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Research Article

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Microbial Quality of Traditional Meat Products Manufactured on a Small Scale by Polish Farms in the Lodz Region

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Abstract

The aim of present study was to assess the microbiological quality of eight traditional meat products (black pudding, white brown, baked pate, roasted pork, raw smoked ham, smoked steamed sausage, raw smoked bacon, raw smoked loin) manufactured by polish farmers in the Lodz region. A total of 37 samples were collected and analyzed twice: within 24 h after purchase from manufactures and after 7 days of storage. Mesophiles, lactic acid bacteria (LAB), Enterobacteriaceae, presence of Listeria monocytogenes and Salmonella spp. were determined. The counts of isolated microorganisms varied depending on the product type and manufacturer. Mesophiles and lactic acid bacteria constituted the main microflora in the tested meat products. Enterobacteriace value was below detection limit in the most samples. The highest mean bacteria counts (mesophiles, LAB and Enterobacteriace) during storage were estimated in black pudding, followed by smoked steamed sausage and white brown. In opposite, the lowest mean bacteria levels were in baked pate and roasted pork. The obtained results showed significant influence of storage time on the mean number of mesophiles and LAB in the meat samples. Negative results for Salmonella spp. and Listeria monocytogenes were observed during 7 days of storage, indicating the safety of the studied meat products.

Keywords: Traditional Polish Meat Products, Microbiological Quality, Pathogenic Bacteria, Food Safety

1. Introduction

Traditional meat products are becoming very popular among consumers worldwide, including Poland [1,2,3,4]. Customers demand natural meat products, produced locally, using traditional methods on small farms, minimally processed, preservatives free and identify them as "high quality" [5,6]. However, the use of natural raw materials and additives, a relatively short and uncomplicated "production route" and immediate distribution do not guarantee appropriate microbiological quality. Meat is very susceptible to the most bacteria growth and the production of meat products does not reduce the number of microorganisms [7]. Meat and meat products are highly perishable because of their composition. The high content of protein, vitamins and minerals, with an almost neutral environmental pH, makes it an ideal medium for the rapid growth of various microflora. The development of undesirable microorganisms deteriorates the sensory quality of meat and meat products and decreases their safety [8,9,10].

Microflora in the final product may come from meat, spices and other components, as well as environment, equipment and handlers during processing can affect the microbiological status of the product. The lack of characterization and standardization of the manufacturing process and deficiencies in production hygiene may also cause microbiological contaminations [11]. The microbiological quality of food, including meat and meat products, is important for the consumer safety, additionally, each manufacturer is obligated to ensure the health safety of his product. Food production in agricultural retail must be carried out in accordance with food law, in particular Regulation (EC) No. 852/2004 and Regulation (EC) No. 853/2004 laying down detailed hygiene rules for food of animal origin. Moreover, the requirements for microbiological safety of final products are set by Regulation (EC) No. 2073/2005. Meat and meat products, manufactured locally in the household, are rarely controlled for safety, as well as the farmers themselves usually have insufficient knowledge about good hygiene and production practice.

Literature data indicate that traditional meat products may be a

source of dangerous pathogens. Research on the health and safety aspects of traditional meat products in the world shows the presence of *Listeria monocytogenes, Campylobacter spp., Salmonella spp., coagulase-positive staphylococci, Escherichia coli* in these products [12]. In the Lithuanian offal product 'Ears tongue roll', available on the British market, the level of *Listeria monocytogenes* was 2.64 log CFU/g, exceeding four times the microbiological criteria applicable in the European Union [13]. The presence of anaerobes spore-forming bacilli and pathogens were found in 'Sarapatel' (traditional products popular in Brazil), the number of *Staphylococcus aureus* exceeded 2.7 log CFU/g of product [14]. *Staphylococcus aureus* was isolated from another offal product produced in Brazil - 'Buchada caprina' [15]. In a study of Turkish 'sucuk' sausage presence of *Listeria monocytogenes* was found in 11.6% of the tested samples [16]. This pathogen was also isolated from smoked fermented Portuguese sausages 'alheira' and from 'Biltong' popular in Africa [17,18]. Biltong was also found to be a source of Staphylococcus aureus, moreover Staphylococcus aureus and Salmonella spp. were isolated from Portuguese 'alheiras' [17-19]. From traditional beef product 'kilishi', produced in Nigeria, *Staphylococcus aureus* and *E. coli* were isolated [20]. The presence of *Listeria spp*. was detected in all tested samples of traditional Greek sausage [21]. In research on traditional pork sausages from Spain, *Salmonella* strain was identified in 'Botillo' and 'Androlla' sausages and *E. coli* in 'Botillo' sausage [22,23].

Moreover, EFSA 2020 Zoonoses report confirmed the highest percentages of *Salmonella*-positive samples in meat and meat products: 12.6% in 'fresh poultry meat', 12.4% in 'mechanically separated meat' (MSM), 5.4% in 'meat products made from poultry meat intended to be eaten cooked' and 0.87% in 'meat products intended to be eaten raw, excluding products where the manufacturing process or the composition of the product will eliminate the Salmonella risk'. In addition, the presence of Listeria monocytogenes was allocated to 90% of 'ready to eat meat and meat products' [24]. According to RASFF Annual report, in 2020 there were 273 notifications on Salmonella in poultry meat and poultry meat products from Poland. The report also revealed that Listeria monocytogenes contamination is mostly found on foods of animal origin (31 notifications in meat and meat products, 21 in poultry meat and poultry meat products). Moreover, 19 notifications on pathogenic Escherichia coli were found in meat products [25]. Chief Sanitary Inspectorate, food safety authority in Poland, reported that the most frequently identified hazard in 2022 is the occurrence of Salmonella, mainly in poultry meat and related products (191 notifications), in meat and meat products other than poultry (5 notifications), however, a decrease in the number of notifications related to the detection of these bacteria in poultry meat and derived products from 2020 to 2022 was observed (273 notifications in 2020, 263 notifications in 2021) [26].

Information on the occurrence of microorganisms in traditional meat products is insufficient. The scientific reports on the microbiological safety of these products in Poland are very limited. Therefore, there is a need to monitor the presence of microorganisms (particularly pathogenic ones), from the animal breeding system to the final product. The objective of this study was to assess the microbiological quality and safety of traditional meat products manufactured on a small scale by polish farms in Lodz region.

2. Materials and Methods

2.1 Sample Collection

The objective of the study were traditional pork meat products manufactured on polish farms. A total of 37 samples were collected from 7 farms in the Lodz region. The product types included: black pudding, white brown, baked pate, roasted pork, raw smoked ham, smoked steamed sausage, raw smoked bacon, raw smoked loin. Samples were purchased directly from farmers, transported to the laboratory at a temperature of 5 ± 2°C in less than 4 hours. The meat products were stored in sterile packaging at a temperature of 3 ± 2°C and analyzed within 24 h after purchase from manufactures and after 7 days (their shelf-life specified by the manufacturer).

2.2 Microbiological Analysis

For the microbiological analysis, tested meat products were prepared in accordance with ISO 6887-2:2017 [27]. 25 g of each product sample were placed into 225 mL of sterile buffered peptone water (BPW) and homogenized in Stomacher (Seward Medical, UK) for 2 min. Then, the initial suspension was used to prepare decimal dilutions in BPW. Mesophiles were performed according to ISO 4833-1:2013-12 after incubating at 30°C for 72 h [28]. Lactic acid bacteria (LAB) were assessed on MRS medium (de Man, Rogosa and Sharpe, Argenta, Oxoid) in accordance with ISO 15214:2002 [29]. Plates were incubated at 30°C for 72 h. Enterobacteriaceae were cultured on VRBG agar (Violet Red Bile Glucose agar, Argenta, Oxoid), incubated at 37°C for 24 h, according to ISO 21528-2:2017-08 [30]. Furthermore, meat samples were tested for pathogenic bacteria. Listeria monocytogenes were detected according to ISO 11290-1:2017-07 [31]. Appropriate dilutions of initial suspension were spread on half-Fraser broth (Argenta, Oxoid) in the first step, incubated at 30°C for 24 h and on Fraser broth (Argenta, Oxoid) in the second step and incubated at 37°C for 24 h. Then, the samples were spotted on Listeria agar according to Ottaviani and Agosti (ALOA, Argenta, Oxoid) and Palcam agar and incubated at 37°C for 24-48 h. The presence of Salmonella spp. was detected according to ISO 6579-1:2017-04 using selective enrichment Salmonella broth - RVS (Rappaport-Vasiliadis, Argenta, Oxoid) and tetrathionate-novobiocin broth - MKTTn (Muller-Kauffmann, Argenta, Oxoid) [32]. Incubation was carried out at 41.5°C and 37°C, respectively, for 24 h. From both media, bacteria were inoculated on XLD agar (Xylose Lysine Deoxycholate agar, Argenta, Oxoid) and Hektoen agar (Argenta, Oxoid) and incubated at 37°C for 24 h. All analytical procedures were carried out in triplicate for each sample. Microbiological results were expressed in log CFU/g.

2.3 Statistical Analysis

The experimental data was statistically evaluated using the STATISTICA 10 statistical package software. One-way analysis

of variance (ANOVA) was used to assess the significance of differences in microbial count of meat product samples during storage. Significance level was set at $p \leq 0.05$.

3. Results

The microbiological quality of traditional meat products varied, depending on the product type, manufacturing farms and the storage time. Summary of the results are presented in Table 1, while detailed data for each farm are shown in the Appendix A (Tables A1-A7).

Product	Storage time (days)	Parameter		
		Mesophiles Mean ± SD (Min. – Max.)	**LAB Mean ± SD (Min. – Max.)**	***Enterobacteriaceae* Mean ± SD (Min. – Max.)**
Black pudding (n=4)	0	5.39 ± 1.06[a] (4.04 – 6.61)	3.17 ± 1.05[a] (2.11 – 4.18)	2.75 ± 1.05[a] (2.01 – 4.41)
	7	7.96 ± 1.02[b] (6.89 – 8.89)	5.98 ± 0.70[b] (5.13 – 6.83)	4.24 ± 0.75[b] (3.38 – 4.98)
White brown (n=3)	0	4.77 ± 1.88[a] (3.55– 6.93)	3.02 ± 1.44[a] (2.08 – 4.68)	< DL
	7	5.64 ± 2.43[b] (4.02 – 7.45)	3.96 ± 1.36[b] (3.15 – 5.53)	< DL
Baked pate (n=4)	0	3.23 ± 0.46[a] (2.60 – 3.65)	< DL	< DL
	7	3.89 ± 0.37[b] (3.62 – 4.36)	< DL	< DL
Roasted pork (n=4)	0	3.68 ± 0.46[a] (2.72 – 4.52)	< DL	< DL
	7	4.16 ± 0.70[b] (3.23 – 4.94)	< DL	< DL
Raw smoked ham (n=6)	0	3.92 ± 1.14[a] (2.71 – 5.04)	2.63 ± 1.46[a] (1.08 – 4.69)	< DL
	7	5.03 ± 2.16[b] (3.20 – 8.26)	3.43 ± 1.99[b] (1.40 – 6.28)	< DL
Smoked steamed sausage (n=9)	0	4.80 ± 1.21[a] (3.74 – 7.08)	3.00 ± 1.04[a] (2.00 – 4.56)	- (< DL – 4.63)
	7	5.70 ± 1.83[b] (3.89 – 8.69)	4.08 ± 1.59[b] (2.80 – 6.78)	- (< DL –4.78)
Raw smoked bacon (n=3)	0	3.41 ± 1.08[a] (2.25 – 4.39)	2.03 ± 0.18[a] (1.90 – 2.24)	< DL
	7	4.74 ± 1.88[b] (3.30 – 6.87)	2.25 ± 0.15[a] (2.15 – 2.42)	< DL

Raw smoked loin (n=4)	0	3.72 ± 0.14[a] (3.60 – 3.91)	2.27 ± 0.84 [a] (1.05 – 2.84)	< DL
	7	4.60 ± 0.76[b] (3.88 – 5.67)	2.83 ± 0.63[b] (2.15 – 3.64)	< DL

CFU- Colony forming unit; n – numer of samples; SD - standard deviation of the mean; LAB - lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g; [a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table 1: Microbiological Results of Traditional Meat Products During Storage (Log CFU/g).

Pathogenic bacteria Salmonella spp. and Listeria monocytogenes were found in none of the tested samples. Mesophiles were detected in all samples, mean concentration ranged from 3.23 log CFU/g to 5.39 log CFU/g in products examined after purchase and increased to 3.89 - 7.96 log CFU/g after 7 days of storage. The highest mean contamination with mesophiles during storage occurred at black pudding, while the lowest at baked pate. Most of the tested samples were characterized by increasing level of lactic acid bacteria (LAB) during 7 days of storage, which increased from initial value of 2.03 - 3.17 log CFU/g to 2.25 - 5.98 log CFU/g on 7th day. Statistical analysis of the microbiological results showed significant influence ($p < 0.05$) of storage time on the mean number of mesophiles and LAB. Meat products exhibited significantly higher mean concentrations with mesophiles and LAB on the 7th day of storage compared to products tested after purchase ($p < 0.05$), excluding raw smoked bacon (there was no significant difference in the mean LAB count). However, in baked pate samples and roasted pork samples, LAB were below the detection limit (less than 1.0 log CFU/g) during storage. Enterobacteriaceae were isolated from all black pudding samples, mean initial count was 2.75 log CFU/g and significantly increased after 7 days of storage to 4.24 log CFU/g ($p \leq 0.05$). Increasing bacteria level was also detected in three smoked steamed sausage samples: in two samples purchased from farm 1 and one sample manufactured on farm 7. Enterobacteriaceae counts were below the detection limit (less than 1.0 log CFU/g) in other samples.

4. Discussion

Poland is known for the manufacture of traditional cold meats such as: ham, sausages, smoked pork loins, bacon and pates. The microbiological quality of meat products depends on many factors, mainly level of contamination of the raw meat material and production environment hygiene. The quality of spices and other components used in production also affect the number of microorganisms in the final product. Additionally, storage time may be important. Results obtained in our study support this statement. Tested meat products were manufactured using traditional methods, specified for each farm. The counts of isolated microorganisms varied depending on the product type and manufacturer. Mesophiles and lactic acid bacteria constituted the main microflora in the tested meat products. Enterobacteriace value was below detection limit in the most samples. Enterobacteriace are indicator of the production process hygiene. The acceptable limit of these bacteria is set for raw meat, the permissible level for pork carcasses is 2.0-3.0 log CFU/g. There are no requirements for pork meat products. In addition, negative results for Salmonella spp. and Listeria monocytogenes were observed during 7 days of storage, indicating the safety of the tested products according to the requirements of Regulation (EC) No. 2073/2005.

The highest mean bacteria load (mesophiles, LAB and Enterobacteriace) during storage were estimated in black pudding, followed by smoked steamed sausage and white brown. This fact may be the result of using blood, natural casings and various spices in these products. The research on fermented sausages from nine small French plants indicated that the main source of bacteria in finished meat products was the raw material used and natural casings, while the microflora of the place of production (house-flora) did not significantly affect the microbiological quality of the tested products [3]. It confirms the observations of the presented study. Furthermore, obtained results showed significant influence of storage time on the mean number of mesophiles and LAB in the meat products. The highest increase in the mean bacterial counts during storage were noticed in black pudding samples. Mesophiles achieved high mean level 7.96 log CFU/g, similarly LAB and Enterobacteriace, 5.98 log CFU/g and 4.24 log CFU/g, respectively. In other study, Migowska - Calik et al. tested traditional Polish offal saussages manufactured in the Pomerania region, found no presence of Salmonella spp. and Listeria monocytogenes in black pudding samples during 4 days of storage and mesophiles in lower mean concentration 3.23 log CFU/g, which did not increase after 7 days of storage [33]. Moreover, authors studied quality of traditional raw smoked meat products from a Masurian butcher and detected Listeria monocytogenes in two raw smoked ham samples, the mesophiles level ranged from 4.77 log CFU/g to 6.20 log CFU/g [34]. Kordowska-Wiater et al.

characterized microorganisms present in selected pate types manufactured in Poland. Salmonella spp. was found in none of the tested samples. Mesophiles counts were estimated at 2.48 - 3.34 log CFU/g and LAB at 1.77 - 2.14 log CFU/g in pork pates without durable packages [35]. The mesophiles concentrations in raw smoked ham and baked pate samples obtained in our study were similar, in opposite to LAB number which was significantly lower (less then 1.0 log CFU/g). In addition, baked pate and roasted pork samples contained the lowest bacteria counts, it may be result of thermal treatment. Literature data demonstrated, that microbiological quality of traditional meat products in Europe

vary and the health safety of some products may be questionable. In the traditional English offal Black pudding, significant fluctuations in the mesophiles count were recorded and more than 19% of the tested samples exceeded 8.0 log CFU/g [36]. In 'Morcilla de Burgos' samples (a traditional sausage from Spain and Portugal, produced using an additive blood of animals), initial mesophiles level was 4.3 log CFU/g, gradually increased during refrigerated storage and reaching a value of 9 log CFU/g after 50 days. Presence of Salmonella spp. was no detected [37]. Study of traditional fermented sausages produced in the south Europe also confirm no presence of the pathogens in finished products [38]. The quality of traditional Portuguese sausages depended on the place of their production [2,16,39]. In traditional product 'lacon gallego' from Spain, no pathogens were isolated, but high mesophiles count, exceeded 7 log CFU/g after 14 days of storage at 2°C, was found [2]. Listeria monocytogenes and Salmonella spp. were isolated from smoked fermented sausages 'alheira' [16]. 'Salpicao' and 'Chourica' characterized the high mesophiles counts in concentrations 7.6 - 10.3 log CFU/g and 8.0 - 9.5 log CFU/g, respectively, with LAB predominance. Enterobacteriace achieved maximum level 6.6 log CFU/g in 'Salpicao' and 6.0 log CFU/g in 'Chourica'. Salmonella spp. and Listeria monocytogenes were not detected in any samples [39].

The production of high quality meat products using natural, traditional procedures is hard, due to the potential problem with ensuring the health safety of the final product. Even slight deficiencies in production hygiene may cause microbiological contaminations. The use of good hygiene practice is an essential factor to obtain the products of high quality. However, the effects of manufacturing meat products under production conditions, using simplified hygiene requirements and their impact on the shelf-life of the homemade product are unknown. Present study showed fluctuations in the bacteria counts in the same product type, depending on the manufacturer. The high microbial load was found in traditional meat products purchased from farm 1, which significantly increased during 7 days of storage: mesophiles achieved 8 log CFU/g, LAB count were 6 log CFU/g and became the predominant microorganisms, Enterobacteriace exceeded the 4 log CFU/g (excluding white brown and raw smoked ham - Enterobacteriace counts were below the detection limit - less than 1.0 log CFU/g). Although Salmonella spp. and Listeria monocytogenes were not detected in any samples from farm 1 and products were potentially safe for consumers, their quality may have decreased because of high microbial load. Obtained results may also suggest, that the tested products from farm 1 were manufactured under deficient hygienic conditions and using raw meat and other components of poor quality.

5. Conclusion

Meat products produced using natural, traditional procedures are very appreciated and becoming very popular among consumers worldwide, due to their unique sensory properties. Presented study showed that traditional meat products, manufactured on a small farms in the Lodz region, did not pose a health risk. Pathogenic bacteria Salmonella spp. and Listeria monocytogenes were found in none of the tested samples during 7 days of storage. Fluctuations in the bacteria counts in the same product type, depending on the manufacturer, were observed. High microbial concentrations in meat products purchased from farm 1 demonstrated that hygienic conditions should be improve or raw meat and components used in production should be of better quality. In addition, differences in the microbiological quality of the tested products revealed the need to focus attention on production hygiene and selection of raw material. Taking into account the results of this work and Polish Chief Inspectorate's report, further research and monitoring of traditional meat products are necessary to ensure health safety of these products.

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Appendix A

Table A1: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 1 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Black pudding	0	6.61 ± 0.18[a]	4.18 ± 0.21[a]	4.41 ± 0.07[a]	Not detected	Not detected
	7	8.89 ± 0.12[b]	6.83 ± 0.18[b]	4.98 ± 0.06[b]	Not detected	Not detected
White brown	0	6.93 ± 0.10[a]	4.68 ± 0.09[a]	< DL	Not detected	Not detected
	7	7.45 ± 0.08[b]	5.53 ± 0.10[b]	< DL	Not detected	Not detected
Raw smoked ham	0	5.04 ± 0.06[a]	3.93 ± 0.03[a]	< DL	Not detected	Not detected
	7	8.26 ± 0.09[b]	6.28 ± 0.06[b]	< DL	Not detected	Not detected
Smoked steamed sausage 1	0	7.08± 0.05[a]	4.56 ± 0.05[a]	4.63 ± 0.01[a]	Not detected	Not detected
	7	8.69 ± 0.14[b]	6.77 ± 0.08[b]	4.78 ± 0.06[a]	Not detected	Not detected
Smoked steamed, sausage 2	0	6.58 ± 0.18[a]	4.58 ± 0.14[a]	4.10 ± 0.11[a]	Not detected	Not detected
	7	8.64 ± 0.15[b]	6.79 ± 0.10[b]	4.72 ± 0.12[b]	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A2: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 2 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Black pudding	0	5.59 ± 0.10[a]	3.96 ± 0.11[a]	2.25 ± 0.06[a]	Not detected	Not detected
	7	8.78 ± 0.16[b]	6.08 ± 0.14[b]	4.75 ± 0.08[b]	Not detected	Not detected
Roasted pork	0	4.52 ± 0.12[a]	< DL	< DL	Not detected	Not detected
	7	4.94 ± 0.07[b]	< DL	< DL	Not detected	Not detected
Baked pate	0	3.20 ± 0.06[a]	< DL	< DL	Not detected	Not detected
	7	3.94 ± 0.07[b]	< DL	< DL	Not detected	Not detected

Raw smoked loin	0	3.72 ± 0.10 [a]	2.84 ± 0.04 [a]	< DL	Not detected	Not detected
	7	4.36 ± 0.11 [b]	2.95 ± 0.06 [a]	< DL	Not detected	Not detected
Raw smoked bacon	0	3.58 ± 0.05 [a]	2.24 ± 0.09 [a]	< DL	Not detected	Not detected
	7	4.08 ± 0.04 [b]	2.42 ± 0.10 [a]	< DL	Not detected	Not detected
Smoked steamed sausage	0	4.34 ± 0.14 [a]	3.36 ± 0.05 [a]	< DL	Not detected	Not detected
	7	4.65 ± 0.18 [a]	3.57 ± 0.05 [a]	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A3: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 3 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	**LAB**	***Enterobacteriaceae***	***Listeria monocytogenes***	***Salmonella* spp.**
White brown	0	3.55 ± 0.10 [a]	2.08 ± 0.05 [a]	< DL	Not detected	Not detected
	7	4.02 ± 0.08 [b]	3.20 ± 0.12 [b]	< DL	Not detected	Not detected
Raw smoked loin	0	3.91 ± 0.06 [a]	2.39 ± 0.03 [a]	< DL	Not detected	Not detected
	7	4.50 ± 0.08 [b]	2.56 ± 0.06 [a]	< DL	Not detected	Not detected
Smoked steamed sausage	0	3.74 ± 0.17 [a]	3.25 ± 0.05 [a]	< DL	Not detected	Not detected
	7	3.89 ± 0.12 [a]	3.38 ± 0.05 [a]	< DL	Not detected	Not detected
Roasted pork	0	3.77 ± 0.10 [a]	< DL	< DL	Not detected	Not detected
	7	4.26 ± 0.09 [b]	< DL	< DL	Not detected	Not detected
Baked pate	0	3.46 ± 0.06 [a]	< DL	< DL	Not detected	Not detected
	7	3.62 ± 0.04 [a]	< DL	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A4: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 4 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Black pudding	0	4.04 ± 0.15 [a]	2.11 ± 0.08 [a]	2.31 ± 0.09 [a]	Not detected	Not detected
	7	6.89 ± 0.10 [b]	5.13 ± 0.18 [b]	3.38 ± 0.11 [b]	Not detected	Not detected
Baked pate	0	3.65 ± 0.10 [a]	< DL	< DL	Not detected	Not detected
	7	4.36 ± 0.08 [b]	< DL	< DL	Not detected	Not detected
Roasted pork	0	3.69 ± 0.17 [a]	< DL	< DL	Not detected	Not detected
	7	4.20 ± 0.19 [b]	< DL	< DL	Not detected	Not detected
Smoked, steamed sausage	0	4.26 ± 0.19 [a]	2.88 ± 0.05 [a]	< DL	Not detected	Not detected
	7	6.32 ± 0.14 [b]	4.04 ± 0.09 [b]	< DL	Not detected	Not detected
Raw smoked bacon	0	4.39 ± 0.20 [a]	1.90 ± 0.05 [a]	< DL	Not detected	Not detected
	7	6.87 ± 0.16 [b]	2.18 ± 0.08 [a]	< DL	Not detected	Not detected
Raw smoked ham	0	3.60 ± 0.21 [a]	1.17 ± 0.04 [a]	< DL	Not detected	Not detected
	7	4.53 ± 0.18 [b]	1.51 ± 0.03 [a]	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A5: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 5 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Raw smoked loin	0	3.60 ± 0.07 [a]	1.05 ± 0.04 [a]	< DL	Not detected	Not detected
	7	3.88 ± 0.10 [a]	2.15 ± 0.05 [b]	< DL	Not detected	Not detected
Smoked steamed sausage	0	3.69 ± 0.16 [a]	1.78 ± 0.09 [a]	< DL	Not detected	Not detected
	7	4.18 ± 0.12 [b]	2.50 ± 0.07 [b]	< DL	Not detected	Not detected

Raw smoked ham	0	2.71 ± 0.20 [a]	2.69 ± 0.08 [a]	< DL	Not detected	Not detected
	7	3.26 ± 0.14 [b]	2.80 ± 0.07 [a]	< DL	Not detected	Not detected
Baked pate	0	2.60 ± 0.11 [a]	< DL	< DL	Not detected	Not detected
	7	3.63 ± 0.13 [b]	< DL	< DL	Not detected	Not detected
Raw smoked bacon	0	2.25 ± 0.06 [a]	1.95 ± 0.10 [a]	< DL	Not detected	Not detected
	7	3.30 ± 0.08 [b]	2.15 ± 0.10 [a]	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A6: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 6 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Smoked steamed sausage 1	0	4.90 ± 0.22 [a]	2.00 ± 0.13 [a]	< DL	Not detected	Not detected
	7	5.08 ± 0.18 [a]	3.28 ± 0.16 [b]	< DL	Not detected	Not detected
Smoked steamed sausage 2	0	4.34 ± 0.09 [a]	2.48 ± 0.18 [a]	< DL	Not detected	Not detected
	7	4.46 ± 0.17 [a]	2.90 ± 0.21 [b]	< DL	Not detected	Not detected
Roasted pork	0	2.72 ± 0.16 [a]	< DL	< DL	Not detected	Not detected
	7	3.23 ± 0.13 [b]	< DL	< DL	Not detected	Not detected
Raw smoked ham	0	3.00 ± 0.19 [a]	1.08 ± 0.15 [a]	< DL	Not detected	Not detected
	7	3.20 ± 0.18 [a]	1.40 ± 0.09 [a]	< DL	Not detected	Not detected
White brown	0	3.82 ± 0.12 [a]	2.30 ± 0.15 [a]	< DL	Not detected	Not detected
	7	5.45 ± 0.14 [b]	3.15 ± 0.19 [b]	< DL	Not detected	Not detected
Raw smoked loin	0	3.63 ± 0.15 [a]	2.79 ± 0.16 [a]	< DL	Not detected	Not detected
	7	5.67 ± 0.11 [b]	3.64 ± 0.12 [b]	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).

Table A7: Microbiological Analysis of Meat Products During 7 Days of Storage - Farm 7 (Log CFU/g).

Product	Storage time (days)	Parameter				
		Mesophiles	LAB	*Enterobacteriaceae*	*Listeria monocytogenes*	*Salmonella* spp.
Black pudding	0	5.32 ± 0.16 [a]	2.44 ± 0.07 [a]	2.01 ± 0.05 [a]	Not detected	Not detected
	7	7.29 ± 0.13 [b]	5.87 ± 0.20 [b]	3.86 ± 0.10 [b]	Not detected	Not detected
Smoked steamed sausage	0	4.31 ± 0.19 [a]	2.10 ± 0.16 [a]	< DL	Not detected	Not detected
	7	5.40 ± 0.15 [b]	3.46 ± 0.20 [b]	3.63 ± 0.12	Not detected	Not detected
Raw smoked ham 1	0	5.57 ± 0.18 [a]	4.69 ± 0.12 [a]	< DL	Not detected	Not detected
	7	6.30 ± 0.14 [b]	5,28 ± 0.14 [b]	< DL	Not detected	Not detected
Raw smoked ham 2	0	3.58 ± 0.09 [a]	2.23 ± 0.16 [a]	< DL	Not detected	Not detected
	7	4.61 ± 0.12 [b]	3.32± 0.11 [b]	< DL	Not detected	Not detected

CFU - Colony forming unit; LAB - Lactic acid bacteria; DL – detection limit less than 1.0 log CFU/g.
Data are expressed as means of triplicate sets of determinations ± standard deviation of the mean (SD);
[a,b] - in each product: means in the same column marked with different small letters differ significantly ($p < 0.05$).