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Review

MEDICAL REVIEW AND ANALYSIS OF CANNED FOOD PRODUCTION SAFETY

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Summary

Food safety is an essential and integral part of public health policies in developed countries. Canned foods play a significant role in modern human nutrition. Improving the safety of internal control in production is additional prevention of the potential risks of consuming contaminated food. The present study aims to perform a health assessment and medical analysis of the Internal Control System and a canning company's Hazard Analysis and Critical Control Points (HACCP) plan. Our study also aimed to find potential mechanisms to increase the safety in producing this type of ready-to-eat foods and possible new approaches in avoiding and managing risks. An audit algorithm was developed to analyze the existing food safety systems in the enterprise to achieve the study's goal. The algorithm was based on the Codex Alimentarius methodology, presented in the document "Food Quality and Safety Systems - A Training Manual on Food Hygiene and the Hazard Analysis and Critical Control Point (HACCP) System. A medical analysis of the Internal Control System was performed, based on the prerequisite programs, technical documentation, and the company's HACCP-plan. The analysis of the documentation and the critical remarks made can provide more reliable conditions for producing products safe for consumers' health. The proposed corrections in the Good Hygiene Practices (GHP), the Good Manufacturing Practices (GMP), and the HACCP plan, mainly through adequately naming authentic hazards of a biological nature, are the basis for more professional verification of the processes and ensuring food safety.

Keywords: HACCP, GMP, GHP, food safety, canned

Introduction

Food safety is an essential and integral part of public health policies in modern developed countries. Every society has to be responsible for the health of its members, including the production and supply of safe food. Canned foods play a significant role in modern human nutrition. During canning, raw materials are processed and placed in hermetically sealed

containers to preserve the food and increase shelf-life.

This makes them a source of specific health problems. Improving the security of internal control in the production is additional prevention of the potential risks of consuming contaminated food.

Aim

The aim of the study is health assessment and medical analysis of the Internal Control System and the HACCP plan of a canning plant. The study also aimed to find potential mechanisms to increase security in producing this type of ready-to-eat food and possible new approaches to preventing and managing risks.

Materials and Methods

The object of the study was a cannery. We developed an algorithm to perform an audit, make the analysis, and thus achieve the study's goal. The algorithm was based on the methodology of Codex Alimentarius, presented in the document "Food Quality and Safety Systems - A Training Manual on Food Hygiene and the Hazard Analysis and Critical Control Point (HACCP) System". We performed:

- Analysis and evaluation of the structure and organization of work in the enterprise, based on the criteria set out in EU Regulation № 852/2004 [1, 2];
- Assessment of the potential risk of food contamination from the environment [3-6];
- Review of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) and assessment of the possibilities for their application and compliance with the General Principles of Food Hygiene [7-9];
- Analysis and evaluation of the Technological Documentation (TD) [8,10];
- Analysis and evaluation of the development and operation of the HACCP system - following the Guidelines for the implementation of procedures based on the principles of risk analysis and critical control points in some areas of the food industry (Brussels, European Commission, Directorate-General for Health)[2].

All key stages of the development and operation of HACCP were covered.

Analysis and evaluation of the structure and organization of work in the enterprise

The food quality and safety management system under FSSC 22 000 standards had been built, maintained, and periodically updated in the enterprise.

The company produces canned vegetables and fruits. Sterilized "ready meals" are ranked separately, as there are no fundamental differences in the technology between them and classic canned vegetables in terms of potential health hazards to the consumer.

TD had been developed for each range. The descriptions of the products were presented explicitly and precisely. The raw materials were presented in detail and the regulatory requirements they should comply with. The main section - "Health and hygiene and quality indicators and standards", had been developed comprehensively. Organoleptic criteria were detailed, objective, and specific. The physicochemical criteria depended on the main composition of the cans and the added non-vegetable components.

The content of organic acids is crucial - both in their natural presence, for example, in tomatoes and the added citric or acetic acids. The most important criterion is the acidity (pH), whose value is crucial for the efficiency of sterilization regimes.

Critical notes:

Not all texts in the TD had been revised and updated following the regulations. The TD did not include the content of dietary fiber.

Part of the company's production is canned with low acidity, with a pH of 6.0 and above. The risk of residual post-sterilization microflora is high, including that of clostridia and C. botulinum in particular. Acidity is standardized in all assortments. In a large part of the production, its value exceeded 4.2, which is the risk limit for developing pathogenic clostridia. In these circumstances, there is also a risk of squamous fermentation [9] due to aerobic bacilli such as *B. stearothermophilus*, *B. coagulans*, *B. megatherium*, *B. subtilis*, *B.*

brevis, *B. cereus*, and anaerobic clostridia such as *C. thermosacharolyticum*, *C. hystolyticum*, *C. sporogenes*, *C. bifermentans*, *C. butiricum*, *C. nigrificans*, *C. pasteruranum*, and others.

The above-mentioned spore-forming microorganisms are found in soil, determining their leading role for residual post-sterilization microflora. Before sterilization, preparation of raw materials by separation, cleaning, washing, flotation, etc., is the most crucial preventive stage of technological processing of canned food [9-11].

The TD also included toxic elements.

Critical notes:

Undoubtedly, it is most appropriate for the requirements for toxic elements to be set at the incoming control through a proper supplier certificate.

The most crucial factor for microbiological safety is industrial sterility, the type and volume of packaging. Various packages were comprehensively reflected concerning mass and volume and as a type, which is also crucial as a starting point for determining the sterilization regimes.

The raw materials, mainly - tomatoes, peppers, etc., provide a favourable environment for the development of microscopic fungi and can be carriers of mycotoxins. However, the problem is still in the research phase [11, 12] and has not been set in the relevant regulations. Therefore, the inclusion of criteria for the absence of mycotoxins was not necessary.

Due to the lack of a stringent sterilization regime and the dangers of developing fungal flora after the consumer opens the hermetic packages, one of the assortments of lyutenitsa utilizes potassium sorbate.

Critical notes:

The use of preservatives in sterilized cans is not allowed, and this must be corrected in the production, respectively, in the relevant documentation [13].

The TD also formulated the requirements for industrial sterility as the most important condition for the safety of canned sterilized foods.

Critical notes:

A factual error was made - the entry "vegetative forms of non-spore-forming and spore-forming" is incorrect. Only spore-forming microorganisms have vegetative forms. Cans should not contain non-spore-forming bacteria and vegetative forms of spore-forming microbes of the Bacillus genus.

Industrial sterility allows only single Bacillus spores to be present in canned food. The other most dangerous microbes in canned food for human health are bacteria of the genus Clostridium, a cause of the most severe food intoxication - Clostridium botulinum - a worldwide recognized danger in hermetically sealed foods. They are limited by the correctly formulated criterion - "mesophilic anaerobic microorganisms," which essentially includes both vegetative and spore forms.

Critical notes:

It is superfluous to insert the sowing quantity "d," which is an attribute of the required method, in the case of BDS 6916-87 [14]. The latter applies to records for all indicators. Only the spores of aerobic spore-forming microorganisms require recording of a quantitative norm - they were correctly determined up to 10 CFU/g.

Yeasts were also omitted in the formulations, which in case of poor sterilization can cause the most undesirable processes of spoilage of the contents.

In the hygiene of cans, some thermophilic microorganisms, representatives of the genera Bacillus and Clostridium, which cause decay and are generally non-pathogenic to humans, are also important. Canned fruits and vegetables are vulnerable, while the phenomenon is infrequent in meat and meat-vegetable products [14-16].

Critical notes:

Therefore, this criterion should appear in the documentation of canned vegetables, noting that their control should be carried out only if there are particular indications.

The test methods were recorded professionally, with few exceptions.

Concerning the text in labels, the nutritional information section presented data for some of the assortments with excessive accuracy, up to the second decimal place, which is also within the limits of analytical errors.

Critical notes:

The numbers need to be appropriately rounded up to a single decimal place, allowing for better user perception.

An essential section laying the foundations of HACCP is the description of the technological

process, which included prerequisite data. Bulgarian practice in this regard builds on the requirements of Codex Alimentarius through the provision of Ordinance № 1/2016 of the Ministry of Health and the Ministry of Agriculture for business operators to develop TD for their products [8]. The technological process was described in principle, and process diagrams were applied. The process diagrams were specific to all 25 assortments. Figures 1, 2 and 3 show three more representative diagrams with marked CP and CCP.

Critical notes:

In the TD and the block diagrams, an important

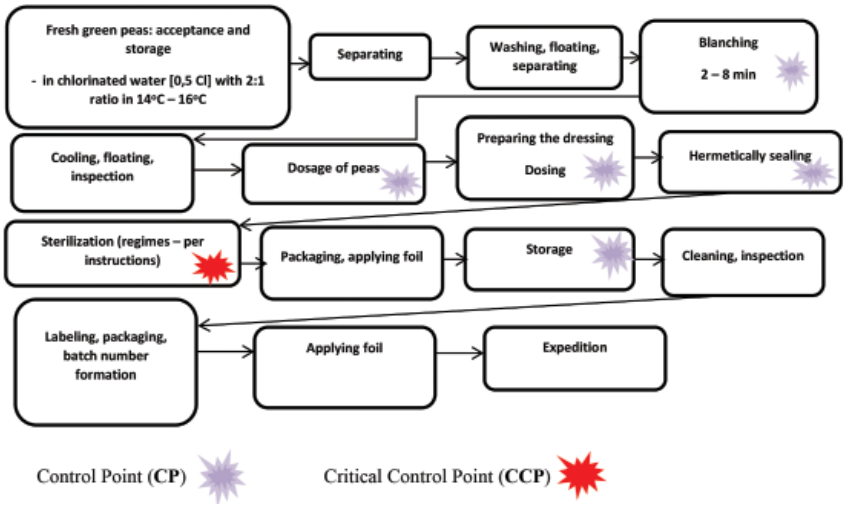

Figure 1. One-component canned vegetables /Sterilized green peas/

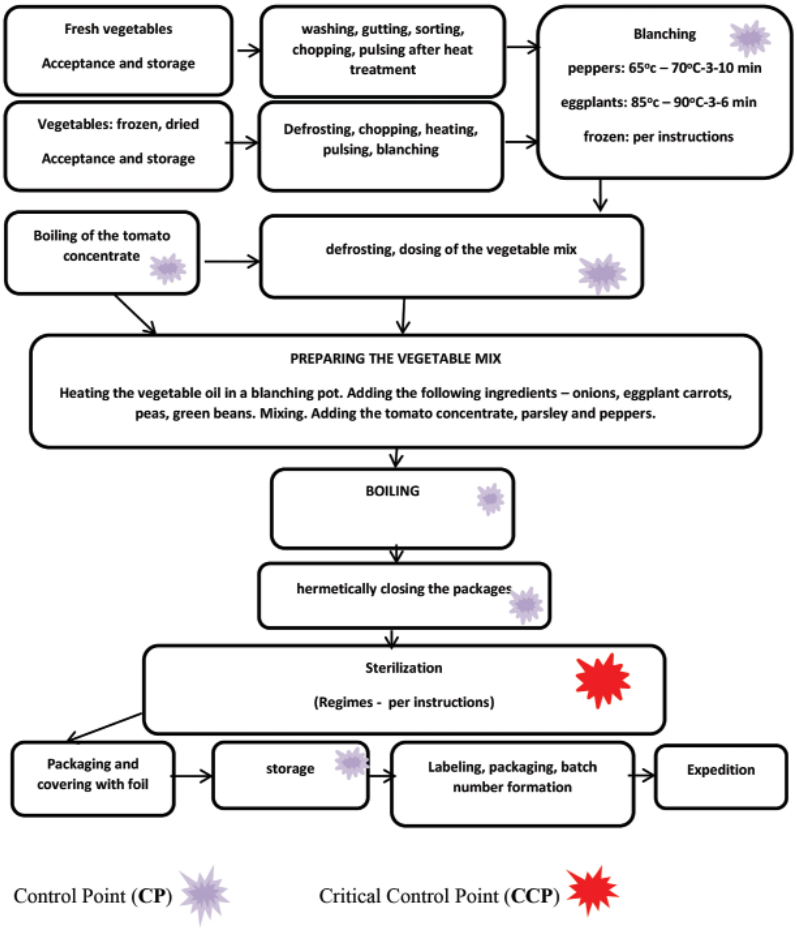

Figure 2. Multicomponent canned vegetables /Casserole - ready meal/

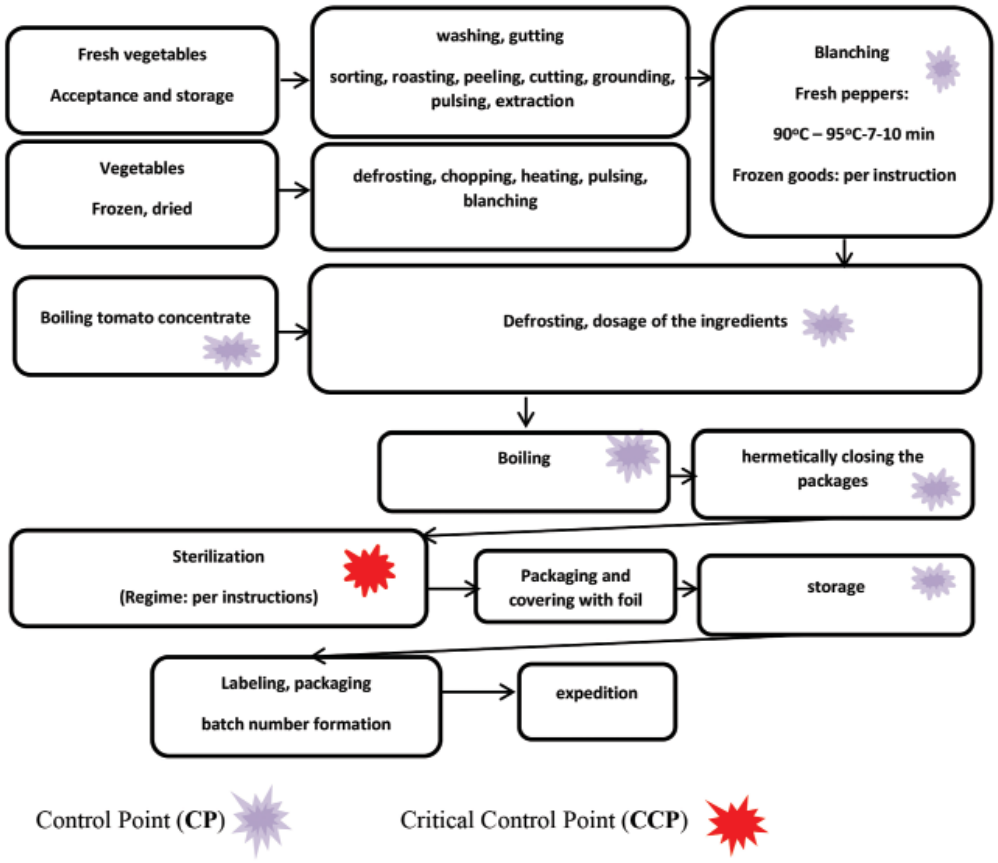

Figure 3. Ready vegetable dish /Lyutenitsa/

point - "storage" of the finished product was missing, i.e., storage of canned food at certain temperature conditions for a certain period, which is standard for the company. During this period, sterilization defects may occur, mainly by expanding cans. This post-sterilization stage should be added to ensure the protection of the quality and safety of all the company's products.

Analysis and evaluation of the development and functioning of the HACCP system

The hazard analysis was detailed and focused, presented separately for sterilized canned vegetables and sterilized ready meals.

Biological hazards came to the fore. The main danger is from pathogenic anaerobes and C. botulinum in particular. The approach adopted by the team was correct. The hazards were considered in detail for each step in the technological process. They were assessed according to the probability and gravity and their complex significance. The physical, chemical, and biological hazards were formulated separately, and the allergens were targeted.

As a final result, the analysis provided a basis for determining the Critical Point (CP) and Critical Control Point (CCP).

Critical notes:

There were inaccuracies in the interpretation of the significance of biological hazards. For example, "staff contamination with pathogenic microorganisms (E. coli)" is inappropriate. The wording "pathogenic and indicator non-spore-forming and spore-forming microorganisms" should be applied. Such a formulation can also serve to verify the processes by determining the total number of microorganisms: Enterobacteriaceae as an integral hygienic indicator, certain thermophiles, and the total number of spore-forming microorganisms - aerobic and anaerobic. No less inaccurate was the wording "Survival of spores of pathogenic bacteria - E. coli, S. aureus, enterococci, coliforms during storage." Obviously, the team was unaware of the microbial indicators of the hygiene of processes, nor of those attributed to pathogens. Red anaerobic microorganisms,

which present a danger originating from raw materials, were not included in the analysis. The cited E. coli, Listeria monocytogenes, Salmonella, S. aureus, hepatitis A viruses are non-spore-forming, and for them, the operations even during blanching are fatal.

The biological danger in the "blanching" stage was professionally noted - "inadequate hygienic maintenance of blanchers, leading to the development of thermophilic microorganisms". This type of facility is likely to become a breeding ground for permanent reinfection with heat-resistant microorganisms, such as thermophilic Bacillaceae, whose spores survive exposure to blanching temperatures.

In the analysis of the dangers of other damage to the products, which pose a risk to human health, the second place in the team's field of vision was occupied by physical dangers. Breaking and falling of glass fragments in the products were recognized as essential and very likely.

Due attention was given to chemical hazards, but descriptions of severity and likelihood of occurrence were not exhaustive.

Undoubtedly, the main danger is the biological danger in the sterilization stage. This is the indisputable CCP in this proceeding, which was correctly defined by the team.

Adequately identified were 4 CP and 1 CCP, as follows:

CP 1: in the stage of pre-processing/blanching - biological;

CP 2: in the stage of dosing vegetables - physical;

CP 3: in the stage of closing the packages - physical;

CP 4: in the stage of post-sterilization storage - biological;

CCP 1: in the stage of sterilization - biological.

The control measures were indicated systematically and consistently in the generalized HACCP plan and presented in Work Instructions and the critical limits. In terms of biological hazards, these are temperatures and exposure during blanching to temperatures and exposure and atmospheric pressure during sterilization. They were also subject to monitoring. Blanching processes were monitored using a peroxidase sample. Sterilization efficiency is a more complex monitoring issue.

The daily control for each batch and device was performed by registering three components - temperature, exposure, and pressure. However, the batch inspection that can give an indirect assessment after storage was not standardized.

A reliable assessment was made through microbiological control of industrial sterility, which cannot be done for each batch. This is where the verification of HACCP procedures can be placed because periodical microbiological analyses answer the questions about their effectiveness in CP or CCP. The documentation provided for our studies did not contain information on implementing this HACCP principle.

Critical notes:

Based on the presented results, we recommend including verification procedures, representing periodic tests on microbiological criteria and those in the contents of sterilized cans in the HACCP System in the production of canned vegetables and ready-made vegetable dishes.

The documentation of HACCP activities for canned vegetables and ready-made vegetable dishes was well constructed and systematized through different forms containing the most critical parameters of the system.

Conclusion

The analyses of the enterprise, the critical remarks, and the proposals for corrections and optimizations can be summarized as follows:

A. Regarding GMP, GHP, and TD, it is recommendable:

- to cite the current legislative and normative acts;
- in the incoming control, requirements need to be set for the content of toxic elements in the raw materials;
- to eliminate the use of potassium sorbate in the assortment of the manufacturer;
- to specify the numerical values for the individual criteria in the labels in the nutritional information section;
- to include "storage" with appropriate standardized temperature and other regimens;
- to eliminate incorrect entries in the industrial sterility indicators and include additional microbiological criteria such as "yeast" and "thermophilic microorganisms." We offer an

entirely new record of microbiological standards and requirements (Table 1).

B. Regarding the HACCP system:

- The incorrect descriptions of biological hazards to be deleted and the texts to be edited;

- It is mandatory to include microbiological tests in the verification procedures. We offer the following two verification procedures in tabular form (Tables 2 and 3).

Based on the prerequisite programs, technological documentation, and HACCP-plan of the company studied, the internal control system is built methodologically correctly. It is successfully applied in the production of sterilized canned vegetables. More appropriate conditions can help provide safe products for consumers by using the proposed adjustments in the GHP and GMP in the HACCP plan, mainly through more adequate naming of the authentic hazards of biological nature and more professional verification of the processes.

Table 1. Recommended microbiological criteria and requirements

Microbiological indicators	**Requirements**
Mesophilic aerobic and facultative anaerobic microorganisms:	
Vegetative forms of spore-forming and non-spore-forming	Not allowed
Spores of aerobic spore-forming agents, CFU/g, not more than:	10
Mesophilic anaerobic microorganisms	Not allowed
Thermophilic microorganisms *	Not allowed
Molds and yeasts	Not allowed

* The indicator is examined only in case of deterioration of the quality, spoilage and other special indications

Table 2. HACCP verification for sterilized canned vegetables in CP 1 (preparation of raw materials/blanching)

Criteria	**Frequency**
Total number of mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	Every 6 months
Spores of mesophilic aerobic and facultative anaerobic microorganisms, CFU/g	Every 6 months
Thermophilic microorganisms - vegetative and spore forms	Every 6 months
Enterobacteriaceae, CFU/g	Every 6 months
Mold and yeast, CFU/g	Every 6 months

Table 3. HACCP verification for sterilized canned vegetables in CCP 1 (sterilization)

Criteria	**Frequency**
Mesophilic aerobic and facultatively anaerobic microorganisms - vegetative forms of spore-forming and non-spore-forming; spores	Monthly
Mesophilic anaerobic microorganisms	Monthly
Thermophilic microorganisms – vegetative and spore forms	Every 3 months
Molds and yeast, CFU/g	Monthly

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