load. (Cardozo, 2020).

Key factors affecting beef include safety, microbial growth during storage and microbial spoilage. Effectiveness in determining beef quality is achieved primarily through microbiological testing, which is necessary to ensure product safety for consumers. However, consumer perception of quality is more complex since it is based on the external and internal characteristics of the meat, including aspects such as flavor, texture, odor and appearance (Hernández, Ledesma, Ángel, & Arizala, 2021)..

The increase in problems related to poor meat quality can be attributed to a large extent to the inadequate implementation of Good Manufacturing Practices during the slaughter process. This situation highlights the crucial importance of compliance with these regulations, since their enforcement is essential to guarantee the safety of meat products. Effective implementation not only minimizes the risk of bacterial contamination and other food safety hazards, but also

improves the overall quality of the meat, ensuring that the product reaches the final consumer in a safe and high quality manner.

In this sense, (Bravo & Ramos, 2021) emphasize the need for strict compliance with GMP regulations as a key factor in improving food safety. This approach not only benefits public health by reducing the risk of foodborne diseases, but also strengthens consumer confidence in meat products and in the food system as a whole. Therefore, implementing these measures is fundamental for meat producers who want to stand out in a market that is increasingly conscious of food quality and safety. (Dier, 2007)

according to the Ecuador Census Portal (Rodriguez, 2023) Guayaquil has a growing population of 2,746,403, predominantly urban (2.6 million) and a slight female predominance, which underscores the importance of ensuring safe and effective food handling. This is especially true for meat products sold in urban markets in the northeast of the city. The high consumption of these products, combined with limited public knowledge about the quality, origin and handling of food during processing, poses serious problems from a food safety point of view.

This context becomes even more relevant when considering the 5,890 cases of foodborne illness reported in Ecuador in 2020, (Ministry of Public Health, 2021) which highlights the urgent need for public health authorities to increase surveillance of hygiene measures in these retail outlets. Strict implementation of good manufacturing practices, and increased hygiene inspections in urban markets are essential to reduce the risk of foodborne illness (FBD), thus contributing to protecting the human health of the vast majority of Guayaquil's urban residents and improving food safety at the national level.

Materials and methods

The research work is of a laboratory and field nature, with descriptive, exploratory and explanatory knowledge to perform adequate microbiological analysis in the laboratory and determine the prevalence of contamination by dE. Coli / Coliforms in beef marketed in the market. Northeast of Guayaquil. The design of the study was not experimental in nature since no variables were modified and the data obtained were only descriptive.

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For the sampling, a non-random sampling design was applied, in which beef samples were collected from the urban markets of northeastern Guayaquil, a complex made up of five urban markets with a total of 42 stalls dedicated to the sale of beef. Mercado Municipal Este, Mercado Florida Norte, Mercado Municipal Gómez Rendon, Mercado Municipal "Bastión Popular" and Mercado Sauces IV. Sampling was carried out during three consecutive weeks and a total of 84 beef samples were collected and analyzed using the Petrifilm E. Coli/Coliforms counting system in the hexagonal laboratory of the Universidad Agrícola del Ecuador.

In this study, the standards established by NTE INEN 1338 (Third revision) related to meat and meat products were followed, which includes guidelines for raw, cured-matured and precooked-cooked meat products, as established by the. (INEN, 2016). The presence or absence of Escherichia coli and Coliforms was investigated as the dependent variable. The independent variables considered included: markets in the Northeast of Guayaquil, Coliform Forming Units, frequency of samples complying with INEN regulations and implementation of Good Manufacturing Practices (GMP).

3. Result

The 84 beef samples were obtained from the 5 municipal markets in the northeast of Guayaquil, with a total of 42 stalls dedicated to the sale of meat, one sample was taken per stall in two weeks.

Table 1. *Presence or absence of E. coli in beef sold in different markets in the northeast of Guayaquil.*

	Presence of E.Coli	**Absence of E.Coli**
Number of samples	81	3
Total% Total	96%	4%

Source: Test results in percentage of the presence and absence of E.Coli.

Prepared by: The authors, 2023

The analysis in Table N° 1 shows alarming data on the food safety of beef sold in the northeastern markets of Guayaquil. A total of 84

samples were analyzed and 81 of them were positive for Escherichia coli, which represents an alarming 96% of the samples analyzed. Only 4%, equivalent to 3 samples, were free of this pathogen. This high proportion of E. coli highlights the urgent need to review and reinforce control and management measures in these establishments.

Table 2 shows the opposite situation for coliforms, where only 4% of the samples (3 of 84) were positive, while the vast majority of 96% (81 of 84) were free of coliforms. These results show clear differences in the occurrence of these two microbiological indicators in beef sold, suggesting different levels of public health risks.

Table 2. *Presence or Absence of Coliforms in beef sold in different markets in the Northeast of Guayaquil.*

	Presence of coliforms	**Absence of Coliforms**
Number of samples	3	81
Total% Total	4%	96%

Source: Results in percentage of presence and absence of Coliforms.

Prepared by: The authors, 2023

For Table 3, the following aspects should be considered than the presence of E. coli and coliforms since it indicates the proportion of stalls that tested positive for each bacterium during the weeks of analysis. Specific CFU (Colony Forming Units per gram) values vary significantly and reflect the degree of contamination.

Table 3. *Presence of E.Coli/Coliforms in municipal markets of Guayaquil.*

Municipal Market	**Presence of E. coli (Week 1)**	**Presence of E. coli (Week 2)**	**Presence of Coliforms (Week 1)**	**Presence of Coliforms (Week 2)**	**Remarks**
North Florida	100% (18/18 positions)	100% (18/18 positions)	Not detected	Not detected	High variability in E. coli counts

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Popular Bastion	100% (6/6 positions)	100% (6/6 positions)	Not detected	Not detected	Consistently low E. coli counts
This	100% (3/3 positions) Varied	100% (3/3 positions) Varied	33% detected (1/3 positions)	Not detected	Notable increase of E.Coli in Week 2
Willows IV	100% detected (3/3 positions)	100% detected (3/3 positions)	Not detected	33% detected (1/3 positions)	E.Coli present in all samples
Gomez Rendon	100% detected (12/12 positions)	100% detected (12/12 positions)	Not detected	Not detected	Maximum observed E.coli counts

Source: E.coli and Coliform count results in Petrifilm dishes.

Prepared by: The authors, 2023

According to the microbiological studies carried out in the municipal markets of Guayaquil, shown in Table 3, the prevalence of E. coli and coliforms in the beef sold is alarming. The incidence of these pathogens varied significantly in several markets, indicating the urgency of implementing more rigorous measures to ensure food safety. In particular, the North Florida market showed a high presence of E. coli, with a notable increase in the detection of coliforms in the second week of analysis. Considering that coliforms are common indicators of fecal contamination, this finding suggests deficiencies in food hygiene and handling practices.

The Bastión Popular Municipal Market, on the other hand, maintained E. coli levels below the limits established by NTE INEN 1338. This result demonstrates that Good Manufacturing Practices (GMP) are effective and that sanitary control is crucial to prevent food contamination. However, the coincidence in the low levels of E. coli contrasts with the variability observed in other markets, highlighting the differences in sanitary conditions and handling practices between different points of sale.

The presence of E. coli and Coliforms in meat products not only represents a direct risk to public health, but also demonstrates the variability in the implementation of food safety practices. The variation in results between markets and positions within markets shows significant variations in management and hygienic conditions. This

situation demonstrates how crucial it is to take a holistic approach to improving food safety. This approach should include strengthening sanitary regulations and enforcement, as well as training vendors in basic elements of food hygiene.

Table 4. *Results obtained from microbiological analyses and the Good Manufacturing Practices manual.*

BPM Category	Presence of E. coli	Presence of Coliforms	Remarks
Gloves	Positive majority unused	1 negative sample with use; majority negative without use	Glove use critical for E. coli control, less influence on Coliforms
Apron	Positives with and without use	2 positives with use; negatives without use	Apron does not significantly impact the presence of E. coli.
Cofia	Positives with and without use	5 positives with use; negatives without use	Use of coping does not reduce the presence of E. coli, similar impact on coliforms.
Closed Footwear	Positives with and without use	1 positive with use; negative without use	Closed footwear essential to control E. Coli, similar for Coliforms
Hand Washing	2 negative samples; majority positive	1 positive; majority negative	Handwashing critical to reduce E. coli, important for Coliform control
Closed Containers (Waste)	Positive majority with and without use	2 negatives with use; most negatives without use	Waste management important for E. coli control, Coliforms less affected
Garbage Bags (Waste)	Positive majority	1 positive; majority negative	Garbage bags influence E. coli control, but not so much Coliforms.
Ventilated Area (Waste)	Positive majority	All negative	Ventilation minimally affects E. coli, no impact on coliforms.

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Pest Control (Residues)	All positive	1 positive; majority negative	Pest control essential for E. coli management, similar for Coliforms.
Waste Deposit (Infrastructure)	Positive majority	1 positive; majority negative	Waste management critical to E. coli management, less impact on Coliforms
Signage (Infrastructure)	All positive	All negative	Signage does not directly impact the presence of E. coli, does not affect coliforms.
Clean Floors (Infrastructure)	Positive majority	3 positive; majority negative	Floor cleaning important for E. coli control, also relevant for Coliforms.
Drainage (Infrastructure)	Positive majority	1 positive; majority negative	Drainage essential for E. coli management, similar for Coliforms
Clean Steel Areas (Infrastructure)	Positive majority	3 positive; majority negative	Cleanliness of steel areas influences E. coli control, also relevant for Coliforms.
Refrigerator (Utensils and Equipment)	All positive unused	3 negative with use; majority positive without use	Refrigeration crucial for E. Coli management, important for Coliforms
Freezer (Utensils and Equipment)	Divided between positive and negative	3 positive; majority negative	Freezing impacts the presence of E. coli and coliforms.
Stainless Steel Utensils (Utensils and Equipment)	Positive majority	3 positive; majority negative	Stainless steel utensils important for E. Coli control, similar for Coliforms
Operation of Freezers (Utensils and Equipment)	Positive majority	3 positive; majority negative	Proper freezer operation essential for handling E. coli, important for Coliforms

Source: Comparison of E.coli and Coliform GMP compliance results.

Prepared by: The authors, 2023

Table 4 shows the importance of using gloves to avoid E. coli contamination. In contrast to the impact on the presence of coliforms, it is necessary to use personal hygiene methods to control the presence of some pathogens in food. On the other hand, products such as aprons and aprons did not significantly reduce these pathogens, indicating that the use of protective equipment alone is not sufficient to ensure food safety. To avoid E. coli contamination, waste disposal must include proper containers and locations. This highlights the importance of having adequate infrastructure and effective cleaning techniques in food markets.

Personal hygiene practices appear to have less impact on the presence of coliforms than on the presence of E. coli. Some practices, such as hand washing and proper waste disposal, are crucial to control E. coli. Contamination by these pathogens can be reduced by the use of stainless steel utensils and proper operation of refrigeration and freezing equipment.

In Table N° 5, of the 84 samples that were fit for human consumption, 6% (5) belonged to the North Florida Municipal Market, 1% (1) to the East Municipal Market and the Sauces IV Municipal Market, while the Gómez Rendon Municipal Market and the Bastión Popular Municipal Market did not present any sample of beef fit for consumption.

Table 5. *Frequency of suitable and unsuitable samples in the different markets described by INEN 1338.*

"MUNICIPAL MARKETS OF NORTHEASTERN GUAYAQUIL".	ADEQUATE SAMPLES (M)1.0 X 102	INELIGIBLE SAMPLES (M)1.0 X 103	NO AP % NO AP % NO AP % NO AP % NO AP % NO AP % NO AP % NO AP % NO AP	AP % AP % AP % AP % AP % AP % AP % AP % AP
NORTH FLORIDA MUNICIPAL MARKET	3	33	39%	4%
EAST MUNICIPAL MARKET	1	5	6%	1%

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MUNICIPAL MARKET GOMEZ RENDON	0	24	29%	0%
SAUCES IV MUNICIPAL MARKET	1	5	6%	1%
BASTION POPULAR MUNICIPAL MARKET	0	12	14%	0%
TOTAL	5	79	94%	6%

Results of samples fit and unfit for human consumption.

Robinzon,2023

On the other hand, 94% (79) of the remaining samples were unfit for human consumption, being the Florida Norte Municipal Market the one with the highest number of unfit samples with a total of 39% (33), followed by the Gómez Rendon Municipal Market with 29% (24), while the East Municipal Market and Sauces IV Municipal Market reflected the same values of unfit samples of 6% (5) and the Bastión Popular Municipal Market with 14% (12). The results collected indicate that there is a higher bacterial contamination of E. coli than of Coliforms analyzed, as shown in Table 1 and 2.

4. Conclusions

In the present study, it can be concluded that all the markets where beef samples were taken for microbiological analysis had high levels of E. coli since most of their samples in the first and second week of the study showed values < 1.0X. 102, meaning that the rate of E. coli presence was 96%. However, only 4% coliform bacteria were detected, which is a completely low result compared to E.Coli. When comparing the results of the microbiological analyses with the GMP, it is possible to identify non-compliances with the regulations, as the vast majority of supermarkets in their tests showed that the presence of microorganisms indicates poor hygiene. A small number of samples were considered fit for human consumption (6%), while the vast majority of samples complied with the permissible CFU values described in the NTE INEN 1338 standard, with 94% due to the fact that the application of GMP is not good.

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