Quality and Safety Assurance According to ISO 22000: 2005 in a Meat Delicatessen Industry of Cyprus

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Abstract: Quality and safety are very important for the meat delicatessen industries. In Cyprus, food industries have started to apply safety programs the past few years in a preliminary way in order to comply with the current food safety directives or regulations. The verification activities in food industries encompass sampling for monitoring GMPs-GHPs and CCPs and determination of microbiological variables, review of records, flow diagrams and HACCP plan. The present paper describes the application of the above according to the standard ISO 22000:2005 in a meat delicatessen industry in Cyprus.

Keywords: Meat delicatessen, meat hygiene, GMPs-GHPs, HACCP, ISO 22000.

INTRODUCTION

Food safety has been the topic of some recent policy changes, increased awareness among the public, and various incidents. These developments indicate that there is a need for a system that can identify food safety hazards in an early stage so that these hazards can be tackled in time, before developing into real risks. With regard to food safety hazards that are known as such, measures can be taken towards the prevention and mitigation of these hazards based on their characteristics, behavior and point of entry into the food chain. For example, good practices for agriculture and manufacturing (GAPs and GMPs-GHPs), as well as the Hazard Analysis Critical Control Points (HACCP) approach to assess risks and control them, have a commonplace in many jurisdictions. However, it can be envisioned that for a number of risks, such measures may not be applicable given that these risks are yet unknown or unanticipated.

Food hygiene is defined by *Codex Alimentarius* as "all conditions and measures necessary to ensure the safety and suitability of food in all steps of food chain" (Codex Alimentarius, 1999, 2002) [1,2]. HACCP system is compulsory in EU member states for safety assurance based on hazard analysis, while prerequisite hygiene programs (GHPs: Good Hygiene Practices, GMPs: Good Manufacturing Practices) are necessary to support the system [3]. According to the HACCP principles, in each step of the food process, all possible hazards (physical, chemical, microbiological) are identified, their importance is evaluated and all the preventive measures for their control are described (principle 1). The Critical Control Points (CCPs) should be identified by risk assessment according to ISO 22000:2005 [4] where monitoring is critical for controlling the safety of the product (principle 2). For each identified CCP, critical limits for preventive measures (principle 3) and monitoring systems (principle 4) are established. When monitoring shows that a critical limit has not been met, corrective actions must be taken (principle 5). Finally, procedures to verify that the system is working properly (principle 6) and effective records to document the HACCP system are established (principle 7), [3,5].

Methods to conduct a hazard analysis [6] and establish critical control points using risk assessment and food borne outbreak evaluations [7-9] have recently been supported by elaboration of the risk profiling approach. HACCP is a highly specialized system for food safety that is needed for carrying out an analytical study about microbiological, chemical and physical hazards. Hazard analysis contains the identifications of potential hazards throughout the food process and the identification of critical steps (CCPs) that must be controlled to assure food safety [3, 5]. HACCP based programs were implemented in the 1990's to enhance food safety and quality. Preventive measures in terms of adequate process controls accompanied by periodic verification and corrective actions were considered more effective than inspecting defects out of each final product [10].

Quality and safety are important for the meat delicatessen industries. Quality assurance of the whole process is significant for the consumer acceptability, while safety assurance is obligatory for protection of public health. Quality is required in order for the product to meet the customers' specifications and may be assured by the application of quality management systems, such as ISO 9001. As far as food safety is

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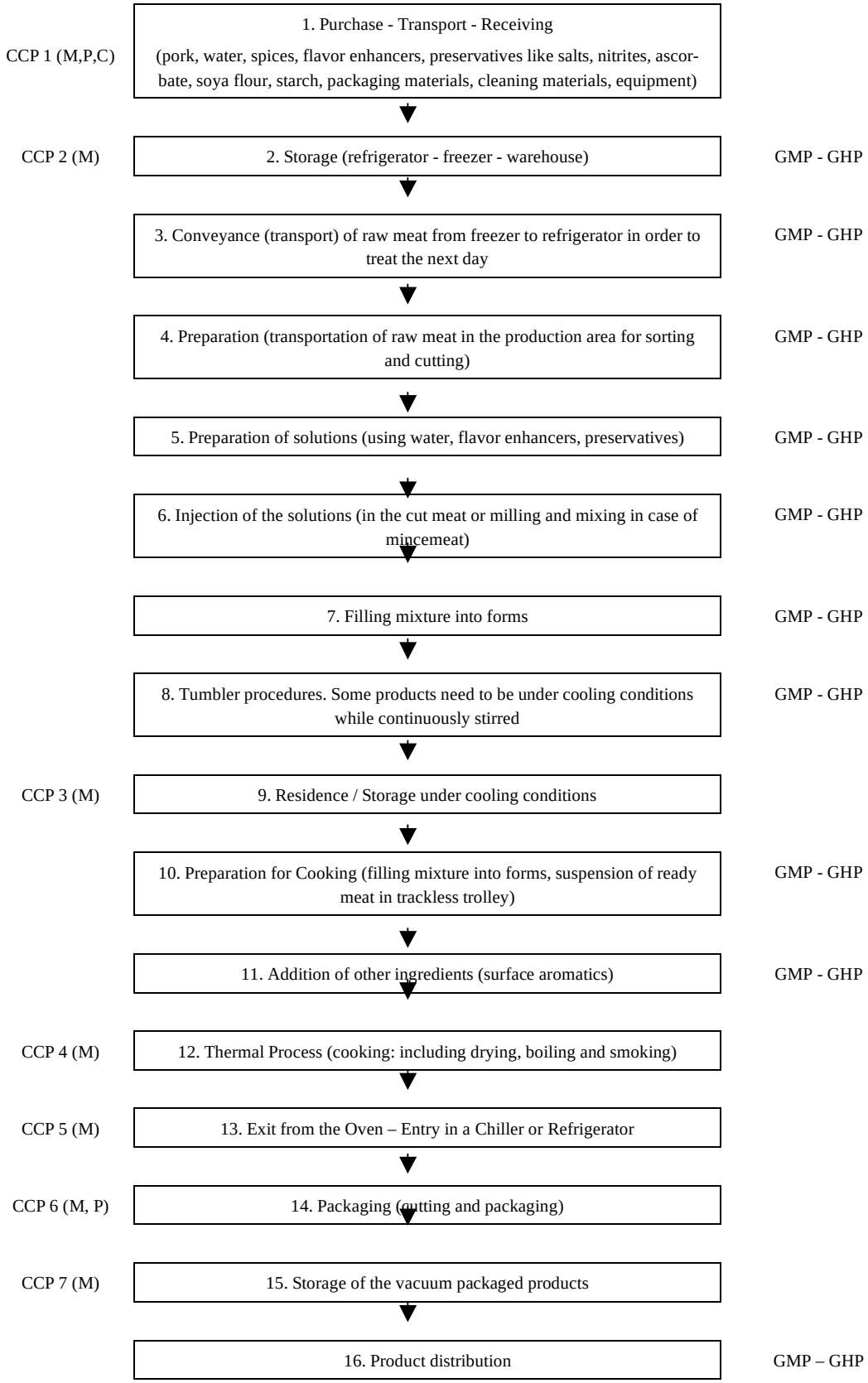

Fig. (1). General flow chart for the production of meat delicatessen (M: Microbiological, P: Physical, C: Chemical hazard).

Table 1. The Possibility of the Appearance of Negative Impact on Public Health (SEVERITY-S)

Grade	Definition
0	No damage or human ill. No legal requirement.
1	Low concentration of microbiological activities in the food which is under the limits. No serious illness of the consumer. No legal requirement. All the parameters, microbiological and chemical, are under the limits of all the directives or legislations. Physical hazards can be controlled.
2	The product can be characterized as degrading (High concentration of microorganisms and the product has low quality). If the product proceeds to the consumer it may affect selected populations, such as the elderly or infants. Mild occurrence of food poisoning. The product should be removed from the market. May have a legal claim.
3	The product is not acceptable. All the parameters are over the limits. If the product is consumed, the consumer may be in hazard. Occurrence of a serious food poisoning. Definite legal claim. The product must be immediately removed from the market.

concerned, food legislation of European Union, recognizing the significance of safety for human health, has established the application of Council Directive 93/43/EEC & Regulation (EC) No 852/2004 [11, 12] in which the basic hygiene and HACCP requirements are defined (directive 93/43 is no longer in force, because it has been repealed by Regulation EC 852/2004). In Cyprus, food industries have started to apply safety assurance programs during the past few years in a preliminary way in order to comply with the current food safety directives or regulations [11-15]. Implementation of HACCP system is a fundamental approach to ensure the safety of food supply, providing a systematic procedure for the identification, evaluation and control of hazards in each operation [16]. Small business may lack in house knowledge and resources required for the correct implementation of HACCP. Before implementing a HACCP system, a food business should already have in place various practices that may be collectively termed "prerequisite programs" (PRPs) (e.g. raw materials' specifications, staff training, hygienically designed facilities and good hygiene practice - GHP) [17-20].

Risk profiling is one activity in preliminary risk management, which has been recently defined as a description of a food safety problem and its context developed for the purpose of identifying those elements of a hazard or risk that are relevant to risk management decisions (Codex Alimentarius Commission, 2002) [2]. Risk profiling involves the systematic collection of information needed to make a decision on what will be done next and which resources should be allocated to more detailed scientific assessment. The risk profiling process typically provides information on: the hazard, exposure to the hazard, adverse health effects, public health surveillance information, control measures and other information relevant to risk management decision-making.

In Cyprus there are about 20 meat delicatessen industries which treat pork, beef, turkey and chicken in order to produce bacon and different kinds of ham, salami, sausages and mortadella. The most common ingredients, in addition to meat, are: water, spices, flavor enhancers, preservatives (like salts, nitrites) or antioxidants (ascorbate), soya flour and starch. Coriander, a local spice with special aroma and taste, is used in many traditional products and is very pleasing to the Cyprian consumers. For proper meat processing, relative or special equipment like cutter machines, tumblers, injections, guillotine, packaging machines, coolers, ovens, smokers, chillers, cutting machines etc. are used in these industries.

The verification activities in food industries encompass sampling for monitoring CCPs and determination of microbiological variables, review of records, flow diagrams and HACCP plan. However, regarding the implementation of such a safety assurance system, hygiene programs like GHPs-GMPs are also required.

MATERIALS AND METHODS

Bacon, lountza, hiromeri, ham and sausages are some of the meat delicatessens produced in Cyprus. Lountza (smoked fillet of pork) and hiromeri are typical meat delicatessen of Cyprus and very common to the culture of Cyprus. Hiromeri resembles the Italian Prosciutto. Pork meat is the main raw material for the production of the above products, while water, spices, flavor enhancers, preservatives (like salts, nitrites), ascorbate, soya flour, starch are necessary ingredients as well.

Bacon, lountza, hiromeri, ham and sausages are produced following a general flow diagram (Fig. **1**). This represents the typical production of meat delicatessen based on both the bibliography [21] and the suggestions of the industry's expertise. The processing steps differentiate depending on the product.

In each step of the process, the first two principles of HACCP are developed. Thus, all possible hazards (physical, chemical, microbiological) are identified, the preventive measures are described and CCPs are identified by risk assessment according to ISO 22000:2005 [4] (Tables **1, 2, 3**). Especially, risk assessment of risk levels taking into account both the possibility of appearance and the severity of the hazard is used. Following, as the remaining principles require, for each identified CCP, critical limits for preventive

Table 2. The Possibility of the Appearance of the Specific Hazard (PROBABILITY -P)

Grade	Definition
0	Maybe or Low possibility of appearance
1	Possible to happen
2	Very Possible to happen

Table 3. Risk Level Estimator [RISK = SEVERITY + PROBABILITY]

	Severity			
Probability	**0**	**1**	**2**	**3**
0	0	1	2	3
1	1	2	3	4
2	2	3	4	5

measures and monitoring systems are proposed, as well as corrective actions. Based on these data, procedures to verify and effective records to document the HACCP system can be established. Also, prerequisite measures related to GMPs - GHPs in each production step are described.

RESULTS AND DISCUSSION

For the meat products examined, processes are applied according to Fig. (**1**). Raw materials receipted in the industry are stored, pork meat under refrigeration (up to 6 days) or in the freezer (up to 6 weeks) and other materials in the warehouse. The required amount of meat, one day before processing, is transported from the freezer to the refrigerator. The rest of the materials, in the required amounts, are transported to the production area. The preparation of meat involves sorting and cutting, as well as the addition of necessary substances in solution (flavor enhancers, preservatives). The solution is injected into the minced meat and the mixture is filled into forms. Following, the mixture is processed in the tumbler and then, either cooled or intended for cooking and the final products are packaged, stored and distributed. Alternative steps which are applied for the production of particular products are referred below.

- For the production of **streaky and back bacon,** all the steps (Fig. **1**) except step 7 are followed. Step 11 takes place in case an aroma of coriander (typical

Table 4. Risk Level Definitions

Risk Level	Definitions	Required control action
0	Uncreated	Very low hazard. Typical preventing actions.
1	Very Low	The hazard is accepted by the company and is under the limits of legislation. The acknowledged hazard presents problems only in selected populations (like: diabetics or persons having cardiovascular problems).
2	Low	Hazard that requires more check and control (optical check is accepted). The acknowledged hazard presents problems only in selected populations (like: diabetics or persons having cardiovascular problems). Perhaps the HACCP plan needs changes. If the corrective actions are repeated more than 30 % in the same point or procedure in the total corrective actions in the same year then must be a Critical Point. Nevertheless, the specific hazard does not present any public health hazard. All the parameters are under the limits and product is safe.
3	Fair	Hazard that is not accepted. However, the miss control of the hazard does not present any hazards to the public health. It presents problems only in selected populations (like: diabetics or persons having cardiovascular problems). Also, the product can be characterized as degrading. If the corrective actions are repeated more than 10 % in the same point or procedure in the total corrective actions in the same year then it must be a Critical Point. The HACCP plan must be re-checked. The product needs laboratory checks and then to proceed with corrective actions in order that the procedures return within safe limits. There is a possibility of food poisoning (with transiently symptoms). If the product is in the market it must be traced back.
4	High	This is a CCP. The hazard is not accepted and if it is out of limits problems can be caused to the consumer. The hazard affects all consumer populations. The product can be characterized as degrading to hazardous for the human health. If the corrective actions are repeated more than 5 % in the same point or procedure in the total corrective actions in the same year then it must be a Critical Point. The HACCP plan must be re-checked. The product needs laboratory checks and then to proceed with corrective actions in order that the procedures return within safe limits. The HACCP Team must be notified and then all the procedures must be stopped. The HACCP team must take corrective actions while the product must be removed from the market.
5	Very High	CCP. The entire recognized hazards are not acceptable. The product is characterized as unacceptable and very hazardous if it is out of limits. The product can be characterized as degrading to hazardous for the human health. If the corrective actions are repeated more than 5 % in the same point or procedure in the total corrective actions in the same year then it must be a Critical Point. The HACCP plan must be re-checked. The product needs laboratory checks and then to proceed with corrective actions in order that the procedures return within safe limits. The HACCP Team must be notified and then all the procedures must be stopped. The HACCP team must take corrective actions while the product must be removed immediately from the market.

aromatic herb from Cyprus) should be obtained for special customer demands.

- **Lountza (or smoked fillet of pork).** This meat delicatessen of Cyprus is prepared from fillet of pork with no covering fat, using all the steps described above (Fig. **1**) except step 7. Similarly, step 11 takes place, if an aroma of coriander is demanded.
- **Hiromeri** is a traditional meat delicatessen of Cyprus which is prepared by following steps 1-4 and 14-16 (Fig. **1**). Mixing of salts with meat and storage in the refrigerator (step 9) is conducted by hands. After a period of 2-5 weeks, the meat is transferred to a wine bath for more than a month in the refrigerator (step 9). Then it remains at dry air under controlled conditions and is finished by drying and smoking (step 13).
- **Leg ham – smoked ham** is prepared (Fig. **1**) by following steps 1-5. In step 6 the meat is mixed in a cutter making a mush sample. Steps 8 and 11 are not applied. The thermal process (step 12) includes boiling and smoking.
- **Sausage (Cyprian Sausage)** is prepared using steps 1-5. Steps 8 and 11 are not applied (Fig. **1**). The meat is cut as mincemeat in step 6. The mixture is filled in natural bowels, remains at dry air under controlled conditions and follows the steps 12-16.

The identification of CCPs and the required actions for their control are crucial for the appropriate HACCP development. However, nowadays, risk assessment and quantification of hazards are recommended focusing on the consumer's health, while a higher safety level is proposed. In order to identify CCPs, the methods used are presented in Tables **1-4**. Table **1** presents the possibility of the appearance of negative impact on public health (SEVERITY-S) using grades 0-3. Table **2** shows the possibility of the appearance of the specific hazard (PROBABILITY-P) using grades 0-2. Table **3** presents the Risk Level, where Risk Level (R) = S + P, using scale 0-2 for probability and scale 0-3 for severity. Table **4** shows the Definitions of Risk Level using levels 0-5. Table **5** presents the risk assessment results of the flow chart (Fig. **1**).

According to ISO 22000:2005, all food safety hazards that are reasonably expected to occur in relation to the type of product, type of process and actual processing facilities should be identified and recorded. The identification is based:

- √ On experience.
- √ On external information from, to the extent possible, epidemiological and other historical data.
- √ On the preliminary information data collected according to the food safety team, the product's characteristics (microbiological, chemical, physical), methods of production, storage conditions and shelf life, preparation and/or handling before using processing, packaging and delivery methods.

Hazard assessment shall be conducted to determine each food safety hazard identified whether its elimination or reduction to acceptable levels is essential to the production of a safe food and whether its control is needed to enable the defined acceptable levels to be met. Each food safety hazard shall be evaluated according to the possible severity of adverse health effects and the likelihood of their occurrence.

CCPs

The results of the analysis on the quality and safety hazards of the meat delicatessen industry are presented in Table **6**. The Table should be used complementary to the following results. Incoming materials, especially raw meat used in large quantities, is a sensitive food as it may support the growth of microorganisms. For the above mentioned reason, raw materials' delivery is characterized as a Critical Control Point (CCP 1) and should be examined in each receipt. Certified suppliers and rigorous criteria for raw materials, additives with low microbial counts and absence of pathogens could greatly contribute to the hygienic quality and safety of the final product. Food handling errors, inadequate storage practices and improper holding temperatures may also occur [22]. The storage temperature consists of an important Critical Control Point (CCP 2, 3, 7). Thus, during storage at chilling conditions the temperature has to be maintained at 4^{o}C or less in order to ensure the microbiological safety of cooked products.

During the thermal process (step 12 from Fig. **1**) the core temperature of a product consists of a Critical Control Point (CCP 4). Cooked products should be heated until they reach an internal temperature well over 72^{o}C. In order to avoid the growth of any thermo-tolerant bacteria or spores potentially present, it is essential to cool products rapidly after processing and to prevent storage at high ambient temperatures. Reducing the temperature from 72 to 10^{o}C has to be attained in less than 2hrs and consequently, the time needed to cool down the cooked product is characterized as a Critical Control Point (CCP 5). Major sources of contamination are the slicing and packaging room (CCP 6). Moreover, the staff's personal hygiene has to be the appropriate.

GMPs - GHPs

Table **7** presents the GMPs and GHPs required in all production steps in order to avoid contamination. In addition to the most significant factors and the relative required controls involved with CCPs, all the other factors in those steps must be controlled in order to assure quality and safety. Such controls usually are prerequisite measures which are grouped and organized by means of hygiene practices.

The processes of Meat Distribution Industry (meat delicatessen) include steps that are not under the industry's responsibilities. The animals' farm, animal feeds, slaughterhouse procedures, transportation of raw meat can not be easily controlled by the industry. The quality and safety of the meat delicatessen are related to the above.

All the requirements related to hygienic practices during the industry's operations, either referred to equipment maintenance or to cleaning / disinfection procedures of equipment or to the control of foreign matters, must be included in the prerequisite programs (PRPs).

Critical factors of hygiene and safety assurance during the production of all meat delicatessen (bacon, lountza, hiromeri, ham, sausages) were the temperature in the processing lines, which must be held below 12^{o}C and hygienic practices, not only by the personnel but also by the sanitation of

Table 5. Risk Assessment Result (M: Microbiological, C: Chemical, P: Physical Hazardous)

Step of the flow chat (Fig.1)	Hazard	Severity (S)	Probability (P)	Risk (R=S+P)	Category CCP/GMP
Purchase – Transport – Receiving	M	3	2	5	CCP 1
	C	3	2	5	CCP 1
	P	3	2	5	CCP 1
Storage	M	3	2	5	CCP 2
	C	2	1	3	GMP
	P	2	1	3	GMP
Conveyance (transport) of raw meat from freezer to refrigerator in order to treat the next day	M	2	1	3	GMP
	C	2	1	3	GMP
	P	2	1	3	GMP
Preparation (Transportation of raw meat in the production area for sorting and cutting)	M	1	2	3	GMP
	C	1	1	2	GMP
	P	1	1	2	GMP
Preparation of solutions (using water, flavor enhancers, preservatives)	M	1	1	2	GMP
	C	2	1	3	GMP
	P	1	1	2	GMP
Injection of solutions (in the cut meat or milling and mixing in case of mincemeat)	M	1	1	2	GMP
	C	2	1	3	GMP
	P	2	1	3	GMP
Filling mixture into forms	M	1	1	2	GMP
	C	1	1	2	GMP
	P	1	1	2	GMP
Tumbler procedures. Some products need to be under cooling conditions while continuously stirred	M	1	2	3	GMP
	C	1	1	2	GMP
	P	1	1	2	GMP
Residence / Storage under cooling conditions	M	2	2	4	CCP 3
	C	1	2	3	GMP
	P	1	2	3	GMP
Preparation for Cooking (Filling mixture into forms, suspension of ready meat in trackless trolley)	M	1	1	2	GMP
	C	1	1	2	GMP
	P	1	1	2	GMP
Addition of other ingredients (surface aromatics)	M	1	2	3	GMP
	C	1	2	3	GMP
	P	1	1	2	GMP
Thermal Process (Cooking: including drying, boiling and smoking)	M	3	2	5	CCP 4
	C	1	2	3	GMP
	P	1	2	3	GMP
Exit from the Oven – Entry in a Chiller or Refrigerator	M	2	2	4	CCP 5
	C	1	2	3	GMP
	P	1	1	2	GMP
Packaging (cutting and packaging)	M	2	2	4	CCP 6
	C	1	2	3	GMP
	P	2	2	4	CCP 6
Storage of the vacuum packaged products	M	2	2	4	CCP 7
	C	1	1	2	GMP
	P	1	1	2	GMP
Product distribution	M	2	1	3	GMP
	C	1	1	2	GMP
	P	1	1	2	GMP

Table 6. HACCP Sheet - Analysis for the Safety Hazards, CCPs and their Control (M: Microbiological, C: Chemical, P: Physical Hazards)

Step of the flow chat (Fig.1)	Hazards	Critical Factor/Limits/ Controls	Parameters to be monitored for a particular CCP	Preventive measure
Purchase – Transport – Receiving (CCP 1 M,C,P) Pork	Microbiological *Salmonella* spp, *Campylobacter*, *Staphylococcus aureus*, *Clostridium perfringens*, *Clostridium botulinum*, *Escherichia coli*, *Yersinia enterocolotica*, *Listeria monocytogenes*, *E. coli*, Faecal coliforms, Coliforms or Enterobacteria Chemical Antibiotics, Mycotoxins (barely), hormone auxin Physical Absence of impurities	TVC: 10^4 or 10^5 - 10^6 *E. coli* and Faecal coliforms: 50-$1x10^2$ Coliforms or Enterobacteria: $1x10^2$ or $1x10^3$ *Salmonella* spp: 0/25g or 50g *Staphylococcus aureus*: $1x10^2$-$1x10^3$ *Clostridium perfringens*: 10-30 Yield and molds: $5x10^3$ Chemical characteristics Shelf life: moisture 85-90%, pH 5-5.5	Temperature Organoleptic characteristics (color, smell, appearance) Microbiological analysis Chemical analysis: moisture, pH	Supplier control and audits Transport control and checks (hygiene checks) Temperature control Control of organoleptic characteristics (color, smell, appearance) Reject improper meat Health certificates
Purchase – Transport – Receiving (CCP 1 M,C,P) Starch	Microbiological *Salmonella* spp, *Bacillus cereus* Chemical Mycotoxins, pesticides Physical Absence of impurities	Product specifications TVC: 10^6 *Salmonella* spp: 0/25g *Bacillus cereus < 20* Shelf life	*Microbiological analysis* *Temperature* *Organoleptic characteristics (color, smell, appearance)* *Chemical analysis*	*Supplier control and audits* *Transport control and checks (hygiene checks)* *Reject improper starch* *Health certificates* *Mycotoxins and pesticides analysis*
Purchase – Transport – Receiving (CCP 1 M,C,P) Spices	Microbiological *Salmonella* spp, *Bacillus cereus*, *Clostridium botulinum*, *Staphylococcus aureus*, *E. coli*, Faecal coliforms, *Clostridium perfringens*, Coliforms or Enterobacteria Chemical Toxins (aflatoxins) Physical Absence of impurities	Product specifications Shelf life TVC: $5x10^5$ *Salmonella* spp: 0/25g *E. coli*: negative – $2x10^2$ *Staphylococcus aureus*: $1x10^2$ *Clostridium perfringens*:$1x10^2$ Coliforms or Enterobacteria: $5x10^2$ Toxins	*Temperature* *Organoleptic characteristics (color, smell, appearance)* *Microbiological analysis* *Chemical analysis*	*Supplier control and audits* *Transport control and checks (hygiene checks)* *Reject improper spices* *Health certificates* *Free of aflatoxins*
Purchase – Transport – Receiving (CCP 1 M,C) Water	Microbiological TVC, *Staphylococcus aureus*, *E. coli*, Faecal coliforms, Coliforms, Enterobacteria Chemical Metals, NH_4, NO_3, NO_2, PO_4, B, Cl, Na, Ka, Ca, Mg	Council Directive 98/83/EC, Directive 2000/60/EC	Microbiological analysis Chemical analysis	Microbiological analysis
Purchase – Transport – Receiving (CCP 1 M,C) Packaging Materials	Microbiological Only from cross-contamination (TVC, *Staphylococcus aureus*, *E. coli*, etc) Chemical Residual substances	Product specifications Food grade certifications Migration test	Migration test	Supplier control and audits Certificates for food grade Hygienic control

(Table 6). Contd…..

Step of the flow chat (Fig.1)	Hazards	Critical Factor/Limits/ Controls	Parameters to be monitored for a particular CCP	Preventive measure
Storage CCP (M) Meat – Pork	Microbiological Increase of pathogens appearing in meat Formation of toxins from microorganisms Cross-contamination from staff Chemical Mycotoxins Physical Absence of impurities (like pieces of packaging materials)	Temperature control / time 2-4 or 6 days for refrigerated and 6 weeks for frozen 0-3°C or < -18°C Calibration of the storage areas Contractors specification of the storage areas Refrigerator and refrigerator insulation FIFO Supplier control Implementation of standard cleaning programs Implementation of maintenance programs	Temperature Microbiological analysis Chemical analysis	Continuous temperature control every 15 minutes Preventive maintenance program Calibration Control and check of resistance time of the meat Internal audits Implementation of standard cleaning programs Plastic boxes must be clear and clean Continuous checks to identify improper meat
Storage areas Additives GMP - GHP	Microbiological Increase of pathogens Formation of toxins from microorganisms Cross-contamination from staff Chemical Mycotoxins, other additives Physical Absence of impurities	Temperature control / time 2-4 or 6 days for refrigerated and 6 weeks for frozen 0-3°C or < -18°C, storage 12-18 °C Calibration of the storage areas Contractors specification of the storage areas Refrigerator and refrigerator insulation FIFO Supplier control Implementation of standard cleaning programs		Continuous temperature control every 15 minutes Checks for the shelf life of the products (expiration dates) Daily internal audits All the additives must be in closed boxes if they are open Implementation and improvement of cleaning programs
Conveyance (transport) of raw meat from freezer to refrigerator in order to treat the next day GHP-GMP	Microbiological Increase of pathogens Formation of toxins from microorganisms Cross-contamination from staff Chemical Chemicals from cleaning materials Physical Absence of impurities	Temperature control / time 2-4 or 6 days for refrigerator 0-3°C Calibration of the storage areas Contractors specification of the storage areas Refrigerator insulation FIFO Implementation of standard cleaning programs Implementation of maintenance programs Avoiding cross-contamination from other stock meat		Continuous temperature control every 15 minutes Preventive maintenance program Calibration Control and check of resistance time of the meat Internal audits Implementation of standard cleaning programs Plastic boxes must be clear and clean Continuous checks to identify improper meat
Preparation (Transportation of raw meat in the production area for sorting and cutting) GHP-GMP	Microbiological Increase of pathogens Viruses Cross-contamination from staff Chemical Chemicals from cleaning materials Physical Absence of impurities (like pieces of packaging materials or equipment)	Personal Hygiene – health certificates Immediate removal of waste Swab test of the working surface Implementation of standard cleaning programs Continuous sterilization of the working cutting knives (83 °C – 45 min). Change knives every 30 min		Internal audits Calibration of the sterilization machine Control and check of resistance time of the meat

(Table 6). Contd…..

Step of the flow chat (Fig.1)	Hazards	Critical Factor/Limits/ Controls	Parameters to be monitored for a particular CCP	Preventive measure
Preparation of solutions (using water, flavor enhancers, preservatives) CCP 2 (C)	Microbiological Cross-contamination from the staff, water, and working environment. Increasing of pathogens Viruses Chemical Chemicals from cleaning materials Physical Absence of impurities	Temperature control of the brine (0-4 °C for 12-24 h) Preparation of the brine according to the recipe. All the quantities of the additives must be according to the legislation and directives (salts, nitrates, coloring, etc.) Personal Hygiene – health certificates Implementation of standard cleaning programs in the preparation area Microbiological analysis of water Balance calibrations	Chemical parameters of the recipes	Internal audits Calibration of the sterilization machine Monitoring of the hygiene of the employees Monitoring of temperature and time of the brine (0-4 ^{o}C, 12-24 h) Monitoring of correct recipes Monitoring of waste production from the production area Monitoring of cleanliness of equipment Disinfection of equipment
Injection of the solutions (in the cut meat and in the milling and mixing in case of mincemeat) GHP-GMP	Microbiological Cross-contamination from staff, water, and working environment Increase of pathogens due to the fact that the product is exposed to the working environment and the conditions favor the increase of microorganisms Viruses Chemical Chemicals from cleaning materials Physical Absence of impurities (like pieces of packaging materials or equipment or from staff)	Monitoring of the injection time required for the uniform dispersion of the solution in the meat mass (as the time of injection increases the solution may affect microbiological quality) Health certificates of staff Implementation of cleaning programs Implementation of maintenance program in the injection The uniform solution is filtered before being recycled. The filter must be cleaned The small pieces of meat that remain in the filter must be removed immediately due to the fact that may affect microbiological quality		Internal audits Monitoring of the hygiene of the employees Monitoring of injection procedure Monitoring of injection time Implementation of cleaning and disinfecting programs Microbiological analysis of the recycled solutions (the parameters must be under the limits of the raw meat)
Filling mixture into forms GHP-GMP	Microbiological Cross-contamination from the staff, and working environment. Increasing of pathogens due to the fact that the product is exposed to the working environment and the conditions favored the increase of microorganisms, microbial load from the stainless steel form or the plastic backs Chemical Chemicals from cleaning materials and the plastic forms Physical Absence of impurities (like pieces of packaging materials or equipment or from staff)	Monitoring of filling time of the mixture Health certificates of the staff Implementation of cleaning programs Working instructions of the filling procedures of the mixture into forms Migration test in the plastic forms Swab test in the forms		Supplier control and audits Certificates for food grade Migration analysis Hygiene control Implementation of cleaning programs

(Table 6). Contd…..

Step of the flow chat (Fig.1)	Hazards	Critical Factor/Limits/ Controls	Parameters to be monitored for a particular CCP	Preventive measure
Tumbler procedures. Some products need to be under cooling conditions while continuously stirred GHP-GMP	Microbiological Cross-contamination from staff and working environment. Chemical Chemicals from cleaning materials and plastic forms Physical Absence of impurities (like pieces of packaging materials or equipment or from staff)	Freezing speed and mixing time (freezing must be achieved quickly in order to avoid the possibility of the increasing temperature) Implementation of cleaning programs Personal hygiene Implementation of maintenance programs		Hygiene control Implementation of cleaning programs and disinfections Monitoring of the freezing speed Temperature must be between -3 and +3 ^{o}C Monitoring of stirring Monitoring of pressure into the tumbler Calibration (temperature, speed and pressure)
Residence / Storage under cooling conditions CCP3 (M)	Microbiological Cross-contamination from staff and the refrigerator Chemical Chemicals from cleaning materials and plastic forms Physical Absence of impurities (from equipment or staff)	Monitoring of temperature control Personal hygiene Implementation of maintenance program of the refrigerator Implementation of cleaning program Swab test on the surface of the refrigerator FIFO	Temperature	Monitoring of temperature and time of the product in the refrigerator Calibration (temperature) Monitoring of maintenance and cleaning programs Internal Audits Hygiene control
Preparation for Cooking (Filling mixture into forms, suspension / hanging of ready meat in trackless trolley) GHP-GMP	Microbiological Cross-contamination from staff, increase of pathogens, formation of toxins Chemical Chemicals from cleaning materials and plastic forms. Physical Absence of impurities (from equipment or staff)	Monitoring of temperature and time of meat (minimum hanging time in order to avoid cross-contamination) Personal hygiene Implementation of cleaning program Swab test in the surface of the hook		Hygiene control Implementation of cleaning programs and disinfections of all stainless steel and especially the hook Working instructions. Avoid doing anything else near the hook
Addition of other ingredients (surface aromatics) GHP-GMP	Microbiological *Salmonella* spp, *Bacillus cereus, Clostridium botulinum, Staphylococcus aureus, E. coli,* Faecal coliforms, *Clostridium perfringens*, Coliforms, Enterobacteria Chemical Toxins (aflatoxins) Physical Absence of impurities	Products specifications Shelf life TVC : $5x10^{5}$ *Salmonella* spp: 0/25g *E. coli*: negative – $2x10^{2}$ *Staphylococcus aureus*: $1x10^{2}$ *Clostridium perfringens*: $1x10^{2}$ Coliforms or Enterobacteria: $5x10^{2}$ Toxins		Supplier control and audits Transformation control and checks (hygiene checks) Temperature control Organoleptic characteristics (color, smell, appearance) Microbiological analysis Personal hygiene Health certificates Free from aflatoxins
Thermal Process (Cooking: including drying, boiling and smoking) CCP4 (M)	Microbiological Elimination of all pathogens (present in raw meat or having increased during previous steps) in safe levels for the consumer Chemical From cleaning materials Physical Absence of impurities (like parts of equipment from the oven)	Monitoring of temperature (T ≥ 73^{o}C) Monitoring of time Implementation of cleaning program Monitoring of maintenance program Calibration	Temperature Calibration	Monitoring temperature and time of thermal process Monitoring maintenance and cleaning programs Monitoring product temperature inside the oven Implementation of oven cleaning program Monitoring of air filtration

(Table 6). Contd…..

Step of the flow chat (Fig.1)	Hazards	Critical Factor/Limits/ Controls	Parameters to be monitored for a particular CCP	Preventive measure
Exit from the Oven – Entry in a Chiller or Refrigerator CCP5 (M)	Microbiological Cross-contamination from staff and the chiller, increasing of pathogens, formation of toxins Chemical From cleaning materials Physical Absence of impurities (from equipment or staff)	Monitoring of temperature < 4°C Personal hygiene Implementation of cleaning program Avoid unnecessary movement in the chiller	Temperature	Monitoring maintenance and cleaning programs Calibration Personal hygiene Internal audits Note: The products are in the final step ready to be sold and should not be cross-contaminated. There is no other step to confront any hazard.
Packaging (cutting and packaging) CCP6 (M, P)	Microbiological Cross-contamination from packaging materials, cutting machines Chemical From cleaning materials, residual disinfectants Physical Typical, like equipment from the cutting machine, pieces from packaging materials	Product specifications Food grade certificates of packaging materials Migration test Batch numbers Monitoring of hygiene program Swab test Calibration of balance Personal hygiene Implementation of maintenance program Metal detector should be checked	Migration test Swab test on the cutting machine, on packaging materials, on the employees' hands (TVC < 10/10cm^2) Monitoring of metal detector	Supplier control and audits Certificates for food grade Hygiene control Monitoring the vacuum machine Calibration of pressure Monitoring of batch numbers Internal audits Monitoring personal hygiene Note: Personal hygiene is very important due to the fact that if the product is contaminated there is no other step to encounter the hazard.
Storage of the vacuum packaged products CCP7 (M)	Microbiological *Salmonella* spp, *Campylobacter, Staphylococcus aureus, Clostridium perfringens, Clostridium botulinum, Escherichia coli, Yersinia enterocolitica, Listeria monocytogenes, E. coli* and Faecal coliforms, Coliforms or Enterobacteria. Chemical Additives, nitrates, glutamate Physical Absence of impurities	Monitoring of storage temperature (0-4ºC) or (-18ºC) Product specifications Microbiological characteristics: TVC (aerobic) : 10^5 TVC (anaerobic) : 10^5 *E. coli* and Faecal coliforms: 0/g– $1x10^2$ Coliforms or Enterobacteria: $5x10^3$ *Salmonella* spp: 0/25g *Staphylococcus aureus*: 0/g - $5x10^2$ *Clostridium perfringens*:0//0.1g *Campylobacter* and *Yersinia*: 0/25g Chemical characteristics: additives, nitrates, etc. according to legislation and directives Monitoring of products' shelf life Pest control Implementation of cleaning program FIFO	Temperature (0-4ºC) or (-18ºC) Microbiological analysis in the final product	Internal audits Monitoring of hygiene program Monitoring shelf life of products
Product distribution GHP-GMP	Microbiological *Salmonella* spp, *Campylobacter, Staphylococcus aureus, Clostridium perfringens, Clostridium botulinum, Escherichia coli, Yersinia enterocolitica, Listeria monocytogenes, E. coli* and Faecal coliforms, Coliforms or Enterobacteria. Chemical Cross-contamination from transportation	Monitoring of storage temperature (0-4ºC) or (-18ºC), moisture 85-90% Product specifications		Monitoring temperature Calibration Internal audits Monitoring of hygiene program Implementation of maintenance program Microbiological analysis

Table 7. General GHPs-GMPs Per Step

Step of the flow chat (Fig.1)	Good Hygiene Practices – Good Manufacturing Practices
Purchase – Transport – Receiving	The raw meat must be transferred immediately to the refrigerator in order to avoid a long period of deterioration or contamination. Raw meat, additives, packaging materials, cleaning materials must be stored and delivered separately in order to avoid any cross contamination. The doors in the reception areas must open only when the suppliers arrive. The reception areas must always be clean and disinfected. During unloading of the meat, its temperature, pH and organoleptic characteristics must be checked. Also, cleanliness of the transportation vehicles must be checked.
Storage	During storage of meat, all raw meat must be in plastic backsets. The counter must be stainless steel and at least 25 cm up from the ground floor. All doors must close hermetically. The refrigerator must be cleaned at least every week while the other storage areas must be cleaned (and disinfected) every day. A calibration procedure at least once per year must be carried out and also a maintenance program.
Conveyance (transport) of raw meat from freezer to refrigerator in order to treat the next day	During the transportation a strict personal hygiene program must be applied.
Preparation (Transportation of raw meat in the production area for sorting and cutting)	A FIFO (First In-First Out) program must be monitored.
Preparation of solutions (using water, flavor enhancers, preservatives)	The person who is responsible to prepare the recipe must be very careful. A calibration of the balance at least once per year must be applied.
Injection of the solutions (in the cut meat and in the milling and mixing in case of mincemeat)	To avoid contamination of thawed meat, fresh brine must always be added. Most of the times old brines contain salt tolerant bacteria. The whole procedure has to be held at low temperature.
Filling mixture into forms	All the forms must be stainless steel and must be disinfected before any use. In case of plastic bowels, these must be food grade.
Tumbler procedures. Some products need to be under cooling conditions while continuously stirred	Time intervals between brine injection and tumbling must not exceed half an hour.
Residence / Storage under cooling conditions	A continuous monitoring of temperature must be applied.
Preparation for Cooking (Filling mixture into forms, suspension / hanging of ready meat in trackless trolley)	The mixture must be filled in the forms quickly in order to avoid increase of the possibility of spillages.
Addition of other ingredients (surface aromatics)	Must be done very carefully.
Thermal Process (Cooking: including drying, boiling and smoking)	A calibration procedure at least once per year must be carried out and also a maintenance and cleaning program.
Exit from the Oven – Entry in a Chiller – Refrigerator	A calibration procedure at least once per year must be carried out and also a maintenance program. The temperature must be decreased from 72 to 10 ^{o}C at least in 2 h.
Packaging (cutting and packaging)	To avoid any contamination during this final step the plant has to establish high standards of hygienic conditions into the slicing and packaging room. Among them, a strict disinfecting program must be applied. All equipment must be disinfected before and after any break or every hour. A typical swab test must be carried out every hour.
Storage of the vacuum package	A calibration procedure at least once per year must be carried out and also a maintenance and cleaning program.
Product distribution	A calibration procedure at least once per year must be carried out and also a maintenance and cleaning program.

equipment and the environment plant. It is obvious that good hygiene practices are a useful prerequisite tool for an efficient HACCP system. Moreover, it is necessary for all products to avoid moving back and forth to minimize possible cross-contamination and their movement from one step of the processing line to another has to be done quickly with no delay.

CONCLUSIONS

The detailed analysis of the safety and hygiene factors affecting the quality and safety the whole processing of the examined meat delicatessen products (bacon, lountza, hiromeri, ham, sausages) proved that the control of CCPs relative to raw materials' specifications or temperatures in retaining or thermal processing steps, as well as the PRPs rela-

tive to the hygienic conditions during production should be satisfied.

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