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Cleaning and hygiene practices in the meat product area of Mexican retail supermarkets

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ABSTRACT

The management of good hygiene and sanitation practices plays a fundamental role in the quality and safety of fresh meat products. An evaluation related to hygiene and sanitation was conducted in situ in four Mexican retail supermarkets, by visual assessment using a 5-level Likert scale. Statistical analysis used a completely randomized experimental design with the chi-square statistical test. The results showed that there were significant temperature fluctuations in the meat self-service area and service areas. Another essential parameter addressed was the correct use and cleanliness of employees' work uniforms. Therefore, it was suggested to conduct training programs for employees and implement activities leading to the maintenance and calibration of cooling equipment to control the meat products deterioration. Finally, combined participation of government authorities and retail companies is necessary to ensure and maintain the quality of Mexican food products available to consumers.

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1. Introduction

Foodborne diseases have become a public health problem worldwide and have been linked to poor food handling and sanitation practices among food handlers, and other factors (1).

Abdullahi et al. (2) noted that animal products are associated with many foodborne diseases. Consequently, hygiene practices and the health status of personnel handling these food products represent the most relevant factors in this problem (3). Animal foods, such as meat, represent an essential source of

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nutrients, but their composition provides a suitable medium for the growth of many microorganisms. The prevalence of inadequate food handling practices among food handlers puts food safety at risk. To increase the sanitation levels of each practice, it is essential to improve the attitude and practice of food handlers (4).

Meat handlers should show a positive attitude to perform their work, along with systematic supervision and adequate sanitary facilities if such high sanitation levels are to be achieved (4). All actors involved in every food supply chain stage have the primary task of ensuring food safety, especially processors and retail outlets, which become crucial safeguards to achieving this objective (5). An essential factor focuses on improving and enhancing food safety in managing meat products, following hygienic-sanitary regulations in conjunction with the cold chain (6). To this purpose, the implementation of prerequisite programs in food retail outlets ensures the operation of good hygienic practices associated with point-of-sale cleaning and disinfection and staff hygiene (7). A close monitoring should be added to ensure retail operations fulfill all hygiene standards to provide consumers with innocuous meat (8).

For a retail meat center to offer safe and high-quality meat products, specific training programs are required at all levels, from management to staff working directly in the meat handling areas, as well as evaluation processes for all activities. Personnel in charge of meat handling should have permanent training on meat and food safety and be willing to apply all regulations learned on this matter (9). It is relevant to highlight that food hygiene after COVID-19 has become a cutting-edge issue (10), requiring effective sanitation methods in conjunction with visual inspections and microbiological data to ensure that these are effective (11,12).

Meat and raw food handlers should be trained on all hygiene practices needed to achieve food safety (13), and retail operations should apply supervision on hygiene regulations (14). Siluma et al. (15) concluded that important variables related to staff compliance with personal hygiene standards were the use of protective clothing and cleanliness of the environment and equipment. Therefore, this research aimed to investigate through on-site inspection the compliance degree of parameters related to cleanliness, hygienic practices, and cold chain in the meat product areas of the major retail commercial chains operating in Mexico.

2. Materials and Methods

Distinct aspects of cleanliness and hygiene practices were evaluated in the points of sale and self-service display of meat products in supermarkets of major chains in the State of Mexico, Mexico. The study was conducted weekly from January 2021 to December 2022; during this time, the evaluation was carried out by visual assessment of cleanliness, using a 5-level Likert scale where 1=very bad, 2=bad, 3=average, 4=good, and 5=very good. The parameters assessed included cleanliness around the service area, employee handling room, equipment in the service area, self-service area, self-service area, and the temperature of meat products displayed on the shelves. Data were compared with that established by NOM-213-SSA1-2018 (16) to assign the score by Likert scale.

For statistical analysis, data were analyzed as categorical data with the chi-square statistical test,

using a completely randomized experimental design. The analyses were performed using the online SAS software (17). The clustering of percentages for hygiene levels was analyzed with confidence intervals with the formula:

$$(Percentage \pm \sqrt{\frac{Percentage * (100 - percentage)}{Number\ of\ records\ for\ percentage}})$$

These were calculated for each category at a probability of $p<0.05$.

3. Results

Results of analyses of components within the meat products section are shown in Table 1**.** The self-service areas indicated that the performance of the open refrigerated meat shelves was poor (60.2%) since they did not show compliance with the temperature limit of 4 °C established by the NOM-213-SSA1-2018 (16), even though the cleanliness factor showed good management (>75%). However, it is necessary to increase the use of adequate clothing in work areas by personnel handling meat products (52%) under the conditions of cleanliness established by regulations (>58%) (16). In contrast, cleanliness was required in the rest of the categories, and the management of equipment, meat handling rooms, and service areas obtained positive percentages. Nevertheless, the four retail supermarkets continue to show significant areas for enhancement.

The results of the individual analysis of each supermarket on sanitary-hygienic parameters are shown in Table 2, where four categories are considered. Firstly, at the four supermarkets, the parameters related to management aspects and related activities in the handling room, equipment conditions, and those prevailing in the service area were recorded as good management. However, a detailed analysis reveals that supermarket S2 was the only one that recorded better cold chain management in the meat self-service areas (Table 2). Nevertheless, the results recorded in S1 (89.11%), S3 (60.4%), and S4 (10.89%) need attention, given that poor management was observed in the different aspects evaluated. In addition, supermarket S3 recorded (21.79%) poor hygiene where meat products were placed, mainly with fluids from the meat, which were a suitable medium for bacterial growth (18).

Table 3 shows the categories related to the cleaning activities of the service area and those fulfilled by the staff. Initially, it may be specified that in supermarket S2, the employees handling food were found not to wear an adequate uniform or to wear it incompletely during working hours (50.5%) and to use it with moderate cleanliness (>80%). Moreover, regarding cleaning of the service area in this study, in supermarket S3, meat products remained out of the cold chain in the sales area for long periods while waiting to be packaged for retail sale (61.4%), with poor cleaning in the same room sporadically (17.8%).

In contrast, supermarkets S1, S2, and S4 showed good cleanliness levels in the service areas.

Table 1. General distribution (%) of ranks in the degree of cleanliness in different areas of the supermarkets evaluated (N=4).

General	Hygienic-sanitary parameters				
Category (pr > Chi Sq)	**1** **very bad**	**2** **bad**	**3** **moderate**	**4** **good**	**5** **Very good**
Service area cleanliness					
Cleanliness (Floor, surface)	0.0	1.23±4.95^{b}	7.43±4.79^{b}	90.35±1.55^{a}	0.99±4.95^{b}
Products in cold chain	0.25± 4.99^{c}	1.73±4.93^{c}	27.73±4.23^{b}	67.57±2.83^{a}	2.72± 4.90^{c}
Employee cleanliness					
Protective clothing	0.74±4.95^{d}	14.60±4.60^{c}	32.67±4.08^{b}	49.76±3.53^{a}	2.23±4.92^{d}
Proper protective clothing	0.0	1.24±4.95^{c}	40.10±3.85^{b}	58.66±3.20^{a}	0.0
Cleanliness	0.0	0.0	13.37±4.63^{b}	86.63±1.82^{a}	0.0
Handling room					
Tools and materials in place	0.0	3.11±4.92^{c}	18.18±4.42^{b}	78.71±2.30^{a}	0.0
Raw standing meat portions	0.0	5.20±4.85^{c}	17.32±4.52^{b}	77.48±2.36^{a}	0.0
Equipment					
Cleanliness	0.0	0.0	4.46±4.87^{b}	95.54±1.05^{a}	0.0
Service area					
Cleanliness	0.0	0.50±4.99^{b}	5.44±4.84^{b}	94.06±1.21^{a}	0.0
Self-service area					
Cleanliness	0.50±4.99^{c}	5.20±4.85^{c}	14.10±4.61^{b}	79.70±2.24^{a}	0.50±4.99^{c}
Proper temperature within refrigerated open displays	7.93±4.77^{b}	22.52±4.38^{a}	29.70±4.17^{a}	29.70±4.17^{a}	10.15±4.72^{b}

Means in the same row with at least one literal in common are not different ($p<0.0001$).

Table 2. Specific distribution (%) of ranks of cleanliness and hygiene practices recorded in four meat areas of four Mexican retail outlets.

Supermarket	Handling room		Equipment	Service area	Self-service area		*Hygienic-sanitary parameters
	TMP	RSMP	CL	CL	CL	PTD	
S1	0.0	0.0	0.0	0.0	0.0	21.78±8.80^{b}	1
	0.0	1.98±9.85^{b}	0.0	0.0	0.0	67.33±5.69^{a}	2
	7.92±9.55^{b}	12.87±9.29^{b}	0.99±9.9^{b}	3.96±9.75^{b}	1.98±9.85^{b}	9.90±9.44^{c}	3
	92.08±2.80^{a}	85.15±3.83^{a}	99.01±0.99^{a}	96.04±1.98^{a}	98.02±1.40^{a}	0.0	4
	0.0	0.0	0.0	0.0	0.0	0.99±9.90^{c}	5
S2	0.0	0.0	0.0	0.0	0.0	0.0	1
	2.97±9.80^{c}	11.88±9.34^{b}	0.0	0.0	0.0	0.0	2
	27.72±8.46^{b}	28.71±8.40^{b}	4.95±9.70^{b}	1.98±9.85^{b}	0.99±9.90^{b}	21.78±8.80^{b}	3
	69.31±5.51^{a}	59.41±6.34^{a}	95.05±2.21^{a}	98.02±1.40^{a}	99.01±0.99^{a}	61.39±6.18^{a}	4
	0.0	0.0	0.0	0.0	0.0	16.83±9.07^{b}	5
S3	0.0	0.0	0.0	0.0	1.99±9.85^{c}	8.91±9.50^{bc}	1
	6.93±9.60^{c}	3.96±9.75^{c}	0.0	1.98±9.85^{b}	19.80±8.91^{c}	16.83±9.07^{b}	2
	35.64±7.98^{b}	25.74±8.57^{b}	10.99±9.43^{b}	12.87±9.29^{b}	42.57±7.54^{a}	52.48±6.86^{a}	3
	57.43±6.49^{a}	70.30±5.42^{a}	89.11±3.28^{a}	85.15±3.83^{a}	33.66±8.10^{ab}	4.95±9.70^{c}	4
	0.0	0.0	0.0	0.0	1.98±9.85^{c}	16.83±9.07^{b}	5
S4	0.0	0.0	0.0	0.0	0.0	0.99±9.90^{c}	1
	0.0	2.97±9.80^{b}	0.0	0.0	0.99±9.90^{c}	5.94±9.65^{c}	2
	3.96 9.75^{b}	1.98±9.85^{b}	0.99±9.90^{b}	2.97±9.80^{b}	10.89±9.39^{b}	34.65±8.04^{b}	3
	96.04±1.98^{a}	95.05±2.21^{a}	99.01±0.99^{a}	97.03±1.71^{a}	88.12±3.43^{a}	52.48±6.67^{a}	4
	0.0	0.0	0.0	0.0	0.0	5.94±9.65^{c}	5

TMP= tools and materials in place; RSMP= Raw standing meat portions; CL= cleanliness; PTD= Proper temperature within refrigerated open displays. *Hygienic-sanitary parameters scores: 1= very bad; 2= bad; 3= moderate; 4= good; 5= very good. Different superscript letters in columns within the supermarket indicated significant differences ($p<0.05$).

Table 3. Specific distribution (%) of ranks of cleanliness and hygiene practices recorded in two meat areas of four Mexican retail outlets.

Supermarket	Service area cleanliness			Employee cleanliness		*Hygienic-sanitary parameters
	CL	CCH	PC	PPC	CL	
S1						1
	0.0	0.99c±9.9^{c}	1.98±9.85^{c}	0.0	0.0	2
	5.94±9.65^{b}	19.80b±8.91^{b}	17.82±9.02^{b}	18.81±8.97^{b}	8.91±9.50^{b}	3
	94.06±2.43^{a}	79.21±4.54^{a}	74.26±5.05^{a}	81.19±4.32^{a}	91.09±2.97^{a}	4
	0.0	0.0	5.94±9.65^{bc}	0.0	0.0	5
S2	0.0	0.0	1.98±9.85^{b}	0.0	0.0	1
	0.0	0.0	48.51±7.14^{a}	3.96±9.75^{b}	0.0	2
	5.94±9.65^{b}	16.83±9.07^{b}	42.57±7.54^{a}	80.2±4.43^{a}	17.82±9.02^{b}	3
	93.07±2.62^{a}	81.19±4.32^{a}	6.94±9.60^{b}	15.84±9.13^{b}	82.18±4.20^{a}	4
	0.99±9.90^{b}	1.98±9.85^{b}	0.0	0.0	0.0	5
S3	0.0	0.99±9.90^{c}	0.0	0.0	0.0	1
	4.95±9.70^{b}	5.94±9.65^{c}	2.97±9.80^{c}	0.0	0.0	2
	12.87±9.29^{b}	55.45±6.64^{a}	40.59±7.67^{b}	34.65±8.04^{b}	14.85±9.18^{b}	3
	81.19±4.32^{a}	34.65±8.04^{b}	55.45±6.64^{a}	65.35±5.86^{a}	85.15±3.83^{a}	4
	0.99±9.90^{b}	2.97±9.80^{c}	0.99±9.90^{c}	0.0	0.0	5
S4	0.0	0.0	0.99±9.90^{c}	0.0	0.0	1
	0.0	0.0	4.95±9.70^{c}	0.99±9.90^{c}	0.0	2
	4.95±9.70^{b}	18.81±8.97^{b}	29.70±8.34^{b}	26.72±8.51^{b}	11.88±9.34^{b}	3
	93.07±2.62^{a}	75.25±4.95^{a}	62.38±6.10^{a}	72.29±5.24^{a}	88.12±3.43^{a}	4
	1.98±4.02^{b}	5.94±9.65^{b}	1.98±9.85^{c}	0.0	0.0	5

CL= cleanliness; CCH= products in cold chain; PC= Protective clothing; PPC= Proper protective clothing. *Hygienic-sanitary parameters scores: 1= very bad; 2= bad; 3= moderate; 4= good; 5= very good. Different superscript letters in columns within the supermarket indicated significant differences ($p<0.05$).

4. Discussion

Analysis conducted in this study shows points that require improvement in hygiene aspects. Bhandari et al. (18) argue that inadequate hygiene protocols in retail meat handling severely affect food safety. Retail meat in developing countries is exposed to extensive handling by staff and a range of pathogen contacts. Therefore, these factors affect food safety, quality, and shelf life. Consequently, foodborne illnesses cause economic losses, which are a potential public health hazard as well; thus, it is essential to establish a visible and permanent commitment to each link in the food supply chain (19).

It can be pointed out that daily and continuous supervision of the six components of the meat section products in all four supermarkets should be emphasized to lower any risk to meat safety on offer to consumers in the meat products sections (8). Furthermore, Santos et al. (20) confirm that food handlers must maintain a high level of personal hygiene and intrinsically safety-related behavior. Therefore, to achieve the competencies required by staff, food safety training is required to maintain a standard of knowledge and update for all personnel handling meat products (21). Nyamakwere et al. (22) report that the area classified as the most susceptible to pathogen contamination is the handling room, which is characterized by intensive tasks.

The main recommendations for retail outlets are to point out as fundamental activities those related to the prevailing hygiene in the handling room, as well as the cleanliness of equipment, floors, walls, and ceilings, structured with appropriate materials. It is also relevant to include the control of the cold chain and the strategic use of the necessary utensils to handle the products. In an Ethiopian study, 85% surveyed reported using appropriate clothing when handling produce, 91% washed their hands at least once before handling produce, 88% used soap when washing their hands, and only 14% received training (23). Nee and Sani (24) similarly suggest that a high level of personal cleanliness with clean and appropriate protective clothing and protective equipment for employees in food handling areas is critical to ensure food safety.

Concerning this research, supermarket S2 was the only one that recorded better cold chain management in the meat self-service areas (Table 2). Nevertheless, the results recorded in S1 (89.11%), S3 (60.4%), and S4 (10.89%) need attention, given that poor management was observed in the different aspects evaluated. In addition, supermarket S3 recorded (21.79%) poor hygiene where meat products were placed, mainly with fluids from the meat, which were a suitable medium for bacterial growth (25,26).

To ensure a cold chain, it is essential to implement continuous improvements in temperature control devices in the refrigerated open displays of meat products (6), a highly relevant aspect of this research. Companies in developing countries are obliged to sensitize their employees on the handling of refrigeration equipment to reduce the problems of microorganism growth in food (27).

Lundén et al. (28) indicate the need for close monitoring by food business operators and management of relevant factors closely related to food safety, such as cleanliness and temperature of refrigeration equipment. It is also appropriate to mention that most fresh foods are highly vulnerable, especially those of animal origin (29,30), which leads to microbial

contamination and intoxication (31). Thus, encouraging hygienic food handling practices and cold chain management are feasible strategies to protect consumers from public health risks (32).

Jianu and Goleț (33) suggested that inadequate protective clothing and failure to use gloves and disinfectants are classified as poor hygienic practices in meat handling areas, leading to food contamination and the spread of disease.

There are intrinsic and extrinsic factors that affect microbial growth (34); an element of the second group is temperature, which alters the shelf life of foods, representing one of the main problems for the industry (35). As the cold chain is a temperature-controlled supply necessary for food safety, the correct application of temperature monitoring and management is required to maintain a sustainable and uninterrupted cold chain (36). The disruption in meat products reduces shelf life, causing microbial growth that leads to spoilage, loss of sensory and nutritional properties, and increasing food wastage or food poisoning if consumed (37,38).

Another factor influencing temperature fluctuations is the storage arrangement of food products, especially the most susceptible to spoilage (39). Therefore, enhancing quality monitoring and cold chain management systems is an important concern for companies and governments to consider (40). Consequently, when offering perishable products to consumers, it is essential to ensure a cold chain with current regulations, thus guaranteeing the food safety of meat products and reducing legal conflicts (41).

The main food contamination risks are associated with food management practices on the body of the staff, which are transferred to the food during processes in the preparation of meat products (42). For example, the Canadian Food Inspection Agency (43) recommendation emphasizes scheduled training of food handlers to update and reinforce key concepts. Meat products are associated with risks caused by biological agents. Similarly, Gutema et al. (44) report that poor hygienic practices lead to contamination and cross-contamination. They also suggest that it is essential to train personnel in food safety to improve hygienic practices significantly towards preventing problems. Training must reinforce that the source of this type of food represents an essential pathway for the transmission of pathogens to ready-to-eat foods (45).

In a study in Mexico about hygienic-sanitary activities carried out in supermarkets in the ground meat handling, deficient activities to be improved, like cleanliness and condition of employee clothing, especially protective clothing, were reported (6). Odetokun et al. (5) report a low level of hygienic practices related to the sale of meat in retail outlets in Nigeria. Therefore, they showed that these purchasing centers must implement operating actions directly. There are also reports that meat handling training courses are urgently needed in two districts of Jammu and Kashmir, India, to improve the viability and safety of consumer protection systems in these regions. Furthermore, Santos et al. (20) mention that food handlers must maintain a high level of personal hygiene and intrinsically safety-related behavior. Therefore, to achieve the competencies required by staff, they need knowledge and updates related to food safety, for which the educational level must be

accompanied by instruments of proven validity and accuracy (21).

Food poisoning outbreaks include three fundamental factors related to the knowledge level, attitudes and practices of personnel involved in food management (46). Bello and Bello (47) suggested that the unsafety of meat could be associated with pathogenic bacteria implicated in different activities during food processing and sale. These operations are connected to poor hygiene of retail and processing staff, contaminated equipment in food handling, poor workplace hygiene, and contaminated materials in packaging. Problems associated with inadequate hygienic procedures can lead to reduced shelf life of food products and increased risks of illness by pathogen contamination (48). Oluwafemi et al. (9) confirmed that the involvement of government and private agents in the meat product production chain is indispensable for achieving quality at the point of sale. Their role is addressed in compliance with current regulations to ensure safe and quality meat for consumers. To this end, promoting hygienic practices among their employees is essential to implement and operate them in retail meat sales centers.

Consequently, the food safety of consumer products is essential at the retail point of sale (49). Studies highlight adverse scenarios in the hygiene conditions of the food trade, particularly in developing countries, which are concerning and dangerous for consumers. They also expressed the multiple challenges for meat supply, as there is a discrepancy between the official standards of each country and what is relevant in each place where meat is produced, processed, and traded (50). Definitely, routine activities that are closely monitored, verified, and validated to achieve results that meet each country's regulations and are valid in the long term must be incorporated (8). Nowadays, retailers must be responsible for providing safe food to consumers (51) because foodborne disease outbreaks in developing countries have a hard impact on health and socio-economic development (52). Then, to achieve this objective, a significant increase in investment is needed (53). Therefore, food processors and retailers must ensure food safety due to the increased demand in developing country markets. This is achieved through hygienic strategies applied during process management, using safety management systems for each type of food (54). For example, Okpala et al. (55) identified that consumers have recently increased their demands and expectations for safe animal products due to population growth and urbanization in developing countries. Nevertheless, the demand for safe food remains an issue of concern in developed countries. However, this demand is even more critical in developing countries, as production and processing conditions often lack the necessary hygienic requirements for a baseline (56).

4. Conclusion

The series of operations carried out in the self-service areas, as well as in the service area of the meat products, fluctuate in temperature, which implies that they do not comply with the current Mexican regulations, that indicate keeping the meat products ≤4 °C, and at the same time, it is essential to improve the cleanliness in both areas mentioned significantly. Another relevant factor recorded relates to the employees, who require clear and precise instructions on using the work uniform and an appropriate design for the functions to

be carried out in the handling of meat products. Therefore, some of the supermarkets do not comply with the required standards. Hence, training courses on good hygienic and manufacturing practices should be designed for personnel. At the same time, it is necessary to implement strategies for monitoring, recording, and maintaining the equipment responsible for refrigerating ready-to-sell meat products to avoid significant temperature fluctuations that impact the quality and safety of meat foodstuffs. Finally, the active participation of government authorities and companies in all these processes is also indispensable for ensuring the safety and quality of meat products in Mexican supermarkets.

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Authorship contribution

Pedro Arriaga L. performed the field work, searched all the supporting bibliography for this article and initiated the writing of it. The statistical analysis was performed by Luis A. Saavedra J. and discussed with Pedro Arriaga L. The discussion of each topic was supervised by all authors: Pedro Arriaga L., Ema Maldonado S., Rodolfo Ramírez V., Pedro A. Martínez H., Deli N. Tirado G. and Luis A. Saavedra J., who also reviewed and finally approved the final paper.

Conflict of interest

All authors declare that they have no financial or personal relationships that could inappropriately influence or bias the work.

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Use of AI-artificial intelligence

No artificial intelligence was used in the preparation of this document.

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