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Control of fermented sausage, salami, sausage, and hamburger meatballs produced in meat production facilities applying the ISO Food Security System for food pathogens

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Abstract: In this study, fermented sausage, salami, sausage, and hamburger meatballs produced by 6 different companies were assessed for pathogen contamination. These firms were either International Organization for Standardization (ISO) 22000-compliant or non-ISO 22000 compliant. Samples were taken 4 times over 4 seasons. The total mesophilic aerobic quantities of *Bacillus cereus*, *Clostridium perfringens*, and *Staphylococcus aureus*, along with the presence of *Salmonella* spp., *Listeria monocytogenes*, and *Escherichia coli* O157:H7, were tested in each sample. In 96 samples, *Salmonella* spp. (3.12%), *L. monocytogenes* (17.7%), and *E. coli* O157:H7 (4.16%) were detected. From the ISO-certified firms, *Salmonella* spp. were detected in one meatball (8.33%). *L. monocytogenes* was detected in 7 meatballs (58.31%), one sausage (8.33%), and one salami (8.33%). *E. coli* O157:H7 was detected in one meatball (8.33%) and one sausage (8.33%). These results indicate that the ISO system by itself is not an effective food security system for public health. All applications of food security related to consumer health are important and must be ensured at all stages of the supply chain, from the general health conditions of animals to the end delivery of products for the consideration of conscious customers.

Key words: Meat products, food safety, International Organization for Standardization 22000, food pathogens, zero-tolerance bacteria

1. Introduction

Studies on food safety have been carried out for nearly 40 years to improve quality of life (1). Since the bovine spongiform encephalopathy (BSE) and dioxin crises in Europe and the beef-based *Escherichia coli* O157:H7 infections in North America (2), many have lost confidence in the institutions responsible for securing food safety (3,4). Consequently, the relevant authorities have an obligation to develop adequate food safety strategies. New or revised legal regulations, as well as the amenities to ensure the adequate application of food security measures, are also needed (2).

It has become apparent that the hazard analysis critical control point (HACCP) approach was an inadequate effort in securing food safety (5,6). Furthermore, the HACCP is not an efficient system (6). To guarantee food safety and eliminate risks, which are compulsory in the HACCP system, prerequisite programs and new HACCP applications are required to adhere to good agricultural practices (6,7).

The International Organization for Standardization (ISO) 22000 standard was introduced by the Codex Alimentarius Commission (CAC) with the aim of fulfilling the HACCP principles. This standard combines prerequirement programs with the HACCP. According to research conducted on pork pâté butchers (7), it is necessary to apply the CAC and HACCP principles that formed the basis of the ISO 22000. Furthermore, the authors of this study acknowledge that many bacterial threats such as *Listeria monocytogenes*, *Salmonella* spp., and *Staphylococcus aureus* could be controlled by the application of good hygiene practices and that 3 bacterial threats, namely *Bacillus cereus*, *Clostridium botulinum*, and *C. perfringens*, could be suppressed by taking specific control measures.

Previously, a study was conducted in order to identify the sources of microbial contamination in a sausage processing line. Total mesophilic aerobic (TMA) bacteria numbers were found to be very high before the cooking process, but they decreased significantly after the cooking process (8). *Bacillus cereus* distribution in processed-meat products (such as ground beef, chicken, Vienna sausages, jambon, and salami) in South Africa was found in one chicken sample, in 3 salami samples, and in 5 Vienna sausages (9). In Iran, 6.66% of 645 raw and cooked meat samples were contaminated with *Salmonella* spp. (10).

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In another study, *Listeria* spp. were isolated from 10 of 11 (90.9%) raw meat products and 11 of 32 ready-to-eat meat products. Four months later, *Listeria* spp. were detected in 4 of 5 (80.0%) raw meat products and 1 of 5 processed meat products (20.0%), irrespective of proper sanitation and hygiene applications (11). In 1993, an epidemic of *E. coli* O157:H7 in North America, resulting from a contamination of raw beef and minced meat, led to 4 deaths and 500 infected individuals (12). In Turkey, an *E. coli* O157 serotype was isolated in one of 41 minced-meat samples (2.43%), 3 of 29 frozen İnegöl meatballs (10.34%), one of 17 nonfrozen İnegöl meatballs (5.88%), and 3 of 25 frozen hamburger meatballs (12%); however, none of these samples contained the H7 serotype (13).

This study was carried out to highlight the importance of ensuring adequate methods for safe food during both primary production and the processing of food manufacturing.

2. Materials and methods

Fermented sausage, salami, sausage, and hamburger meatballs were obtained from 3 different ISO-certified and 3 different undocumented production facilities in 4 seasons (winter, spring, summer, and autumn) following production. For each season, 4 samples were collected from each company. A total of 96 samples comprising fermented sausage, salami, sausage, and hamburger meatballs were tested for *Salmonella* spp., *L. monocytogenes*, and *E. coli* O157:H7. The enumeration of *S. aureus*, *B. cereus*, *C. perfringens*, and TMA microorganisms was also noted.

Samples were divided into pieces with a scalpel and adjusted to a weight of 25 g before testing for each estimated pathogen. Samples were diluted with 225 mL of suitable diluting agents in sterile bags and smashed in a Stomacher bag for 1–2 min. Decimal dilutions were performed as described previously (14).

Cells were transferred to plates containing sterile plate count agar culture medium (Merck, Germany) and incubated at 35 °C for 48 h. Colonies observed on plates were regarded as TMA microorganisms (15).

Isolation of *S. aureus* was carried out using an egg yolk tellurite with Baird Parker agar (Merck). Plates were incubated at 35 °C for 48 h (16,17). Black colonies were considered to represent the genus *Staphylococcus*. Identification tests were performed on at least 3 typical and atypical *S. aureus* colonies in which lecithinase activity either yielded a positive and bright zone or did not. Isolated bacteria were incubated at 35 °C for 24 h in brain heart infusion broth (Merck). After performing catalase and coagulase tests, positive colonies were determined by biochemical tests (API STAPH, bioMérieux, France) (18).

The egg yolk, combined with a supplement of tryptose sulfite cycloserine broth (Merck), was used for enumeration of *C. perfringens*. Plates were incubated anaerobically at 35 °C for 24 h (19). Black colonies were assumed to be *C. perfringens*. The opaque zones of 2 or 3 black colonies were enriched at 35 °C for 24 h anaerobically (19). Biochemical tests (API 20A, bioMérieux) were applied to these colonies.

For *Bacillus cereus* enumeration, Brilliance's *Bacillus cereus* agar (Merck) with Brilliance's *Bacillus cereus* selective supplement was used. Blue colonies on the incubated plates (30 °C for 48 h) were suspected to be *Bacillus* and *B. cereus*. These colonies were transferred to Columbia blood sheep agar (Merck) and incubated at 37 °C for 24 h (20). Biochemical tests (API 20E, API 50 CHB, bioMérieux) were applied to detect *Bacillus* species.

Salmonella spp. were detected by testing 25 g of meat sample that was weighed in 225 mL of tamponed peptone water (Merck) and incubated at 35 °C for 24 h for preenrichment. From the selective enrichment, 0.1 mL was put into 10 mL of Rappaport-Vassiliadis broth medium (Merck). The tubes were incubated at 42 °C for 24 h. For the purpose of isolation, drawings were done from xylose lysine deoxycholate agar (Merck) according to the accepted streak plate techniques with sterilized single-use loops. Plates were incubated at 35 °C for 24 h and spotty black-colored colonies were suspected to be *Salmonella* spp. We also performed an oxidase test (21). Finally, the existence of *Salmonella* spp. was evaluated by applying biochemical tests (API 20E, bioMérieux).

Samples of 25 g of hamburger meatball, salami, fermented sausage, and sausage were added to 225 mL of a Fraser broth base (Merck) with a Listeria Half-Fraser supplement and incubated at 30 °C for 24 h. For selective enrichment, 0.1 mL was transferred from the enrichment medium to the buffered Listeria enrichment broth base (BLEB, Merck) and incubated at 35 °C for 24 h (22). From the BLEB, drawing was made for Palcam or Ottaviani Agosti and nutrient agars (Merck). Plates were incubated for 48 h at 30 °C (BLEB, Ottaviani, and nutrient agar) and 37 °C (Palcam agar), and at least 5 typical colonies were transferred to tryptone soya yeast extract and Columbia blood sheep agars (Merck). Beta-hemolysis formation was observed. API Listeria (bioMérieux) was used for biochemical tests.

In order to test for *E. coli* O157:H7, 225 mL of modified tryptone soy broth medium (Merck) with 5 mg of novobiocin supplement (Merck) was added to a meat sample of 25 g before being incubated at 37 °C for 24 h. After the incubation, the plates containing sorbitol MacConkey (SMAC) medium (Merck) with a full loop of cefixime tellurite were drawn according to the streak plate technique (23). Plates were incubated at 35 °C for 24 h. After the incubation, gray-colored colonies that did not ferment the sorbitol were identified. A light yellow color was indicative of colonies suspected to be

E. coli O157:H7 strains on the SMAC agar plates that could not ferment sorbitol. The colonies were drawn on Columbia blood sheep agar and incubated at 35 °C for 24 h. Agglutination was observed by applying a Wellcolex latex test (bioMérieux) to the suspicious colonies in order to detect *E. coli* O157 and *E. coli* O157:H7. The plates were identified as positive when agglutination was observed and negative when agglutination was not observed. Mean and standard deviation were calculated with Excel (Version 2003, Microsoft, USA). Pearson's chi-square test was used to check bivariate associations with the categorical variable and an independent t-test was used to evaluate associations with continuous variables by SPSS (Version 16.0, SPSS Inc., USA).

3. Results

The samples of fermented sausage, salami, sausage, and hamburger meatballs were classified in terms of their number of TMA microorganisms and evaluated as shown in Table 1. They were concluded to be either under or over the determination level. When results were compared between the ISO-certified and the unlisted firms, the number of TMA microorganisms in hamburger meatballs from unlisted firms was considerably higher than in those produced by ISO-certified firms ($P < 0.01$) (Table 1).

When each sample was assessed for enumeration of *S. aureus*, *C. perfringens*, and *B. cereus*, they were mostly at or near the level of determination (Table 1). The differences between the products from the ISO-certified and unlisted firms were insignificant for the enumeration of *S. aureus*, *C. perfringens*, and *B. cereus* ($P > 0.05$) (Table 1).

S. aureus contamination was detected in 9 of 96 samples. Seven of the contaminated samples were produced by ISO-certified firms and 2 were produced by unlisted firms. On the other hand, of the 10 samples contaminated with *C. perfringens*, 4 belonged to ISO-certified firms and 6 belonged to unlisted firms.

B. cereus contamination was detected in only 3 of 96 samples. One of these samples was produced by an ISO-certified firm. *Salmonella* spp. contamination was detected in only 3 hamburger meatballs (Table 2). It was observed that one of these meatballs was produced by an ISO-certified firm and 2 were produced by unlisted firms ($P > 0.05$) (Table 3).

L. monocytogenes contamination was detected in 17 of 96 samples. The 17 samples consisted of 2 salami samples, one sausage, and 14 hamburger meatballs (Table 2). Nine of these samples were produced by ISO-certified firms and 8 were produced by unlisted firms ($P > 0.05$) (Table 3).

E. coli O157:H7 contamination was detected in only one sausage and 3 hamburger meatballs (Table 2). Two samples were produced by ISO-certified firms and 2 were produced by unlisted firms ($P > 0.05$) (Table 3).

Salmonella spp. and *L. monocytogenes* contamination was detected in 2 hamburger meatball samples, and *L. monocytogenes* and *E. coli* O157:H7 contamination was detected in one sample. Two samples contaminated with *Salmonella* spp. and *L. monocytogenes* were produced by an unlisted firm and one hamburger meatball contaminated with *L. monocytogenes* and *E. coli* O157:H7 was produced by an ISO-certified firm (Table 3).

4. Discussion

In this study, fermented sausage, salami, sausage, and hamburger meatballs from firms that applied or did not apply for ISO 22000 Food Safety Management Systems certification were tested for food pathogens, and relative levels of contamination were compared between ISO-compliant and unlisted firms.

There was a wide range of TMA microorganisms in the samples. (Table 1). This may indicate that standardized production was not carried out. However, one study reported that the TMA microorganism levels of ethnic sausages produced in the Himalayas were within a considerably wide range: between 10^5 and 10^9 CFU/g (24). In South Africa, the red meat and meat product TMA count was from 1.7×10^5 to 1×10^7 CFU/g (9), and this result is consistent with other similar studies (25,26).

The high levels of TMA bacteria probably resulted from the large number of microorganisms in the raw material, inadequate heat treatment applied to the meat products, bare-hand contact, and conservation heat and cross-contamination. Within this context, it has been suggested that some issues concerning consumer health that can be addressed include the quality of the raw material, the hygiene of the staff and equipment used in processing lines, and the appropriate temperature and cooking time (5).

The number of *S. aureus* in the samples was detected under or over the determination level (Table 1). Studies have shown that samples produced in Taiwan had *S. aureus* contamination in 26.1% of 69 ready-to-eat meats and jambon (27). This is similar to the characterization of *S. aureus* strains associated with food poisoning outbreaks in France, which showed 19.35% contamination of 31 raw and cooked pieces of meat (beef, chicken, pork, and lamb) (28). The above-mentioned percentages are consistent with those found in this study. There was no significant difference between ISO-certified and unlisted firms in *S. aureus* bacteria numbers found in each product group ($P > 0.05$). It is remarkable, however, that 7 of the 9 samples contaminated with *S. aureus* were produced by ISO-certified firms. Staphylococcal infections generally occurred following heat treatment and were probably due to human contamination. Cross-contamination due to insufficient hygiene and sanitation applications were probably also important factors (5).

Table 1. Number of microorganisms per sample (CFU/g).

			Fermented sausage*	Salami*	Sausage*	Hamburger meatball*
Total mesophilic aerobic microorganisms	ISO-certified	Number (viability %)	11 (91.66%)	9 (75%)	12 (100%)	10 (83.33%)
		Min	2.18	<1.00	<1.00	<1.00
		Average	4.07 ± 8.21	2.38 ± 1.44	3.59 ± 9.89	4.02 ± 5.69
		Max	6.00	5.23	7.04	5.82
	Unlisted	Number (viability %)	11 (91.66%)	9 (75%)	10 (83.33%)	12 (100%)
		Min	1.00	<1.00	<1.00	3.90
		Average	4.39 ± 2.61	2.92 ± 3.46	3.51 ± 6.00	5.27 ± 6.46
		Max	7.46	5.62	5.85	7.89
Significant mean		T	0.53	0.83	0.01	2.25**
Staphylococcus aureus	ISO-certified	Number (viability %)	1 (8.33%)	2 (16.66%)	2 (16.66%)	2 (16.66%)
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.07 ± 5.0	1.28 ± 5.75	1.15 ± 8.62	1.30 ± 2.63
		Max	1.85	1.85	2.00	2.43
	Unlisted	Number (viability %)	1 (8.33%)	-	-	1 (8.33%)
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.00 ± 0.0	<1.00 ± 0.00	<1.00 ± 0.0	1.46 ± 2.23
		Max	1.00	<1.00	<1.00	2.40
Significant mean		t	1.00	1.47	1.48	0.70
Bacillus cereus	ISO-certified	Number (viability %)	-	1 (8.33%)	-	-
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.65 ± 1.79	1.08 ± 7.5	1.64 ± .1.25	1.37 ± 4.84
		Max	4.30	2.00	8.18	2.78
	Unlisted	Number (viability %)	-	2 (16.66%)	-	-
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.00 ± 0.0	1.08 ± 7.5	<1.00 ± 0.0	1.68 ± 1.62
		max	1.00	2.00	<1.00	4.26
Significant mean		t	1.78	0.00	1.08	0.79
Clostridium perfringens	ISO-certified	Number (viability %)	1 (8.33%)	-	1 (8.33%)	2 (16.66%)
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.00 ± 0.0	<1.00 ± 0.0	1.02 ± 0.83	1.06 ± 1.79
		Max	1.00	<1.00	<1.30	1.48
	Unlisted	Number (viability %)	4 (33.33%)	-	-	2 (16.66%)
		Min	1.00	<1.00	<1.00	<1.00
		Average	1.14 ± 17.2	<1.00 ± 0.0	<1.00 ± 0.0	1.09 ± 9.09
		Max	2.30	<1.00	<1.00	2.04
Significant mean		t	1.28	0.00	1.00	0.29

* N = 24.

** TMA microorganisms detected in hamburger meatballs were significantly different between ISO-certified and noncertified firms ($P < 0.01$).

t: Results were not significantly different between ISO-certified and noncertified firms ($P > 0.05$).

T: Results were significantly different between ISO-certified and noncertified firms ($P < 0.01$).

Table 2. Number of samples contaminated with zero-tolerance food pathogens.

Sample	N	*Salmonella* spp., number (viability %)	*Listeria monocytogenes*, number (viability %)	*Escherichia coli* O157:H7, number (viability %)
Fermented sausage	24	-	-	-
Salami	24	-	2 (8.33%)	-
Sausage	24	-	1 (4.16%)	1 (4.16%)
Hamburger meatball	24	3 (12.50%)	14 (58.31%)	3 (12.50%)
Total	96	3 (3.12%)	17 (17.70%)	4 (6%)

Table 3. Number of samples contaminated with zero-tolerance food pathogens in ISO-certified and noncertified samples.

		Fermented sausage, number (viability %)	Salami, number (viability %)	Sausage, number (viability %)	Hamburger meatball, number (viability %)
Salmonella spp.	ISO Certified	-	-	-	1 (8.33%)
	Unlisted	-	-	-	2 (16.66%)
Listeria monocytogenes	ISO-certified	-	1 (8.33%)	1 (8.33%)	7 (58.31%)
	Unlisted	-	1 (8.33%)	-	7 (58.31%)
Escherichia coli O157:H7	ISO-certified	-	-	1 (8.33%)	1 (8.33%)
	Unlisted	-	-	-	2 (16.66%)

The number of *C. perfringens* found in the fermented sausage samples was 1.00–2.30 CFU/g, while it was 1.00–1.00 CFU/g in the salami samples, 1.00–1.30 CFU/g in the sausage samples, and 1.00–2.04 CFU/g in the hamburger samples (Table 1). The relative resistance of the vegetative form of *C. perfringens* was high, which is likely due to the survival of this pathogen because of inadequate heat treatment and its capability to form heat-resistant spores (29). On the other hand, slow and/or inadequate cooling can result in food infection or intoxication by triggering the reproduction of *C. perfringens* and spores (9,30,31).

The average *B. cereus* number found in the samples was 1.00–8.18 CFU/g in the fermented sausage samples, 1.00–2.00 CFU/g in the salami samples, 1.00–8.18 CFU/g in the sausage samples, and 1.00–4.26 CFU/g in the hamburger samples (Table 1). A previous study found that *B. cereus* numbers from 3 salamis and 5 Vienna sausages out of a total of 51 samples examined in South Africa were 1.00–3.10 CFU/g (9), which is in accordance with the findings of the present study. In Spain, researchers isolated 48 strains of *B. cereus, B. licheniformis*, and *B. subtilis* from 9 of 23 fresh and pasteurized food products (31). Studies found that one in 3 salamis contaminated with *B. cereus* were produced by an ISO-certified firm, while 2 were produced by unlisted firms. The difference in the number of *B. cereus* bacteria in samples produced by ISO-certified versus unlisted firms was not statistically significant ($P > 0.05$). It terms of consumer health, it is significant that *B. cereus* was detected in salami and sausages that had been exposed to heat treatment. The primary reason for this was probably faulty heat treatment during production, fast cooling applications, or improper product storage (long periods of storage at inadequate temperatures) (9,31).

In this study, the *Salmonella* spp. contamination detected in 3 of 96 samples (3.12%) poses a consumer health risk in Turkey. The principal factor for this risk was the general health condition of the animals. Moreover, animal stress prior to slaughter may increase the risk of contamination by pathogenic microorganisms as well as cross-contamination (32,33). The *Salmonella* spp. contamination levels of the samples in this study are consistent with those reported in other studies. Previous studies isolated *Salmonella* spp. from 8 of 101 raw meat products (7.92%) and 2 of 118 (1.69%) cooked meat products produced in Iran (10); 4 of 120 (3.3%) minced-meat samples in Ankara, Turkey (34); 7 of 13 (53.84%) chicken/turkey samples (35); and 3% of 200 minced meat samples tested in Van, Turkey (36). *Salmonella* spp. were detected in one sample produced by an ISO-certified firm and 2 samples produced by unlisted firms. These findings highlight deficiencies in food safety such as raw material contamination, cross-contamination at the butcheries in the facilities (37), inadequate heat treatment, lack of hygiene and training of the personnel, improper sanitation

and disinfection applications, and cross-contamination at the time of sale (38). Because of their high capacity to form biofilm, *Salmonella* spp. survive and increase the chance of cross-contamination on the surface of food processing lines. Current hygiene procedures are inadequate as they do not address this life history trait of *Salmonella* spp. (39).

L. monocytogenes contamination was also found to be considerably high (detected in 17 of 96 samples (17.7%)) and is thus a serious health hazard to consumers (11). *L. monocytogenes* contamination was detected in 2 salamis (8.33%), one sausage (4.16%), and 14 hamburger meatballs (58.33%). Eight of the 17 contaminated samples were produced by ISO-certified firms and, remarkably, 3 of the contaminated products were salami and sausages exposed to heat treatment. The reasons for this may be inadequate heat treatment applied in the production of salami and sausage, slicing following heat treatment, and unsanitary packaging applications (6,35,40,41). A previous study isolated *Listeria* spp. from 10 of 11 samples of ready-to-eat meat products. *Listeria* spp. were detected in 4 of 5 raw meat products and one of 5 end products following 4 months of sanitation and hygiene application, before and after production at the facility. In light of these findings, the researchers emphasized the importance of hygiene and sanitation (11).

In this study, *E. coli* O157:H7 contamination was detected in 4 of 96 samples (4.16%). In addition to the high rate of *E. coli* O157:H7 infection and its associated mortality (42), this bacterium is an important health risk because it reproduces well in variable environments (including high temperature), adapts well to different environmental conditions, and forms many different serotypes within only a few years (43). In this study, *E. coli* O157:H7 contamination was detected in one sausage (4.16%) and 3 hamburger meatball samples (12.5%). In particular, the values related to the hamburger meatballs contaminated with *E. coli* O157:H7 were similar to the findings reported in other studies. Because *E. coli* O157:H7 contamination was higher in samples of hamburger meatball than other meat products, hamburger may be a particularly serious health risk. On the other hand, researchers detected *E. coli* O157 contamination in only one minced-meat sample, 3 of 17 cooled hamburger meatballs, and one of 25 frozen hamburger meatballs in a study conducted on 41 minced-meat and 42 hamburger meatball samples (13). In light of these results, the researchers suggested that the production of the frozen hamburger meatballs was not carried out in hygienic conditions. It is of note that one of the contaminated samples was sausage, highlighting the fact that the destruction of *E. coli* O157:H7 during pasteurization, normally caused by adequate heat and time settings, did not occur during the production of sausage and other food (44). Moreover, one sample out of the 24 sausage samples being contaminated with *E. coli* O157:H7 demonstrates that the contamination occurred during production under unhygienic conditions, that the time and heat settings were not adequate, and/or that hygiene rules were ignored at the time of slicing and packaging. Considering that beef and slaughterhouses were the main sources of *E. coli* O157:H7 contamination, the significant deficiencies concerning ISO certification, as well as raw material contamination, demonstrate the seriousness of the problem. Moreover, these deficiencies demonstrate that current applications of hygiene and personnel training, as well as methods of sanitation and disinfection, are not adequate to ensure food safety.

According to these results, we believe there are issues of food safety and public health related to meat products produced in Turkey. Determination of some important foodborne bacterial pathogen contamination in meat products produced by meat plants that adhere to the ISO 22000 Food Safety System could be linked to the use of contaminated raw materials, inadequate and ineffective temperature and time applications, inappropriate applications in hygiene and sanitation, cross-contamination, and the employment of personnel who do not receive adequate training on food safety and food production. It could be said that each of the applications related to food safety and public health is important and begins from the general health status of the animals and ends with the informed consumer. Firms should inspect their systems according to ISO 22000 and HACCP procedures. It is clear that raw material and last product analysis frequency is not enough and that a new vision for quality control checks of raw material and last products should be developed. After quality control results, corrective action should be taken. Other less costly options could be using preventive actions and increasing personnel knowledge. If analytic reports can be done in an honest, real, and safe manner, this will be a more effective, consumer-friendly, and optimistic approach. Raw material control, personnel education, preventive action, and honest corrective actions can improve fermented sausage, salami, sausage, and hamburger meatballs production quality on a microbiological level.

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