



# Microbiological parameters and sensory characteristics of sliced meat products packaged in modified atmosphere throughout the shelf life

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## ABSTRACT

Demand for food, such as ready to eat food which is easy to consume with as long as possible shelf life, has continuously increased due to the modernization and growth of the human population. Sliced meat products that were normally packed and placed on the market in vacuum packaging, were packed in MAP with the aim of extending the shelf life. The research objective of this study was to determine the microbiological parameters and sensory characteristics of 6 sliced meat products packaged in modified atmosphere (smoked pork loin with added water, Budim sausage, Kamendin pancetta, Smoked pork neck with added water, Kulen, Ham for pizza with added water) during the expected shelf life. This study included sensory analysis and microbiological parameters (*Listeria monocytogenes*, *Enterobacteriaceae* and total aerobic mesophilic microorganisms). All samples of sliced meat products packaged in modified atmosphere had satisfactory microbiological and sensory characteristics during the expected shelf life which ranged from 30 to 90 days.

## 1. Introduction

Despite the growing number of vegans and vegetarians, i.e., people who endorse the benefits associated with adopting a meat-free diet (Bolderdijk & Cornelissen, 2022), meat and meat products are an important part of diet of a large number of people worldwide and represent an important source of protein in the human diet (Font-i-Furnols & Guerrero, 2014). The share of meat in the human diet has been constantly increasing since 1960s (Halagarda & Wójciak, 2022). The demand for food, such as ready to eat

food that is easy to consume with a shelf life as long as possible, has continuously increased due to the modernization and growth of the human population.

Considering that consumers are the last step in the production chain, meeting their expectations is an important part of their satisfaction and purchasing behaviour. Multiple determinants shape consumer behaviour toward meat and meat products (Font-i-Furnols & Guerrero, 2014). In this regard, manufacturers make a great effort to meet all consumer expectations. When deciding what to buy, the consumer is guided by many factors such as motivation,

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perception, attitudes and expectation. The consumer of the new age, in addition to a safe and high-quality product, also demands easy consumption, attractive packaging and a long shelf life. The advantages of food packaging in vacuum and modified atmosphere are reflected in extending the shelf life, increasing the efficiency of production and distribution, reducing costs and increasing the sale of products that meet the ever stricter demands of consumers for natural preservation of food quality, without additives and preservatives, market expansion, greater flexibility of packaging and distribution, availability of as much information as possible and better appearance. Because of that, sliced meat products that normally have been packed and placed on the market in vacuum packaging, were packed in MAP. The research objective of this study was to determine the microbiological parameters and sensory characteristics of six sliced meat products packaged in modified atmosphere (70% N and 30% CO<sub>2</sub>) (smoked pork loin with added water, Budim sausage, Kamendin pancetta, smoked pork neck with added water, kulen, and ham for pizza with added water) during the expected shelf life.

## 2. Materials and methods

### 2.1. Meat product production

Smoked pork loin with added water was obtained from pork loin with injected brine, followed by mechanical processing of the loin in a tumbler during five hours. Heat treatment of the product was carried out in an ATMOS smoking chamber by warm and hot smoking, and then the loin was heated at pasteurization temperature until reaching 70°C in the centre of product. After cooling to 4°C, the product was sliced in a meat slicer and packed in MAP mixture for 45 days' storage. Budim sausage was obtained by cutting frozen pork meat (category I) into pieces on a frozen meat shredder. Fresh pork meat (category I) and solid fatty tissue were chopped in a meat grinder through a grid (diameter: 7.8 mm). Crushed pieces of frozen meat were chopped and combined with salt, additives and spices in a cutter. Ground fresh pork meat and solid fatty tissue were then added to the obtained mass, and the mass was then mixed in a cutter. The stuffing was filled using vacuum filler into artificial casings made of polyamide with a diameter of 60 mm, permeable to smoke and moisture. The product was then subjected to cold smoking treatment in a smoking chamber for 20 hours, followed by drying and ripening of the product under controlled conditions (humidity and temperature), until the appro-

priate quality was achieved. The finished product was sliced using a meat slicer and packed in MAP mixture for 90 days' storage. Kamendin pancetta was obtained from meat bacon, which was preserved by the process of dry salting and then aged for a defined number of days. After that, it was desalinated, dried, and smoked with beech wood in a smokehouse. Smoking was done in a classic smokehouse for 24 hours at up to 25°C to produce cold smoking conditions in the chamber. The smoked bacon was then dried in a chamber with defined humidity and temperature. The finished product was sliced using a meat slicer and packed in MAP mixture for 90 days' storage. Smoked pork neck with added water was obtained from pork neck into which brine had been injected, followed by mechanical processing of the pork neck in a massaging device (tumbler), lasting five hours. Heat treatment of the product was carried out in the ATMOS smoking chamber by warm (65 °C for 10 min) and hot smoking (65 °C for 10 min), and then the product was heated at pasteurization temperature until reaching 70°C in the thermal centre. After cooling to 4°C, the product was sliced in a meat slicer and packed in MAP mixture for 45 days' storage. Kulen was obtained by chopping frozen pork meat (category I) into pieces on a device for crushing frozen meat. Fresh pork meat category I and solid fatty tissue were chopped on a meat grinder through a grid (diameter: 7.8 mm). Crushed pieces of frozen meat were chopped and combined with salt, additives and spices in a cutter. Ground fresh pork meat and solid fatty tissue were added to the obtained mass, and the mass was then mixed in a cutter. The stuffing was filled using vacuum filler into artificial casings made of polyamide with a diameter of 60 mm, permeable to smoke and moisture. The product was then subjected to cold smoking treatment in a smoking chamber for 20 hours, followed by drying and ripening of the product under controlled conditions (humidity and temperature), until the appropriate quality was achieved. The finished product is sliced in a meat slicer and packed in MAP mixture for 90 days' storage. Ham for pizza with added water was obtained by grinding pork shoulder meat on a grinding machine through a grid (diameter: 7.8 mm). Salt, additives and spices were dissolved in water and ice in a cutter, and then, minced meat was added to the resulting brine. After that, the mass was mixed for 40 min. The compact mass obtained was left to stand for 24 h at 0 to 4°C. The mass was filled using a vacuum filler into polyamide casings and placed in an appropriate mould. Heat treatment was performed in the ATMOS smoking chamber by steaming until reaching 70°C in the

thermal centre of the product. After cooling to 4°C, the product was sliced using a meat slicer and packed in MAP mixture for 30 days' storage.

After production and packaging, sampling was performed (30 packages for each sample – 6 tests in 5 units). Samples were transported in a dedicated vehicle, with a refrigerator, at a temperature of 0°C to 4°C. All products were stored under estimated conditions in the fridge at 3°C until examination.

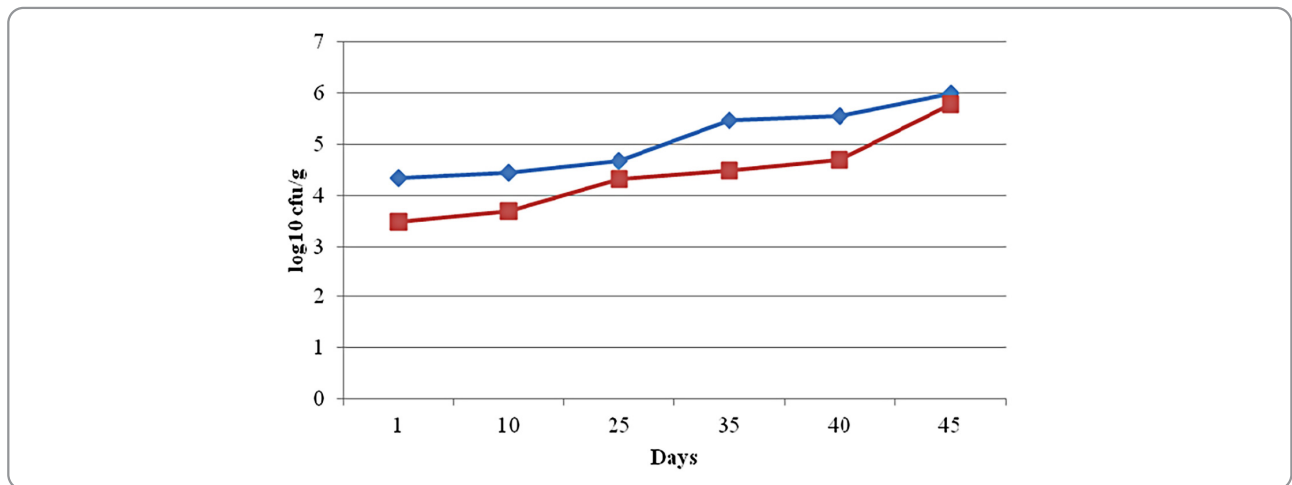
### 2.2. Microbiological analysis and sensory evaluation

Determination of the presence of *Listeria monocytogenes* in the samples (on the first day of testing) was carried out by an ISO accredited method (ISO, 2017a). The number of *L. monocytogenes* in the samples was determined by an accredited

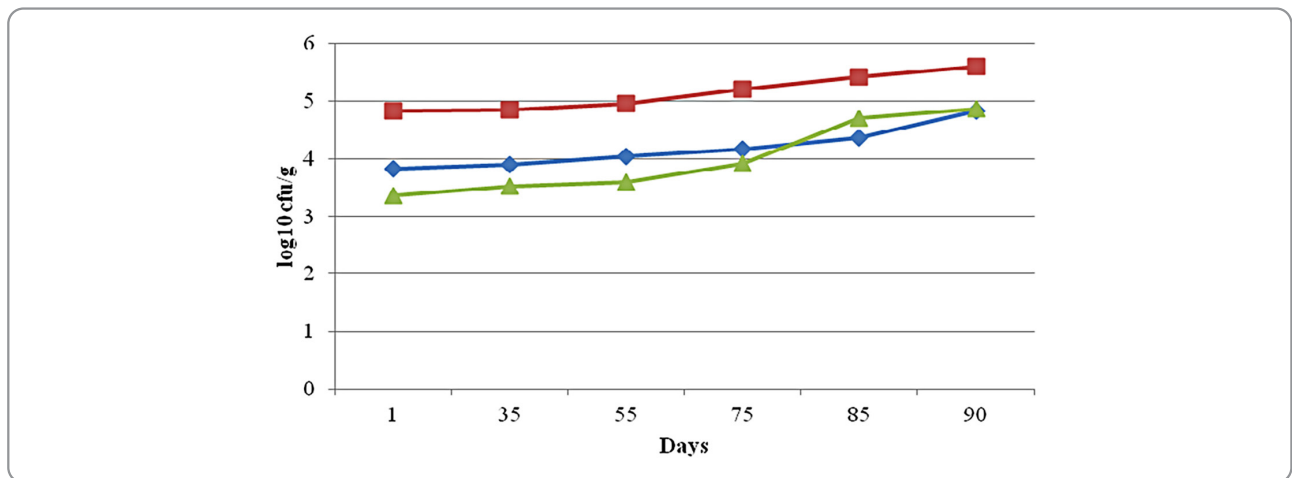
method (ISO, 2017b). The number of *Enterobacteriaceae* in the samples was determined using an accredited method (ISO, 2017c). The total number of mesophilic aerobic bacteria in the samples was determined according to ISO (2014). Sensory evaluation was performed using an accredited method according to Sensory examination of foodstuffs — qualitative descriptive test.

### 3. Results

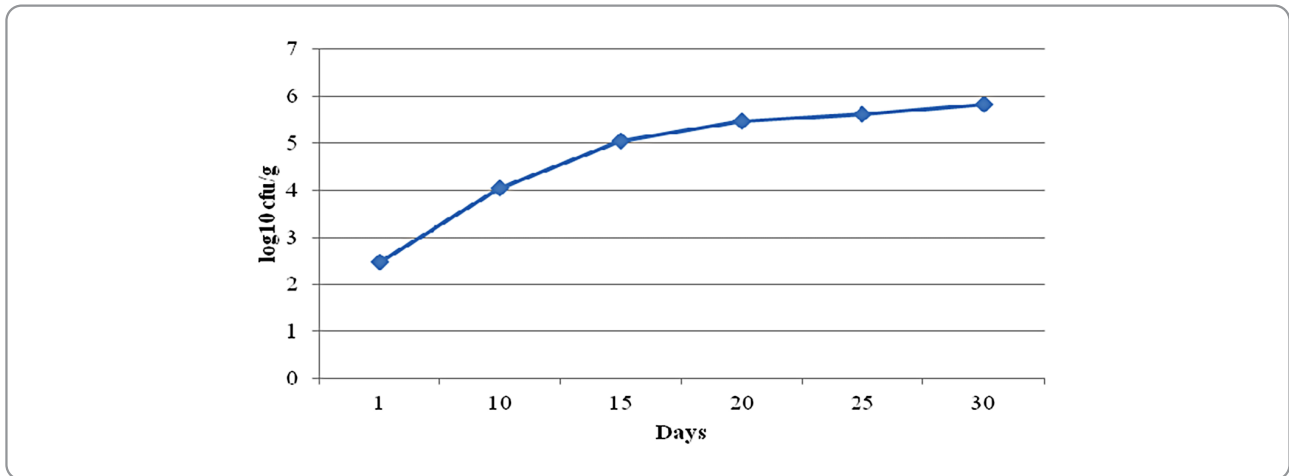
*L. monocytogenes* was not detected in any of the examined samples on the first day of the study. The numbers of *L. monocytogenes* and *Enterobacteriaceae* in all examined samples were below the limit of quantification (less than 10 cfu/g). The counts of total aerobic mesophilic bacteria are shown in Figures 1, 2 and 3.



**Figure 1.** Total aerobic mesophilic bacteria during shelf life in smoked pork loin with added water (blue line) and smoked pork neck with added water (red line)



**Figure 2.** Total aerobic mesophilic bacteria during shelf life in Budim sausage (blue line), Kamendin pancetta (red line) and Kulen (green line)



**Figure 3.** Total aerobic mesophilic bacteria during shelf life in Ham for pizza with added water

Sensory ratings of all tested smoked meat products during their expected shelf lives were in accordance with the criteria prescribed by legislation in Serbia (*Republic of Serbia*, 2019).

#### 4. Discussion

The most common format of the sliced meat products for selling is vacuum packaging, but vacuum packaging has some negative consequences related to the plastic of the packaging. Plastic adheres closely to the product, so there is a problem of adhesion between the slices as well. The use of MAP is becoming more common on the market because this format avoids those problems (*Parra et al*, 2012). Regarding this packaging, MAP preserved better sensory characteristics (primarily color) of the *Iberian chorizo* slices than vacuum packaging for a long period (*García-Torres et al.*, 2021). MAP packaging is more in line with the current consumers trends and habits (*Ortiz et al.*, 2020).

Considering that *L. monocytogenes* is ubiquitous and has ability to grow at refrigeration temperature, *L. monocytogenes* is a significant threat to the safety of RTE meat products (*Zhu et al.*, 2005). Its absence primarily indicates good hygienic practice

and good manufacturing practice during slicing and packaging after cooking.

A large number of studies have shown that ready to eat meat products sliced in retail shops often have a higher level of bacterial contamination than ready to eat meat products sliced and packed in meat factories (*Chaitiemwong et al.*, 2014; *Curpas et al.*, 2018). The results of our study show that the number of total aerobic mesophilic microorganisms during the expected shelf life was satisfactory according to the recommendations by *Health Protection Agency* (2009), *Health Canada* (2010) and the *Centre for Food Safety* (2014).

When purchasing, consumers are guided by knowledge and tradition, which inclines them towards sliced meat products packed in vacuum packaging (*Ortiz et al.*, 2020).

#### 5. Conclusion

All samples of sliced meat products packaged in modified atmosphere had satisfactory microbiological and sensory characteristics during their expected shelf lives, which ranged from 30 to 90 days. This study enables this meat industry to offer more safe and trendy alternative packaging instead of the previously used vacuum packaging.

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