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Safety in Serbian animal source food industry and the impact of hazard analysis and critical control points: A review

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Abstract. There is a significant lack of HACCP-educated and/or HACCP-highly trained personnel within the Serbian animal source food workforces and veterinary inspectors, and this can present problems, particularly in hazard identification and assessment activities. However, despite obvious difficulties, HACCP benefits to the Serbian dairy industry are widespread and significant. Improving prerequisite programmes on the farms, mainly through infrastructural investments in milk collectors and transportation vehicles on one hand, and increasing hygiene awareness of farmers through training on the other hand has improved the safety of milk. The decline in bacterial numbers on meat contact surfaces, meat handlers' hands and cooling facilities presents strong evidence of improved process hygiene and justifies the adoption of HACCP in Serbian meat establishments. Apart from the absence of national food poisoning statistics or national foodborne disease databases, the main obstacle to fully recognising the impact of HACCP on the safety of animal source food in Serbia is the lack of research regarding the occurrence of chemical and/or physical hazards interrelated with its production.

1. Introduction

Hazard Analysis and Critical Control Points (HACCP) seven principles today are read like the “ten commandments” among food producers whenever they discuss food safety. HACCP, which started as an idea between Howard Bauman from Pillsbury Company and NASA, has attained significant authority and will remain as a legacy that will not fade away. However, the way it has been implemented in different parts of a world, especially its inspection and control, although seven principles are widely understood and accepted, varies greatly [1]. HACCP is capable of accommodating changes, such as advances in equipment design and processing procedures, as well as technological developments. It can be tailored to address individual product or process. It is the best system currently available for maximising the safety of meat and meat products, as well as food in general, which is why it has been recommended for use in the food industry and promoted by governments and scientific groups for decades [2].

Once a visionary approach and today almost 60 years old, HACCP is an integral part of the American food industry but above all, the food safety inspection system. Richard Rominger – the Acting Secretary of Agriculture in its time, said: “We are proposing to reinvent the meat and poultry inspection system. HACCP will fundamentally reform our inspection system into a science-based system – a system which will ensure an even safer food supply.” [3]. For this purpose, the Food Safety and Inspection Service (FSIS) created a



new brigade of several thousand newly-employed Consumer Safety Officers (CSOs) who were charged with keeping meat safe from contamination.

In 1995, the US Food and Drug Administration (FDA) issued regulations that made HACCP mandatory for fish and seafood products, and in 2001, they issued regulations for mandatory HACCP in juice processing and packaging plants. HACCP has also been implemented by the United States Department of Agriculture (USDA). In 1998, USDA's FSIS mandated HACCP for the nation's meat and poultry processing plants. In addition, a voluntary HACCP program was implemented in 2001 for Grade A fluid milk and milk products under the cooperative federal/state National Conference on Interstate Milk Shipments (NCIMS) program [4].

The Republic of Serbia, within its process of legal harmonization with the EU, recently reorganized its food safety system to comply with EU regulations according to *acquis communautaire*. The main goal of the on-going harmonization is to allow subjects in the food chain to perform their activities according to the EU regulatory requirements. Among the legislative changes, a new Food Safety Law was introduced in 2009 [5]. This law mandatory requires implementation of a food safety system based on HACCP principles for all subjects in the food chain, except primary production. Full implementation of this law was set at June 1 2011 when the inspection service started on-site verification [6].

The introduction of this new Food Safety Law and mandatory HACCP implementation for all food producers, regardless of their type and size, achieved one goal with certainty and that was to fundamentally shift the burden of food safety regulation from the government onto the Serbian food industry. Rather than having the government assess the risk inherent in different food production difficulties (and bear the responsibility if it was wrong), Serbian food producers became responsible for the risk assessment. However, as in most developing countries, Serbian food processing industries lack the necessary basic scientific information (i.e., national food poisoning statistics or national foodborne disease databases) required to develop reliable hazard assessments [7] or to effectively assess the benefits of mandatory HACCP in terms of its ability to reduce the occurrence of foodborne illness.

In 1995, US Government officials said that the system shaped by the new red tape – known as HACCP – will mean a safer food supply, if not immediately, then after the 3.5 year phase-in period [3]. Nowadays, we are celebrating the 6th birthday of HACCP in the Serbian food industry and the only thing we can be sure about is that it has not revolutionized our food safety inspection. Since its phase-in period was exceeded years ago, we believe that it is the time to evaluate the impact of HACCP on safety in the Serbian animal source food industry, at least.

2. Materials and methods

2.1. Survey on HACCP implementation in animal source food industries

For both meat and dairy industries, a questionnaire was developed to identify the effects of HACCP implementation in Serbian meat industry, which included the issues regarding general information about the food business operators (such as the number of employees, status of HACCP system, information about the educational level, age and work experience of HACCP team members). Questions related to prerequisite programs (PRPs) that are implemented in the company were also included. Further questions were related to the incentives for implementing the HACCP system, costs, benefits and difficulties in implementation/operation of HACCP. All producers were visited and on-site interviews were performed. Respondents were mainly HACCP team leaders, production managers or owners. The respondents ranked these factors in order of importance according to their own conditions and experiences.

2.2. Meat industry sampling and methods

A total of 48,246 swab samples were analysed from two types of meat establishments: 130 meat plants and 220 meat retailers. The period covered was seven years long (from 2008 to 2014) divided into two terms:

first from January 1 2008 until May 31 2011 (a period of 41 months before mandatory HACCP implementation) and second from June 1 2011 until December 31 2014 (a period of 43 months after HACCP became obligatory). Samples were taken from three types of surfaces: food (meat) contact surfaces (cutting boards, machines, knives and slicers, tables and containers), cooling facilities (refrigerators, freezers and other meat and meat products cooling devices) and meat handlers' hands.

During the first term (January 1 2008 – May 31 2011) samples were analysed according to the Regulation (8) in force, for Aerobic Colony Count (ACC) using methods coherent with ISO 4833:2003. The new Regulation (9), effective from June 1 2011, legally prescribed methods that were used in the second term of our investigation. Samples were analysed for Aerobic Colony Count (ACC) according to ISO 4833:2003, *Enterobacteriaceae* (ISO 21528-2:2004), coagulase positive *Staphylococcus* (ISO 6888-1:1999), *Salmonella* (ISO 6579:2002) and *Listeria monocytogenes* (ISO 11290-1:1998). Samples were examined in an ISO/IEC 17025:2005 accredited laboratory.

For the purpose of our investigation all the results and the respective number of microorganisms detected (n) were divided into four classes as follows: Class I ($n \leq 1 \log_{10}$ CFU/cm²); Class II ($1 \log_{10}$ CFU/cm² < $n \leq 2 \log_{10}$ CFU/cm²); Class III ($2 \log_{10}$ CFU/cm² < $n \leq 2.7 \log_{10}$ CFU/cm²); Class IV ($n \geq 2.7 \log_{10}$ CFU/cm²).

2.3. Dairy industry sampling and methods

Samples of raw milk were analysed at the reception of dairy plants and total of 45,600 samples from different locations were collected on a daily basis during four years (from 2006 to 2009). Samples of pasteurized milk were analysed after packaging in the dairy plants over three different periods. A total of 558 samples were collected in the period before HACCP system implementation, 260 samples during first eight months following HACCP implementation and the final 677 samples in the period after additional infrastructural investments in the dairy plants.

Samples of raw and pasteurized milk were analysed for total plate count (TPC), while pasteurized milk samples were also analysed for the presence of coagulase positive *Staphylococcus*, sulphite-reducing *Clostridia*, *Proteus* spp. and *Escherichia coli*. Methods for the laboratory determination of TPC, *E. coli*, coagulase positive *Staphylococcus*, sulphite-reducing *Clostridia*, *Proteus* spp. were adjusted to the National Regulation on microbiological methods for analysis of food (Regulation on methods for microbiological analysis and super analysis of food. Official Gazette SFRY No 25/1980. All raw milk samples were also investigated for the presence of antibiotics using the commercial SNAP tests (IDEXX Laboratories, USA). Tests were performed according to the manufacturer's protocol. The acidity of milk was analysed by titratable method and expressed in Soxlet-Henkel degrees (°SH). Somatic cell count was determined using Fossomatic Minor (Foss, Denmark). Additionally, temperature of raw milk at the reception was also determined.

Based on the TPC and somatic cell count, raw milk was classified into four different quality categories being extra class with TPC not exceeding 100,000 CFU/ml, I class with TPC between 100,001 and 500,000 CFU/ml, II class with TPC between 500,001 and 1,000,000 CFU/ml, and III class with TPC greater than 1,000,000 CFU/ml. Requirements for the somatic cell count were always the same, less than 400,000 cells/ml. The percentage of raw milk which belongs to the specific category was calculated as the amount in the total quantity of received raw milk for each year during the examined period. The percentage of raw milk that did not comply with the given specifications regarding presence of antibiotics, acidity > 6.8°SH or temperature of raw milk >10°C was calculated as the quantity of non-conforming raw milk in the total quantity of received raw milk.

2.4. Analysis of results

The results obtained for TPC in pasteurized milk during the examined period were expressed as \log_{10} CFU/ml, and used for the calculation of mean values, standard deviation and significance of difference between means using one-way ANOVA. Categorical variables (classes of surface hygiene in meat producing facilities) were expressed as percentages. Chi-Square test for association was used to discover possible relationships between results of meat process hygiene and the period (time) they were sampled. Yate's correction was calculated when the expected frequency was less than 5. The level of statistical significance for all was set at 0.05. Statistical processing was performed using Microsoft Excel 2010 and SPSS Statistics 17.0.

3. Results and discussion

3.1. Impact of HACCP in the Serbian Dairy Industry

From 27 companies that responded to the survey, 19 companies (70.4% of the respondents) claimed that they had a fully operational and certified HACCP system in place, while 8 companies (29.6%) implemented HACCP, but they had no third party certification at the time the survey was conducted. Almost 60% of the Serbian dairy industry respondents estimated that it had taken 12 months or less to implement HACCP system, while only 14.8% estimated that it took more than that. The most important motive for implementing HACCP system for Serbian dairy producers was to increase and improve safety of their products. The second most important incentive was the quality increase of their products, which was unexpected since HACCP was designed primarily with the food safety in mind. The cost of product investigation/analysis was on the top of their financial concerns, although it was logical to assume that HACCP is a system that minimizes testing by focusing on critical control points. The cost of hiring external consultants was rated as the second most important expense, in spite of the relatively high education level of their respective HACCP team members. A major difficulty encountered during HACCP implementation and operation was associated with the attitude/motivation of production staff and the need to retrain production and managerial staff. Cleaning and sanitation control of health and hygiene of employees, equipment maintenance and calibration, pest, water and temperature control together with traceability was used by almost 100% of the Serbian dairy plants covered by our survey. The most important identified benefits were increased safety of dairy products followed by increased customer confidence [10].

Our microbiological test results for TPC in raw milk indicated that in 2006, more than 55% of accepted milk belonged to the III class, which did not satisfy even official Serbian requirements. In the same period, only 36% of milk was of high quality (extra and I class). When the microbiological results of raw milk were examined for the following three years (from 2007 till 2009), the percentage of class III milk in total raw milk decreased, being only 20.3% in 2009. At the same time, the percentage of raw milk of extra and I class increased from 36.5% in 2006 to 53.7% in 2009. In addition, the percentage of milk that was classified as non-conforming (related to the specification set up for antibiotic residues, SH-acidity or temperature of raw milk), decreased or fell to completely non-existent levels [11].

Microbiological analysis of pasteurized milk samples was also performed in the periods before and after HACCP implementation. The results obtained indicated a significant decrease ($p < 0.05$) in TPC from 3.32 ± 0.48 to 3.11 ± 0.30 log CFU/ml for results obtained before HACCP implementation and during the first eight months after implementation. The other investigated bacteria were not present in all investigated periods. The reason the results indicated only 0.21 log CFU/ml decrease in TPC after HACCP was implemented can be explained by the fact that the time/temperature regime during pasteurization process had been already followed before HACCP was put in place. As a result of HACCP implementation, pasteurization of milk has been more carefully followed and monitored, resulting in the obtained decrease. Eight months after HACCP implementation, the results showed even more pronounced decrease, from 3.11 ± 0.30 to 2.18 ± 0.54 log CFU/ml ($p < 0.05$). This improvement in microbiological quality of pasteurized

milk was possibly related to the infrastructural investments in the factory, mainly concerning new pasteurization units and automated cleaning and disinfection systems [11].

3.2. Impact of HACCP in the Serbian Meat Industry

From 77 companies that responded to the survey, 72 companies (93.5% of the respondents) claimed that they had a fully operational and certified HACCP system in place, while 5 companies (6.5% of the respondents) implemented HACCP, but they had no third party certification at the time the survey was conducted. Almost 50% of the Serbian meat industry respondents estimated that it had taken 12 months or less to implement HACCP system, while only 11.7% estimated that it took more than that. It was apparent that regulation is a very important incentive for HACCP implementation and the degree of enforcement can cause even the smallest of enterprises to comply without question, as was the case with 100% of the meat producers in our investigation. The other major incentive for the implementation of HACCP was an increase in product safety and quality. Major costs of implementing HACCP were associated with investment in new equipment while major difficulties experienced while implementing it were associated with recouping its costs. It was obvious that most of the costs involved with HACCP could not be recouped in the short term [12].

The most widely followed PRPs in the Serbian meat industry were cleaning and sanitation, temperature control, pest control and the control of the health and hygiene of the employees, all above 90% among the surveyed meat producers. Only 60% of respondents used waste and wastewater management and less than 30% of respondents regularly controlled air in their processing area or had allergen declaration [13].

The most evident impact of HACCP on meat process hygiene was observed in meat contact surfaces, where 90.45% of the ACC samples taken in meat plants and 98.3% of the ACC samples taken in meat retail were above $2 \log_{10}$ CFU/cm² before HACCP. After mandatory HACCP implementation, these values dropped below $2 \log_{10}$ CFU/cm² in 96.38% of the cases for meat plants and 85.8% of the cases for meat retail. Class IV ($n \geq 2.7 \log_{10}$ CFU/cm²) of the hand swab ACC results was the prevailing category in Serbian meat plants (52.71%) and meat retailers (51.10%) until May 31 2011. In the period of 43 months that followed, Class III ($2 \log_{10}$ CFU/cm² < $n \leq 2.7 \log_{10}$ CFU/cm²) took precedence, accounting for 97% and 98.96% of the hand swab ACC samples for meat plants and meat retailers, respectively. In the same period, the number of surfaces positive for *Enterobacteriaceae* steadily declined in both meat plants and meat retailers for all types of surfaces examined. The improvement in process hygiene was even more obvious in meat retail facilities, especially regarding food contact surfaces where the percentage of positives dropped from 31.4% in the second half of 2011 to 14.4% in 2014. The same period for meat plants indicated a 10% decrease of *Enterobacteriaceae*-positive food contact surfaces [14].

Because meat handlers have a very important role in the prevention of meat poisoning, as they can introduce pathogens within the entire food chain, we also investigated the level of food safety knowledge among meat handlers in the Serbian meat industry, in different stages of the meat chain, i.e. in slaughterhouses, meat processing plants and retail stores. The average food safety knowledge score for all 352 Serbian meat handlers surveyed was 64%, whereas handlers from slaughterhouses and meat processing plants obtained significantly better scores (65% and 66%, respectively) than handlers from retail (60%, $p < 0.05$). The knowledge score among all meat handlers was significantly associated with the age, education and previous food safety training. Meat handlers with the lowest education (only primary school) scored the lowest values (59%), and the highest educated participants (holding university degrees) scored the highest values (76%). Results indicated that 57.9% of meat handlers could identify that bacteria will readily multiply at 25°C, but they did not understand the manifestation of bacterial growth and incidence in food, as only 5.5% of all meat handlers knew that food contaminated with food poisoning bacteria cannot be recognized by visual, olfactory or taste checks [15].

4. Conclusions

There is a significant lack of HACCP-educated and/or HACCP-highly trained personnel within the Serbian animal source food workforces and veterinary inspectors, and this can present problems, particularly in hazard identification and assessment activities. The supply of Serbian language HACCP guidelines is also very limited and therefore a heavy reliance upon foreign language (predominantly English) documentation is evident.

However, despite obvious difficulties, HACCP benefits to the Serbian dairy industry are widespread and significant. In particular, Serbian dairy producers reported increased safety and quality of the products, increased customer confidence and better discipline of the employees. Increased product sales and the ability to use HACCP as a legal instrument against complaints were equally important. Improving PRPs on the farms, mainly through infrastructural investments in milk collectors and transportation vehicles on one hand, and increasing hygiene awareness of farmers through training on the other hand improved the safety of milk.

The main reasons for successful implementation of HACCP among the Serbian meat producers were well placed and closely followed PRPs. The decline in bacterial numbers on meat contact surfaces, meat handlers' hands and cooling facilities presents strong evidence of improved process hygiene and justifies the adoption of HACCP in Serbian meat establishments.

Apart from the absence of national food poisoning statistics or national foodborne disease databases, the main obstacle to fully understanding the impact of HACCP on safety of animal source food in Serbia is the lack of research regarding the occurrence of chemical and/or physical hazards interrelated with its production.

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