Level of compliance with good manufacturing practices and microbiological profile of mixed fresh sausages

Grau de cumprimento das boas práticas de fabricação e perfil microbiológico de linguiças frescas mistas

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Abstract: Good manufacturing practices in production facilities are necessary to control microbiological growth and prevent foodborne illnesses. Among the various foods that can be contaminated by intensive handling, meat products such as fresh sausages stand out. With this in mind, the aim of this study was to establish a microbiological profile of the fresh sausages produced in the municipality of Alegrete-RS, Brazil, as part of the SIM/SISBI inspection between 2014 and 2016 and to promote and evaluate the producing establishments in terms of compliance with good manufacturing practices. Samples were regularly taken from 10 businesses in the city and tested for thermotolerant coliform bacteria, sulphite-reducing *Clostridium*, coagulase-positive *Staphylococcus* and *Salmonella* spp. In addition, the adequacy of good manufacturing practices was assessed and measures in the form of questionnaires, guidelines and training to improve the production chain were implemented in these companies. Over the years, significant improvements in compliance with good manufacturing practices have been observed in the production units. The microbial count of thermotolerant coliforms, sulphite-reducing *Clostridium*, coagulase-positive *Staphylococcus* and *Salmonella* spp. decreased significantly, indicating that the interventions contributed to improving the microbiological profile of the fresh sausage produced in the community.

Keywords: *Salmonella* spp; sulphite-reducing *Clostridium*; coagulase-positive *Staphylococcus*; thermotolerant coliform bacteria; contamination.

Resumo: Boas Práticas de Fabricação nas agroindústrias são necessárias para controlar a multiplicação de microrganismos e prevenir a ocorrência de doenças veiculadas por alimentos. Dentre os diversos alimentos que podem ser contaminados pela manipulação intensiva, destacam-se os produtos cárneos, como a linguiça frescal. Com base no exposto, objetivou-se avaliar o nível de contaminação

de linguiças frescais produzidas no município de Alegrete (RS) no âmbito da fiscalização do SIM/SISBI entre 2014 e 2016 e correlacionar ao atendimento das Boas Práticas de Fabricação (questionários, orientações e treinamentos). Amostras regulares foram coletadas em 10 estabelecimentos da cidade e testadas para coliformes termotolerantes, *Clostridium* sulfito redutor, *Staphylococcus* coagulase positiva e *Salmonella* spp. A quantificação microbiana de coliformes termotolerantes, *Clostridium* sulfito redutor, *Staphylococcus* coagulase positiva e *Salmonella* spp. diminuiu significativamente, indicando que as intervenções contribuíram para melhorar o perfil microbiológico da linguiça frescal produzida na cidade.

Palavras-chave: *Salmonella* spp; *Clostridium* sulfito redutor; *Staphylococcus* coagulase positiva; coliformes termotolerantes; contaminação.

1 Introduction

The microbiological quality of food is directly related to the hygiene of the industrial environment, the raw materials, the personnel and the surface of the production line [1,2]. If this quality is not guaranteed, food can be a carrier of pathogenic microorganisms that cause foodborne diseases (FBD), which can affect the health of consumers [3]. These diseases, which are caused by various microorganisms and their toxins following the consumption of contaminated water and/or food, lead to major public health problems as well as significant economic losses [4,5].

In Brazil, between 2013 and 2022, the main pathogens causing FBD were *Escherichia coli* (32.3%), *Salmonella* spp (10.9%), *Staphylococcus aureus* (10.8%) and *Bacillus cereus* (6.5%). The manifestations of FBD in the body depend on the pathogen and can range from mild to severe symptoms, such as death [6].

Foods that can be a source of contamination with pathogenic microorganisms include cured meat due to its intensive handling [7]. "Cured meats" are all products made from edible meat or organs that are cured, seasoned, cooked, smoked and dried and have an animal or artificial casing [6]. Sausage is the most produced meat product in Brazil, made from beef, pork or poultry, and may or may not be salted, aged, dried or cooked [8]. Among the types of sausage, fresh sausage stands out due to its great acceptance among consumers [8-10].

There is a risk of microbiological contamination in fresh sausages, as they are subjected to high stress during processing and are not heat-treated. Since production requires several operations, the possibility of contamination with different types of pathogenic or harmful microorganisms increases, which may affect the quality and safety of the product [7,8,11].

In this context, the support, guidance, control and inspection of establishments processing cured meat, such as fresh sausages, by public bodies is essential to promote improvements in the production chain and, above all, to ensure the safety of consumers of this type of product.

Based on the above, the main objective of this study was to establish a microbiological profile for the production of fresh cured meats in this municipality which were under the control of the Municipal Inspection Service for Animal Products during the 2014-2016 period — to promote and evaluate the manufacturing establishments in terms of their compliance with good manufacturing practices.

2 Materials and Methods

2.1 Selection of facilities

The present study was carried out in the municipality of Alegrete, Rio Grande do Sul, Brazil, in collaboration with the Secretariat of Agriculture and Livestock of the municipality; specifically, the Municipal Inspection Service for Animal Products (SIM-POA) and registered units of this service, which currently comprises 38 establishments. Of these registered production units, ten were randomly selected (defined by lot) to be evaluated.

After the selection of the establishments, data was collected through surveys in which the adequacy of good manufacturing practices was assessed using questionnaires with checklists (supplementary material) and microbiological analyses of fresh sausage samples between 2014 and 2016.

2.2 Inspections of manufacturing establishments

The establishments were assessed during twice-monthly inspections, using a questionnaire in the form of a checklist based on good manufacturing practices. The checklist used included the assessment of 18 points relating to raw materials, production, packaging, storage, transportation, cleaning and hygiene of the establishment and employees. After applying the questionnaires, the data obtained was converted into a percentage of adequacy and classified as excellent (100% to 90%), very good (89% to 80%), good (79% to 70%), regular (69% to 60%) or bad (less than 59%). For each inspection, measures were implemented in the form of instructions for the employees involved in the process.

2.3 Microbiological analyses

Samples of fresh sausages were taken once a month in the production and storage rooms of the establishments. The samples were taken according to a predetermined scheme in which a sausage was selected at random and a portion of it was cut up with previously sterilized knives. At the time of sampling, the samples had a temperature between 0 and 7 °C. After collection, the samples were sterile-packed, stored at a temperature of 5 to 7 °C in an isothermal container with ice and sent to the laboratory for analysis.

On arrival at the laboratory, the samples were separated from their origin and coded from "1" to "10" depending on the production unit and analysed for the presence of *Salmonella* spp, quantification of thermotolerant coliform bacteria, coagulase-positive *Staphylococcus* and sulphite-reducing *Clostridium*.

The analysis of *Salmonella* spp. (presence or absence) was performed according to method ISO 6579:2002 (12). The count of thermotolerant coliform bacteria was performed according to the AFNOR method, Certificate no. 3M 01/02-09/89 (13). Coagulase-positive *Staphylococcus* were counted according to the method ISO 6888-1:1999[14]. Finally, the number of sulphite-reducing *Clostridium* was determined according to method ISO 15213:2003[15].

2.4 Statistical analysis

Differences between quarters of the years and between the establishments in terms of the presence of Salmonella in the samples and the number of other microorganisms were checked by subjecting them to an analysis of variance (ANOVA, one-way ANOVA) followed by a Fisher's Least Significant Difference test (LSD test, $p < 0.05$).

3 Results and Discussion

3.1 Adequacy of good manufacturing practices in the establishments

Significant improvements in the adequacy of good manufacturing practices have been observed in all manufacturing plants over the years (Table 1), possibly due to the measures implemented through training. This result confirms what was reported in the study by Lopes et al. [2], who found an improvement of more than 60% in the good manufacturing practice index after the implementation of training for food artisans. According to Vidal-Martins et al. [16], implementing good manufacturing practices in sausage factories is difficult because monitoring is not strict enough. Therefore, the training of workers in these factories was ultimately inadequate. This result is consistent with the findings of the present study, as there was not only strict supervision, but also guidance for those interested.

Other possible factors that led to the acquisition of this data were the investments made in the inspection service during this period, with the purchase of consumables and works that allowed for better training of staff and effective inspection measures. It should be noted that the improvement observed from 2014 to 2016 results in greater public health benefits for consumers who have access to a product with greater food safety.

Table 1 Rating of facilities in terms of degree of adequacy by quarter for the years 2014, 2015 and 2016, Alegrete, RS, Brazil.

							2014	
Est	**1st Qua**	**Clas**	**2nd Qua**	**Clas**	**3rd Qua**	**Clas**	**4th Qua**	**Clas**
01	74.2%	Go	65.0%	Re	55.0%	Ba	77.5%	Go
02	72.5%	Go	75.8%	Go	66.7%	Re	74.3%	Go
03	85.0%	VGo	80.0%	VGo	81.7%	VGo	71.7%	Go
04	78.3%	Go	73.3%	Go	81.7%	VGo	82.5%	VGo
05	88.3%	VGo	75.0%	Go	67.5%	Re	65.8%	Re
06	75.7%	G	69.2%	Re	64.2%	Re	78.3%	Go
07	80.0%	VGo	72.5%	Go	61.7%	Re	80.8%	VGo
08	69.2%	Re	55.0%	Ba	72.5%	Go	77.5%	Re
09	89.7%	VGo	76.7%	Go	81.7%	VGo	80.8%	VGo

10	85.0%	VGo	64.2%	Re	79.2%	Go	74.2%	Go
2015								
Est	**1st Qua**	**Clas**	**2nd Qua**	**Clas**	**3rd Qua**	**Clas**	**4th Qua**	**Clas**
01	76.7%	Go	86.7%	VGo	86.7%	VGo	80.8%	VGo
02	75.8%	Go	77.5%	Go	82.5%	VGo	87.5%	VGo
03	74.1%	Go	83.3%	VGo	94.2%	Ex	80.8%	VGo
04	76.7%	Go	81.7%	VGo	89.9%	VGo	87.5%	VGo
05	69.2%	Re	85.0%	VGo	74.2%	Go	82.5%	VGo
06	70.0%	Go	84.2%	VGo	80.0%	VGo	84.2%	VGo
07	84.2%	VGo	85.0%	VGo	88.3%	VGo	90.0%	Ex
08	71.7%	Go	84.6%	VGo	87.5%	VGo	88.3%	VGo
09	82.5%	VGo	86.7%	VGo	85.8%	VGo	88.3%	VGo
10	77.5%	Go	81.7%	VGo	85.0%	VGo	78.3%	Go
2016								
Est	**1st Qua**	**Clas**	**2nd Qua**	**Clas**	**3rd Qua**	**Clas**	**4th Qua**	**Clas**
01	93.3%	Ex	92.5%	Ex	90.0%	Ex	91.7%	Ex
02	85.8%	VGo	74.2%	BO	88.3%	VGo	85.8%	VGo
03	85.0%	VGo	91.7%	Ex	77.5%	Go	85.0%	VGo
04	90.0%	Ex	89.9%	VGo	88.3%	VGo	87.5%	VGo
05	84.2%	VGo	75.8%	Go	85.8%	VGo	90.0%	Ex
06	87.5%	VGo	91.7%	Ex	79.2%	Go	87.5%	VGo
07	93.3%	Ex	89.2%	VGo	87.5%	VGo	86.7%	VGo
08	73.3%	Go	94.2%	Ex	87.5%	VGo	85.0%	VGo
09	83.3%	VGo	90.0%	Ex	86.6%	VGo	90.0%	Ex
10	95.0%	Ex	86.7%	Ex	91.7%	Ex	90.0%	Ex

Establishments (Est), Quarter (Qua), Classification (Clas), Excellent (Ex), Very Good (VGo), Good (Go), Regular (Re), Bad (Ba). The classification used in Table 1 corresponds to the checklist attached in the supplementary material.

3.2 Microbiological control of fresh mixed sausages

Improvements were also observed in the microbiological analyses, which may be related to the training of the staff and the commitment of the entire team to the application of good manufacturing practices. These results confirm the findings of Senter et al.[17], who found a decrease in contamination of meat products after staff training. When evaluating the number of sulphite-reducing *Clostridium* (Table 2), a decrease in contamination of fresh mixed sausages from the city of Alegrete was found when comparing 2014 and 2016. However, there were no significant differences ($p < 0.05$) in the bacterial counts between the quarters and between the 10 farms studied.

Table 2 Total number of sulphite-reducing *Clostridium* in fresh mixed sausages in manufacturing establishments by quarter for 2014, 2015 and 2016, Alegrete, RS, Brazil.

	2014			
Est	**1st Qua (Log CFU g⁻¹)**	**2nd Qua (Log CFU g⁻¹)**	**3rd Qua (Log CFU g⁻¹)**	**4th Qua (Log CFU g⁻¹)**
1	2.6	2.2	2.4	2.3
2	2.1	1.9	1.7	1.6
3	2.9	2.2	2.4	2.4
4	1.1	2.1	1.4	1.5
5	1.8	1.9	2.0	2.1

6	2.5	2.0	1.0	2.2
7	2.0	1.8	2.7	2.9
8	2.3	2.5	2.0	2.6
9	1.5	2.8	1.2	2.2
10	4.7	2.2	2.4	1.2

2015			
Est	1st Qua (Log CFU g^{-1})	2nd Qua (Log CFU g^{-1})	3rd Qua (Log CFU g^{-1})	4th Qua (Log CFU g^{-1})
1	2.3	1.0	1.1	1.1
2	3.1	2.1	2.4	1.4
3	2.7	2.1	1.4	2.7
4	2.0	1.3	2.7	2.4
5	2.2	2.1	1.0	2.0
6	2.9	2.1	2.0	1.4
7	1.6	2.1	2.0	1.1
8	2.2	1.0	2.3	2.3
9	2.0	2.1	3.2	2.2
10	2.9	2.1	2.3	2.3

2016			
Est	1st Qua (Log CFU g^{-1})	2nd Qua (Log CFU g^{-1})	3rd Qua (Log CFU g^{-1})	4th Qua (Log CFU g^{-1})
1	1.1	1.0	1.0	1.6
2	2.1	2.3	1.0	2.0
3	1.0	1.0	1.0	1.1
4	1.0	1.3	1.8	2.1
5	1.1	1.9	2.1	2.1
6	1.0	1.0	1.0	1.9
7	1.0	2.3	2.0	1.1
8	1.0	2.9	1.0	1.0
9	1.0	1.1	1.0	2.1
10	1.0	1.1	1.1	3.1

Establishments (Est), Quarter (Qua).

In a study conducted with tested sausages, Montovani et al. [18] found levels of sulphite-reducing *Clostridium* reducer within the parameters of the legislation that we can correlate with the data found. These results can be associated with the following factors: Compliance with control standards and corrective actions when deviations are found in the checklist.

The current Brazilian legislation (Normative Instruction - IN No. 161, of July 1, 2022, of the National Health Surveillance Agency – ANVISA, of the Ministry of Health – MS of Brazil) does not establish parameters for *Clostridium perfringens* in fresh sausages; however, for products made from cooked meat, whether cured or not, smoked or not, dried or not, sausages or not, refrigerated or not (mortadella, sausage, ham, black pudding, pâtés, galantines) a maximum value of 10^3 (3 log CFU g^{-1}) for *Clostridium perfringens* is defined. Looking at the latter parameters, only four samples showed values above the maximum permitted level.

Contamination of food by *Salmonella* spp. is one of the main origins of illness worldwide, caused by contaminated food, which is detrimental to public health. According to Brazilian

law, the presence of *Salmonella* spp. in fresh sausages is not allowed [6]. Nevertheless, the presence of *Salmonella* spp. was detected in some of the samples analysed (Table 3). This result is consistent with the results of the study by Pavelquesi et al. [7], who found the presence of the microorganism in 25% of the samples of fresh chicken sausages analysed in the Federal District, and with the study by Cabral et al. [19], who found the presence of *Salmonella* spp. in 26% of the fresh chicken and pork sausages analysed.

Table 3 Presence of *Salmonella* spp in fresh mixed sausages in production establishments by quarter for 2014, 2015 and 2016, Alegrete, RS, Brazil.

2014				
Est	**1st Qua** (Presence)	**2nd Qua** (Presence)	**3rd Qua** (Presence)	**4th Qua** (Presence)
1	0	1	0	1
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	1	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	1
9	0	0	0	0
10	0	0	0	0
2015				
Est	**1st Qua** (Presence)	**2nd Qua** (Presence)	**3rd Qua** (Presence)	**4th Qua** (Presence)
1	0	0	1	0
2	1	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	1
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
2016				
Est	**1st Qua** (Presence)	**2nd Qua** (Presence)	**3rd Qua** (Presence)	**4th Qua** (Presence)
1	1	0	0	0
2	1	0	0	0
3	0	0	0	0
4	0	0	0	0
5	1	0	0	0
6	1	0	0	0
7	0	0	0	1
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

Establishments (Est), Quarter (Qua).

When comparing the samples regarding the presence or absence of *Salmonella* spp. in the quarters and years, there were no significant differences, showing that contamination was not related to the period studied, but there was a significant difference ($p < 0.05$) between the production sites. As can be seen in Table 3, production site "1" was statistically different from the others, with the exception of production sites "5" and "7".

This contamination could be related to the fact that these production facilities are less in line with good practices, necessitating more effective work to improve sanitary and hygienic conditions. Souza et al. [20] found in their study that 30% of fresh sausage samples were contaminated with *Salmonella* spp, while Alberti and Nava [21] found 67%. These authors cited the production of contaminated raw materials and/or industrialization without hygienic care as possible causes of contamination. These could also be the causes of the presence of *Salmonella* spp. in the samples of this study, in which more effective control is required at production establishments "1", "5" and "7".

The third quarter includes the cold months (July, August), which could have been one of the reasons for this difference. Among the production establishments, all samples had thermotolerant coliforms, but production establishments"3", "9" and "10" had the lowest values and were statistically different ($p < 0.05$) from the others, with lower values, which can be verified in Table 4.

Thermotolerant coliforms are indicators of the hygienic and sanitary conditions of food [22]. In this study, when comparing the quarters of the period from 2014 to 2016 (Table 4), a significant difference ($p < 0.05$) was found between the 3rd quarter and the other quarters, with the lowest values for these microorganisms in the third quarter.

Table 4 Number of thermotolerant coliforms in fresh mixed sausages in production establishments by quarter for 2014, 2015 and 2016, Alegrete, RS, Brazil.

2014				
Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
1	2.8	2.2	3.3	2.3
2	2.2	2.2	2.1	2.3
3	2.0	2.2	2.0	1.5
4	1.2	2.1	2.5	2.7
5	2.3	2.9	2.1	2.8
6	2.3	2.1	1.0	2.2
7	2.5	1.4	2.6	2.4
8	1.7	1.1	2.8	2.4
9	1.5	2.2	1.3	3.0
10	2.3	1.5	3.1	2.1
2015				
Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
1	2.3	2.8	2.5	3.2
2	3.7	1.9	3.2	2.1
3	2.1	2.1	3.1	3.4
4	3.0	2.1	2.2	1.9

Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
5	2.5	3.5	2.2	3.1
6	2.6	3.3	1.9	2.6
7	3.3	1.8	3.0	2.3
8	3.0	2.9	1.9	3.0
9	3.0	2.4	3.0	3.4
10	3.3	2.6	1.9	2.0
2016				
Est	**1st Qua (Log CFU g⁻¹)**	**2nd Qua (Log CFU g⁻¹)**	**3rd Qua (Log CFU g⁻¹)**	**4th Qua (Log CFU g⁻¹)**
1	2.4	2.4	1.3	3.1
2	2.9	2.5	2.2	1.7
3	3.4	2.9	1.3	1.3
4	2.4	1.9	1.3	2.5
5	2.3	3.1	2.1	2.3
6	3.3	3.0	2.5	2.9
7	3.9	2.0	2.0	1.2
8	3.9	2.2	2.4	2.0
9	3.2	1.9	1.0	2.1
10	1.1	2.4	1.8	2.0

Establishments (Est), Quarter (Qua).

According to Sirtoli and Comarella[23], food contamination is closely related to poor hand hygiene, inadequate temperatures, cross-contamination and recontamination. Among these factors, in the present study, we may add the temperature of the production areas, because in establishments "3", "9" and "10" the ambient temperature in the production areas remained stable at values below or equal to 10 °C due to industrial cooling systems. This also confirms the data in Table 4, which show the influence of temperature, where contamination by thermotolerant coliforms decreased in the coldest quarters.

Table 5 shows the results on the number of coagulase-positive *Staphylococcus*.

Table 5 Number of coagulase-positive *Staphylococcus* in fresh mixed sausages in production establishments by quarter for 2014, 2015 and 2016, Alegrete, RS, Brazil.

		2014		
Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
1	2.1	2.7	2.7	2.4
2	1.8	2.3	2.3	2.3
3	2.4	2.0	3.1	2.1
4	2.6	3.2	2.1	2.0
5	2.1	2.3	2.2	2.0
6	2.5	1.7	1.7	2.4
7	1.7	1.9	2.1	2.2
8	2.0	2.0	1.9	1.8
9	2.3	2.0	3.0	2.2
10	2.1	2.1	3.4	2.3

2015				
Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
1	3.4	2.0	2.3	2.1
2	2.1	2.1	2.1	1.9
3	2.0	2.2	2.3	2.5
4	3.1	3.1	2.0	2.2
5	2.3	2.3	2.1	1.8
6	2.1	2.1	2.0	2.3
7	2.0	1.8	2.0	1.8
8	2.1	2.0	2.0	1.8
9	2.0	2.0	1.8	2.3
10	1.9	2.2	2.3	1.9
2016				
Est	1st Qua (Log CFU g⁻¹)	2nd Qua (Log CFU g⁻¹)	3rd Qua (Log CFU g⁻¹)	4th Qua (Log CFU g⁻¹)
1	3.2	2.3	2.3	2.5
2	2.2	2.6	2.0	2.1
3	2.6	2.3	2.3	2.1
4	2.5	2.3	2.0	2.0
5	2.1	2.2	2.0	1.6
6	3.5	2.0	1.1	1.8
7	2.5	2.0	2.2	2.1
8	2.2	2.0	2.6	2.1
9	2.0	3.1	2.0	2.0
10	2.2	2.2	1.6	2.2

Establishments (Est), Quarter (Qua).

In production establishments "5", "7" and "8", the number of coagulase-positive *Staphylococcus* differed significantly ($p < 0.05$) from the others and was lower than in production establishments "1", "3" and "4". Considering that operators are the main source of coagulase-positive *Staphylococcus*, factors such as the high turnover of employees and the lack of continuous training of operators in production establishments "1", "3" and "4" could be related to these results.

Souza et al. [20], in a study of controlled and artisanal fresh sausages, demonstrated the presence of coagulase-positive *Staphylococcus* in the samples analysed. The authors found greater contamination in artisanal sausages and associated this with excessive manipulation and lack of hygienic controls. In the present research, samples of controlled fresh sausages were analysed. It was found that the number of coagulase-positive *Staphylococcus* was higher in some production establishments (Table 5) than in the others, yet within the thresholds established by Brazilian legislation.

4 Conclusion

The results show that training in the agribusiness for meat products, especially fresh sausage in Alegrete, RS, Brazil, between 2014 and 2016 brought great improvements in terms

of good manufacturing practices. It was found that the contamination with sulphite-reducing *Clostridium* decreased. The current Brazilian legislation does not establish parameters for *Clostridium perfringens* in fresh sausage, but for other products, a maximum count of 10^3 (3 log CFU g^{-1}) is allowed. If we consider these last parameters, only four samples have counts above the maximum allowed. However, higher levels of coagulase-positive *Staphylococcus* and, especially, *Salmonella* spp. were detected in some production establishments in relation to others, requiring stronger intervention, retraining of staff and more effective control at all production stages. Lower levels of thermotolerant coliforms were found in cold rooms and in production establishments with effective temperature control, demonstrating the importance of adapting refrigeration to the production environment.

Declaration of conflict of interest

The authors declare that there is no conflict of interest.

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