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THE IMPORTANCE OF HYGIENE SYSTEMS IN QUALITY ASSURANCE IN THE MEAT INDUSTRY IN GYULA

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Abstract

For several years, we selected certain manufacturing sites where we performed hygiene assessments. To determine the hygienic status of a certain site, we collected samples regularly, on a daily basis, from the same places, during working hours. When needed, we proposed ways of improvement and development.
We assessed the presence of Salmonella, Listeria monocytogenes, Escherichia coli and Escherichia coli O157. Heat-treated, sliced, vacuum-packed final products and sausages were regularly tested microbiologically, including the detection of Listeria and other food-borne pathogens.
The above mentioned studies were conducted between 2004 and 2006, that is, we evaluated the presence of Salmonella, Listeria monocytogenes, Staphylococcus aureus, Escherichia coli and Coliform microbes at the plants and in heat-treated, vacuum-packed final products and sliced, packed dry food.
These appraising tests are to define the level of microbiological contamination their results show the base line, meaning the average level of microbiological contamination, for a manufacturing site or an industry.
In the selected manufacturing sites (a slaughterhouse and a processing plant) we took samples from pre-determined areas. In the processing plant the samples were taken from different points of the site, from the final product, as well as from the tools and hands of the workers. In the slaughterhouse, the samples were collected from the pork and beef muscle tissues.
We selected swab and meat samples to detect Salmonella which proved positive in some cases; at one of the sites Salmonella was detected in the swab sample as well as in the purchased meat. All tissue samples were Salmonella negative.
The number of incidence both for Listeria and L. monocytogenes had increased year by year, but sampling was made from the critical points identified during the previous years, which can be an explanation for the increase of incidence in the swab samples.
The high number of suppliers is not ideal. The chances of Listeria and Salmonella contamination were higher at the suppliers who were investigated many times.
39,6% of the swab samples and 51,1% of the meat samples were contaminated with S. aureus (2006). These figures are in line with the Staphylococcus contamination level of the half carcasses.
Keywords: performing hygiene assessments, contamination level, Listeria and Salmonella, „base line".

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Introduction

When planning our research our objective with my colleagues was to assess the operation of the hygienic systems in practice. Our aim when analysing the collected data was to draw a picture of the status of food safety in processing sites. During our work we collected data regarding the status of hygiene in processing plants. These data confirmed the efficiency of cleaning and disinfecting.

In the field of meat industry, an immaculate final product that is microbiologically safe for the consumer can be produced only from proper raw material with adequate technology and impeccable personnel.

However, in the procedures of slaughtering, processing and storage, several incidents might occur for contamination. Consequently, the microbiological safety of the products can be at risk. Therefore, special attention must be paid to the disinfection and cleaning of slaughterhouses and meat processing plants, and also to the control and maintenance of their hygienic conditions.

The present thesis intends to provide a comprehensive overview of the methods that can be applied to manufacture safe meat products.

During our preparatory studies, my colleagues and I assessed the hygienic conditions of slaughterhouses, meat processing and additive producing plants. We put special emphasis on the detection of the presences of such microbial communities as *Listeria* and *Salmonella,* which are of particular concern regarding food and nutritional health (*Gudbjörnsdottir et al.* 2004).

Literature overview

We were carrying out observations during the process of production, as well as after cleaning and disinfection. Besides detecting pathogens, in certain cases we also estimated total plate count, *Coliform* number and *Escherichia coli* number.

Despite the regular previous inspections by the Animal Health and Food Control Station, there has not been enough information provided about so-called ‘base-line studies’ so far, however, they are well-known in international literature. Without results of such studies, it is hardly imaginable to further improve the microorganism-focused and general hygiene conditions of meat processing plants (*Riviera-Betancourt et al.* 2004).

One study in Mexico, determined the microbiological conditions during the slaughter process of a municipal slaughterhouse in Hidalgo, Mexico. Samples from carcasses of cattle and swine, personnel, utensils, and water from the scalding and clearing process of the carcasses were taken by swabbing selected areas. Aerobic mesophilic bacteria (AMB), coliforms, *Escherichia coli*, *Salmonella* and *Staphylococcus aureus* were enumerated in each sample. *S. aureus* was not detected in any of 158 samples analyzed, white the average of AMB was around 4,5 log UFC/cm^2. Coliforms and *E. coli* were also detected in most of the samples and were more abundant in the pork slaughter line than in beef. *Salmonella* was detected in 31% of pork line samples and 11% of the beef line samples. Microbial counts present in carcasses, utensils and personnel indicated poor hygienic conditions in the slaughtering establishment and implementation and maintenance of good manufacturing practise (GMP) should be the first step in order to assure the microbial safety of meat *(S. Hernandez et al.* 2007*).*

Therefore, our objective is to conduct the above mentioned studies on microbial communities such as *Listeria* and *Salmonella*, which are of utmost importance concerning healthcare. (*Thimothe et al.* 2004.)

Prendergast and his partners monitored the presence of Salmonella in Irish

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slaughterhouses. In Ireland they've monitored the presence of Salmonella three times before slaughter, involving 24-24 animals. Based on the results they've separated the stock into 3 categories, in category 1 the incidence of Salmonella was ≤10%, in category 2 >10% ; ≤50% of the samples were positive and in category 3 the incidence was greater then 50%. They have slaughtered the pigs from category 3 settlements separatedly. The samples were taken from boning room at 3 different slaughter houses two times, sampling was repeated in the morning and in the afternoon. According to the current research 1,11% of the samples were positive. As per another essay the incidence of Salmonella is decreased to 2% in 2003 from the 9% of the year 2000 in Ireland, therefore the result of the microbiological test from 2005 fits the decreasing trend of previous years (*Prendergast et al*. 2006).

Base-line studies serve to assess the level of microbiological contamination. Their results show what can be regarded as a 'base line' in connection with a certain plant or industry, that is, they set the average microbiological contamination level.

Our objective is to provide a reliable production basis through the results of studies in Hungary. In light of results, the data can be adapted in various ways, they can be put to use in the circumstances of Hungary as well (*Gasparik-Reichardt et al.* 2004).

Firstly, the results can reveal the weak points of a certain plant, technology or product; that is, it is an opportunity to detect the gaps through which contamination types are hazardous to final products and thus consumers can sneak into the system.

Secondly, due to the results, sanitation technology, procedures and the overall hygiene system can be optimized and made cost-effective.

Material and methods

We tested a total of 292 samples taken from the plant in order to detect the presence of *Listeria, Salmonella, E. coli* and *E. coli* O157. 200 samples were taken in the summer period, in May and June and 92 samples were taken in a colder period, in October. The number of samples, taken in the summer season, is higher since we wanted to see the general hygienic status of the manufacturing site. The winter season's samples are focused on the "hygienic warm spots". Unfortunately the financial limits of the tests are not allowed us to take the same high number of samples in all seasons.

Location and Time of the Studies

Among the slaughterhouses and meat producing plants of Hungary, we decided to study large-scale plants*: the Meat Combine of Gyula Ltd.* (Henceforward: 'A' plant in Hungary.) We assessed their microbiological and hygienic conditions, with particular emphasis on the presence of microbe communities such as *Listeria, Salmonella, Escherichia coli* and *Escherichia coli O157*, all of which microbes mean hazards in terms of food and nutritional health. We carried out our studies during the whole process of the production, both in a summer and in a winter period, between 2004 and 2006.

Sampling

The porosity of the head of modern sampling swabs is 100 ppi (pore per inch) cells and they are made from open-, or closed-cell polyurethane, while the handle is made from clean, virgin polypropylene. The head is attached to the handle without gluing, by thermal binding. The sample swabs used by me were traditional sterile cotton swabs on wood sticks. On the day of the collecting, samples were transported to the laboratory in coolers at the temperature of 5-6 ℃.

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Samples were collected with sterile swabs in the animal shelter, the slaughterhouse, the cold storage room and the processing departments. The swabs were pre-moistened with physiological saline solution, then a 100-cm^2 area was covered for sampling. We took further samples from the hands of the workers, from tools, the surfaces of equipment and also from the surface of cleaned and cut pork meat. In compliance with the regulation in force, we based our final product studies on a 25 g sample.

With the occasion of a sampling only one sample was collected from the same sampling site. On the following occasion the sample was collected from the same site; during the testing period we collected samples twice a week. We allocated sequence numbers for each site, thus, the samples could be identified, and the analysis and management of data was easier. In the laboratory, samples were analysed in accordance with the standards in force at that time, as already mentioned in the literature review section of this article.

The samples were tested at the Hungarian Meat Research Institute's accredited laboratory (OHKI, 1097 Budapest, Gubacsi út 6/b) according to the current standards.

Detection of Listeria monocytogenes

Swab samples were incubated in FRASER broth at 37°C for 48 hours, then were subcultured onto *Listeria* selective agar (OXFORD, RAPID L'MONO, OCLA, LIMONO-IDENT). From the selective agars, we tested suspect colonies in accordance with the prevailing *Listeria* standards (MSZ EN ISO 11290-1).

Detection of Salmonella

At the first stage, swab samples were inoculated in a selenite cystine enrichment broth and incubated at 37 °C 24 hours, then plated out onto *Salmonella* selective HEKTOEN enteric and RAMBACH agars. From the selective agars, we tested the presumptive colonies in accordance with the prevailing *Salmonella* standards (MSZN EN 12824). Confirmatory testing was made using Enteroclon Anti-*Salmonella* A-67 ambivalent.

Detection of Escherichia coli

Swab samples were enriched in LMX broth for 18 hours, then were plated out onto Fluorocult ECD agar, finally, typical colonies were identified.

Detection of Escherichia coli 0157

Samples were enriched in a modified *E. coli* broth (mEC) supplemented with novobiocin for 6 hours, then we applied immuno-magnetic separation (IMS). The isolated material was plated out onto sorbitol MacConkey agar supplemented with cefixime and potassium tellurite (CT-SMAC). The plates were incubated for 24 hours and, finally, we used *E. coli* O157 immunoassay for the final confirmatory testing of the typical colonies.
Escherichia coli standard (MSZ ISO 16649-2-2005)

Concerning the analysis of semi-finished and final products, we employed the following accredited and valid methods

Microbiology. General guidance for the enumeration of yeasts and moulds. Colony-count technique at 25°C: MSZ ISO 7954:1999

Microbiology of food and animal feeding stuffs. Horizontal method for the enumeration of beta-glucuronidase-positive *Escherichia coli*. Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl beta-D-glucuronide: MSZ ISO 16649-2:2005

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Microbiology of food and animal feeding stuffs. Horizontal method for the enumeration of coagulase-positive *staphylococci* (*Staphylococcus aureus* and other species). Part 1: Technique using Baird-Parker agar medium: MSZ EN ISO 6888-1:2000

Microbiology of food and animal feeding stuffs. Horizontal method for the detection and enumeration of *Listeria monocytogenes*. Part 1: Detection method. Modification of the isolation media and the haemolysis test, and inclusion of precision data: MSZ EN ISO 11290-1:1996/A1:2005

Microbiology of food and animal feeding stuffs – Horizontal method for the detection of *Salmonella spp.*.: EN ISO 6579: 2002

Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of microorganisms – Colony count technique at 30 degrees C: EN ISO 4833: 2003

Results and discussion

Evaluation of the year 2004

The microbiological results and the distribution of the samples taken during the summer. Out of 200 examined samples, (6,5%) yielded *Listeria*; however, we could detect *Listeria monocytogenes* in one case only, and *Salmonella spp.* in another incidence, but in both cases the samples were obtained from the animal shelter. The frequency of *E. coli* incidence was higher, (35,5 %), most positive samples were isolated from the animal shelter again, while the fewest samples (9,37%) were from the cold storage room (*vid. Table 1*).

16 samples were collected from the slaughter line, 80 from the boning rooms, 64 from the cold storage rooms and 40 from the animal shelter. All *Listeria* isolates derived from the summer sampling of the animal shelter.

Indicate the microbiological results and the distribution of the samples obtained during the colder period (October). Out of 92 analysed samples, (17,4%) proved positive for *Listeria*, however, in no cases were *Listeria monocytogenes* or *Salmonella spp.* detected.

8 samples were collected from the slaughter line, 40 samples from the boning room, 32 from cold storage rooms and 12 from the animal shelter. *Listeria* could be detected at all the sampling sites, most isolated microbes derived from the boning room sampling in the colder season.

Compared to the summer sampling, the occurrence of *Escherichia coli* dropped significantly, to (9,8%), again most positive samples were the ones taken from the animal shelter (41,6%), and the fewest (3,1%) from the cold storage room.

Based on the results of our *Listeria* tests, we can conclude that there is a difference between the samples of the two seasons (vid. *Table 1*). While in summer the occurrence of *Listeria* was only (6,5%), in the colder month the frequency of its incidence was (17,4%), Frequency regarding all the samples (9,93%) was (0,5%) lower than the result of the previous year (10,53%). Slight difference between the testing periods had also appeared the year before. As in 2004, the frequency of *Listeria* was also higher in the colder period, which phenomenon can be explained with the high cold tolerance quality of *Listeria*. Then, with a similar amount of samples, the difference between the acquired values was not more than (3%), Compared to the data of the previous year, the frequency of *Listeria* incidences had slightly decreased.

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Table 1: **Incidence of *Listeria* strains, in 2004, at the "A" plant; figures regarding *Listeria monocytogenes* are shown in brackets**

The results of the tests carried out in the production units of 'A' plant in 2004						
Production unit	Number of samples (pc)		Positive samples (pc)		Positive rate %	
Slaughterhouse	24		3		12,5	
Boning room	120		8		6,6	
Cold storage room	96		2		2,1	
Animal shelter	52		16		30,8	
Total ( ) *Listeria monocytogenes aggregatevalue*	**292**		**29** *(1)*		**9,93** *(0,3)*	
Examined period Production unit	**Winter Months**			**Summer Months**		
	Number of samples	Positive Samples (pc)	Positive Rate %	Number of Samples (pc)	Positive Samples (db)	Positive Rate %
Slaughterhouse	8	3	37,5	16	0	0
Boning room	40	8	20	80	0	0
Cold storage room	32	2	6,25	64	0	0
Animal shelter	12	3	25	40	13	32,5
Total ( ) *Listeria monocytogenes aggregatevalue*	**92**	**16**	**17,4**	**200**	**13** *(1)*	**6,5** *(0,5)*

The occurrence of *E. coli* was more frequent (approx. 35%) in the summer months (*vid. Table 2*), but its occurrence decreased significantly (9,8%) in the colder months. *E. coli* O157 microbes were not detected in the *E. coli* positive samples.
The result of the *Salmonella* test was also promising, as *Salmonella* occurred only once, in a sample from the animal shelter.

Evaluation of the year 2005

In the year 2005, I continued the hygiene assessment of the slaughterhouse and the processing plant; that is, we carried out the identification of *Salmonella*, *Listeria monocytogenes*, *Escherichia coli* and *Coliform* microbes. We also examined heat-treated, vacuum-packed final products and sausages from a microbiological point of view, focusing on *Listeria monocytogenes* and other pathogens specified by the relevant regulation.

The studies of the selected plants were conducted at pre-determined sampling sites. Sampling was targeted to areas such as the animal shelter, the processing department, final products and the tools of the personnel.

In 'A' plant, we have examined a total of 145 samples for the presence of *Listeria*, *Salmonella*, *E. coli* and *Coliform* bacteria. The samples were obtained during the summer season, after that, slaughter terminated in the plant.

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Table 2: **The incidence of *E. coli* in 'A' plant in the examined periods, in certain production units of 'A' plant in 2004**

The results of the tests carried out in the production units of 'A' plant in 2004						
Production unit	Number of samples (pc)		Positive samples (pc)		Positive rate %	
Slaughterhouse	24		8		33,3	
Boning room	120		21		17,5	
Cold storage room	96		7		7,3	
Animal shelter	52		26		50	
Total	**292**		**62**		**21,2**	
Examined period	**Winter Months**			**Summer Months**		
Production unit	Number of Samples (pc)	Positive Samples (pc)	Positive Rate %	Number of Samples (pc)	Positive Samples (pc)	Positive Rate %
Slaughterhouse	8	1	12,5	16	7	43,75
Boning room	40	2	5	80	19	23,75
Cold storage room	32	1	3,1	64	6	9,37
Animal shelter	12	5	41,6	40	21	52,50
Total	**92**	**9**	**9,8**	**200**	**53**	**35,30**

Distribution and microbiological results of the summer samples are shown in Table 3.The plant in question is several hours from the institute, thus we often received the swabs a day after sampling. Therefore we expanded our methods to a new swab study which contained transport medium so that we could detect the pathogens that otherwise could die during transport. From the samples analysed, (11,3%) yielded *Listeria* positive by pre-moistened swab studies, while from the swabs containing transport medium (27,7%) tested positive, that is, more than twice (*vid. Table 3*).

Table 3: **The occurrence of *Listeria* strains based on samples collected using different testing methods in certain production units of 'A' plant in 2005**

The results of the tests carried out in the production units of 'A' plant in 2005						
Production unit	Number of samples (pc)		Positive samples (pc)		Positive rate%	
Slaughterhouse	14		1		7,1	
Boning room	70		17		24,3	
Cold storage room	56		12		21,4	
Animal shelter	5		0		0	
Total	**145**		**30**		**20,7**	
Testing methods	**During transport**			**Swabs containing transport**		
Production unit	Number of samples (pc)	Positive samples (pc)	Positive rate %	Number of samples (pc)	Positive samples (pc)	Positive rate %
Slaughterhouse	6	0	0	8	1	12,5
Boning room	30	5	16,6	40	12	30
Cold storage room	24	2	8,3	32	10	31,3
Animal shelter	2	0	0	3	0	0
Total	**62**	**7**	**11,3**	**83**	**23**	**27,7**

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14 samples were obtained from the slaughter line, 70 from the boning room, 56 from cold storage rooms and 5 from the animal shelter. In the previous year, all isolated *Listeria* came from the animal shelter sampling in the summer season. In 2005, no positive samples were from the shelter, which can be due to the small amount of samples. Positive isolates were from the pig slaughter room, the boning room and from the cold storage room; percentage of their distribution is also indicated in *Table 3*.

Salmonella was not detected from any of the samples using either method.

The occurrence of *E. coli*, when tested with swabs, turned out to be (17,7%). When tested using swabs with transport medium, the result was (32,5 %), in case of employing transport medium, most positive swabs (100%) were obtained from the animal shelter and the lowest percentage (15%) from the boning room (*vid. Table 4*).

Table 4: **The presentation of the occurrence of E. coli in the production units of 'A' plant, when employing different testing methods in 2005**

The results of the tests carried out in the production units of 'A' plant in 2005						
Production unit	Number of samples (pc)		Positive samples (pc)		Positive rate%	
Slaughterhouse	14		6		30	
Boning room	70		11		17,3	
Cold storage room	56		18		5,8	
Animal shelter	5		3		50	
Total	**145**		**38**		**20**	
Testing methods	**During transport**			**Swabs containing transport**		
Production unit	Number of samples (pc)	Positive samples (pc)	Positive rate %	Number of samples (pc)	Positive samples (pc)	Positive rate %
Slaughterhouse	6	1	16,6	8	5	62,5
Boning room	30	5	16,6	40	6	15
Cold storage room	24	5	20,8	32	13	40,63
Animal shelter	2	0	0	3	3	100
Total	**62**	**11**	**17,7**	**83**	**27**	**32,5**

When traditional swab samples (62 pieces) were employed, the frequency of *Listeria* occurrence was (11,5%) in 2005, which is slightly higher than the results of the previous years, (9,44%) in 2004 and (10,53%) in 2003. When transport medium swabs were used (83 pieces), the frequency was (28%).

The incidence rate for *E. coli* in 2004 was (20%), while in 2005 using the previous year's method, we observed a similar value, (18%). When we employed transport medium swabs, the frequency increased to (32,5%).

The incidence rate for *Coliform* microbes using traditional swabs resulted in (37,1%), while using transport medium swabs, it resulted in (72,3%) (*vid. Table 5*).

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Table 5: **The presentation of the occurrence of *Coliform* in the production units of 'A' plant, when employing different testing methods in 2005**

The results of the tests carried out in the production units of 'A' plant in 2005						
Production unit	Number of samples (pc)		Positive samples (pc)		Positive rate%	
Slaughterhouse	14		6		30	
Boning room	70		44		62,85	
Cold storage room	56		29		51,8	
Animal shelter	5		4		80	
Total	**145**		**83**		**57,2**	
Testing methods	**During transport**			**Swabs containing transport**		
Production unit	Num-ber of samp-les (pc)	Positive samples (pc)	Positive rate%	Number of samples (pc)	Positive samples (pc)	Positive rate %
Slaughterhouse	6	1	16,6	8	5	62,5
Boning room	30	13	43,3	40	31	77,5
Cold storage room	24	8	33,3	32	21	65,6
Animal shelter	2	1	50	3	3	100
Total	**62**	**23**	**37,1**	**83**	**60**	**72,3**

Evaluation of the year 2006

In the year 2006, I also carried out hygiene assessment, I was collecting samples during production throughout a longer period but from the same locations in order to determine the hygienic conditions of the plant, and, if needed, to make suggestions for development and improvement. Based on my assessment, I analysed certain parts of the hygiene system and also modified it when it was needed. With my colleagues, we studied the presence of *Salmonella*, *Listeria monocytogenes*, *Escherichia coli* and *Escherichia coli* 0157. Heat-treated, sliced, vacuum-packed final products and sausages were studied constantly. We broadened our studies to detect *Listeria* and other pathogens.

In 2006 we conducted the above tests and we detected *Salmonella*, *Listeria monocytogenes*, *S. aureus*, *Escherichia coli* and *Coliform* microbes in a plant and also identified *Listeria* and other pathogens in heat-treated, vacuum-packed final products and sliced, packed dry goods.

Researches were made in pre-determined sampling sites of the specified plants (a slaughterhouse and a processing plant). Sampling was focused to different parts of the processing plant, the final products, the tools and hands of the personnel. As for the slaughterhouse samples were muscle tissues from pork and beef carcasses. Throughout the year, 338 swab and meat samples were tested for *Salmonella* and we could detect its prevalence in 8 cases, from swab samples obtained from one the plants and from purchased meat. The examined tissue samples yielded no detectable *Salmonella*.

Compared to the previous years, the incidence rate for both *Listeria* and *L. monoytogenes* had increased (51,6% compared to 11, 3% in 2005). However, being supported by our previous experience, in 2006 we collected the samples from critical points which can explain the higher frequency. Also, in case of too many suppliers, there is a higher chance of *Listeria* and *Salmonella* contamination as the suppliers are examined repeatedly.
(39,6%) of the tested swabs and (51,1%) of the meat samples were contaminated with *S. aureus*.

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These figures correlate with the *Staphylococcus* contamination of the observed half carcasses.

The occurrence of *E. coli* (53,7%) was similar to that of the previous year. All the muscle tissues obtained from the slaughter line tested negative for *Salmonella spp*.

Taken into account the set values of the Commission Regulation (EC) No. 2073/2005. , the 5-unit samples exceeded the limit three times: in one case the total plate count, and twice the *Enterobacteriaceae* number.

A basic objective would be to further reduce the pathogenic contamination of all meat plants, that is, further monitoring and control measures are needed. In addition, in the light of microbiological results, the efficiency of interventions and hygiene control action (cleaning and disinfection) can be judged as well.

Analyses of Final Products

We have also studied heat-treated, sliced, vacuum-packed, modified atmosphere packaged (MAP) foods and sausages produced by 'A' plant. It was the microbiological test of 52 different products and also complex shelf life assessment of 23 products. We could not detect any *Listeria monocytogenes* in 2006, which verifies that the heat treatment and the slicing and packaging technology meet the requirements for pathogen destruction.

We assessed the presence of *Listeria*, *L. monocytogenes*, *Salmonella*, *S. aureus*, *Coliform*s and *E. coli* during processing at nine specified areas (which we had chosen according to the results of the previous year) on a weekly basis; in case of presumption, swab sampling was made on further areas.

In light of the results, we came to the conclusion that raw materials are main source of contamination in the processing line. Therefore we analysed the microbial contamination of primary materials. In the plant there is no slaughter, instead, Hungarian and foreign meat is purchased and processed. Samples were taken with pre-moistened swabs and muscle tissue samples were collected as well. The samples were tested within an hour.

Out of the 300 examined swabs and meat samples (*vid. Table 6*), 155 yielded positive result for *Listeria* (51,6%). Result for *L. monocytogenes* contamination was similar, 3 meat samples (3,6%) and 8 swabs (3,7%) were positive.

***Table 6: Listeria monocytogenes* contamination rate for swab and meat samples at 'A' plant 2006**

Sample Type	**Total *Listeria* (pc)/ Positive samples (pc)**	**Total *Listeria mono-cytogenes* (pc)/ Positive samples (pc)**	***Listeria* Positive rate %**	***Listeria monocytogenes* %**
Swabsamples	221/122	221/8	55,2	3,6
Meatsamples	79/33	79/3	41,7	3,7
Total	**300/155**	**300/11**	**51,6**	**3,6**

The occurrence of *E. coli* was also high, (53,7%), in case of meat samples their frequency was even slightly higher, (59,5%). Sampling sites and the results are shown in Table 7. (*vid Table 7*).

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Table 7: **Data regarding the occurrence of *E. coli* in ''A'' plant, based on tests employing swab and meat samples, expressed as a percentage by using the *E.coli* positivity as a basis, showing the rate of positive samples of all the collected samples. 2006**

SampleType	**Total Samples (pc) / Positive samples (pc)**	***E. coli* Positive rate%**
Swabsamples	217/112	51,6
Meatsamples	79/47	59,5
Total	**296/159**	**53,7**

9 swab samples (3,9%) and 3 meat samples (3,8%) were positive for *Salmonella*, which reveals similar frequency (*vid. Table 8*).

Table 8: **Data regarding the occurrence of *Salmonella* strains in the processing plant in 'A' plant. 2006**

SampleType	**Total Samples (pc) / Positive samples (pc)**	***Salmonella* Positive rate %**
Swabsamples	229/9	3,9
Meatsamples	79/3	3,8
Total	**308/12**	**3,9**

When using swab sampling, we could detect *Salmonella* from the slaughter line (3 positive), the meat processing tables, the cut resistant gloves, the meat shovel and the sausage stuffing table; it means that pathogens might spread through the whole production line. Therefore we drew the conclusion that, instead of regular swab testing, it was more effective to examine pork carcasses and other meats (certainly, parallel with all hygienic and other, specific examinations after the cleaning and disinfection process). This way, more useful data regarding the processed products could be gained.

Item-monitoring of the suppliers helps the intensive control of the items liable to *Salmonella.* It also helps to choose the circumstances of the maturation process carefully as well as the convincing analysis of chemical and microbiological parameters of the final product.

In case of meat inspection for *S. aureus*, not only pure detection of contamination is essential, but also the identification of the level/quantity of contamination. 10^2-10^3/CFU/g or higher *Staphylococcus* contamination of pork cuts results in loss of the quality of the final product, and *S. aureus* number in sausages will not decrease significantly even if the product undergoes further drying. (39,6%) of the tested swabs and (51%) of the meat samples were *Staphylococcus* contaminated, which result is close to the *Staphylococcus* contamination of the examined half-carcasses (*vid. Table 9*).

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Table 9: **Data for the occurrence of *S. aureus* in the processing plant.2006**

SampleType	***S. aureus*total (pc) / positive (pc)**	***S. aureus* positive rate %**
Swabsamples	187/74	39,6
Meatsamples	88/45	51,1
Total	275/119	43,3

The suppliers who regularly deliver their products with such plate count should be informed of the problem first, then, if they cannot improve the quality of their meat, for food-safety reasons, they should be excluded from the range of suppliers. This also applies to the suppliers who regularly deliver *Salmonella* contaminated meat (*vid. Table 10*).

Table 10: **Supplier-based assessment of meat**
Total Samples (pc) / Positive samples (pc).

Assessment sequentially numbered	***Listeria* (total/positive)**	***Listeria monocytogenes* (total/positive)**	***Salmonella* (total/positive)**	***S. aureus* (total/positive)**
1	15/6	15/1	15/0	15/7
2	12/8	12/1	12/1	12/7
3	10/3	10/0	10/1	18/6
4	8/2	8/0	8/0	8/4
5	7/1	7/0	7/0	5/5
6	4/1	4/0	4/0	4/3
7	4/0	4/0	4/1	4/3
8	4/3	4/0	4/0	4/2
9	4/1	4/0	4/0	4/3
10	3/1	3/0	3/0	3/1
11	3/2	3/0	3/0	3/1
12	2/2	2/1	2/0	2/1
13	2/2	2/0	2/0	2/0
14	1/1	1/0	1/0	1/0

All muscle tissue samples collected from the slaughter line were negative for *Salmonella* , in 6 cases the total plate count exceeded the limit specified by the Commission Regulation (EC) No. 2073/2005., while the *Enterobacter* number was higher in 10 cases. The average log value of the 5-unit samples was exceeded once by the total plate number and twice by the *Enterobacter* number (*vid. Table 11*). In one of the cases the samples were received in the laboratory with a one-day delay. Unfortunately, due to the closing down of the slaughterhouse, we had no opportunities for further analyses.

In ‘A’ plant we have analysed heat-treated, vacuum-packed or MAP foods and sausages as well (microbiological examination of 52 different products and comprehensive shelf-life analysis of 23 products). In the examined products, no *Listeria monocytogenes* were detected in 2006.

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Comparing the results of the current research with the international scientific literature. The hygienic level of the tested facilities and the microbiological attributes of the final products are meeting the international expectations. The results are pointing to the fact that season when the samples were taken has significant influence on the *Listeria* contamination. Although the contamination level of the raw material has increased, this level of the environment samples has slightly grown and was negligible for final products. Despite that the raw materials *Listeria* contamination was around 50% their heat treatment combined with a proper *Listeria* conditioning and preventing cross-contamination will keep final products contamination level low.

Table 11: **Result of the microbiological assessment of tissue samples from the slaughterhouse**

Register number of microbiological log	**Total Plate Count CFU/cm^2**	***Enterobacteria ceae*** **CFU/cm^2**
M117	3,2 x 10^3	< 1,0 x 10^1
M118	8,0 x 10^2	< 1,0 x 10^1
M 119	2,2 x 10^2	3,6 x 10^1
M 120	1,6 x 10^3	2,9 x 10^1
M 121	3,6 x 10^3	1,2 x 10^1
M 239	1,1 x 10^4	2,7 x 10^1
M 240	2,1 x 10^3	6,1 x 10^1
M 241	6,0 x 10^3	1,1 x 10^1
M 242	3,8 x 10^3	< 1,0 x 10^1
M 243	1,3 x 10^3	< 1,0 x 10^1
M 284	*1,8 x 10^5*	*2,8 x 10^4*
M 285	3,4 x 10^4	*1,2 x 10^4*
M 286	2,6 x 10^4	*1,1 x 10^4*
M 287	2,1 x 10^4	*3,7 x 10^3*
M 288	3,7 x 10^4	*7,1 x 10^3*
M 420	1,1 x 10^2	< 1,0 x 10^1
M 421	3,7 x 10^1	< 1,0 x 10^1
M 422	2,1 x 10^1	< 1,0 x 10^1
M 423	0,5 x 10^1	< 1,0 x 10^1
M 424 M	1,4 x 10^2	1,0 x 10^1
M 425 M	4,3 x 10^2	0,5 x 10^1
M 426 M	2,1 x 10^1	0,5 x 10^1
M 427 M	8,0 x 10^1	0,5 x 10^1
M 428 M	1,7 x 10^2	1,6 x 10^2
M 597	2,3 x 10^3	3,2 x 10^2
M 598	1,4 x 10^3	1,9 x 10^2
M 599	7,0 x 10^2	7,0 x 10^1
M 600	1,1 x 10^3	1,3 x 10^2
M601	2,4 x 10^3	2,6 x 10^2

The results are showing well that the *Listeria* was carried by the animals to the facilities, this is in-line with the international statements. Scaldingduring the production process can significantly reduce the number of *Listeria* although during the defeathering and the evisceration the risk of cross-contamination is high. We could detect the microbe on cut animals, knives and on the hands of the workers. In most cases E. coli also could be explored from the samples. In-line with the international expectations, based on the test results we are suggesting the maintenance of HACCP and GMP systems and to expan the range of control to the suppliers as well.

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Conclusions

In the case of meat inspection for *S. aureus*, not only pure detection of contamination is essential, but also the identification of the level/quantity of determination. 10^2-10^3/CFU/g or higher *Staphylococcus* contamination of pork cuts results in loss of final product quality, and *S. aureus* number in sausages will not decrease significantly even if the product undergoes further drying.

Listeria incidence during colder months is nearly 3 times higher than that of the summer months. Therefore we can draw the conclusion that a plant is protected against particulates more effectively than against the mud which is introduced into the plant from the skin of the animals. The data highlights the importance of animal shelter, supplier and transport vehicle hygiene. Frequent change of plucking tub water and intensive rinse of the plucking machine can add to lowering the incidence of *Listeria*, however, it is much less cost-effective than demanding proper animal and transportation hygiene towards the suppliers. The risk of contamination from the mud and faeces on the animal skin, which is due to the low temperature of colder months, can be decreased by always providing clean and dry animal bedding.

Chances for the survival of *Listeria* are the highest in the pharynx, as neither the plucking tub nor the singeing machine can raise oral cavity temperature so high as to kill the bacteria. At home slaughtering, I could observe that the gas torch in all cases was directed to both the open oral cavity and the nasal cavity of the animal. Also at home slaughtering, the pharynx is cooked in boiling water which is a satisfactory type of heat treatment. In a plant, the splitting saw means a high risk as it can spread the contamination throughout the whole carcass. Consequently, attention should be paid to the proper hygiene and disinfection of the splitting saw. A burner suitable for singeing the pharynx should be set up. Unfortunately, it is technologically impossible due to the different carcass sizes and the water dripping from the carcass.

The results gained in our studies are supported by other experts' observations. Hence we state that *Listeria* can be transferred to a meat processing plant by animals. It can settle and grow in the plant and contaminate all the products. However, in case of proper heat treatment, *Listeria* is killed and does not cause any problems. On the other hand, products are at risk of re-contamination during slicing and packing processes. Furthermore, the bacteria can also reproduce during the cold storage stage which can result in infection or even in fatal illnesses.

Parallel with effective HACCP programs, in a plant there is a strong need to strictly separate raw meat from final products and to obey hygienic regulations in order to prevent cross-contamination. Maintaining effective HACCP and GMP systems (of which adequate sanitation and disinfection is an essential part) helps to lower the risk of pathogen occurrence.

Swab tests are useful in the rapid detection of microbiological contamination and for taking quick measures, however they are not a substitute for GMP and GHP.

This method allows for the quick integration in the HACCP system of the microbiological results collected during the analysis.

Our results support the fact that slight fluctuation can occur even if all regulation are observed. Regular assessments and inspections help the plants to further improve their hygiene standards.

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