AUTOR'S SUMMARY OF SCIENTIFIC ACHIEVEMENTS

(Appendix 3)

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I. BIBLIOGRAPHIC DATA

1.1. First and last name

Joanna Trafiałek

1.2. Diplomas and scientific degrees

- **Doctor of Philosophy in Agricultural Sciences (**19 March 2008), major: Food Technology and Nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, title of Ph.D. thesis: "Evaluation of the degree of implementation of a Safety Assurance System in food production in Poland". Supervisor: prof. dr hab. Danuta Kołożyn–Krajewska. Reviewers: prof. dr hab. Stefan Ziajka and prof. dr hab. Wiesław Przybylski.
- **Master of Science Engineer** (10 July 1996), major: Food Technology and Human Nutrition, discipline: Human Nutrition, M.Sc. thesis title: "Mathematical models of changes in selected rheological parameters of batters used in the process of automatic formation". Supervisor: prof. dr hab. Andrzej Neryng.

1.3. Information about employment in research units

2008 until now Research Assistant, since 2010 Assistant Professor at the Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences;

2009 until now Secretary, since 2015 Head of Postgraduate Studies "Safety management and food quality systems" realized at the Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences.

II. PRESENTATION OF THE MAIN SCIENTIFIC ACHIEVEMENT RESULTING FROM THE ART. 16 PT. 2 OF THE ACT OF 14 MARCH 2003 ON SCIENTIFIC DEGREES AND A SCIENTIFIC TITLE, AND ON DEGREES AND TITLE OF ARTS (JOURNAL OF LAWS NO. 65, ITEM 595 WITH AMENDMENTS)

2.1. Title of the Main Scientific Achievement

"Study on system-based assurance of food safety".

2.2. Works presenting results of studies constituting the Main Scientific Achievement

1. Lücke F.K., Trafiałek. J., 2010. Umsetzung der HACCP-Prinzipien in Fleisch verarbeitenden Betrieben in Polen und Deutschland (j. pol. Stosowanie zasad systemu HACCP w zakładach mięsnych w Polsce i Niemczech). Fleischwirtschaft, 90, 1, 43-45.

   IF= 0.127; MNiSW = 13 pts., number of cites = 4

2. Trafiałek J., Lehrke M., Lücke F.-K., Kołożyn-Krajewska D., Janssen J. 2015. HACCP-Based Procedures in Germany and Poland. Food Control 55, 66-74.

   IF= 2.806; MNiSW = 35 pts., number of cites = 1

3. Trafiałek J., Kolanowski W., 2014. Application of Failure Mode and Effect Analysis (FMEA) for audit of HACCP system. Food Control, 44, 35–44.

   IF= 2.806; MNiSW= 35 pts., number of cites = 6

4. Trafiałek J., Laskowski W., Kolanowski W. 2015. The use of Kohonen's artificial neural networks for analyzing the results of HACCP system declarative survey. Food Control, 51, 263-269.

   IF= 2.806; MNiSW = 35 pts., number of cites = 1

5. Trafiałek J., Kaczmarek S., Kolanowski W. 2016. The risk analysis of metallic foreign bodies in food products. Journal of Food Quality, 39, 398–407.

   IF= 0.838; MNiSW = 20 pts., number of cites = 0

The total score of all works constituting the Main Scientific Achievements is **138** points acc. to **MNiSW** journals' rank and total **IF** is **9.383 (**IF from the year of publishing). Copies of manuscripts included in the monograph constituting the Main Scientific Achievement together with declarations of co-authors concerning their contribution to each of these manuscripts are enclosed in Appendix 4.

2.3. Presentation of research objective and results obtained within the Main Scientific Achievement

Introduction

Food production and processing pose some risks to food safety. It has become especially significant with the onset of industrial production. In the XIX century and at the beginning of the XX century, many methods have been developed for preservation, stability extension and safety assurance of food products. They have, however, turned out insufficient in the 1970s. A need has emerged, then, for food safety assurance methods, the most commonly applied of which is the Hazard Analysis and Critical Control Points (HACCP).

Although the HACCP principles have been obligatorily imposed in the EU Member States almost a decade ago (art. 5 of EC Regulation 852/2004), the process of food safety assurance is still pending. It was proved by multiple cases of food poisonings and emergence of many situations posing hazard to consumer health (European Commission, 2015).

In the food production and processing facilities located in the EU Members States, the degree of HACCP system implementation before the accession of new members was higher than in plants located in countries that had accessed the EU in 2004, including Poland (Panisello et al., 1999, Henson et al., 1999; Beyer and Krieger, 2004; Baş et al., 2007; Trafiałek and Kołożyn-Krajewska, 2011). HACCP implementation into the Polish plants has begun approximately in 2000 and initially the degree of implementation was satisfactory. After Poland's accession to the EU, the number of facilities declaring system implementation has considerably increased (Morkis, 2010; Trafiałek and Kołożyn-Krajewska, 2011, Main Sanitary Inspectorate, 2015).

In 2017, it has been 11 years since the implementation and application of procedures consistent with the principles of the HACCP system have been made obligatory. In this respect, I have conducted multidirectional studies addressing food safety system analysis and food safety risk assessment. Results obtained in these studies are novel and so far unreported in the respective literature. Works constituting the Main Scientific Achievement present pioneer uses of the quality assessment tools applied in other countries, e.g. in social sciences, that have so far never been used for the scientific evaluation of food safety. The use of tools uncommon in the research discipline of food technology and nutrition has enabled presentation of thus far unknown solutions. Considering the above, the results obtained allow for novel approach to this issue in the area of food technology and nutrition.

One of these tools included the Failure Mode and Effect Analysis (FMEA) method (Luning et al., 2002), and Kohonen artificial neural networks (Kohonen, 2001).

Although the FMEA is presented in scientific literature as a method for determination of Critical Control Points in the HACCP system (Scipioni et al., 2002; Arvanitoyannis and Varzakas, 2008), it is not commonly applied in the food technology and nutrition discipline. In the works constituting the Main Scientific Achievement, it has been applied for food safety assessment in two different experiments: 1 – for interpretation of outcomes of HACCP system audit, and 2 – for risk assessment of metallic bodies occurrence in finished products. These applications are innovative and have never been used in this context. No identical solutions were reported in literature. In the first case, the FMEA was used to evaluate the already functioning HACCP system, whereas in the second one – risk assessment was applied as a component of the complex risk analysis pursuant to EU Regulation 178/2002.

Neural networks are applied to detect typicality in a multidimensional system and have been addressed in many research works from various disciplines (Wesołowski, et al. 2001; Kondo et al., 2013; Torrecilla et al., 2004). So far, however, they have not been applied to interpret results of questionnaire surveys concerning food safety.

Today, there are no complex and reliable methods for the scientific and unbiased evaluation of the existing food safety assurance systems. Therefore, studies conducted and their results are of great significance to the science of food technology and nutrition.

Outcomes of investigations conducted in a few stages include published research works and communications presented and domestic and international conferences. Out of them, I have selected five works constituting a monograph of research publications. **The objective of the presented cycle of research works was the analysis and assessment of safety assurance systems in food production and the development of innovative research tools to be applied in risk assessment of food safety systems functioning**

Specific objectives of the monograph include:

1. Science-based analysis and assessment of the condition of food safety assurance in Polish and German plants (works no. 1-2).

2. Development, application and verification of innovative research tools to be used in the evaluation of food safety systems and in risk assessment (works no. 3-5).

The following research hypothesis was formulated:

Risk assessment and system-based assurance of health safety of foods require applying innovative and verified research tools developed based on scientific studies.

Results

1. Science-based analysis and assessment of the condition of food safety assurance in Polish and German plants

Works no 1 and no 2:

No 1 - Lücke F.K., Trafiałek. J., 2010. Umsetzung der HACCP-Prinzipien in Fleisch verarbeitenden Betrieben in Polen und Deutschland (j. pol. Stosowanie zasad systemu HACCP w zakładach mięsnych w Polsce i Niemczech). Fleischwirtschaft, 90, 1, 43-45.

No 2 - Trafiałek J., Lehrke M., Lücke F.-K., Kołożyn-Krajewska D., Janssen J. 2015. HACCP - Based procedures in Germany and Poland. Food Control 55, 66-74.

The objective of the study described in **work no 1** was to analyze the HACCP system in selected plants located in different Member States of the European Union, i.e. in Germany and Poland, and to compare problems encountered during system implementation and consequences of its implementation in the studied countries. The obligation of HACCP implementation has been imposed in both countries in different times and based on different legal acts: in Germany – based on 93/43/EC Directive, whereas in Poland – based on the Act on Health Conditions of Food and Nutrition of the 11 May 2001 (with amendments).

Investigations were conducted in four Polish and four German food processing plants in the years 2008 – 2009, namely 4 years after Poland's accession to the EU and two years after entering into force of the obligation of HACCP principles application pursuant to the Art. 5 of EC Regulation no. 852/2004. The plants were medium and small enterprises from the meat production sector. The study was conducted with the method of a questionnaire consisting of 16 closed-type questions concerning problems encountered during implementation of the HACCP system, difficulties in its everyday functioning and positive outcomes of its implementation. The study resulted in the identification of discrepancies and common traits of the HACCP system in Polish and German plants. Similarities were noted in difficulties with system implementation, whereas differences in the benefits observed after implementation. In the analyzed Polish and German plants, the HACCP system was

implemented in different periods. In Germany, it was implemented a few years earlier than in Poland. The Polish plants implemented the HACCP system when Poland had joined the European Union.

Both in the Polish and German plants, the key problems faced during HACCP implementation included increased documentation and the necessity of making investments. None of the Polish plants declared increased demand for administration staff resulting from documentation load, whereas such a need was identified in one of the German plants. Similar problems were highlighted regarding the functioning of the implemented system, with the main drawback being the increased number of documentation, as declared by four German plants and three Polish plants. Similar problems were observed, e.g., in British facilities which struggled with elaboration, verification and storage of documents (Henson et al., 1999).

Earlier investigations (Trafiałek and Kołożyn-Krajewska, 2011) reported about the problem of misunderstanding of the idea of the food safety system, mainly among production line staff. It was, therefore, checked whether this problem still occurred after a few years and whether a similar situation was observed in the German plants. Study results demonstrated that the problem of misunderstanding HACCP concept still existed among unqualified staff in all German and in two Polish plants. In addition, in two Polish plants, the idea of the system was not comprehended also by the qualified staff and even by plant owners.

The analysis of benefits resulting from HACCP implementation was carried out by dividing them into financial and non-financial ones (Trafiałek and Kołożyn-Krajewska, 2011). The major financial benefit was the possibility of continued activity on the market, as perceived by 3 out of the 4 Polish plants and by 2 German plants. Only in one German plant and in two Polish ones was the number of claims observed to reduce after HACCP implementation. Different opinions were expressed by the representatives of the analyzed plants as to the effect of HACCP system implementation on keeping the current clients and gaining new ones, on increased demand and improved capability to compete on the international market. In the case of the German entrepreneurs, the most important was to keep and to attract new clients, whereas in the case of the Polish ones – it was completely insignificant. In turn, representatives of Polish plants emphasized the improved competition skills on the international market and demand increase, which was not highlighted by the German plants. There were no such great discrepancies regarding the non-financial benefits. Two Polish and two German plants indicated a higher quality of products, better qualified and trained staff and improved hygienic conditions in the plant. In contrast, differences pertained to the improvement of production processes and greater responsibility of the staff for the work

done. The facilitated production processes were more often identified in the German than in the Polish plants. In turn, representatives of all Polish plants and of two German plants, agreed about the increased responsibility of the staff for the work done.

The objective of the study reported in **work no 2** was to identify problems and inconsistencies in the implementation of the HACCP system. It was assumed that better understanding of specific shortcomings and misunderstandings of the HACCP system may help the entities acting on the food market and consultants improve system effectiveness. Within continued cooperation with the German partners, a questionnaire survey was conducted regarding the HACCP system in 86 German and 66 Polish facilities that had implemented the system. The questionnaire referred to the 12 HACCP implementation steps according to the *Codex Alimentarius* (2009). The plants were recruited from different branches of the food sector.

Non-conformities and differences in HACCP system implementation were identified in both countries. One of the differences was the various number of technological schemes and groups of products selected during system implementation. The Polish plants specified less groups of products and made a lower number of technological schemes compared to the German plants. Representatives of the Polish plants declared 4-10 schemes in the HACCP system, whereas in Germany the respective number accounted for over 10. The high number of schemes and no division of products into groups with a similar risk or requiring a similar production process is against WHO recommendations (1999) and may decrease system effectiveness. For this reason, solutions observed in the German plants were found inappropriate. The second difference concerned the execution of hazard analysis (HA). The German plants identified a total of 184, whereas Polish plants – 74 hazards. In German plants, the biological and physical hazards represented 43% and 42% of all identified risks, respectively, whereas in Polish plants prevailing were the biological hazards (66%). In both countries, specification of biological hazards was imprecise and often insufficient to ensure proper preventive actions and monitoring the critical control points (CCPs). The CCPs established for biological hazards were correct. It may, therefore, be hypothesized that the CCPs did not actually result from the in-depth risk analysis but rather from intuitive knowledge about hazards. Completely different observations were made regarding risk assessment. The German plants usually applied the FMEA method and the likelihood x significance matrix (in Poland called ‘priority index’). In turn, the priority index and self-assessment predominated in the Polish plants.

Great discrepancies were found in the realization of the 2. principle of HACCP concerning identification of CCPs, and – to be more specific – in the number of determined CCPs. Although the same method of identification was used in both countries, i.e. a decision tree, the final numbers of identified CCPs varied, being higher in German than in Polish plants. For instance, in 36% (n=86) of the German plants the declared number of CCPs was over 10, e.g. 28, 32, 55, which may impair the appropriate control of hazards accordingly to *Codex Alimentarius* (2009). This non-conformity was not observed in the Polish plants. In-depth CCP analysis allowed concluding that in 27% (n=86) of the German plants the identified CCPs were inconsistent with the definition stipulated in *Codex Alimentarius* (2009). Similar mistakes did not occur in any of the Polish plants. The detailed analysis of elements of the HACCP system revealed another inconsistency. Namely, most of the representatives of the tested plants were incorrectly including GHP as an element of the HACCP system (85% in Poland and 69% in Germany). It was also incorrectly declared that the HACCP system consists of CP (Control Point) or from PRP (Prerequisite Programme) and OPRP (Operational Prerequisite Programme), in understanding of ISO 22000. Such declarations were made more frequently in the German than in the Polish plants.

Summary of accomplishing objective no 1 - Science-based analysis and assessment of the condition of food safety assurance in Polish and German plants

Representatives of Polish and German plants encountered similar problems with implementation of the HACCP system, but also noticed positive aspects of system implementation. Many similarities were identified in the group of non-financial benefits, and many differences – in the group of financial benefits. The analysis of food safety systems demonstrated that the systems implemented and functioning in both countries differed regarding realization of HACCP principles and non-conformities. The food safety systems functioning in Poland were scored higher than these implemented in Germany. It is due to a lower number of technological schemes elaborated, a lower and more feasible to control number of CCPs and correct identification of CCPs consistent with *Codex Alimentarius* (2009) in the Polish plants.

The revealed faults proved that the obligatory verification of the HACCP system is ineffective or that improper tools are applied for the assessment of system functioning. The mistakes may be due to the insufficient knowledge of the food safety systems, despite the

availability of multiple trainings, scientific articles for the general public, and expert guides. The EC Regulation no. 852/2004 is, however, imprecise when it comes to the obligatory trainings. It is the likely cause of the insufficient knowledge in the field of food safety and of the observed inconsistencies in the implementation and functioning of the HACCP system. Incorrect implementation and functioning of food safety systems fails to ensure complete health safety. Hence, it is necessary to develop science-based methods for the evaluation of food safety systems that would be useful in practice.

2. Development, application and verification of innovative research tools to be used in the evaluation of food safety systems and in risk assessment

Works no 3, no 4, and no 5:

No 3 - Trafiałek J., Kolanowski W., 2014. Application of Failure Mode and Effect Analysis (FMEA) for audit of HACCP system, Food Control, 44, 35–44.

No 4 - Trafiałek J., Laskowski W., Kolanowski W. 2015. The use of Kohonen's artificial neural networks for analyzing the results of HACCP system declarative survey. Food Control 51, 263-269.

No 5 - Trafiałek J., Kaczmarek S., Kolanowski W. 2016. The risk analysis of metallic foreign bodies in food products. Journal of Food Quality, 39, 398–407.

In **work no 3**, a method was proposed for the audit of the implemented and functioning HACCP system. It was hypothesized that the implementation of procedures based on HACCP principles does not ensure food safety. It was assumed that the assessment of the functioning HACCP system based on audit findings interpreted with the FMEA method might become a useful tool in identifying areas of the system being at a higher risk of food safety loss. The objective of the study reported in this work was to develop a method for HACCP system audit that would enable evaluation of its functioning in practice. Audits were carried out in two similar bakeries located in central Poland based on a two-part audit questionnaire. The first part referred to HACCP implementation, whereas the second one to system functioning in practice. An even-number scale was applied to evaluate the degree of meeting audit's criteria that contained the following scores: 2, 3, 4, 5, with 2 denoting that none of the criteria were met, and 5 that all criteria were fulfilled. It was assumed that only score 5 meant complete food safety assurance. The outcomes of the audits allowed conducing food safety risk

assessment. The risk was calculated using the FMEA method as a ratio of three coefficients: significance of audit criteria for food safety which reflected severity of the non-conformity effects (S), the frequency of the non-conformity occurrence based on audit evidence (O), and detectability of the non-conformity (D). Each coefficient was assigned value in the range from 1 to 10 and the relative risk index (R) was calculated from the formula: R = S x O x D. Precise guidelines were developed for estimating the significance (S), frequency (O) and non-conformity detection (D) values in the form of detailed tables. In spite of the fact that each step of HACCP implementation and each principle of the HACCP system are significant to the food safety, it was assumed that some of them, e.g. CCP monitoring, corrective actions and verification procedures, are of greater importance than the others. In compliance with *Codex Alimentarius* (2009), the preliminary stages of HACCP were assigned values from 1 to 5, HACCP principles were assigned values from 6 to 9, and the proper functioning of HACCP procedures was reflected in the value 10. The non-conformity frequency (O) was assigned the score from the audit, assuming that the higher the score, the lesser is the frequency of non-conformity. The non-conformity detection (D) was estimated as possibility of non-conformity detection in the system without the need for audit. The axis of food safety risk levels was elaborated. It was used to calculate the risk (R) in four risk categories: minor, moderate, high and critical, depending on the value.

Findings of audits carried out in bakery A and bakery B were presented as scores. The mean scores obtained demonstrated that, in both bakeries, the implementation and the functioning of the HACCP system did not ensure complete food safety, and that HACCP documentation was scored higher than system functioning in practice. The scores from audits were collected in a table and relevant values were assigned to the significance (S), occurrence (O), and possibility of detection (D) of non-conformity; afterwards the risk (R) was calculated based on the food safety risk axis.

The risk assessment analysis was conducted in two aspects: HACCP implementation and HACCP functioning in practice. It was found that in the aspect of HACCP implementation, food safety risk was moderate in both bakeries regarding only principle 6. - establishment of verification procedures. Auditor reservations concerned the wrong choice of verification methods, inadequate frequency of planned verifications, lack of real control of the process being monitored and disregard of the calibration of the instrumentation used for CCP monitoring during verification. Other aspects of HACCP implementation in both bakeries were characterized by minor risk.

The functioning of HACCP principles in practice was characterized by a higher risk posed to food safety than the implementation. In bakery A, a critical risk was established in two areas of HACCP functioning: verification and recordkeeping, and a high risk – in corrective actions. In the second audited bakery (bakery B), none of the evaluated areas was at critical risk, however a high risk was estimated for system verification. The manuscript provides description of exemplary non-conformities and auditor's reservations.

In this work, we developed a concept of food safety risk assessment, that may be used in practice by various plants of the food sector. The proposed audit questionnaire associated with FMEA analysis of audit findings turned out to be a precise method for the food safety system evaluation. It was estimated that the greatest risk to food safety was posed by verification procedures, HACCP recordkeeping and corrective actions. Identification of elements of the HACCP system posing high risk to food safety is of great practical significance and may indicate areas requiring special surveillance.

The aim of the study described in **work no 4** was to apply Kohonen artificial neural networks (ANNs) for the analysis HACCP system-related data declared by representatives of the analyzed enterprises and for the assessment of food safety assurance systems. Use was made of results of investigations conducted in Polish enterprises during accomplishment of a project with German partners, and then ANNs were used to find common opinions about selected elements of the HACCP system.

The first analysis of results with ANNs was conducted in relation to the incorrect identification of HACCP system elements (work no 2). The artificial neural networks allowed proving the incorrect classification of these elements. It was found that in the opinion of the representatives of most of the surveyed food operators, the HACCP system consists of the Critical Control Points (CCPs), which is a correct element of the system, as well as other elements that do not underlie the principles of the HACCP system. Among these, the highest number of respondents declared that the elements of HACCP system included together GHP, CP and CCP (28 out of 66), followed by CCP and GHP (17 out of 66). These results showed confusion in understanding the food safety system, despite exhaustive approach to HACCP issues provided in ample literature works (*Codex Alimentarius*, 2009; Mortimore and Wallace, 2013).

Another analysis with the use of Kohonen artificial neural networks was applied for HACCP system verification. Many methods of system verification are applied in practice and results obtained in the survey showed that the largest group of businesses declared frequent internal audits (76%), review of complaints (68%) and checking the documentation (60%).

Much less common were microbial tests, external audits, and other methods. The application of ANNs allowed concluding that the surveyed enterprises did not use exclusively one method of verification, but were coupling two or even three methods to this end. Two of the most frequently listed coupled methods included internal audits and review of complaints, whereas three methods applied together usually included: internal audits, review of complaints, and documentation checking. Even these enterprises which did not conduct internal audits, declared using more than one verification method, usually: review of complaints and document checking.

Another analysis involving the Kohonen ANNs was used to identify difficulties in the implementation and functioning of the HACCP system as well as to establish positive outcomes of its implementation. The most frequently declared difficulties included the necessity of introducing organizational changes (45.3%) and of investing (34.3%). In the case of the positive outcomes of HACCP implementation, in opinions of almost all surveyed persons, the implementation of the HACCP system resulted in the assurance of food products safety (84.3%), followed by improved skills (57.8%) and responsibility of the staff (42.0%). Using the Kohonen artificial neural networks, an attempt was undertaken to determine difficulties and benefits that usually appeared together. It was impossible to separate the common groups of difficulties and groups of positive outcomes of system implementation, declared by the surveyed representative of enterprises. It points to individual opinions held by study participants regarding the HACCP system.

The Kohonen ANNs turned out to be a useful statistical tool for analyzing the results from the questionnaire survey and for evaluating the applied food safety systems. Among satisfactory findings there should be considered declarations of using more than one method for HACCP principles verification by the majority of the surveyed businesses. However, highly dissatisfactory turned out to be the misunderstanding of issues related to the Good Hygiene Practices and Control Points as part of the HACCP system. Results obtained in this study are of practical significance to coaches, trainers and consultants, as they may affect development of training programs for the staff of the food sector.

Work no 5 presents results of the risk analysis linked with the occurrence of metallic foreign bodies in food products. The available literature lacks works addressing the risk analysis as understood based on the EU Regulation 178/2002 and *Codex Alimentarius* (2009), regarding physical hazards in a selected food processing plant using the FMEA method. A decision about undertaking a study on the likely occurrence of metallic foreign bodies in food products was made considering the lack of relevant exhaustive and science-based reports from

the food quality control area. In turn, these issues are relatively often addressed in medical manuscripts in terms of the negative health outcomes to consumers, children in particular (Rimell et al., 1995; Waltzman, 2006; Cutajar et al., 2011). The study was aimed at developing and validating the risk analysis procedure of metallic foreign bodies occurrence in food in a selected food processing plant. The food processing enterprise selected for this study dealt mainly with packaging cereal products (cereals, dried fruits, vegetables, nuts, flakes), owing to the frequent occurrence of foreign bodies in products of this type (European Commission, 2015). It was a medium-size enterprise located in central Poland. The study was conducted for 4 months and consisted in the identification of foreign bodies with a Cassel Metal Shark metal detector (Cassel Messtechnik GmbH, Germany). Based on results collected and considering the specific character of enterprise activity, a complex risk analysis procedure of foreign bodies occurrence was developed. Risk analysis components, as provisioned in the EC Regulation 178/2002 were taken into account as well.

The FMEA method was selected for risk assessment and management. Three parameters were estimated, as described in work no 3. The risk analysis was performed for each stage of the production process according to the scheme presented in the manuscript and for all raw materials incoming to the plant. Risk assessment was made using a specially designed form containing name of stage / raw materials / packages, identified risks, methods of control and risk assessment. To determine the level of risk, an adequate, specially developed risk matrix was used. The risk matrix defined the risk depending on the obtained value, i.e. very low, low, medium, high and very high. For each of these risk levels adequate corrective actions were indicated. Within 4 months of the study, a total of 37 foreign bodies of various sizes were identified, namely from 5 mm – like e.g. metal beads to 15-70 mm – like e.g. pieces of wire and hairclips.

During validation of the risk analysis procedure in the food processing plant, the risk was assessed as “medium” in two particular stages of the production process, i.e. reception of raw materials by the plant, as well as packaging into retail packages units. The high risk of finished food products contamination was identified in the case of raw materials received by the plant. The most contaminated raw materials included cereal products like: oat flakes, buckwheat groats, oat bran, linseed, millet, red rice, tropical müsli, followed by dried fruits, like: raisins, figs, goji berries, prunes, and dates. Foreign bodies were identified in particular raw materials with various frequency. In each month, they were most frequently identified in dried prunes imported from the USA and in domestic buckwheat groats. They appeared less

frequently in brown cane sugar, linseeds from Kazakhstan and in tropical müsli, half of which was imported from Germany.

When implementing the risk analysis procedure in the plant, risk management methods were established and risk communication strategy in the plant was developed.

The handling procedure presented in the manuscript is a ready-to-use tool to be applied in various enterprises of the food sector where the risk of metallic foreign bodies occurrence in finished products is high. The development of the concept and validation of the tool for risk assessment is a pioneer solution that has so far been unreported in the respective literature. The proposed tool may encourage food producers to conduct risk analysis, and its practical application will contribute to increasing the safety of food products.

Summary of accomplishing objective no 2 – Development, application and verification of innovative research tools to be used in the evaluation of food safety systems and in risk assessment

In the above-presented works, there were developed, implemented and presented innovative tools for the assessment of food safety systems and for risk assessment. The food safety risk assessment was conducted based on the FMEA method, whereas food safety assurance systems were evaluated using Kohonen artificial neural networks.

The concept of applying the FMEA method for the assessment of food safety risk linked with the functioning of food safety systems was validated in selected and functioning enterprises, which enabled practical evaluation of the systems applied. Its use may contribute to the repair of system elements that pose risk to the food safety.

The use of Kohonen artificial neural networks allowed for extensive and in-depth analysis of results of questionnaire surveys and for the evaluation of system-based assurance of food safety. The Kohonen's networks may be successfully applied for audits of food safety systems based on data collected by various institutions and interested entities. Their application affords the possibility of diagnosing difficulties in implementation and non-conformities in the functioning of the HACCP system in plants, including both those occurring alone and jointly. Similar effects may be achieved regarding the outcomes of system principles implementation.

The development and implementation of the risk assessment and risk management methods in an enterprise, as components of the complex risk analysis, are of practical value

and may initiate decisions concerning food safety at many fields of enterprise activity. The presented risk assessment provided evidence that enables making decisions which affect the safety of products regarding the reception of raw materials and functioning of two production processes.

Summary of the Main Scientific Achievement

Considering my application for the degree of Philosophy Doctor with Habilitation in Agricultural Sciences (according to Art. 16 pt. 2 of the Act of 14 March 2003 on scientific degrees and a scientific title, and on degrees and title of Arts (Journal of Laws no. 65, item 595 with amendments), my Main Scientific Achievement includes a cycle of five research works addressing multi-oriented studies and evaluation of the system-based assurance of food safety.

Results of my studies demonstrated that multiple changes have been introduced in Polish production plants after Poland's accession to the European Union in order to comply with its legal regulations. The presented works provided a multi-aspect analysis of food safety systems, difficulties in development of HACCP-based procedures as well as benefits extended after their implementation. Investigations conducted so far regarding food safety systems (Konecka-Matyjek et al., 2005; Morkis, 2010; Main Sanitary Inspectorate, 2015) were mainly presenting the status of HACCP system implementation in Poland and some related issues, e.g. difficulties in elaborating the HACCP system or benefits from its implementation. No works have, however, been published that would present results of comparative analyses of food safety systems functioning in Poland and in other countries, e.g. in Germany. There are no publications that would depict differences in the implementation of HACCP system principles in Polish and German enterprises. Results of my studies demonstrated the common misunderstanding of the food safety system and diverse accomplishment of HACCP system principles.

The investigations have demonstrated that the implemented food safety systems require continuous upgrading as well as regular assessment and analysis with using appropriate tools. For this reason, innovative tools and methods were proposed that would enable the analysis and evaluation of the system-based assurance of food safety as well as food safety risk assessment. Their use in practice may effectively contribute to the improvement of the safety of both food products and consumer health.

Apart from the cognitive values, results of the multi-stage investigations may also be found innovative owing to the application of so far non-used methods for food safety systems assessment. Use was made of methods and tools for statistical calculation that have never been applied in food technology and nutrition discipline. These tools allowed for in-depth analysis and evaluation of the implementation of food safety systems. Considering that implementation of the HACCP system is obligatory and that no integrated actions have been planned to enable its evaluation, the methods for the analysis and assessment of food safety systems presented in my works provide a significant contribution into the science and practice.

Food safety systems were analyzed with the use of tools usually applied in other research disciplines, e.g. in social surveys (FMEA analysis) or medical studies (neural networks). These analyses allowed identification of areas that pose risk the health safety of consumers and that deserve special attention. Study results obtained are consistent with guidelines of EC Regulation no. 178/2002 and provide science-based evidence for the reliable, unbiased and transparent risk assessment as part of the evaluation of the system-based food safety assurance.

The presented tools for risk assessment are of practical significance, universal and may be exploited in any enterprise. Upon using them, participants of the food sector will have to possibility of obtaining individual results being dependent on the enterprise-specific factors like knowledge and engagement of the staff and the level of the elaborated system documentation. These tools may be modified by potential users as needed. Their application will enable risk assessment and evaluation of food safety assurance systems, thereby leading to the real improvement of the functioning of the weakest areas of the food safety systems applied.

Statements

1. Comparative analysis and assessment of the level of food safety assurance in Polish and German enterprises pointed to many drawbacks resulting from misunderstanding and wrong interpretation of the binding principles. Special attention should be paid to the verification of food safety systems functioning.
2. Considering the identified non-conformities in the implementation and functioning of food safety systems, it is indispensable to apply tools for the assessment of risk and food safety

assurance systems, which will ensure both the effectiveness of these systems and consumer health protection.

3. Concepts were developed and verified regarding the use of innovative tools in the assessment of risk linked with the functioning of food safety systems and system-based assurance of food safety with the use of Kohonen artificial neural networks and Failure Mode and Effect Analysis method.

Conclusions

1. The system-based assurance of health safety in food producing facilities should be subject to regular evaluation using verified tools for risk assessment of the functioning systems.
2. FMEA method (Failure Mode and Effect Analysis) and application of Kohonen artificial neural networks are useful tool for assessment of system-based assurance of food safety.

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III. PRESENTATION OF OTHER SCIENTIFIC AND RESEARCH ACHIEVEMENTS

Research issues that I have been undertaking since the beginning of my scientific and research carrier are mainly focused on food safety and, to be more specific, on implementation and application of principles of Good Hygienic Practice, Good Production Practice, principles of the HACCP system, as well as food quality and food safety management systems including mainly the Food Safety Management System consistent with ISO standard of the 22000 series. I am an author or co-author of scientific manuscripts, chapters in monographs and in an academic course book addressing these research areas. My research carrier was supported by over 10-year professional experience gained in many enterprises and institutions before and during my employment at the Warsaw University of Life Sciences as well as during many trainings I had a chance to attend.

The vast area of investigations I have been conducting so far in a research group headed by prof. dr hab. Danuta Kołożyn-Krajewska, may be divided into a few thematic groups:

1. **Implementation and functioning of food safety assurance systems;**
2. **Food and nutrition hygiene;**
3. **Audits as a verification tool of food safety assurance systems.**

The most significant studies and modes of their documentation were presented based on the list of published works (Appendix 5).

Ad. 1. Implementation and functioning of food safety assurance systems

An especially important research area in my scientific activity covers the issues linked with food safety assurance and implementation of obligatory procedures based on the principles of the HACCP system. Significant transformation was observed in the years 2001 – 2004 in the Polish food law that has led to its harmonization with EU legal regulations, in particular regarding food safety and implementation of the principles of the HACCP system. Despite exhaustive literature available in this respect, it was a peculiar novelty to the Polish entrepreneurs and only sparse works presented results depicting the state of its implementation in enterprises. The most significant findings from studies conducted in this research area were presented in the cycle of works constituting my Main Scientific Achievement. The remaining results from studies addressing these issues were provided in many scientific manuscripts and conference communications which I co-authored (Appendix 5 - works A3, B1-8, B13, D1, D4-5, E1-2, E5, E7).

In 2004, 60% of large enterprises were meeting HACCP requirements, whereas in the case of medium and small enterprises the extent of HACCP implementation was unsatisfactory. The HACCP system was implemented in 16% of small and in 34% of medium enterprises. In spite of the fact that one year after Poland's accession to the European Union the situation was considerably improved and the system had been implemented in 26% and 52% of small and medium enterprises, respectively, the process of food safety assurance was still incomplete (Works B1-5, B8, D1, E5). The extent of HACCP system implementation in retail stores was at a similar level, although investigations were carried out 4 years later than in production plants (Work D4). Seven years since the HACCP principles had become obligatory, the system was implemented in majority of the enterprises that were highly satisfied of the outcomes of system implementation (Work E5). In my multi-aspect surveys concerning HACCP implementation, I identified factors that were determining its implementation, namely: size of the enterprise, implementation of Good Production Practice and Good Hygienic Practice, implementation of quality management systems, training for the staff, knowledge of the food law and of the possibilities of getting financial support for implementation activities (Works B6, B8, D1, D4).

Enterprises of the food sector had to not only implement HACCP principles but also to modernize their buildings in order to complete the process of preliminary conditions implementation, i.e. Good Hygienic Practice and Good Production Practice. In my studies, I identified areas of the Polish food processing plants that required modernization for the need

of implementing the HACCP system (Works B5 and B7). These areas were identified in two periods of the study, namely before and after Poland's accession to the European Union. Study results demonstrated that before the accession the most significant changes were necessary regarding the sanitary status of the plants, whereas after the accession – such a need was declared by a significantly fewer number of entrepreneurs. In the opinion of study participants, after Poland's accession to the EU, necessary changes had to be made regarding modernization of air-condition systems, while this was not so needed before the accession (Work B7). The greatest need for modernization was declared by representatives of medium-sized meat processing plants (Work B5). In another work, I compared systems of meal distribution in a hospital considering economic concerns and functional design of the object (Work A3). The research addressed in this work was aimed at analyzing two systems of dishes distribution: tray and bain-marie (water bath). Based on the analysis of organizational and economic factors of the hospital designed for 600 patients, it was concluded that the tray system of distribution should be found recommendable.

Very significant issues undertaken in my research activities were related to the identification of problems encountered during HACCP implementation. Their identification was supposed to contribute to the better learning of the situation of Polish enterprises during implementation works. I demonstrated that employees involved in the process of HACCP system implementation encountered many difficulties while developing HACCP-based procedures, with the most common including: modernization of plant buildings resulting from the necessity of their adjustment to legal regulations, financial outputs, and misunderstanding of the idea of the HACCP system (Work B5).

The knowledge about the status of HACCP implementation was completed by the analysis of benefits from the implementation observed by the enterprises and their classification. I demonstrated that despite difficulties in HACCP implementation, the system extended many benefits to the enterprises (Works B8, E1-2). In the context of food safety, the key one included improvement of products safety. Many observed benefits were linked to the changes in employees engagement and to their improved qualifications. HACCP implementation was also significant from the economic perspective as it allowed the enterprises to stay on the market, to increase their prestige, and to make their offer competitive to other domestic or foreign products. The perception of benefits from food safety systems implementation was different among representatives of retail stores. The main difference concerned food safety, as only 30% of the stores reported improvement in this respect (Work D4).

It is also crucial to prepare appropriate documentation of food safety systems. It was demonstrated that the necessity of keeping documentation was underestimated and misunderstood. Hence, I have proposed several solutions regarding documentation of this type in my few works (Works D5, E7 and E4 from the third thematic group) and I have noticed a ceaseless need for generally-available articles presenting practical solutions.

Quality and safety systems of food production between food industry plants and catering establishments was compared in the work B13, specifying differences in the system approach to the aspects of food safety and quality. In catering establishments implementing systems to the same extent as in the food industry is difficult due to the specificity of work in catering. Implemented systems are mainly GHP, GMP and HACCP. Large gastronomic and catering firms dedicate more attention to ensuring and managing the quality and safety of food. The practical aspect of the study means that it presents opportunities of food quality and safety improvement in catering as a result of collaborating with food industry companies.

Ad 2. Food and nutrition hygiene

A considerable part of my scientific achievements is devoted to the aspects of food and nutrition hygiene. Results of investigations addressing these issues are presented in works: A1, A2, A4, B9, B11, B12, C1, C2, E6, and E8-10.

A special role in food contamination is ascribed to the staff taking part in the production process or distribution of foods and to the level of their knowledge regarding hygiene issues. A study was designed and conducted that allowed verifying the level of staff knowledge before and after training, and respective results were provided in work A1. This research was aimed at analyzing the effectiveness of staff training in a catering company with implemented food safety management system pursuant to ISO standard of the 22000 series measured based on the coefficient of knowledge increase. Results obtained allowed estimating the risk of making mistakes by employees during fulfilling their on-the-job duties, caused by the insufficient mastering the knowledge introduced at the training. It was demonstrated that the acceptable risk of employee mistakes concerned exclusively those hired as cooks. Significant correlations were confirmed between the level of knowledge gain and position held at the company. The risk assessment turned out to be a useful tool to analyze staff training effectiveness. It was proved that staff trainings played a significant role in the upskilling of the catering employees and in minimizing the risk of their making mistakes.

Results described in this work are consistent with recommendations provisioned in *Codex Alimentarius* (2009) and ISO standard of the 22000 series.

The objective of the study described in work E8 was to compare the knowledge of employees of selected catering enterprises regarding food hygiene. The survey was made in 2012 in Poland and in the United States using individual interviews. Results obtained allowed concluding that most of the employees surveyed in Poland and in the USA underwent appropriate training in terms of hygiene principles (82% in the USA and 76% in Poland), however not all of them, in both countries, were using them in practice. It was found that 18% of the surveyed employees in Poland and 30% in the USA did not apply the principles of hygiene in everyday work with food. During work involving contacts with food, they employees washed their hands with a similar frequency, i.e. ca. 5 times a day and temporarily when needed (84% in Poland and 78% in the USA). The pathogenic bacteria reported in Poland included: *E. coli* bacteria, *Staphylococcus aureus*, *Clostridium botulinum*, and *Salmonella*, whereas in the USA: *Salmonella* and *Shigella.* In respect of keeping the hygienic principles obligatory for each staff member, it was demonstrated that in Poland this situation was more satisfactory, e.g. more employees (80%) were taking their jewellery off before work than in the USA (56%). In turn, production equipment was scored similarly in both countries. In the opinion of study participants, the equipment was evaluated as good (72% in Poland and 66% of enterprises in the USA). However, the knowledge of and the practical use of the HACCP system were greater in the USA (74%) than in Poland (56%).

While continuing investigations on the use of hygiene principles, an analysis was carried out with the inspection method to determine compliance with hygiene principles in fish stands during distribution of fish and fish products (Work A4). To this end, a special inspection form was developed that was used in the assessment of 100 selected retail shops. The form enabled detailed evaluation of hygienic requirements collected in three blocks of questions: 1. hygiene of distribution processes, 2. hygiene of personnel, and 3. hygienic conditions at the stand. The survey demonstrated that the level of hygiene at fish sale stands was low. The greatest compliance with hygienic standards was observed in the sector of distribution processes hygiene (44%), and lesser one in the sector of personnel hygiene (18%), and hygienic conditions at the stands (23%). Statistical calculations proved that the location of a retail shop and its type did not affect the level of compliance with hygienic standards.

The key reason behind non-conformities reported in different studies could be insufficient knowledge of the employees regarding food safety, production hygiene and practices, which was demonstrated in the research presented in work B11. Not all surveyed employees hired in

the catering enterprises were found to know e.g. optimal temperature of bacteria growth and development or sources of bacteria in the finished products. Gaps in employees knowledge may result in contamination of finished products and in food poisonings. In another work, namely a chapter in an academic course book, I described requirements for catering enterprises in the context of food safety considering the contemporary food law (Work E9). In addition, I presented a list of exemplary documents concerning Goody Hygienic Practice, Good Production Practice and HACCP system principles most often elaborated for the enterprises of this type.

A significant part of my research work was focused on nutrition hygiene linked with the adverse carcinogenic substances, owing to their increased prevalence in the natural environment and in food. In several works, I presented issues concerning selected compounds and I undertook attempts of risk analysis of their negative impact on human health. In the study reported in work C1, I focused on one group of such compounds, i.e. heterocyclic aromatic amines. A man is exposed to frequent intake of these compounds, because amines are synthesized during heating high-protein products. Amine uptake risk from the most often consumed product, i.e. pork meat, was determined. A useful method was developed that enabled identifying the group at risk of the development of carcinogenic lesions induced by the intake of heterocyclic amines from heat-treated pork meat. This method is based on a risk analysis procedure. The applied procedure revealed that the greatest likelihood of heterocyclic amines penetration to a human body resulted from meat quality and technology of its processing (grilling, frying, use of seasonings, pre-treatment). The exposure to risk may be minimized and, hence, respective methods were postulated. In turn, work A2 provided a summary of and emphasized the significance of different factors contributing to the synthesis of carcinogenic substances during heat treatment of meat and fish. Ample epidemiological surveys, meta-analyses and clinical trials demonstrated that the high intake of meat (especially red meat and processed meat) was positively correlated with the increased risk of cancer development, colorectal cancer in particular. Discussion held in this work included various detrimental factors, like: nitrogen compounds, heterocyclic amines, and polycyclic aromatic hydrocarbons. It was concluded that risk assessment should involve many factors: type of meat, temperature and methods of processing (including meat turning, seasonings applied and brining), degree of frying, formation of aromatic skin, use of gravy, the size of ingested food portion, consumption of meat and vegetables, etc. Depending on the variant and intensity, these factors may differently affect the synthesis of harmful substances, which was depicted in a table presented in this work. The table shows that the risk of cancer development

may be classified as very low or very high, and should be estimated in relation to a specified meat-type meal. It was concluded that the risk of exposure to neoplasmic diseases was different for each consumer depending on his/her dietary habits and on meat treatment method.

Further investigations addressing neoplasmic lesions led to the development of a rapid method for the assessment of risk of exposure to carcinogenic substances associated with meat (Work C2). The main assumption was the simplicity of method application by an individual consumer. The method was based on the designed formula that included factors involved in the synthesis of carcinogenic compounds and linked with meat processing. The formula allows computing the so-called Meat Carcinogenicity Index (MCI), which enables determining the number value of hazard category. This method may be utile in each family and may lead to reduced intake of meat containing carcinogenic compounds, thus minimizing the risk of cancer development.

In the food production process, increasingly often use is made of the so-called combined methods involving biopreserving agents. Bacteriocins represent a numerous group of compounds produced by Gram-positive and Gram-negative bacteria that are capable of inactivating or inhibiting the growth of other microorganisms. Work B9 presents the characteristics of bacteriocins, short descriptions of their particular classes, and their applications in the food industry.

The objective of the study reported in work E6 was to discuss the quality of regional and traditional food products as perceived by consumers. Most of the respondents declared the knowledge of the terms “regional product” and “traditional product”. In the case of these products, the key reason behind purchase decisions of the respondents was the willingness of trying a new product. In consumers’ opinion, the quality of regional and traditional food products was mainly linked with freshness (as declared by 78% of the consumers), lack of chemical additives (53%), and flavor (50%). Study results demonstrated that the growing interest of consumers in regional and traditional food products resulted from the search for unique high-quality products with exceptional sensory values.

Work E10 presented the MOST Project, the final stage of which included development and dissemination of Procedures for Minimization of Food Losses and Food Waste with Benefits to the Society (MOST procedure). It was linked with generally-observed waste of food products, most of which would be still suitable for consumption. The work presented the MOST procedure which provides the method for establishing and validation of food Recovery Points (RP) intended for social purposes. These points are validated with the

use of the adapted FMEA method, which for the needs of this project was called the FMEA-RP method. The adaptation of the FMEA-RP system consists in the selection of components being typical of the food wasting process, like: possibility of hazard detection in a plant, possibility of product management by public benefit organizations, and preservation of products quality till consumption.

The objective of the research study (B12) was to assess, on the basis of the authors' own research and the GUS (*Central Statistical Office in Poland*) data, the use of microwave ovens by Polish consumers. The questionnaire survey was conducted on a random sample of 250 respondents. A significant increase was found in the number of households in Poland equipped with microwave ovens. A major percentage of respondents (46 %) used microwave ovens on a daily basis or several times a week, mainly to heat food (73.2 %) or, less frequently, to defrost and cook. Primarily, main course dishes and appetizers were prepared in the microwave ovens, whereas soups and desserts were made significantly less frequently. The type of the prepared dishes depended significantly on the age and education of the respondents; though, the respondents' place of residence had no impact on it. The largest group of respondents rated the quality of the prepared food as good or average, and the taste of dishes as worse than that of the traditionally prepared dishes. The vast majority of respondents (73.6 %) considered the microwave oven as being safe for health. A small percentage of respondents feared radiation and the risk of developing cancer diseases.

Ad 3. Audits as a verification tool of food safety assurance systems

During my research carrier, I have also conducted studies regarding the effectiveness of food safety systems. In work E3, I presented verification methods, including the frequently applied method of internal audit. Apart from the work being part of the Main Scientific Achievement, I published also other manuscripts presenting results of surveys conducted with the use of the internal audit method: A5, B10, D2, D3, E4. Results of all these works indicate that the effectiveness of food safety systems may be impaired as a result of non-conformities in the elaboration and in the everyday functioning of systems as well as insufficient knowledge of the staff.

Work E3 provides an overview of verification methods most commonly applied in Polish enterprises from the food sector in comparison to methods applied in Germany. In German enterprises, the verification procedures were used more frequently than in the Polish ones in

spite of the fact that not all German plants declared its regular conduct. In Polish enterprises, the most frequently mentioned methods of verification included internal audits and microbiological analyses. In turn, apart from these methods, the German plants used also other methods of verification like best-before tests and review of complaints.

In works D2, D3, E4 and A5, I reported on results of food safety system audits. For instance, in work D2 I analyzed non-conformities of the HACCP system detected during audits conducted in two mass catering facilities and two production plants, and made an attempt of their evaluation regarding their impact on consumer health. The following techniques of the audit survey were used as research methods: analysis of documentation and current records, inspections of the production process, visual observations of employees, assessment of the compliance of the production process with system documentation, and interviews with the staff. These audits allowed identifying many non-conformities linked to critical limits, CCPs monitoring, corrective actions, documentation, and system verification. For each noted non-conformity, the risk of its adverse impact on consumer health was computed using the FMEA method. The identified non-conformities were found to pose various risks on consumer health. The unacceptable risk concerned critical limits, CCPs monitoring, corrective actions, and HACCP system verification.

The objective of the study presented in work D3 was to evaluate documentation of a safety system for dishes manufactured in catering units of selected hospitals and nursery schools based on outcomes of audits. The audits were aimed at demonstrating whether the implemented HACCP system is complete and whether it is applied in practice accordingly to the developed plan. The study material included documentation from catering units of three selected hospitals and three selected nursery schools. Audits were conducted based on the overview and analysis of documents, i.e. HACCP Record Book, system documentation, reports from activities including from the production process starting from the reception of raw materials, through storage, production and to expedition of ready meals. Only in one out of the six audited units, no reservations were made as to the development and functioning of the HACCP system. One of the audited hospitals, received a very negative score. In all nursery schools and in one hospital, the lowest scores were given to Critical Control Points monitoring and system verification. Although procedures of HACCP system monitoring had been elaborated and implemented in these facilities, their employees did not know how to monitor selected parameters or did not apply monitoring procedures with the established frequency. Monitoring cards lacked systematic records, operational recordkeeping by employees was not verified, and the functioning of the HACCP system was not audited.

Work E4 presents results of verification of Good Practices and HACCP system conducted via audit procedures made in a sanatorium kitchen additionally providing external catering services and in a sanatorium café visited by persons from outside the sanatorium. Audit results were categorized as non-conformities or observations, and corrective actions were proposed for the identified non-conformities. The latter had a great impact on health safety of the manufactured products and occurred both during accomplishment of Good Hygiene / Production Practice and HACCP procedures. The work contained a report from the audit as an example of completing audit documentation.

The study described in work A5 was aimed at evaluating the food safety systems in 20 non-certified facilities and 20 facilities with certificates of any private standard or e.g. ISO 9001, ISO 22000, BRC, or IFS standard. These facilities were from 4 sectors: meat processing, catering, fruit and vegetable processing, and beverage production. They were assessed via audits and results of these audits were subjected to a statistical analysis with the Spearman's test and multi-way cluster analysis. The general assessment of HACCP principles in the certified facilities was better than in the non-certified ones which received worse scores in audits. In each analyzed sector, the implementation and functioning of HACCP principles were better evaluated in the certified facilities than in the non-certified ones. However, only in the meat processing and beverage production sectors were the mean scores from audits in the certified facilities significantly higher than in the non-certified ones. The type of sector had no effect on better audit scores. The functioning of HACCP principles was significantly poorer than their implementation in both groups of facilities.

In work B10, I presented the degree of compliance with hygienic principles in catering facilities producing foods in the presence of a consumer. The assessment was made with the audit method in facilities located in Poland and other countries, namely: Germany (Bavaria and Hesse), Austria, China (Taiwan), and the United States of America (New York). Member States of the EU as well as the USA take great care of consumer health and food safety, whereas in other regions of the world, e.g. in Asia, the HACCP system is not obligatory and had been implemented in a few facilities only. Multiple non-conformities were observed in all assessed catering facilities, regardless of cultural differences and binding legal regulations. They concerned mainly the area of personnel hygiene (hands, head) as well as hygiene of production rooms and of food production process. The following drawbacks were found: incorrect functional design of rooms, and no separation into the clean and unclean zones of work. Many mistakes were demonstrated regarding personnel hygiene. The greatest number of non-conformities was identified in the catering facilities in Taiwan, and the least number in

the German ones. In Polish facilities, there was an insignificantly higher number of non-conformities than in Bavaria and significantly less than in the USA. No compliance with the principles of hygiene in catering facilities is commonly occurring worldwide.

IV. SUMMARY OF THE SCIENTIFIC ACTIVITY

Publication record including number of points acc. to MNiSW's journal rank and to *Impact Factor* values was presented in the table below.

No.	Publication	Number of publications		Points acc. to MNiSW[a]	IF (from the year of publishing)		IF (5-year)		Total points [b]
		Before PhD	After PhD	assigned to one publication	Publi-cation	Total IF	Publi-cation	Total IF	
A. Publications in scientific journals with the *Impact Factor* (IF), and indexed in the *Journal Citation Reports* (JCR)									
1.	Food Control	0	3	35	2,806	8,418	3,085	9,255	105
2.	Fleischwirtschaft	0	1	13	0,127	0,127	0,096	0,096	13
3.	Journal of Food Quality	0	1	20	0,838	0,838	0,938	0,938	20
4.	British Food Journal	0	2	20	0,973	1,946	1,308	2,616	40
5.	Żywność. Nauka. Technologia. Jakość	0	2	15	0,311	0,622	0,295	0,59	30
6.	International Journal of Food Sciences and Nutrition	0	1	20	1,206	1,206	1,315	1,315	20
	Total	**0**	**10**	**-**	**-**	**13.157**	**-**	**14.81**	**228**
B. Publications in scientific journal without the *Impact Factor*, included in the B List of MNiSW' journal rank									
1.	Food. Science. Technology. Quality	2	0	4	-	-	-	-	8
2.	Food. Science. Technology. Quality	0	2	13	-	-	-	-	26
3.	Food Industry	2	0	4	-	-	-	-	8
4.	Food Industry	1	0	6	-	-	-	-	6
5.	Food Industry	0	2	12	-	-	-	-	24
6.	Quality Management	0	1	2	-	-	-	-	2

7.	Polish Journal of Food and Nutrition Science	1	0	9	-	-	-	-	9
8.	Polish Journal of Food and Nutrition Science	0	1	8	-	-	-	-	8
9.	Progress Technology Food Processing	0	1	6	-	-	-	-	6
Total		**6**	**7**	-	-	-	-	-	**97**
C. Original research works published in English in other international scientific journals									
1.	Fleischwirtschaft International	0	1	4	0	0	0	0	4
2.	International Journal of Clinical Nutrition & Dietetics	0	1	4	0	0	0	0	4
Total		**0**	**2**	-	-	-	-	-	**8**
D. Chapters in scientific monographs									
1.	Research works published in English as chapters in a monograph	1	4	5	0	0	0	0	25
2.	Research works published in Polish as chapters in a monograph	1	8	4	0	0	0	0	36
Total		**2**	**12**	-	-	-	-	-	**61**
E. Chapters published in Polish in academic course books									
1.	Chapter	0	1	0	0	0	0	0	0
Total		**0**	**1**	-	-	-	-	-	**0**
F. Publications in conference materials not indexed in Web of Science									
1.	In the form of abstracts, in Polish	2	1	-	-	-	-	-	-
2.	In the form of abstracts, in English / German	2	5	-	-	-	-	-	-
Total		**4**	**6**	-	-	-	-	-	**0**
G. Scientific articles for the general public									
1.	Safety and Food Hygiene	17	7	-	-	-		-	-
2.	Europuls	5	0	-	-	-		-	-
3.	Biuletyn DDD	7	0	-	-	-		-	-
4.	Coutry of tomorrow	2	0	-	-	-		-	-
5.	Kaleidoscope of Meat	1	0	-	-	-		-	-
6.	Hygiene of Pest Control	0	1	-	-	-		-	-
7.	Baking	0	1	-	-	-		-	-
Total		**32**	**9**	-	-	-	-	-	0

Summary					
Publications in total	**91**	Total points	**IF (from the year of publishing)** **13.157**	**IF (5-year)** **14.81**	**Total points 394**

a) Number of points according to Ministry of Science and Higher Education (MNiSW) journal rank assigned to a publication based on:
1. Standardized journal rank from the MNiSW website (2007-2010)
2. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 20 December 2012
3. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 17 December 2013
4. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 31 December 2014 (with amendments from the 19 December 2015)
5. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 23 December 2015
6. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 9 December 2016
7. Announcement of the Minister of Science and Higher Education on the list of scientific journals of the 26 January 2017

b) Total points acc. to the Ministry of Science and Higher Education journal rank multiplied by the appropriate number of publications

My scientific achievements cover in total **91** works, including **10** research manuscripts published in journals indexed in the *Journal Citation Report* (JCR) in the years 2010-2017. The remaining achievements include:

- 13 manuscripts published in domestic journals without the IF and included in the B List of MNiSW journal rank,
- 2 articles published in English in other international journals,
- 14 chapters published in English and in Polish in scientific monographs,
- 1 chapter in an academic course book,
- 10 publications in the form of abstracts in conference materials,
- 41 scientific articles for the general public.

The total number of points for publications acc. to MNiSW's journal rank (acc. to the year of publishing) is **394 points,** including **138 points and IF 9.383** for works constituting the Main Scientific Achievement for Habilitation procedure.

The total IF acc. to JCR (acc. to the year of publishing) is **13.157,** and the 5-year IF acc. to JCR is **14.81.**

According to the ICI Web of Science database the number of cites accounts for 22 (without self-cites for 15), and according to Scopus database – for 21. The Hirsch Index acc. to the ICI Web of Science database is 4.

Joanna Trafiałek