Hazard Analysis and the System Aimed at Ensuring the Safety of Semi-Dry Sausage-Based Products

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Scientific work

Summary

Meat industry aims at producing consumer-safe and top-quality products, employing thereby its overall resources to an optimal extent. Therefore, all available measures as to ensure the safety of the products have been undertaken, and risk analysis and monitoring of critical control points have been implemented in order to enable systematic elaboration of all process steps and the implementation of preventive measures aimed at controlling the entire production process, and at protecting customers in terms of the presence of pathogens and potential food poisoning-causative agents, falling within Salmonella, Campylobacter, Clostridium perfringens, Echerichia coli O175:H7, Yersinia enterocolitice and Listeria monocytogenes, as well as Clostridium botulinum and Pseudomonas aeruginosa species.

The research was conducted in the meat industry settings, investigating in particular the technological process targeted at the production of the semi-dry sausage-based products, widely known under the brand-name "Jeger (the Hunter's Sausage) of Ivanec".

This study aims at implementing the HACCP system via hazard analysis, identification of critical control points and definition of control measurements to be observed with all process steps, as well as at evaluating its 12-month efficiency via a series of microbiological assays targeted at verifying the presence, or the absence, of pathogenic microorganisms and, by virtue of their results, also the safety of semi-dry sausage products, widely known under the brand-name "Jeger of Ivanec".

The results obtained by this research ensure the production of the safe food, which represents the ultimate goal of each and every food industry, and the prerequisite for launching our homeland products into the world market.

Keywords: *HACCP, meat industry, critical control point (CCP)*

Introduction

Under the Ordinance on the implementation of compulsory measures to be observed in selected plants and facilities in order to reduce microbiological and other kinds of meat contamination, meat products and other foodstuffs of animal origin intended for human use, the implementation of compulsory measures and the compliance to the stipulated veterinary and safety conditions applicable to the selected plants and facilities hosting animal slaughtering, preparation, processing and storage of foodstuffs of animal origin, have been provided for, and are aimed at reducing microbiological hazards and at ensuring consumer-safe and top-quality products by virtue of an optimal employment of all resources available (Anon., 1997).

Monitoring of foodstuffs' safety includes sensor assessment, physical parameters' metrics, chemical analyses and microbiological assays. Alternatively, health institutions and competent bodies are entitled to lay down the methodology to be employed in the identification of the infected food handlers, as well as the measures to be taken in order to prevent food contamination. As a replacement for physical examinations and laboratory analyses of samples taken from the food-handling personnel, the novel concept offers a solution in terms of targeted education on safe food handling, to be carried out among the professionals concerned. The novel concept aims at creating a safe product, while, in contrast, the existing one utilises microbiological assays in order to establish the level of safety of the product already launched (Turčić, 2000).

The primary obligation and responsibility of the managerial structure present in all professional activities dealing with food, is to prevent the establishment of conditions that will allow for the development and spreading of food-borne diseases (ICMSF, 1986 a.; WHO, 1989).

In line with the foregoing, a number of international organisations have adopted various documents outlining the principles of quality control and preventive insurance of food safety, which are to be observed throughout the entire food production chain (Anon., 2003d; Mortimore and Wallace, 2001).

The novel approach as to the prevention and control of food-borne diseases represents the system of hazard analysis based on the assessment and control of the critical control points – the so called "Hazard Analysis Critical Control Point" (HACCP). Within the frame of that system, efforts are firstly directed towards the recognition of hazards that might arise in any stage of the food production, processing and preparation, and subsequently to the assessment of risks imposed by the detected hazards, as well as the estimation of locations at which the control measures will be successfully put in effect (Hoornstra, Northolt, Barendsz, 2001).

Practical implementation of the HACCP took place in 1993, when the joint body of the International Food and Agricultural Organisation (FAO) and the World Health Organization (WHO), named the Codex Alimentarius Commission, adopted the famous document widely known as the "Guidelines for the Application of the Hazard Analysis Critical Control Point (HACCP) System". As for the Europe, the HACCP-based system is incorporated into the "Guidelines for the Foodstuffs' Hygiene", issued by the European Union (EU) (the Codex Alimentarius Commission, 1997).

The implementation of the HACCP system is under-pined by the Good Manufacturing (GMP) and Good Hygiene Practice (GHP) (Walker, Pritchard, Forsythe, 2003). Field experience has supported the standpoint that the HACPP system may be considered implemented once all the GMP and GHP issues have been resolved (Early, 1995; Wallace and Williams, 2001).

On the occasion of the HACCP system implementation, a HACCP expert team is to be appointed, bound by the obligation to conduct the study that should observe the following seven basic principles: hazard analysis; identification of critical control points (CCPs); the estimation of critical limits; CCP control insurance; allocation of the corrective measures; foundation of documentation; allocation of verifying procedures (the Codex Alimentarius Commision, 1997).

The HACCP system consists of the planning elements that should be corroborated i.e. validated, in order to assess the ability of the HACPP plan to meet the needs of an efficient hazard control. The primary

Table 1 Product description - "Jeger of Ivanec"

PRODUCT DESCRIPTION
1. Product group: semi-dry sausage
2. Intended use and mode of utilisation: direct consumption in slices
3. Consumers: general use in the domestic market: household, retail-and wholesale
4. Package type, materials: the filling is stuffed into the natural pork or collagen-made (Kranz) intestine, and is sold out package-free or vacuumed (plastic foil), and further put in the collective outer cartoon.
5. Composition: pork shovel, bloody meat, pork hearts, ice, beef heads´meat, firm adipose tissue, pork cuticles, *lianotox, Jeger combi spice, carminex, nitrite pickling salt, knobalan spice, emulin hv*
6. Repro-material: pork intestines measuring 44 mm in diameter, collagen-made intestines, Kranz clips, plastic foils, aluminium seals, outer cartoons Z-IV and Z-1M, sticky tape, europallets
7. Technological procedure: Meat pastry is mixed in a cutter, out of the appropriate raw materials and additives, observing thereby the working receipt and instructions. The meat pastry is subsequently supplemented by already-prepared emulsion consisting of pork cuticles, as well as with firm adipose tissue fragmented in a cutter, and beef head meat fragmented in a Wolf cutter. The obtained mixture is stuffed into the wraps, hanged on a wagon and transported to the automatic smoky chambers (kiln-dries) in order to be thermally processed. Subsequent to cooling, the product is transported to the final products´ warehouse. Prior to shipping, the product undergoes vacuuming, or is sold package-free.
8. The description of organoleptic properties: The sausage wrap is clean, intact and moderately folded. The consistency can be described as firm-elastic. The cross-sections reveal red to dark-red meat particles and white particles of the firm adipose tissue, homogenised by a pink-orange meat mass. The odour and flavour are characteristic of that product type.
9. Expiry date: 20 days, 45 if vacuumed.
10. Storage conditions: to be stored in a dry and dark place, at the temperature not exceeding 7°C.
11. Distributing conditions: truck transport to the distributive centre, truck transport to the selling points or a variety of other institutions, ambulatory selling, etc., as well as direct selling
12. Instructions placed on the label/package: Immediately after arrival, the shipment should be unpacked and stored in a cold and dark place.
13. Other referral data: The product complies with the currently enacted Ordinance on the Quality of Meat Products (Official Gazette of the Republic of Croatia, No 53/91)

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Table 2 Hazard analysis carried out within the technological process of semi-dry sausage production

Process step	Chemical hazard	Microbiological hazard	Physical hazard	Preventive measures
The purchase of meat, additives, spices, wraps & packages	Noxious chemical substances contained in additives, spices, wraps and raw-materials, migrants into the packages and wraps, present in quantities above those maximally permissible according to the referent Ordinance.	Poor microbiological quality (an excessive number of microorganisms, hazardous microorganizms in quantities above those maximally permissible according to the referent Ordinance and the internally set standards. Changes in organoleptic properties (the appearance , flavour, odour, colour, consistency), occuring in raw-materials, additives, spices, and wraps, as a result of microbiological activity.	Impurities of the mechanic nature, contained in additives, spices, and raw-materials.	Veterinary surveillance (certificates, chemical & physical analyses) of the meat entering the magazine, contracting of a purchase of standardsed raw-materials of the pre-set quality, certificates and analyses of spices, additives, wraps and packages, quality control by means of an organoleptic examination and laboratory testing performed by a licensed laboratory, sampling thereby entrusted with a certified veterinary inspector.
Receipt of the frozen goods shipped from the frozen goods' warehouse	Not established	Due to the prolonged storage, raw-materials might get spoiled (oxidation of the adipose tissue, multiplication of microorganisms).	Not established	Storage duration control, organoleptic examination of raw-materials prior to their processing, carried out by the employee engaged at the workplace in reference, separation of inappropriate raw-material into the confiscate.
Partial melting of the frozen meat	Not established	Due to the surface melting and heating of the raw-material, possible multiplication of microorganisms due to the prolonged melting.	Not established	The hazards are insignificant, allowing the subsequent thermal processing to reduce the possibility of the survival of pathogenic microorganisms. The temperature of the cooling chamber should be kept bellow 8°C, and the processing should by all means be initiated within the next day or two.
Fragmentation of the frozen adipose tissue and meat blocks	Not established	Not established	Due to the inappropriate removal of the padcage off the meat, or machinery damages, contamination of the filling with the package and metal particles may occur.	Careful removal of the package, contracting of the padcaging modality and the package material that enables smooth separation of the foil prior to crushing in the frozen state, avoiding thereby the possibility of its tearing and accumulation of its left-over, visual inspection of the machinery and raw-material prior to further processing. Due to the low risk of its occurrence, the hazard in question is considered insignificant.
The receipt of the newly processed raw-material shipped from the chopping facility	Not established	Due to the surface heating of the raw-material, possible multiplication of microorganisms attributed to the prolonged processing at excessive temperatures, taking place in the chopping facility.	Not established	The hazards are insignificant, allowing the subsequent thermal processing to the survival of pathogenic microorganisms. The temperature in the chopping facility should be kept at 12°C, and the processing should be initiaded in the next 4 hours.
Cooling and storage of the raw-material prior to the processing	Not established	Due to the surface heating of the raw-material, possible multiplication of microorganisms attributed to the prolonged storage at excessive temperatures.	Not established	The hazards are insignificant, allowing the subsequent thermal processing to reduce the possibility of the survival of pathogenic microorganisms. The temperature of the cooling chamber should be kept bellow 8°C, and the processing should by all means be initiaded within the next day or two.
Storage of additives, spices and wraps in the additives' store until further processing	Various additives and spices may unintentionally become a content of other additives and spices, which is attributed to the negligence in handling. Content alterations due to the prolonged storage.	Due to the impact of insects and rodents, microbiological contaminations of additives may occur; content alternations due to the prolonged storage	Due to the package damage, contamination of additives with foreign objects (metal, wood, glass), insect body parts, etc.may occur	The hazard can be avoided based on the visual control of the expiry date, veterinary surveillance of the compliance to the methods of disinfection, disinsection,deratisation; the hazards are insignificant and easily eliminated.
Weighting of fresh and frozen raw materials, additives and spices.	Possible over-concentration of some filling ingredients. For instance, nitrites and polyphosphates, present in excessive concentrations, may pose as a human hazard.	Not established	Possible contamination of the filling with foreign objects, occuring during the course of the weighting procedure.	The hazards can be efficiently prevented by punctual weighting of all the ingridients, by checking the expedients which is entrusted with the warehouseman, by checking the balance prior to its use and during the course of it, as well as by educative courses structured in line with the particular ingridients and processes employed, and accompanied by visual inspection of the weighted ingridients prior to their mixing in the cutter.
Preparation of storage of the emulsion until further processing	Not established	Due to the prolonged storage, inadequate cooling of the raw-material, or excessive temperature of the storage chamber, possible multiplication of microorganisms	Possible contamination of the filling with foreign objects, that might occur during the course of the emulsion preparation	Visual inspection of the device prior and after work, visual inspection of the emulsion, possible multiplication of microorganisms will not significantly affect hygienic safety of the final product, since the latter is subjected also to the thermal processing.
Preparation of the filling in the cutter, with the addition of nitrite pickling salt, additives, spices and emulsion	Not established	Not established	Possible contamination of the filling with foreign objects.	Hazards can be efficiently prevented by visual control of booth the device and the filling.
Passage of the filling through a Wolf micro-cutter	Not established	Due to the excessive heating of the filling, possible multiplication of microorganisms	Possible contamination of the filling with foreign object.	Hazards can be efficienty prevented by visual control of booth the device and the filling; possible multiplication of microorganisms will not significantly affect hygienic safety of the final product, since the latter is subjected also to the thermal processing.
With-holding of the filling until stuffing	Not established	In case of a surface heating, multiplication of microorganisms may be triggered	Not established	The hazards can be efficiently prevented by in-process keeping of the filling at the temperature of approximately 12°C for a shorter time-period, possible multiplication of microorganisms will not significantly affect hygienic safety of the final product, since the latter is subjected also to the thermal processing.
Preparation of the wraps to be stuffed	Not established	Due to the contamination of water in wich they are immersed over a longer period of time, possible contamination	Not established	Possible multiplication of microorganisms will not significantly affect hygienic safety of the final product, since the latter is subjected also to the thermal processing.
Stiffing the filling into the wraps	Not established	Not established	Possible contamination of the filling with foreign objects, attributed to the damage of the sausage filling apparatus, etc.	The hazards can be efficiently prevented by scrupulous working performance and the visual control of the device prior and after work.
With-holding the sausages until thermal processing	Not established	Due to the undue postponement of the thermal processing, multiplication of microorganisms might occur	Not established	Processing temperature up to 12°C for a shorter period of time (4-12h), possible multiplication of microorganisms will not significantly impact the safety of the final product. Calibration of automatic smokey chambers intended for thermal processing.
Thermal processing	Not established	Due to an inappropriate thermal processing regimen, possible survival of pathogenic microorganisms.	Not established	Thermal processing in the line with the pre-set thermal regimen. The achivement of the temperature >74°C, as measured in the product centre. Calibration of automatic smoky chambers intended for thermal processing.
Cooling of thermally processed products	Not established	Due to the inappropriate cooling, possible multiplication of the microorganisms that managed to survive thermal processing.	Not established	The hazard is insignificant, since the product had undergone pasteurisation and is able to cool off very quickly and maintain a low temperature value. Overall, it prevents the multiplication of microorganisms that might manage to survive thermal processing. In addition, prior to the issuing products into the warehouse, cooling down to the temperature of <-5°C within 2-6 hours following thermal processing.
Storage	Not established	Possible multiplication of anaerobic pathogenic microorganisms which managed to survive thermal processing, in case the cooling was insufficient.	Not established	Provided that the storage chamber temperature does not exceed 8°C, the hazard is substantially reduced.
Vacuuming	Not established	Possible multiplication of microorganisms due to the undesired temperature of the vacuuming facility, inappropriate packaging, etc.	Due to the inadequate packaging, possible contamination of the products by migrants originating from the packaging.	The hazards are insignificant, since in a real-life processing only packages of the suppliers being issued an appropriate documentation have been utilised, and the temperature in the vacuum facility is kept up to 12°C.
Shipping	Not established	Possible multiplication of microorganisms due to the undesirable temperature of the warehouse hosting the labelling process, packaging into the collective package, arrangement on the pallets, etc.	Not established	The hazards are insignificant, since the warehouse temperature does not exceed 8°C.

Table 3 Hazard analysis carried out within the technological process of emulsion production

Process step	Chemical hazard	Microbiological hazard	Physical hazard	Preventive measures
Purchase of additives & spices	Noxious chemical substances contained in additives and spices, present in quantities above those maximally permissible according to the referent Ordinace.	Poor microbiological quality (an excessive number of microorganisms, hazaordus microorganizms in quantities above those maximally permissible according to the referent Ordinance and the internally set standards. Changes in organoleptic properties (the appearance , flavour, odour, colour, consistency), occuring in raw-materials, additives, spices, arising as a consequence of microbiological activity.	Impurities of the mechanic nature, contained in additives & spices.	Certificates, chemical and physical analyses of additives and spices prior to their storage, contracting of a purchase of additives and spices of the pre-set quality, quality control by means of an organoleptic examination carried out prior to use, and verification by means of a laboratory testing performed by the licensed laboratory, sampling thereby entrusted with a certified veterinary inspector.
The receipt of the newly processed raw-material shipped from the chopping facility	Not established	Owing to undue cooling, or prolonged processing in undesirable thermal surroundings of the chopping facility, multiplication of microorganisms may occur		Organoleptic examination of the raw-material prior to its processing, carried out by the employee engaged at the very workplace, separation of inappropriate raw-material into the confiscate
Freezing prior to the processing	Not established	Not established	Not established	
Receipt of the frozen goods shipped from the frozen goods' warehouse	Not established	Due to the prolonged storage, the spoiling of the raw-material (adipose tissue oxidation, multiplication of microorganisms) may occur	Not established	Storage duration control, organoleptic examination of raw-materials prior to their processing, carried out by the employee engaged at the workplace in reference, separation of inappropriate raw-material into the confiscate.
Separation of package from a frozen raw-material	Not established	Not established	Residual package peaces, incomplete package separation.	Hazard insignificant, since cuticles are packed into the thick plastic bags not prone to tearing, visual inspection.
Fragmentation of frozen cuticles by means of a crusher	Not established	Not established	Pieces of metal arising from the damage of the device.	Visual inspection prior and following the crushing, visual inspection of raw-material.
Storage of additives, spices and wraps in the additives' store until further processing	Various additives and spices may unintentionally become a content of other additives and spices, which is attributed to the negligence in handling. Content alternations due to the prolonged storage.	Due to the impact of insects and rodents, microbiological contaminations of additives may occur; content alternations due to the prolonged storage.	Due to the package damage, contamination of additives with foreign object (metal, wood, glass), insect body parts, etc. may occur .	The hazards can be avoided based on the visual control of the expiry date, veterinary surveillance of the compliance to the methods of disinfection, desinsection, deratisation; the hazards are insignificant and easily eliminated.
Weighting of fresh and frozen raw materials, additives and spices	Possible over-concentration of some filling ingredients. For instance, nitrites and polyphosphates, present in excessive concentrations, may pose as a human hazard.	Not established	Possible contamination of the filling with foreign objects, occuring during the course of the weighting procedure.	The hazard can be efficiently prevented by punctual weighting of all the ingridients , by checking the expedients which is entrusted with the warehouseman, by checking the balance prior to its use and during the course of it, as well as by educative courses structured in line with the particular ingridients and processes employed, and accompanied by visual inspection of the weighted.
Preparation of the emulsion by means of a cutter, adding nitrite pickling salt, water and additives	Possible over-concentration of some emulsion ingridients.	Not established.	Possible contamination of the filling with foreign objects, that might occur during the course of the emulsion preparation	The hazards can be efficiently prevented by punctual weighting of all the ingridients, by checking the expedients which is entrusted with the warehouseman, by checking the balance prior to its use and during the course of it, as well as by educative courses structured in line with the particular ingridients and processes employed, and accompanied by visual inspection of the weighted ingredients; possible multipilication of microorganisms will not significantly affect final product safety, since the latter is subjected also to the thermal processing.
Additional fregmentation of the emulsion by means of a micro-cuter	Not established	Possible multiplication of microorganisms due to the excessive emulsion heating	Not established	Possible multiplication of microorganisms will not significantly affect final product safety, since the products containing emulsion are also subjected to the thermal processing.
Storage until processing	Not established.	Possible multiplication of microorganisms due to prolonged storage, undue cooling or an excessive temperature of the emulsion storage chamber.	Not established.	Hazards can be efficiently prevented by controlling the time and the temperature of the emulsion storage, as well as its organoleptic examination prior to its processing; possible multiplication of microorganisms will not significantly affect final product safety, since the products are also subjected to the thermal processing.
Adding the emulsion while processing semi-dry, stewed sausages and semi-caned meat products	Not established.	Not established.	Not established.	

focus is represented by the critical control points (Scott, 2005).

EU candidate countries, Croatia thereby included, are not only to confront the ignorance of the consumers and food safety issues, but also the issues concerning harmonisation and coordination of the control employed in the field. As indicated by the EU member states, a special attention should be paid to weaknesses and needs (Bánáti, 2003).

The HACCP system had also been adopted by the laws, regulations and administrative provisions enacted in the Republic of Croatia, the issues relevant for the HACCP system and the requirements related to the self-control system thereby being covered by the Law on Food (Anon., 2003a). As a throughout-elaborated system, the HACCP was first put in use in the Republic of Croatia in early 1996, when the American restaurant chain McDonalds opened its

Table 4 Designation of critical control points-„the decision tree“

Process step	Risk Hazard(s): C-chemical M-microbiological P-Physical	P1. FOR THE HAZARD IDENTIFIED, ARE ANY PREVENTIVE MEASURES ALREADY IN PLACE? If NOT: it cannot be considered the CCP If YES: move to the next question	P2. DOES THIS HELP ELIMINATE OR REDUCE PROBABLE HAZARD OCCURRENCE TO AN ACCEPTABLE LEVEL? If YES: CCP If NOT: move to the next question	P3. COULD A HAZARD EMERGE ONLY FROM THE EXCESS ABOVE ACCEPTABLE LEVEL, OR MIGHT REACH AN UNACCEPTABLE LEVEL? If YES: move to the next question If NOT: it cannot be considered the CCP	P4. IS THE NEXT STEP CAPABLE OF ELIMINATING HAYARD(S) OR REDUCE ITS OCCURENCE TO AN ACCEPTABLE LEVEL? If YES: it cannot be considered the CCP If NOT: CCP	Critical Control Point
The purchase of meat, additives, spices, wraps & packages	C,P,M	YES	NO	NO	-	NO
Receipt of the frozen goods shipped from the frozen goods´ warehouse	M	YES	NO	NO	-	NO
Fragmentation of frozen adipose tissue and meat blocks by means of a crusher	P	YES	NO	YES	YES	NO
Partial melting of the frozen meat	M	YES	NO	NO	-	NO
The receipt of the newly processed raw-material shipped from the chopping facility	M	YES	NO	NO	-	NO
Cooling and storage of the raw-material prior to the processing	M	YES	NO	NO	-	NO
Storage of additives, spices & wraps in the warehouse until further processing	C,P,M	YES	NO	NO	-	NO
Weighting of the frozen raw-material, additives and spices	C,P	YES	NO	YES	-	NO
Preparation and storage of emulsion until further processing (refer to the CCP and hazard analysis concerning emulsion preparation)	-	-	-	-	-	-
Preparation of the filling in a cutter, with the addition of nitrite pickling salt, additives, spices and emulsion	P	YES	NO	YES	NO	YES
Passage of the filling through a Wolf micro-cutter	M,P	YES	NO	YES	NO	YES
With-holding of the filling until stuffing	M	YES	NO	NO	YES	NO
Preparation of the wraps to be stuffed	M	YES	NO	NO	YES	NO
Stiffing the filling into the wraps	P	YES	NO	NO	YES	NO
With-holding the sausages until thermal processing	M	YES	NO	NO	YES	NO
Thermal processing	M	YES	YES	YES	NO	YES
Cooling of thermally processed products	M	YES	NO	NO	YES	NO
Storage	M	YES	NO	NO	-	NO
Vacuuming	M,P	YES	NO	NO	-	NO
Shipping	M	YES	NO	NO	-	NO

branches in the City of Zagreb. By virtue of regulations issued by the Ministry of Agriculture and Forestry in July 1997, stipulating the implementation of the HACPP system in plants and facilities licensed for the production of animal-derived foodstuffs, the implementation of the system was substantially enhanced (Anon., 1997.) The document issued by the Ministry of Health under the title“Croatian policies and strategies, Health for all until 2005” claims that the insurance of foodstuffs' safety calls for"...the creation of monitoring and control program that should comply with the principles of the so called HACCP system…" (Mihoković, 1998a).

Other institutions and experts have also taken the standpoint on the HACPP system; the efficiency of the existing system, under-pined by the analysis of the final product samples, is unsatisfactory; food safety should be warranted by the technology of production and the process control, while the critical issue within this frame is the collaboration of experts of different professional backgrounds, embraced by a multidisciplinary expert team (Mihoković, 1998 a; Mihoković, 1998 b; Mihoković, 1998 c). It is of note that the most significant share in the total number of alimentary infections and intoxications diagnosed in the Republic of Croatia, is represented by those caused by the bacteria of *Salmonella* (39.1%) and *Clostridium* species (22.2%), as well as by *Staphylococcus aureus* (8.9%), and other bacteria (29.8%). As for the food poisoning etiology, the leading role is played by contaminated meat (26.5%), followed by various salads (24.7%), sweets (24%), meat prod-

Table 5 Designation of critical control points-„the decision tree“

Process step	Risk Hazard(s): C-chemical M-microbiological P-Physical	P1. FOR THE HAZARD IDENTIFIED, ARE ANY PREVENTIVE MEASURES ALREADY IN PLACE? If NOT: it cannot be considered the CCP If YES: move to the next question	P2. DOES THIS HELP ELIMINATE OR REDUCE PROBABLE HAZARD OCCURRENCE TO AN ACCEPTABLE LEVEL? If YES: CCP If NOT: move to the next question	P3. COULD A HAZARD EMERGE ONLY FROM THE EXCESS ABOVE ACCEPTABLE LEVEL, OR MIGHT REACH AN UNACCEPTABLE LEVEL? If YES: move to the next question If NOT: it cannot be considered the CCP	P4. IS THE NEXT STEP CAPABLE OF ELIMINATING HAYARD(S) OR REDUCE ITS OCCURENCE TO AN ACCEPTABLE LEVEL? If YES: it cannot be considered the CCP If NOT: CCP	Critical Control Point
Purchase of additives & spices	C,P,M	YES	NO	NO	-	NO
Receipt of fresh raw-material shipped from the chopping facility	M,F	YES	NO	NO	-	NO
Freezing prior to the processing (refer to the Chopping Facility HACCP Plan)	-	-	-	-	-	-
Receipt of the frozen goods shipped from the frozen goods´ warehouse	M	YES	NO	NO	-	NO
Separation of the package from the frozen raw-material	F	YES	NO	NO	-	NO
Fragmentation of frozen cuticles by means of a crusher	F	YES	NO	NO	-	NO
Storage of additives, spices, and wraps in the warenhouse until further processing	C,P,M	YES	NO	NO	-	NO
Weighting of the frozen raw-material, additives and spices	C,P	YES	NO	YES	YES	NO
Emulsion preparation in a cutter, with the addition of nitrite pickling salt, additives and spices	P	YES	NO	YES	NO	YES
Additional emulsion fragmentation by means of a micro-cutter	M	YES	NO	YES	NO	YES
Storage until processing	M	YES	NO	NO	YES	NO
Addition of the emulsion while processing semi-dry, stewed sausages and semi-caned meat products	-	-	-	-	-	-

Table 6 The HACCP Plan

Hazard	Critical limits	Monitoring	Control frequency, documentation	Corrective measures	Responsible persons	Verification
Due to the inadequate thermal processing regimen possible survival of pathogenic microorganisms	Thermal processing should be undertaken in accordance to the pre-set thermal processing regimen. The temperature that is to be achieved in the centre of the product within 20 minutes should be > 72°C.	Visual monitoring of the compliance to the pre-set regimen Thermograp-hic datasheet printouts Control of the temperature in the centre of the product using a pin meat thermometer.	Each and every batch The sheet comprising data on the corrective measure undertaken Daily. Daily thermographic list Each and every wagon. The sheet covering thermal processing data, issued on a daily basis.	- Calibrate temperature-controlling instruments - Re-program the device. Check performance characteristics and correct if deemed necessary. Prolong the thermal processing until the pre-set temperature - In case of the chamber performance termination (failture), complete thermal processing in another kiln-dry - Repeat thermal processing in case of a 2-3 hour-lasting process termination (drop-out of electricity, failure) - In case of the termination of the thermal processing lasting longer than 2-3 hours, products should be taken out of the kiln-dry, cooled down to 15°C in their centres, and repeatedly thermally processed; following the microbiological analysis and in line with its results, approve the release of the products from a warehouse or safely dispose of them - In case that >5 samples per month fail to comply with the requirements of the Ordinance on Microbiological Standards Applicable for the Foodstuffs, enforce the thermal processing regimen.	The employee engaged in thermal processing Processing Manager Technologist	Microbiological analysis of final products, entrusted with a licensed laboratory, accompanied by product sampling in line with the annual Sampling Plan. In case that >10% of the samples fail to comply with the requirements of the Ordinance on Microbiological Standards Applicable for the Foodstuffs (Official Gazette of the Republic of Croatia No 125/03), hazard analysis should be reinforced.

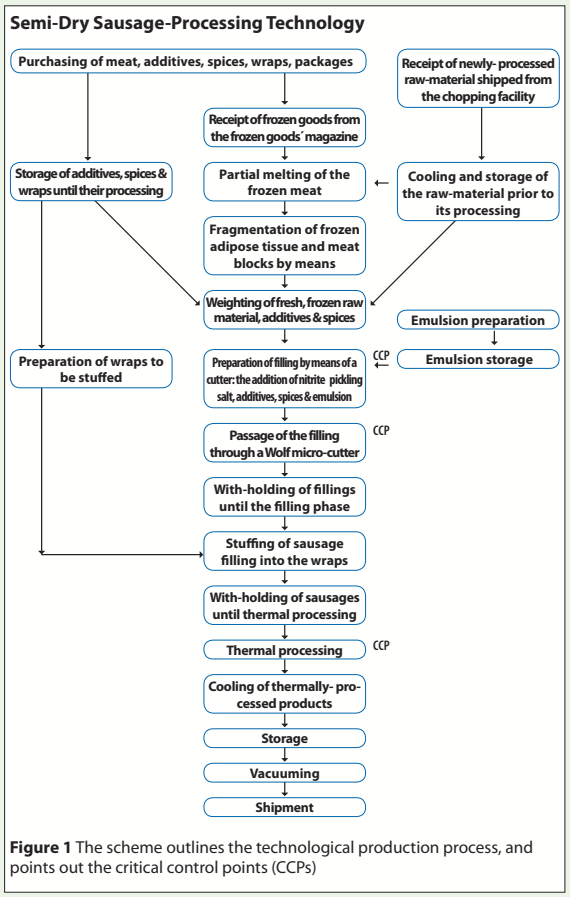


Figure 1 The scheme outlines the technological production process, and points out the critical control points (CCPs)

ucts (16.7%), fish (5.3%) and eggs (2.8%) (Ražem and Katušin-Ražem, 1994). Microbiological norms and monitoring are vital for the functional prevention of alimentary intoxications (Živković, 2001).

Materials and methods

The production process aimed at obtaining the aforementioned product, had utilised raw materials provided for in the receipt for the technological production process in reference.

Based on the flaw charts, the hazard analysis was carried out by making a list of hazards (chemical, microbiological, and physical) present in each of the process steps, and subsequently adjudicating all the measures necessary to gain control over the hazard identified.

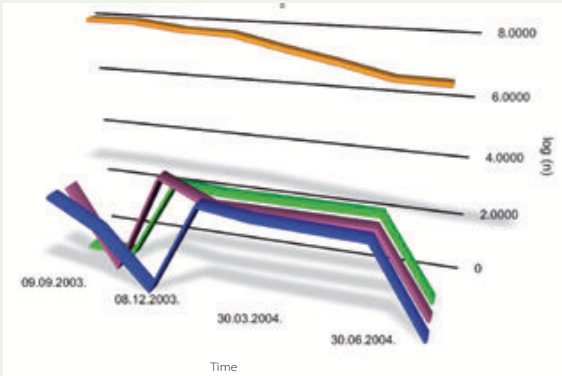
As an aid in designating critical control points, the decision-making tree had been employed. Each step comprised by the production of semi-dry sausage and emulsion, was a subject to questioning under the tree. The decision-making tree is under-lied by four questions, and the combination of affirmative and negative answers provides information on the accuracy of critical point designation (Živković, 2001).

Critical limits, the frequency of control checking, monitoring, corrective measures and verification, had been covered in accordance to the laws, regulations and administrative provisions currently enforced in the Republic of Croatia, as well as in accordance with the available referent literature. Parameters employed in such a monitoring process, were selected based on the existing technological and instrumental equipment available at the meat industry concerned. The responsible person was appointed within the frame of the HACCP plan.

The follow-up had been focused on the cleanness of the working surfaces and technological equipment utilised within the technological process of semi-dry sausage production. The checks were scheduled twice a month, and carried out at 16 workplaces designated by the SSOP monitoring plan, an hour prior to the start of the production process (HRN EN ISO 6887-2:2004).

Within the frame of this study, the microbiological analysis of the emulsion, "rebound", and the final product had been carried out twice a month over a 12-month period, accompanied by the entries and monitoring of the raw-materials used for the production of semi-dry sausage on each given day (HRN EN ISO 6887-2:2003; HRN ISO 5552:1997; HRN ISO 6391:1997; HRN EN ISO 6579:2002; HRN EN ISO 6888-3:2003).

The thermal processing regimen employed herein, complied with the duly chosen pre-defined regimen carried out in automatic pre-



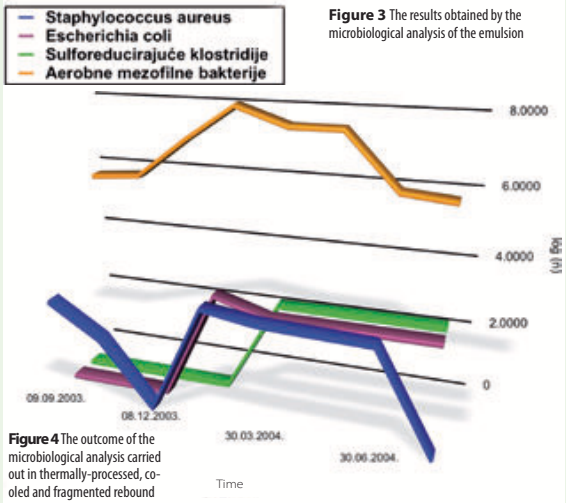


Figure 3 The results obtained by the microbiological analysis of the emulsion

Figure 4 The outcome of the microbiological analysis carried out in thermally-processed, cooled and fragmented rebound

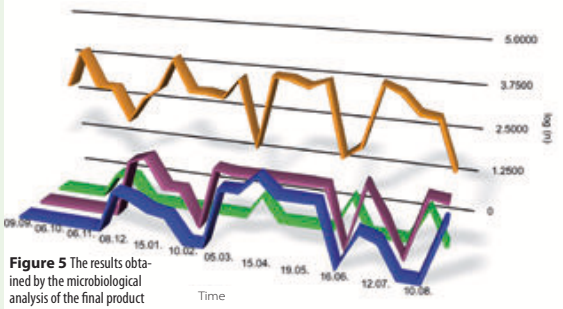


Figure 5 The results obtained by the microbiological analysis of the final product

set chambers, and ending up when a certain temperature has been achieved. Temperature measurements, carried out via inserting a pin meat thermometer into the very centre of the product, had been undertaken twice a month in a series of four (24 times in total). On each of these occasions, the time necessary to complete thermal processing had been registered. The cooling of the product was obtained by cold water showers, observing thereby the time-to-cooling and the temperature achieved in the product centre (the latter decreasing to 30 °C). Further cooling of the product was carried out in the premises situated in front of the final products' warehouse, using a cold air flow. This procedure had been followed by repeated measurement of the time-to-cooling and the temperature achieved in the centre of the final product. According to the results obtained by a pin meat thermometer, the temperature in the centre of the product had gone further down, and was at least 15°C.

Discussion and conclusion

Based on the 12-month follow-up of all the ingredients involved in the production sequence, and the equipment utilised in the semi-dry sausage [2]Jeger of Ivanec[2] production settings, the obtained product (Table 1) complies with the currently enacted Ordinance on the Meat Product Quality (Anon., 2007).

Within the framework of the HACCP plan employed in the production and processing of semi-dry sausage-based products, and based on the hazard analysis (Tables 2 and 3), critical control points designation (Tables 4 and 5), and the production technology (Figures 1 and 2), the major hazard pointed out [2]by the end of the day[2] turned out to be thermal processing, since a misconduct of the latter may lead to the survival of pathogenic microorganisms.

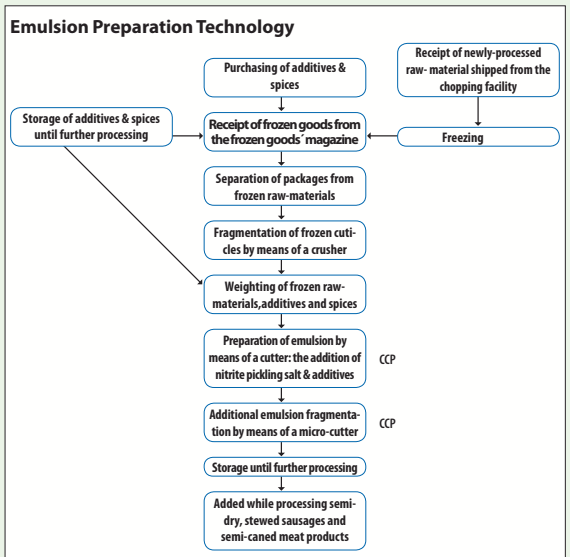


Figure 2 The scheme outlines the technological production process, and points out the critical control points (CCPs)

Critical limits, defined within the pre-set thermal regimen, impose the need for achieving the central product temperature of >72°C within 20 minutes. The monitoring refers to the visual check-up of the degree of compliance of every batch with the pre-defined regimen, and lies within the responsibility of the employee involved in thermal processing, but relies also on thermographic data, printed out daily, and controlled by the Process Manager, as well as on the temperature control, performed daily in the centre of the product on each wagon and being entrusted with the technologist. Corrective measures to be undertaken in case of a deviation from the HACCP plan, had also been defined. Verification is provided for by microbiological analyses of the final products, carried out by the licensed laboratory, and preceded by product sampling carried out in accordance with the annual Sampling Plan (Table 6).

Microbiological purity of the technological equipment had been followed-up over a 12-month period on a total of 432 samples. The follow-up had revealed 78 samples which did not meet the stipulations of the Ordinance, the latter corresponding to less than 20% of the total samples analysed; according to the currently valid legal provisions, in case such a share does not exceed 20% of analysed sample total, the microbiological purity of the facility can still be regarded as being in line with the regulations (Anon., 2009). These results suggest that the prerequisite programs have been well-managed.

Microroganisms falling into *Salmonella* and *Listeria monocytogenes* species failed to be detected in any of the emulsion samples analysed (Figure 3). As for the presence of *Staphylococcus aureus* and Escherichia *coli,* only one sample failed to meet the stipulations of the Ordinance, respectively. The total number of sulphur-reducing Clostridia, encountered in the tested samples, was in line with the requirements set out in the Ordinance, unlike the number of mesophyllic bacteria, that initially failed to comply with these requirements, but following the implementation of the HACCP system and the prerequisite programs, exhibited an uninterrupted trend towards steady decrease (Anon., 2009).

The analysis of thermally processed, cooled and fragmented rebound (Figure 4), failed to reveal the presence of either *Salmonella* or *Listeria monocytogenes* species in any of the tested samples. In two of them *Staphylococcus aureus* had been isolated, but subsequent analyses failed to reproduce such an unsatisfactory result, while the values in questions came round to normal. One sample was *Escherichia coli*-positive. The number of sulphur-reducing Clostridia established in all the tested samples, met the requirements imposed by the law, while the number of aerobic mesophyllic bacteria initially failed to comply with these requirements, but had exhibited a steady decrease following the implementation of the HACCP system and the prerequisite programs (Anon., 2009).

The temperature obtained in the centre of the product, ranged from 70°C to 74°C, while the cooling temperature obtained following the cooling of the final product with the second measurement, ranged from 8°C to 18°C, corroborating the compliance to the pre-defined regimen.

Results of bacteriological analysis of the final product reveal this product to be safe and accordant to the requirements laid down in the Ordinance (Figure 5). Sample analysis of the final product did reveal neither the presence of *Salmonella* species, nor the presence of *Listeria monocytogenes*. *Staphylococcs aureus* had been isolated in only one sample. As for *Enterobacteriaceae* and the number of aerobic mesophyllic bacteria, the samples comply with the Ordinance stipulations (Anon., 2009).

The results obtained by this study can be deemed as the indicators of good microbiological purity of the facility in question, which, beyond any doubt, should be attributed to the implementation of the HACCP system, preceded by the prerequisite programs.

The assessment and reorganisation of the system aimed at food controlling, which are targeted at the improvement of those systems, rationalisation of the human resources and the inclusion of approaches under-pined by risk analysis, is currently underway all over the world. Within these preventive approaches, the key role has been played by the HACCP system principles. The implementation of the HACCP system is the responsibility of food industry, but also of governmental control agencies which are held responsible for the monitoring and assessment of the appropriateness of the HACCP implementation (Soriano et al., 2002). The organisation of the ²self-control² should be considered in the best interest of the entire legal state system and the entrepreneurs, but also in the best interest of consumers, who should be held co-responsible.

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