POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES

www.pan.olsztyn.pl/journal/
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Pol. J. Food Nutr. Sci.
2007, Vol. 57, No. 4(A), pp. 169-173

MICROBIOLOGICAL RISK ASSESSMENT IN THE FOOD CHAIN BASED ON THE EXAMPLE OF MEAT PRODUCTS – PILOT RESEARCH

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Key words: food chain, food safety, risk assessment, meat product

Risk assessment is a tool to estimate food safety for health. It is also one of components of risk analysis. The aim of this paper was to analyze a chosen food chain "from field to table" and related potential hazards for human health. The material of the research were a feed production plant, a farm, a meat production plant and the distribution chain. The research method were audits and surveys in all links of the examined chain, verification of used food safety assurance systems as well as the analysis of product quality assessment data. On the basis of performed research, it was observed, that there are two main hazards to the safety of end-user products: *Salmonella* bacteria and mycotoxins.

INTRODUCTION

Till 2002, food safety measures were based on efforts to achieve suitable food safety in individual food production plants and distribution. Such practice did not fully prevent food poisoning and infections. There was a raising need to introduce actions enabling risk assessment in all food chain, starting from primary production, and in case of food of animal origin, from the feed production step. The EU Regulation 178/02, stating general rules of food law [Regulation, 2002] forces a need of scientific risk analysis in order to ensure food safety of end-user.

Risk analysis as a process contains: risk assessment – scientific assessment of knowledge and potential negative effects on health; risk management – assessment, selection, and introducing alternatives of reacting and communicating the risk – information exchange between all involved elements [Guidelines, 2000]. Although differentiation of the three elements is important, equally important are relations between them.

Risk assessment in relation to microbiological hazards in food is defined by the Food Code Committee as a basic process consisting of the following steps: hazard identification, exposition assessment, hazard characterization and risk characterization. The goal of risk assessment is to predict a degree of exposition to pathogenic diseases in a researched population [Principles, 1999].

Risk assessment contains four components (Figure 1): (1) *hazard identification* – a qualitative process planned to identify microorganisms present in food and water; (2) *exposition assessment* – a result of the frequency of occurrence and quantities of possible pathogens in a given food portion; (3) *hazard characterization* – gives a description of negative effects, which can be a result of ingestion of microorganisms in a dose triggering those effects, for various groups of consumers, in relation to their susceptibility, age, health state; and (4) *risk characterization* – is integrally related to the three previous steps and their results. It is a comprehensive risk possibility assessment (*e.g.* probability of occurrence and acuteness of results, which may occur in a population in relation to uncertainty) for a given consumer.

As the production chain of food of animal origin is longer, it consists of more links than in the case of vegetable food. Moreover, there is a possibility of occurrence of animal pathogens, which are directly hazardous to human health. Thus, it was decided, that a risk analysis in the animal product chain should be performed. Considering the fact, that in Poland pork meat is statistically most frequently consumed, a pork product was chosen in a longest possible chain [Anonymous, 2006a]. All elements of the chain were analyzed from

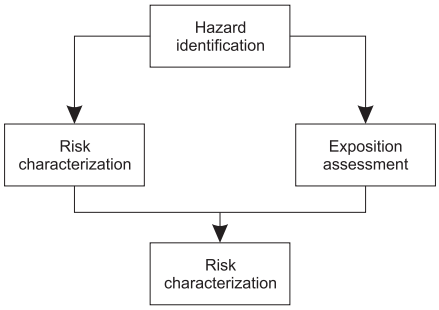

FIGURE 1. Risk Assessment Components (WHO/FAO Guidelines on Hazard Characterization for Pathogens in Food and Water – MRA 00/06).

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the point of view of potential hazards influencing the product and those dangerous for the end user.

MATERIAL AND METHODS

Research material were food-processing plants and farms included in the surveyed food chain, such as: feed premixes production plant, feed production plant, a farm (crop farming and breeding pigs), meet production (abattoir, meat cutting, cold meat production), transport and selling as well as household. The surveyed chain is visualized on Figure 2.

The above plants were chosen in order to survey one entire food chain, the end product of which is smoked meat – a smoked and scalded pork product. The research was started in the meat processing plant, and after that all former elements of the chain were analyzed. The next step was an analysis of links occurring in the surveyed chain after the meat processing plant.

Research method – Auditing and surveying the plants, verification of documentation (GHP, GMP, HACCP) from the point of view of correctness, completeness (including records) and an analysis of food quality assessment results.

RESULTS AND DISCUSSION

In 2005 meat consumption in Poland was 4698 thousand tones, most of which, 2540 thousand tones, was pork consumption [Anonymous, 2006b]. This consumption is visualized on Figure 3.

An example of a meat product that belongs to this group is ham. A detailed description of smoked, scalded ham is in Table 1.

The surveyed food chain consisted of 10 elements (Picture 2). Plants and farm were: feed premixes production, feed production, feed mixing plant, breeding farm, meat processing plant including abattoir, cutting, cold meat department,

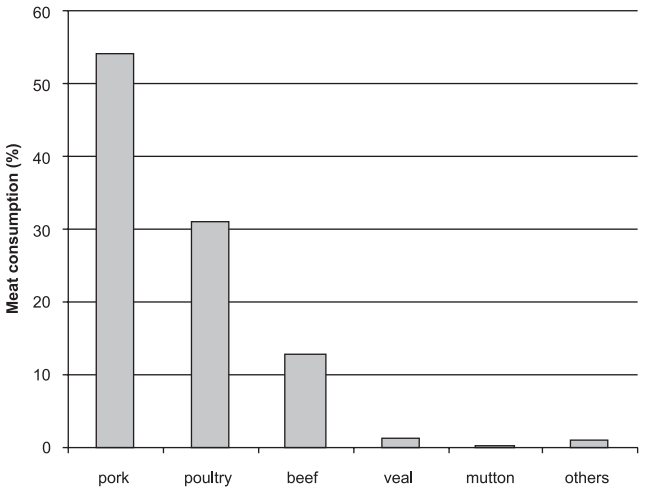

FIGURE 3. Meat consumption in Poland in 2005 – percentage relations (own study on the basis of data acquired from Statistics Office).

distribution department, with its own means of transport to deliver products to its own retail points, the chain is closed with a household.

Each element of the aforementioned chain was analyzed from the point of view of potential hazards influencing the product as well as those dangerous for end-user's health.

It is specific for the chain, that the product needs to be stored in conditions specified in detail – it means that storing continuation is to be preserved from the point of abattoir. There are only two points, when the continuation is broken: heat processing of the half-finished product – smoking and scalding. The other point is consumption.

Feed premixes production plant

Feed premixes production plant produces additives for individual feed mixing in a breeding farm. They are a mixture of

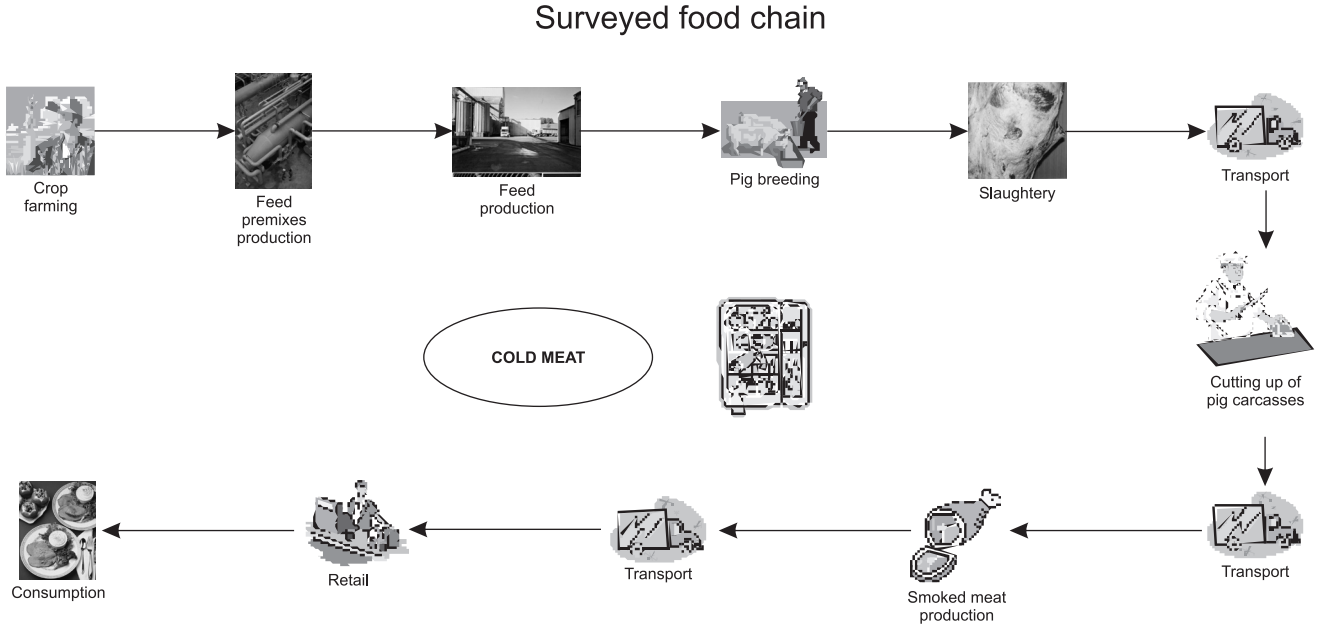

FIGURE 2. Surveyed food chain (own study).

TABLE 1. Product description (own study).

Product: Smoked meat: • Smoked, scalded ham		*Destination*: All groups of population, excluding individuals with health contradictions and infant and children under 3.
Product susceptible to rot: ☑ Yes ☐ No	*Physicochemical features*: In relation to the type of smoked food per 100 g of the product – kcal – 230-250 – water – 60-65g – fat – 17-20g – protein – 15-17g – salt – 0.8-1.2g – cholesterol – 45-60mg [Kunachowicz, 1998]	*Raw material composition*: Pork – whole muscles of ham, blade and other large muscles together with fat layer, pickle mix, water, preservatives, smoke
Description of production process: After the abattoir, pork half carcasses are chilled and cut off to elements, which are transported to pickling department. Meat is injected with pickle mix, then it is packed in nets or casing, next meat is hang-dried, smoked, boiled, cooled, and then packed and labeled [Olszewski, 2002]. Cool storage, special vehicle transport, retail by pieces or sliced.		
Packing: Products are packed in nets or casings, then welded in threesome in plastic bags, then stacked in plastic boxes or closed cardboard boxes.		*Storage and transport*: Temp. 2-6°C. – cooling vehicles or refrigerators
Distribution: Carts or boxes, and then cooler shelves in shops.	*Consumption conditions*: Ready-to-eat or alternatively for another use in the household.	Expiry period: According to type: • From 3 days to 3 months • According to the declaration of the producer put on the label – on the basis of storage stability tests
Consumer information placed on the packaging: Name of product, producer, ingredients, storage conditions, expiry date: day, month, year		

vitamins, macro- and micro-minerals, amino acids, optionally enzymes and other additives, *e.g.* preservatives or feed acidifiers. A separate group are medical premixes, produced under supervision and on prescription of a veterinarian.

Premixes are based on wheat bran and/or calcium carbonate. The surveyed plant produced only premixes pre-ordered by feed producers, in order to keep control on feeding animals with dangerous substances.

The HACCP system was implemented in the plant, the whole production was computer-controlled – an additional measure of produced food safety eliminating human mistakes.

There were 3 Critical Control Points (CCP) appointed: raw material reception, vet medicines weighing and dispensing medical premixes to medicinal feeds.

CCP1 is a stage, where raw material deliveries are received, and where factory standards are monitored. A detailed factory standards are in Table 2.

Raw material reception is realized on the basis of quality certificates from the deliverers, there are periodical internal tests of delivered raw materials to verify reliability of producers' certificates.

CCP 2 is weighing veterinary medicines for medicinal premixes. The process is realized with the use of electronic scales connected to the PC controlling the whole production in the plant with the accuracy up to 0.1 g in the case of weighing a raw material up to 5 kg per production batch or 1 g for 5-10 kg per production batch.

CCP 3 is dosing medical premixes to medicinal feeds, where the critical limit is safety of a utilized mix, correctness of its formula and ability of its components to mix with one another and with the medium., as well as reactions among individual components. Those activities are performed in the plant laboratory, and only after a positive opinion is given and the formula is tested, a new mix may be introduced in production.

TABLE 2. Factory standards concerning content of undesired ingredients in raw materials (factory materials).

Contamination	Maximum allowed quantity in mg/kg
Arsenic	12
Lead	30
Cadmium	20
Mercury	0.1
Nickel	5-100 (depends on raw material)
Chromium	10
Mycotoxins	Absent in 1g
Salmonella spp.	Absent in 1g

Plant standards take also into consideration procedures within Good Practice: Hygiene (GHP) and Production Management (GMP). One of them is printing labels for end products only and immediately after the product has been put to its package and sealed. This prevents from erroneous labeling.

As a result of the performed audit it was observed, that quality of the product is influenced by: hygiene of raw materials used in production (no contamination), hygiene of production area (cross-contamination), product homogeneity and concentration (concentration of mixture). The plan has determined their own raw material standards (mort restrictive than country law standards) (contamination level – heavy metals, microorganisms and their residue).

The presence of *Salmonella* bacteria was defined as the most dangerous hazard in the plant, as it emerges the risk of appearance and residence of the bacteria in all products of the food chain.

Feed production

The second element in the surveyed feed chain is the plant producing feed of premixes and other vegetable raw materials – mainly corn and oily plant grain and their process products.

The plant, at the time of auditing, did not have a HACCP system implemented. The plant documentation showed, that the contents of the unwanted residues was only periodically monitored by the Veterinary Inspection. It is positive, that the plant buys most of its raw materials from food processors, so there were no unwanted substances detected till the time of the audit.

In the plant, mould growth was considered as the most dangerous hazard. Moulds can endanger feed by production of mycotoxins and depravation of produced feed of the ingredients declared by the producer.

Breeding farm

The third element of the surveyed chain is a breeding farm located at the former PGR (state farm) which was a pig breeding farm and where feed plants were cultivated and feed was produced from premixes made of plants and food industry refuse.

At the moment of auditing, the farm did not have any health safety system implemented, and documentation concerned only pig breeding.

This element in the chain induces the following risks: (1) in the scope of plant cultivation – residues of fertilizers and pesticides, pests destroying production, accumulation of heavy metals originating from heavy traffic road; (2) in the scope of feed mixing – risk of mould growth, generation of mycotoxins, danger of mixing contaminated food processing refuse (produced incorrectly) as a result of incorrect storage of premixes, feed mix substrates and ready feed products; (3) in the scope of breeding residues of veterinary medicines and growth stimulants, presence of parasites and pathogens as a result of using contaminated feed, incorrect breeding – no separation of ill animals, incorrect hygienic conditions, cross-contamination with microorganisms among animals in the herd.

In the farm, animal diseases were considered as the most dangerous hazard. They are directly related to calculable economic losses (costs of medicines, prolonged fattening).

Residues of pesticides were recognized as insignificant, because in the process of feed production for pigs a procedure of seed shelling is implemented, which cleans these chemicals off.

The bred animals are transported to a meat processor nearby, which is the sole recipient.

Meat processor

The researched meat processor has an HACCP system implemented and export qualification since 2002. The plant is divided into following divisions: abattoir, meat cutting, cold meat (divided into smoked meat and sausages), transportation and sales, which manages brand shops. The plant sells its products mainly in those brand shops, the rest is exported to the East and UE countries, such as Germany or the Netherlands.

The most dangerous hazards in the plant are: (1) in the scope of slaughter – pathogens, viruses, parasites through the transition of contaminations onto healthy animals, risk of meat contamination from the personnel or slaughter utilities, risk of permeating microflora through organisms' barriers and infection of meat; (2) in the scope of meat cutting – pathogens, viruses, parasites – risk of meat contamination between food contents in the alimentary canal of one animal or several animals cut simultaneously, risk of cross-contamination from the personnel, equipment and auxiliaries, risk of growth of transferred microorganisms as a result of improper post-slaughter cooling; (3) smoked meat production – overdosage of nitrates (III) at the stage of pickling, especially after a proper heat processing, inobservance of parameters of heat processing (too low temperature), too long cooling time after heat processing; (4) packaging – contamination with pathogens present in air, from personnel, equipment and packages; and (5) storage – growth of potentially introduced microorganisms as a result of inobservance of cooling conditions.

The tests on end products from 2002 to 2005 showed too high level of microorganisms in only 2% of samples, whereas pathogens were not found. In the analogical time period, in swabs taken from working surfaces (table tops, machines) and in microbiology of air, results were correct.

Transportation of smoked meat must be performed with the use of specialized vehicles, which can hold temperature between 0-6°C. As in this stage the product is packed, food health hazards concern exclusively potential microbial growth in improper temperature and time.

Brand shops

The most important hazards at the stage of selling smoked meat in brand shops are microbial growth resulting from inobservance of cooling string and contamination and growth of microorganisms originating from the product as well as the personnel, equipment (cutter, cooling counter) and utilities (knives, trays, containers).

Household

In the last element of the food chain, the household, products are susceptible to similar sources of contamination and microbial growth, as in the case of brand shops.

SUMMARY, FINDINGS, CONCLUSIONS

On every stage of the surveyed food chain, the crucial issue is to prevent contamination, especially with microorganisms for the risk of rapid microbial growth. Any production, irrespective of its nature, requires proper hygienic conditions and standards, which prevent from cross-contamination. The most crucial hazard are *Salmonella* bacteria and moulds, which in favorable conditions may generate mycotoxins.

Another crucial element, difficult to detect and triggering delayed consumers' reactions are chemical contaminants, that cumulate in the organisms of animals, and then people. This group contains all veterinary medicines and preparations, remaining in products if the waiting period was too short. However, mycotoxins appear to be more dangerous for health. Hitherto performed tests do not substantiate a thesis, that risk assessments of parallel food chains should be similar to one presented in this paper. Both basic hazards (microorganisms, mainly *Salmonella* bacteria and dangerous chemical substances) are to be verified in further researches.

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OCENA RYZYKA MIKROBIOLOGICZNEGO W ŁAŃCUCHU ŻYWNOŚCIOWYM NA PRZYKŁADZIE PRODUKTÓW MIĘSNYCH – BADANIA PILOTAŻOWE

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Ocena ryzyka jest narzędziem pozwalającym oszacować bezpieczeństwo zdrowotne żywności. Jest też jedną ze składowych analizy ryzyka. Celem pracy było przeanalizowanie wybranego łańcucha żywnościowego „od pola do stołu" i zagrożeń dla człowieka mogących w nim wystąpić. Materiałem badawczym były zakłady przemysłu paszowego, gospodarstwo rolnicze, zakłady przemysłu mięsnego oraz łańcuch dystrybucyjny. Metodą badawczą było przeprowadzenie auditów i ankiet we wszystkich ogniwach badanego łańcucha, weryfikacja funkcjonujących tam systemów zapewnienia bezpieczeństwa zdrowotnego żywności oraz prowadzonej dokumentacji a także przeanalizowanie wyników oceny jakości wyrobów. Na podstawie przeprowadzonych badań stwierdzono iż dla bezpieczeństwa produkowanych konsumenta ostatecznego wyrobu są istotne dwa zagrożenia – bakterie z grupy *Salmonella* oraz mykotoksyny.