Examination of meat preparations in order to control process hygiene in retail

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Abstract. The production and trade of meat preparations (minced meat and semi-finished meat products, including fresh sausages) are registering significant annual increases in Serbia. There is an increasing number of specialized plants, as well as suppliers who directly supply consumers with this type of meat preparation. The aim of this paper is to determine the microbiological risks in the meat preparations production process by taking samples from retail facilities in order to verify HACCP compliance. HACCP systems and good hygiene practices as their pre-requisite programs, require food business operators to identify potential hazards that threaten product safety in order to eliminate or control them. Over 27 months, 297 samples of meat preparations were taken from nine retail stores. Escherichia coli was detected in 5% (16/297) of the meat preparations, and Salmonella spp. were found in 1.6% (5/297). The results obtained are signals for initiating corrective measures in the production processes and improving current sanitary procedures.

1. Introduction
Meat and meat products are recognised as good sources of high biological value proteins, liposoluble vitamins, minerals and bioactive compounds. Changes in socioeconomic factors in recent years have increased the consumer's willingness for ready-to-eat (RTE) food [1]. Baltić believes the fast food and all related spreading phenomena are related to the quick and efficient service of this type of food to the consumers. The true symbol of Serbian national cuisine, above all is grilled meat [1].

Meat preparations are obtained from fresh meat which has been minced and to which other foods, spices and additives, are added, but without modifying muscle structure and its fibres in order to eliminate the fresh meat characteristics. These meat preparations are intended for use after heat treatment [2].

However, the meat as raw material can be microbiologically burdened by inadequate technological operations combined with a lack of appropriate hygiene measures at the slaughterhouse level. Also, during storage and transport, an additional microbiological burden can be added. Therefore, preventive hygiene measures must be taken to obtain a hygienically correct product.

The retail meat trade is on a small scale, where customer is served by the vendor [3]. Hygienic sanitary conditions in retail are more demanding than in wholesale [4]. Most foodborne diseases occur due to inadequate handling with the result of food contamination, or due to previously delivered contaminated food [5]. Preventive hygienic measures in production, processing and trade are aimed at ensuring product safety and quality of meat preparations. The hazard analysis and identification of critical control points (HACCP) is a legal obligation for food business operators, as it is the most effective system for reducing or eliminating contamination during food production. For successful implementation of the HACCP system, it is necessary to obtain data on microbiological risks. Food business operators must have self-control plans where microbiological testing is defined (type of examined microorganisms, dynamics, limits, etc.) in order to validate HACCP system. Meat
preparations must have a microbiota that fulfils set criteria, so there is a need for greater hygienic control, since number and type of microorganisms present depends on hygienic performance. Also, meat preparations are most often sold unpacked, and therefore, the risk of microbiological contamination is higher.

Hygienic measures in production, processing and trade are aimed at ensuring product safety and preventing the rapid deterioration and quality of meat. HACCP is the most effective system for reducing or eliminating contamination during food production. For successful implementation of the HACCP system, it is necessary to have data on microbiological contamination. For the validation and verification of the HACCP system, a food business operator is required to have continuous microbiological data that follows specific dynamics defined in the self-control plan that the operator itself prescribes in accordance with legislations. Microbiological data on hygienic indicators are important for assessing the level of hygiene in the facilities in which semi-products are produced, and the categorization of the risk is assessed by monitoring indicator microorganisms.

By following the presence of indicator microorganisms, it is possible to indirectly monitor the likely presence of pathogenic microorganisms such as *Salmonella* spp., *Listeria monocytogenes*, *Campylobacter jejuni*, *Escherichia coli* and *Yersinia enterocolitica*. These food pathogens are considered to be major sources of human infections [6]. In order to prevent contamination, during processing and trafficking, it is very important to apply hygienic procedures on work surfaces that come into direct contact with food, tools, equipment and workers hands [7]. A high level of hygiene in the work environment is fundamental for preventing microbiological contamination [8]. Inadequate cleaning and disinfection can lead to microbial contamination and reduction of product shelf life [9]. Workers who come in direct contact with food must be trained and informed about the importance of proper food handling. Their hygiene and work habits must be properly applied. Constant attention and compliance with the good hygienic practice (GHP) within HACCP is required. Aksoydan states that apart from legal requirements, hygiene and adequate training of workers, it is a key factor in food safety [10]. Wearing gloves, both in the preparation of raw materials for the production of meat preparations, and in manipulating the finished product, is considered an effective way of preventing the transmission of bacteria to food [11]. According to Tomasevic, 93.5% of slaughterhouses, meat processing and trade chains in Serbia have an implemented and certified HACCP system [12]. Despite the legal requirements for the implementation of GHP and HACCP, cross contamination remains an important factor in food poisoning and epidemics that occurred in fast food facilities [13]. The application of standard sanitary operative procedures (SSOP) is necessary in order to carry out proper sanitation. Improper sanitation is directly related to various cases of foodborne disease epidemics. Several pathogenic microorganisms, including *Staphylococcus aureus*, *Listeria monocytogenes*, *Salmonella* spp. and enteropathogenic strains of *Escherichia coli* can survive on different surfaces over a period of several hours to a few days, and form a biofilm [14].

*E. coli* is a faecal contamination indicator and an indicator of compliance with the basic principles of GHP during the production process [15]. *Salmonella* spp. was monitored as a safety criterion suitable for application in retail. It is recommended that sampling occurs at the last moment when the final product is under the direct control of the food business operator that produced it, in order to carry out risk analysis. Microbiological criteria are stated in Serbian legislation [16], as well as corrective measures in case of unsatisfactory results.

2. Materials and Methods
In order to assess the microbiological risk involved in the production of meat preparations (formed minced meat – kebabs and burgers, fresh sausages), samples were taken in accordance with the self-control plans of the businesses that participated in the study. The frequency of sampling is defined by current legislation, or by the food business operator itself with the consent of the official veterinary inspection service. In a period of 27 months (October 2016 to the end of 2018), 297 samples of formed minced meat (kebabs, burgers or fresh sausages) were taken from 9 retail stores. In the first 6 months,
samples were taken from each store twice a month, and further samples taken once a month. Each sample consisted of 5 units. Samples were tested for the presence of *E. coli* and *Salmonella* spp.

The limits for *E. coli* (Table 1) are 500 cfu/g to 5000 cfu/g as the two limit values (m and M), respectively, so a three-class plan is applied. The results are interpreted in three categories: as satisfactory (if all obtained values are less than 500 cfu/g or <m), as acceptable (if a maximum 2 (c) of 5 (n) obtained values are between 500 and 5000 cfu/g (between m and M), and the other obtained values are less than or equal to 500 cfu/g (≤ m)), or as unsatisfactory (if one or more of the obtained values are greater than 5000 cfu/g (> M), or if more than 2 (c) of the tested 5 (n) units have values between 500 and 5000 cfu/g (between m and M). This type of interpretation is commonly used for hygiene criteria in the production process [17].

The limits for *Salmonella* spp. are absence in 10 g of any tested unit in the sample of 5, as a one-limit (M), two class plan is applied. The results obtained are interpreted as satisfactory (if *Salmonella* is not found in any tested unit) or as unsatisfactory (if the presence of *Salmonella* spp. is detected in any of the sample units). This type of interpretation is commonly used for food safety criteria in the production process [17].

**Table 1.** Limits for the numbers of *E. coli* in meat preparations

| Food Category       | Microorganisms | Sampling plan | Limits     | Analytical reference method | Phase where the criterion applied | Action in case of unsatisfactory results |
|---------------------|----------------|---------------|------------|-----------------------------|-----------------------------------|-------------------------------------------|
| Meat preparation    | *E. coli*      | 5             | 2          | 500 cfu/g to 5000 cfu/g     | At the end of the production process | Improvement of process production hygiene and improving the choice and origin of raw material |

The following methods were used for laboratory testing of the meat preparation samples:

SRPS ISO 16649-2: 2008 Microbiology of food and animal feeding stuffs - Horizontal method for determining the number of s-glucuronidase positive *Escherichia coli* - Part 2: Colony count technique at 44 °C using 5-bromo-4-chloro-3-indolyl sD-glucuronide [18].

SRPS EN ISO 6579-1: 2017 Microbiology of food and animal feeding stuffs - Horizontal method for the detection of *Salmonella* spp. [19].

### 3. Results and discussion

In a period of 27 months, 297 meat preparations (kebabs, burgers or sausages) from 9 retailers were examined. Of the 108 tested meat preparations collected in the first 6 months (Table 2), the presence of *E. coli* was found in 11 meat preparations, which is 10.2% (11 out of 108), while *Salmonella* spp. was determined in 4 meat preparations, which is 3.7% (4 out of 108).

**Table 2.** Presence of *Escherichia coli* and *Salmonella* spp. in meat preparations during the first 6 months of the study

| Microorganisms | Number of samples | Positive samples | %    |
|----------------|-------------------|------------------|------|
| *Escherichia coli* | 108               | 11               | 10.2 |
In the next 21-month period (Table 3), 189 meat preparations were examined. The presence of *E. coli* was found in 5 meat preparations, which is 2.6% (5 of 189). *Salmonella* spp. was determined in one meat preparation, which is 0.5% (1 of 189).

**Table 3.** Presence of *Escherichia coli* and *Salmonella* spp. in meat preparations during the last 21 months of the study

| Microorganisms | Number of samples | Positive results | %  |
|----------------|-------------------|------------------|----|
| *Escherichia coli* | 189               | 5                | 2.6|
| *Salmonella* spp. | 189               | 1                | 0.5|

The results obtained in this study are worse than those obtained in Ireland, where the prevalence of *Salmonella* spp. was from 0.1%, and *E. coli* 0.2% in similar products [20]. Regarding data from 2010, published by EFSA and ECDC and originating in 12 countries in the EU, 2.8% of such meat preparations contained *Salmonella* spp., and 0.6% contained *E. coli* [21].

Based on the microbiological criteria and given limit values (m and M), i.e., when a three-class plan was applied, the results obtained by examining 297 samples were interpreted as satisfactory, acceptable or unsatisfactory, or based on a two-class plan, the results were interpreted as satisfactory or unsatisfactory (Table 4). Among these 297 meat preparations examined, *E. coli* was not detected in 94.6% of the meat preparations, while *Salmonella* spp. were not detected in 98.3% of the meat preparations. We speculate that such results are likely to have benefited from continuous and intense education of employees plus positive and good management.

**Table 4.** Interpretation of microbiological results for meat preparations at retail over the entire examined period

| Microorganisms | Number of samples | Satisfactory Results | Acceptable Results | Unsatisfactory Results |
|----------------|-------------------|----------------------|--------------------|------------------------|
| *Escherichia coli* | 297               | 281                  | 9                  | 7                      |
| *Salmonella* spp. | 297               | 292                  | /                  | 5                      |

**4. Conclusion**

A popular practice in the meat preparation trade at retail is the cooking and sale of unpacked product, which causes additional microbiological risk over that of packaged produce. When unsatisfactory results for the hygienic indicator *E. coli* occur, as they did in 2.4% of the samples of meat preparations we examined, the food business operators concerned must take appropriate corrective measures. Corrective measures should be determined in each operator’s self-control plan, and focus on improving process hygiene. Additionally, selection of more hygienic raw material is needed. Corrective actions should include: what needs to be done with the production batch with unsatisfactory results; who should be notified of the nonconforming production lot; how to determine the cause of non-compliance, and; how to eliminate the cause of non-compliance so it does not recur. Hygiene non-compliance demands corrective measures be implemented (increased sampling frequency, increased cleaning and disinfection, change of disinfection products, improved selection of raw material, monitoring the mode of transport, maintenance of cold chain, improved personal hygiene of workers, tools and equipment, revision of the HACCP plan). One of the preventive measures for food safety management is the use of good quality equipment that facilitates effective cleaning and sanitation. Production facilities must have implemented HACCP plans, and so continuous and intensive
education of employees must be conducted. Before meat preparations are exposed to thermal treatment (i.e., before they are cooked by the retailer), only properly implemented sanitary procedures help to reduce the presence of microorganisms, some of which may be potentially pathogenic.

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