

# Collective Food, Health Space: Microorganisms on Food Preparation Surfaces in a Water Terminal

Alimentação Coletiva, Espaço de Saúde: Microrganismos em Superfícies de Preparo de Alimentos em Terminal Aquaviário  
Espacio Colectivo de Alimentación y Salud: Microorganismos en Superfícies de Preparación de Alimentos en una Terminal de Agua

## RESUMO

**Objetivo:** realizar análise microbiológica de superfícies utilizadas no preparo de alimentos comercializados em Terminal Aquaviário. **Método:** Foram coletadas 21 amostras em superfícies de utensílios e equipamentos e realizadas a enumeração de bactérias aeróbias mesófilas e *Staphylococcus* sp., quantificação de coliformes totais e pesquisa de enterobactérias e de *Salmonella* sp. **Resultados:** Constatou-se elevadas contagens de bactérias mesófilas, *Staphylococcus* coagulase negativa e positiva em 95,24 %, 100 % e 28,58 % das superfícies, respectivamente. Quanto aos coliformes totais, 57,14 % das amostras estavam contaminadas. As enterobactérias foram encontradas em altas populações, com a obtenção de 30 isolados, mas com ausência de *Escherichia coli*. Não foi identificada *Salmonella* sp nas amostras avaliadas. **Conclusão:** Conclui-se que microrganismos indicadores e patogênicos se encontravam em altas populações, como contaminantes das superfícies avaliadas, o que desperta para a necessidade de implementação de práticas voltadas para o controle microbiológico no Terminal Aquaviário, com vistas a promoção de saúde pública.

**DESCRIPTORES:** Controle de qualidade; Microbiologia ambiental; Microrganismos indicadores; Terminal portuário.

## ABSTRACT

**Objective:** The aim of this study was to perform a microbiological analysis of surfaces used in the preparation of food sold at a waterway terminal. **Method:** For this purpose, 21 samples were collected from the surfaces of utensils and equipment, and the enumeration of mesophilic aerobic bacteria and *Staphylococcus* sp., quantification of total coliforms and research of enterobacteria and *Salmonella* sp. were performed. **Results:** High counts of mesophilic bacteria, coagulase-negative and coagulase-positive *Staphylococcus* were found in 95.24%, 100% and 28.58% of the surfaces, respectively. Regarding total coliforms, 57.14% of the samples were contaminated. Enterobacteriaceae were found in high populations, with 30 isolates obtained, but with the absence of *Escherichia coli*. No *Salmonella* sp. was identified in the samples evaluated. **Conclusion:** It is concluded that indicator and pathogenic microorganisms were found in high populations, as contaminants of the evaluated surfaces, which highlights the need to implement practices aimed at microbiological control in the Waterway Terminal, with a view to promoting public health.

**DESCRIPTORS:** Quality control; Environmental microbiology; Indicator microorganisms; Port terminal.

## RESUMEN

**Objetivo:** El objetivo de este estudio fue realizar un análisis microbiológico de superficies utilizadas en la preparación de alimentos vendidos en una terminal fluvial. **Método:** Para este propósito, se recolectaron 21 muestras de las superficies de utensilios y equipos, y se realizó la enumeración de bacterias aeróbicas mesófilas y *Staphylococcus* sp., la cuantificación de coliformes totales y la investigación de enterobacterias y *Salmonella* sp. **Resultados:** Se encontraron altos recuentos de bacterias mesófilas, *Staphylococcus* coagulasa negativos y coagulasa positivos en 95.24%, 100% y 28.58% de las superficies, respectivamente. Con respecto a los coliformes totales, el 57.14% de las muestras estaban contaminadas. Las Enterobacteriaceae se encontraron en altas poblaciones, con 30 aislamientos obtenidos, pero con la ausencia de *Escherichia coli*. No se identificó *Salmonella* sp. en las muestras evaluadas. **Conclusión:** Se concluye que los microorganismos indicadores y patógenos fueron encontrados en altas poblaciones, como contaminantes de las superficies evaluadas, lo que resalta la necesidad de implementar prácticas dirigidas al control microbiológico en la Terminal Intravehicular, con miras a la promoción de la salud pública.

**DESCRIPTORES:** Control de calidad; Microbiología ambiental; Microorganismos indicadores; Terminal portuaria.

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## INTRODUCTION

The foodservice sector integrates the entire chain of production, distribution of food, supplies, equipment, packaging, and services<sup>1</sup>. Data from the Brazilian Association of Collective Meal Companies<sup>2</sup> show that in 2021, the collective meal market provided approximately 35.5 million meals per day, and in 2019, 250,000 direct jobs were created and R\$20.6 billion were generated<sup>3</sup>.

Data from the Brazilian Association of Food Service Companies indicate that in 2021, the food service market provided 35.5 million meals per day (ABERC, 2022). Therefore, it is important to carefully monitor the preparations produced in food service establishments to ensure they

are microbiologically safe and free from contamination (Silva, Boni & Schlindwein, 2019), avoiding or minimizing the risk of foodborne illness (hereinafter, DVA) (Pereira & Lemos, 2021).

However, the promising growth trend in the collective food sector must be accompanied by intense professionalization and attention to government and consumer market requirements, so that food is safe from a microbiological point of view and free from contamination<sup>4</sup>, avoiding or minimizing the risk of occurrence of Waterborne and Foodborne Diseases<sup>5</sup>.

Data from the World Health Organization (WHO) shows that approximately 600 million people worldwide are affected by DTHAs

annually (one in 10) after consuming contaminated food, resulting in the deaths of 420,000 people<sup>6</sup>. According to the Ministry of Health<sup>7</sup>, in Brazil, these figures are also high, with 6,347 foodborne outbreak reports recorded between 2012 and 2021, resulting in a total of 610,684 people exposed, 104,839 cases of illness, and 89 deaths. Of this total, 15.1% of the reports were recorded in restaurants and similar establishments, making them the second most frequent location for foodborne illness outbreaks.

In the food production environment, the air, preparation surfaces, equipment, and utensils must be monitored to promote greater microbiological safety. Cross-contamination is a concern in food pro-

duction, as foodborne pathogenic microorganisms can be transmitted from the environment (air and surfaces of equipment and utensils) and by food handlers<sup>8</sup>.

In these scenarios, there is evidence that several classic and opportunistic pathogens contaminate surfaces and equipment (boards, refrigerators, cutlery, dishes) most frequently handled by food handlers, including coagulase-positive *Staphylococcus*, *Escherichia coli*, *Salmonella* sp. and other potential DTHA agents<sup>9</sup>. Toxi-infections related to the collective food environment demonstrate an imminent risk to consumer safety and are associated with contaminated raw materials, lack of hygiene during preparation, inappropriate locations, and failures in surface cleaning and disinfection processes that can result in the spread and transfer of microorganisms<sup>10</sup>.

Within the context of collective food services in the state of Maranhão, the Maranhão Waterway Terminal (Terminal Aquaviário Maranhão) boasts dozens of vendors operating in standardized stalls. This arrangement offers consumers a revitalized space and a variety of foods (raw, cooked, animal, and vegetable products; liquid, solid, and paste-based; snacks and meals, etc.), generating employment and income for many families, in addition to attracting local labor. Therefore, the sale of food at this location generates the prospect of continuous improvement in the quality of life of the population working and living near the terminal, with positive impacts also on stimulating local production.

Given the population flow at the Maranhão Waterway Terminal and the importance of food consumption there, the study aimed to conduct microbiological analysis of surfaces used in the preparation of food sold at the Waterway Terminal.

## METHOD

### Research Environment

As a territorial focus of the research, the study was conducted at the Waterway Terminal, located in the state of Maranhão. This multimodal terminal connects the waterway system (ferry) to the Alcântara road system, serving as a strategic hub for passengers and residents of the Baixada Maranhense region, and also plays an important role in regional development. According to the latest census conducted by the Brazilian Institute of Geography and Statistics 11, Alcântara has a population of approximately 18,467 and an HDI of 0.571.

### Research Design and Collection of Samples of Utensils and Equipment

The study included all food and beverage stalls operating at the Waterway Terminal during the technical visits. Thus, 14 stalls were sampled out of a total of 48 existing stalls, named according to their location number (B1 to B14).

Ten utensils (five knives, two spoons, one fork, one cake spatula, and one glass serving dish) and 11 pieces of equipment (four refrigerators, two microwaves, two rice cookers, and three barbecue grills) were sampled, totaling 21 surfaces evaluated and considered clean by the local merchants.

Sample collection was performed using the swab technique, delimiting a 10 x 25 cm area using a sterile mold. This essentially consisted of applying pressure to the surfaces at a 45° angle after moistening the swab in sterile 0.85% saline solution. All collected material was immersed in sterile test tubes containing 9 mL of saline solution.

### Microbiological Analysis on Surfaces of Utensils and Equipment

All microbiological analyses followed the procedures and recommendations of the American Public Health Association - APHA<sup>12</sup> and were carried out at the Food and Water Microbiology Laboratory linked to the Center for Agricultural Sciences - CCA of the State University of Maranhão - UEMA. The enumeration of viable mesophilic and facultative aerobic bacteria and *Staphylococcus* sp., the quantification of total coliforms and the research of enterobacteria and *Salmonella* sp. were performed.

### Analysis of Results

The laboratory results were processed and interpreted, stored in a database, organized, and presented in tables to provide a clear overview of the variables as a whole. The results were compared with the microbiological standards suggested by the ABERC Manual of Practices for the Preparation and Service of Meals for Groups<sup>14</sup>, APHA<sup>12</sup> and by Silva Jr.<sup>15</sup>

## RESULTS

The quantitative results of the enumeration of viable mesophilic and facultative aerobic bacteria are summarized in Table 1, which shows high counts of this group of microorganisms in 95.24% (n=20/21) of the surfaces evaluated.

# Original Article

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**Table 1 - Enumeration of viable mesophilic and facultative aerobic bacteria on surfaces of utensils and equipment used in a food marketing environment at a Waterway Terminal**

Quantity (n= 10)	Utensils	Viable Aerobic Mesophilic and Facultative Bacteria (CFU/cm <sup>2</sup> )
5	Knife	9,0 x 10 <sup>6</sup>
	Knife	< 10
	Knife	4,9 x 10 <sup>5</sup>
	Knife	6,2 x 10 <sup>6</sup>
	Knife	1,4 x 10 <sup>7</sup>
2	Spoon	2,8 x 10 <sup>6</sup>
	Dessert spoon	3,4 x 10 <sup>7</sup>
1	Fork	1,9 x 10 <sup>6</sup>
1	Cake spatula	1,7 x 10 <sup>6</sup>
1	Glass dish	1,4 x 10 <sup>4</sup>
Quantity (n= 11)	Equipments	Viable Mesophilic and Facultative Aerobic Bacteria (CFU/cm <sup>2</sup> )
4	Refrigerator	5,04 x 10 <sup>5</sup>
	Refrigerator	5,2 x 10 <sup>6</sup>
	Refrigerator	1,8 x 10 <sup>6</sup>
	Refrigerator	3,3 x 10 <sup>6</sup>
3	Griddle	4,7 x 10 <sup>6</sup>
	Griddle	1,1 x 10 <sup>6</sup>
	Griddle	6,8 x 10 <sup>6</sup>
2	Rice cooker	3,0 x 10 <sup>5</sup>
	Rice cooker	4,5 x 10 <sup>6</sup>
2	Microwave	7,8 x 10 <sup>8</sup>
	Microwave	5,6 x 10 <sup>6</sup>

CFU = Colony Forming Units.

Source: Prepared by the authors.

The number of surfaces with the

presence of *Staphylococcus* sp. and the bacterial populations of coagulase-negative *Staphylococcus* (CNS) and coagu-

lase-positive *Staphylococcus* (CPS) are summarized in Table 2.

**Table 2 - Enumeration of *Staphylococcus* sp. on surfaces of utensils and equipment used in food marketing environments at a waterway terminal**

Quantity (n= 10)	Utensils	<i>Staphylococcus</i> sp.	
		<i>Staphylococcus</i> coagulase negativa (CFU/cm <sup>2</sup> )	<i>Staphylococcus</i> coagulase positiva (CFUcm <sup>2</sup> )
5	Knife	7,4 x 10 <sup>4</sup>	< 10
	Knife	3,3 x 10 <sup>3</sup>	< 10
	Knife	1,2 x 10 <sup>5</sup>	< 10
	Knife	1,6 x 10 <sup>5</sup>	< 10
	Knife	1,0 x 10 <sup>6</sup>	< 10
2	Spoon	9,7 x 10 <sup>4</sup>	< 10
	Dessert spoon	2,0 x 10 <sup>5</sup>	< 10
1	Fork	7,0 x 10 <sup>4</sup>	< 10
1	Cake spatula	2,2 x 10 <sup>5</sup>	< 10
1	Glass tray	1,3 x 10 <sup>6</sup>	2,0 x 10 <sup>4</sup>

Quantity (n= 11)	Equipments	Staphylococcus sp.	
		Staphylococcus coagulase negativa (CFU/cm <sup>2</sup> )	Staphylococcus coagulase positiva (CFU/cm <sup>2</sup> )
4	Refrigerator	8,1 x 10 <sup>6</sup>	< 10
	Refrigerator	4,8 x 10 <sup>6</sup>	2,0 x 10 <sup>5</sup>
	Refrigerator	2,9 x 10 <sup>6</sup>	2,5 x 10 <sup>6</sup>
	Refrigerator	3,7 x 10 <sup>4</sup>	3,4 x 10 <sup>3</sup>
3	Griddle	5,1 x 10 <sup>4</sup>	< 10
	Griddle	2,2 x 10 <sup>6</sup>	< 10
	Griddle	1,1 x 10 <sup>6</sup>	< 10
2	Rice cooker	1,0 x 10 <sup>5</sup>	< 10
	Rice cooker	1,4 x 10 <sup>4</sup>	< 10
2	Microwave	2,1 x 10 <sup>6</sup>	1,4 x 10 <sup>6</sup>
	Microwave	1,5 x 10 <sup>6</sup>	1,2 x 10 <sup>6</sup>

CFU = Colony Forming Units.

Source: Prepared by the authors.

The isolation of *Staphylococcus* sp. allowed us to determine its qualitative presence on both utensils and equipment. Regarding the quantitative eval-

uation, it was found that 100% of the surfaces contained high levels of SCN (3.3 x 10<sup>3</sup> to 78.1 x 10<sup>6</sup> CFU/cm<sup>2</sup>) and 28.58% (n = 6/21) presented SCP in high bacterial populations (3.4 x 10<sup>3</sup> to 2.5 x 10<sup>6</sup>). Considering the limit of

up to 50 bacteria/cm<sup>2</sup> on equipment and utensil surfaces established by ABERC<sup>14</sup>, 57.14% (n=12/21) (Table 3) of the samples evaluated would be non-compliant for the quantification of total coliforms.

**Table 3 - Quantification of total coliforms and research of enterobacteria on surfaces of utensils and equipment used in food marketing environments at a Waterway Terminal**

Quantidade (n= 10)	Utensils	Total Coliforms (MPN/cm <sup>2</sup> )	Enterobacteriaceae (CFU/cm <sup>2</sup> )
5	Knife	1.100	7,60 x 10 <sup>6</sup>
	Knife	2.400	9,48 x 10 <sup>6</sup>
	Knife	20	1,38 x 10 <sup>5</sup>
	Knife	2.400	7,09 x 10 <sup>6</sup>
	Knife	290	1,37 x 10 <sup>6</sup>
2	Spoon	2.400	1,3 x 10 <sup>6</sup>
	Dessert spoon	290	5,77 x 10 <sup>6</sup>
1	Fork	29	2,61 x 10 <sup>6</sup>
1	Cake spatula	6.1	4,8x10 <sup>5</sup>
1	Glass dish	7.3	1,0 x 10 <sup>3</sup>
Quantidade (n= 11)	Equipments	Total Coliforms (MPN/cm <sup>2</sup> )	Enterobacteriaceae (CFU/cm <sup>2</sup> )
4	Refrigerator	2.400	4,03 x 10 <sup>6</sup>
	Refrigerator	2.400	2,87 x 10 <sup>6</sup>
	Refrigerator	2.400	2,96 x 10 <sup>5</sup>
	Refrigerator	2.400	9,68 x 10 <sup>6</sup>
3	Griddle	< 3	5,5 x 10 <sup>5</sup>
	Griddle	< 3	7,0 x 10 <sup>3</sup>
	Griddle	< 3	1,68 x 10 <sup>6</sup>
2	Rice cooker	< 3	1,6 x 10 <sup>4</sup>
	Rice cooker	2.400	1,10 x 10 <sup>5</sup>
2	Microwave	< 3	1,44 x 10 <sup>6</sup>
	Microwave	2.400	1,61 x 10 <sup>6</sup>

MPN = Most Probable Number; CFU = Colony Forming Units.

Source: Prepared by the authors.

# Original Article

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Enterobacteriaceae were found in high populations, both on utensils ( $1,0 \times 10^3$  a  $9,48 \times 10^6$  NMP/cm<sup>2</sup>), as in equipment ( $7,0 \times 10^3$  a  $9,68 \times 10^6$  NMP/cm<sup>2</sup>). Thirty strains of en-

terobacteria were isolated from the surfaces evaluated and phenotypic analyses were performed, identifying eight bacterial species, as summarized in Table 4.

isms on equipment and utensils. A possible explanation for these microbiological findings may be related to the frequent handling of equipment and utensils in the evaluated location, in addition to the lack of proper hygiene.

It should be noted that CNS are constituents of the resident skin microbiota. However, they have been implicated in a growing number of infections, notably caused by *S. epidermidis*, *S. hominis*, *S. haemolyticus*, and *S. capitis*, most often multidrug-resistant to various antimicrobials<sup>17</sup>. To Pereira et al.<sup>18</sup>, CNSs are opportunistic agents of community-acquired infections, such as otitis media, urinary tract infections, osteomyelitis, endocarditis, and even septicemia. To Sued<sup>19</sup>, This group of microorganisms signals an emerging public health problem, especially given the imminent occurrence of multidrug-resistant bacterial isolates.

It is noteworthy that 45.45% (n = 5/11) of the equipment surfaces analyzed by SCP were colonized, including three refrigerators and two microwaves. These results demonstrate the ability of this group of microorganisms to resist temperature variations (cold and heat). According to Dos Santos et al.<sup>20</sup>, *Staphylococcus aureus*, the main representative of SCPs, is capable of withstanding desiccation and low temperatures, and can remain viable for long periods in dust particles, in addition to integrating the normal microbiota of human skin and other anatomical sites, such as the nasal cavities and oral cavity.

To Alves, da Costa and Braoios<sup>21</sup>, *S. aureus* contamination is associated with poor or nonexistent hygiene, which reinforces the importance of sanitation in preventing the transmission of these microorganisms in collective foodservice environments.

*S. aureus*, in addition to being the

**Table 4 - Phenotypic identification of enterobacteriaceae from surfaces in the food marketing environment of the Waterway Terminal**

Bacterial isolates (n= 30)	Species Identified
3	<i>Enterobacter aerogenes</i>
3	<i>Citrobacter sakazaki</i>
3	<i>Citrobacter koseri</i>
3	<i>Kluyvera ascorbata</i>
3	<i>Escherichia fergusonii</i>
3	<i>Hafnia alvei</i>
6	<i>Hafnia alvei</i> bligrupo 1
6	<i>Klebsiella pneumoniae</i> sub. <i>Ozaenae</i>

Source: Prepared by the authors.

In all the samples analyzed, the bacteria *Salmonella* sp. was not identified.

## DISCUSSION

Equipment and utensils in general must contain a maximum of 50 bacteria/cm<sup>2</sup> and be free of potentially pathogenic microorganisms or indicators of fecal contamination, according to the Brazilian Association of Collective Meal Companies<sup>14</sup>. According to the American Public Health Association - APHA<sup>12</sup>, surfaces should be considered in adequate hygienic-sanitary conditions when they present counts of up to 2 CFU/cm<sup>2</sup> for total mesophilic heterotrophic aerobic bacteria. Silva Junior<sup>15</sup>, suggests for tableware (cutlery, plates and trays), counts up to 10<sup>2</sup> CFU/cm<sup>2</sup>.

Considering the values mentioned above, this microbiological criterion was not met for equipment/utensils at the site evaluated, as bacterial populations ranging from  $1.4 \times 10^4$  to  $7,8 \times 10^8$  CFU/cm<sup>2</sup> (Table 1). In only 4.76% (n= 1/21) of the surfaces, these microorganisms were within

the established limits.

Vila, Silveira and Almeida<sup>16</sup> evaluated microbiological contamination in kitchen equipment and utensils in public schools in Itaquí, Rio Grande do Sul, and found the presence of fungi and aerobic bacteria on at least one surface analyzed. Some researchers believe the American Public Health Association's recommendation<sup>12</sup> is strict for food processing establishments in Brazil, since the average temperatures in the country are different and higher than those found in North America.

Rodrigues *et al.*<sup>8</sup> highlight that high counts of mesophilic bacteria are worrying because many of them belong to pathogenic microbial groups. Piotto, Rosa and Almeida and Borgem<sup>9</sup> infer that the enumeration of mesophilic bacteria is widely used as an indicator of hygienic quality and, when found in large quantities, as evidenced in this study, may indicate operational failures.

The results obtained for the enumeration of coagulase-positive and -negative *Staphylococcus* (Table 2) were not in agreement with ABERC 14 which regulates the absence of potentially pathogenic microorgan-

most virulent, is the species most frequently associated with staphylococcal diseases, whether foodborne or not, making this group the subject of numerous studies. Food handlers, whether in the food industry or retail trade, are important sources of this species because most of them are asymptomatic carriers. Throughout the production chain, the presence of this microorganism is indicative of unsatisfactory hygienic and sanitary conditions and is interpreted as suggestive of contamination from the skin, mouth, and/or respiratory tract of food handlers<sup>22</sup>.

Pedrosa, Sylvestre and Fernandes<sup>22</sup> state that *S. aureus* is capable of multiplying and producing toxins at room temperature. For Murray, Rosenthal, and Pfaller<sup>23</sup>, Enterotoxins are heat-stable at 100°C for up to 30 minutes, and are resistant to hydrolysis by gastric and jejunal enzymes, making them structurally suited to causing DTHA. Thus, once a food product or surface has been contaminated with enterotoxin-producing staphylococcus and the toxins have been produced in sufficient quantity, even reheating will not be sufficient to prevent poisoning.

The precise mechanism of toxic activity is not yet fully understood, but it is considered that between 10<sup>5</sup> to 10<sup>6</sup> CFU of *S. aureus* per gram of food is necessary for the toxin to be formed at levels capable of causing poisoning.<sup>23</sup> At this point, it is important to highlight that of the total surfaces with SCP, 19.05% (n = 4/21), all equipment, presented bacterial populations that ranged from 2,0 x 10<sup>5</sup> to 2,5 x 10<sup>6</sup> CFU of coagulase-positive *Staphylococcus* per cm<sup>2</sup>, which makes this result of epidemiological importance in the cross-contamination of foods that come into contact with these contaminated surfaces.

When comparing the results described in Table 3 with the limits

established by APHA<sup>12</sup> and Silva Jr.<sup>15</sup>, As described above, 76.20% (n=16/21) and 57.14% (n=12/21) of the surfaces, respectively, were found to be in unsatisfactory hygienic conditions. Among the surfaces evaluated, 100% (n=10/10) of the utensils were contaminated with total coliforms. The equipment, despite having larger bacterial populations, was less affected (54.54%; n=6/11), notably the barbecue grill, which may be related to the greater sensitivity of this group of microorganisms to higher temperatures.

Surface contamination by coliform bacteria is a concern, despite being common in food processing facilities, especially when adequate sanitation methods are not used. Quantifying total coliforms is used to assess the hygienic conditions of the processing facility, signaling inadequate hygiene. The detection of a high number of enterobacteria should be interpreted as an indication of the presence of intestinal pathogens.

Based on the results obtained and interpreted<sup>13</sup>, *Escherichia coli* was absent among the isolates. This result presupposes the absence of this health indicator on the 21 surfaces analyzed, but does not rule out its possible presence on other surfaces in the food sales environment evaluated.

The bacteria belonging to the Enterobacteriaceae family are Gram-negative, facultatively anaerobic, non-spore-forming rods characterized by the presence of the enzyme  $\beta$ -galactosidase and the ability to ferment lactose with gas production in media containing bile salts or other surfactants with similar inhibitory properties. The most frequently isolated enterobacteriaceae are *Citrobacter*, *Enterobacter*, and *Klebsiella*, including the identification of these three genera in the present study.

The absence of *Salmonella* sp. is

an important and reassuring result, as this bacterium constitutes one of the biggest public health problems. This bacterium is a major concern and unacceptable in most food sectors (primary production and food industries).

The utensils and equipment evaluated had smooth, impermeable surfaces, and were made of a material that prevented food contamination. It should be noted that all of them were sanitized with water and mild detergent prior to swab collection. Therefore, high counts of microbial contaminants after sanitization indicate: (i) deficiencies in standard operational hygiene procedures; and/or (ii) the presence of biofilms, which, even with a single sanitization process, even if correct and adequate, would not reduce the microbiota present.

It's important to note that the surfaces of the utensils, unlike the equipment, appeared to be in good aseptic condition. However, the fact that they were stored while still damp and remained exposed to the environment for long periods of time can also favor the adhesion of microorganisms and the formation of bacterial colonies. As for the equipment, wear and tear from use and the evident deficiencies in sanitation procedures may have favored colonization by the various microorganisms identified in this study. It is clear that hygiene in the food preparation area plays a central role in food quality. Therefore, it is necessary to monitor the food production environment, including utensils and equipment, to ensure greater microbiological safety.

The identification of various microorganisms on the surfaces evaluated (Tables 1, 2, 3, and 4) indicates inadequate hygienic and sanitary conditions in which the food is produced. This fact highlights the importance of good food handling practices in mitigating the transmis-

sion of DTHAs. In Brazil, results similar to those found in the present study are common and Silva et al.<sup>24</sup> cite low levels of compliance with Good Manufacturing Practices (GMP) in collective foodservice environments, which contributes to perpetuating contamination.

For Moura, Silva, and Mota<sup>25</sup>, Bacteria have the ability to adhere to the surfaces of food-contact utensils, making sanitation more challenging. If this procedure is not performed properly, it can facilitate the transmission of pathogenic microorganisms to food. Therefore, given the results obtained, it is important to emphasize that surface sanitation is necessary to aid in the microbiological control of food produced.

It is important to emphasize the

lack of regulation regarding the microbiological analysis of surfaces in Brazilian legislation, which hinders monitoring of sanitation routines. The researchers emphasize the importance of adopting ongoing continuing education programs for food handlers, led by qualified professionals, contributing to GMP in the production of safe food.

## CONCLUSION

The identification of viable mesophilic and facultative aerobic bacteria, coagulase-negative and -positive *Staphylococcus*, total coliforms, and Enterobacteriaceae, highlights the need to implement practices aimed at controlling waterborne and foodborne diseases (FBDs) at the Water-

way Terminal.

The identification of two groups of *Staphylococcus* sp. in the study, coagulase-negative and -positive *Staphylococcus*, including in equipment operating at low and high temperatures (refrigerators and barbecue grills), raises the debate on the human skin microbiota as a potential reservoir of these microorganisms. This requires reflection and expansion of strategies that contribute to raising awareness among food handlers regarding hand hygiene procedures, the proper use of personal protective equipment (PPE), and periodic examinations.

Continuing education may be a possible path to achieving contamination control.

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