**American University Kyiv**

# IMPROVEMENT OF FOOD SAFETY MANAGEMENT SYSTEM FOR THE UKRAINIAN MANUFACTURER: A CASE STUDY OF MEETING THE REQUIREMENTS OF THE ISO 22000 STANDARD AT LLC 'SMACHNI TRADYZII'

(УДОСКОНАЛЕННЯ СИСТЕМИ УПРАВЛІННЯ БЕЗПЕЧНІСТЮ ХАРЧОВИХ ПРОДУКТІВ ДЛЯ УКРАЇНСЬКОГО ВИРОБНИКА:
НА ПРИКЛАДІ ВІДПОВІДНОСТІ ВИМОГАМ СТАНДАРТУ ISO 22000
НА ТОВ «СМАЧНІ ТРАДИЦІЇ»)

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**ABSTRACT**

Ensuring food safety is critical to the food industry, as it directly impacts public health, brand reputation, and regulatory compliance. This capstone project explores the importance of implementing Food Safety Management Systems (FSMS) in food companies, focusing on how these systems enhance operational efficiency and reduce risks associated with foodborne illnesses.

The project aims to enhance the operational efficiency, compliance, and sustainability of the company LLC 'SMACHNI TRADYZII' by developing and implementing a modernized food safety management system. The project seeks to address current challenges in streamlining processes and align them with international and state standards to promote continual improvement and stakeholder satisfaction and avoid extra losses in terms of recalls, loss of reputation, and other expenses.

The object of the research is the operational processes, frameworks, and compliance strategies employed by the company LLC 'SMACHNI TRADYZII' in the sphere of food safety. This includes analyzing how these entities implement ISO standards and enhance their effectiveness to meet organizational objectives and stakeholder expectations.

The study evaluates global standards, such as ISO 22000 and HACCP, highlighting their role in identifying, preventing, and managing hazards throughout the food supply chain. By integrating FSMS, food companies can ensure consistent compliance with legal requirements, improve consumer trust, and gain a competitive edge in the market.

Through case studies and data analysis, this project underscores the financial and ethical implications of neglecting food safety and provides practical recommendations for successful FSMS implementation. The main outcomes include recommendations for improving the food safety system, including the implementation of new equipment based on cost-benefit analysis (CBA). The findings emphasize that adopting robust food safety practices is not only a regulatory necessity but also a strategic investment in long-term sustainability and market growth.

Keywords: Food Safety Management System, ISO 22000, HACCP, operational processes, regulatory compliance, business models, cost-benefit analysis, sustainability.

# CHAPTER 1 INTRODUCTION

The compulsory implementation of Food Safety Management Systems (FSMS) is critical for ensuring the safety and quality of food products. FSMS frameworks, such as Hazard Analysis and Critical Control Points (HACCP) and ISO 22000 standard, help food companies systematically identify, assess, and control potential hazards—whether biological, chemical, or physical hazards throughout the food production process. These systems are mandated by regulatory bodies worldwide and provide guidelines to prevent contamination, maintain hygiene, and ensure compliance with food safety standards. All three hazards are dangerous for people, but I would like to highlight physical hazards and the harm they can cause in my project.

One of the core benefits of FSMS is its ability to mitigate physical hazards, which occur when foreign objects like metal, glass, or plastic inadvertently enter food products. Such hazards can cause serious health risks, including injury or choking. Food recalls due to physical contamination are common examples of what can happen when safety measures fail.

## CHAPTER 2 RECALL PRODUCTS AND THE IMPORTANCE OF RECALL ANALYSIS

Recalls involve removing potentially unsafe products from the market, disrupting production, and damaging brand reputation. The cost of wasted products, logistics, and consumer compensation can be substantial. Food safety standards help businesses avoid these hefty costs.

For instance, The Penn State College of Agricultural Sciences has gathered information about products that were recalled due to foreign contamination:

(Penn State Extension, 2019) in their blog issued information about "Two Recalls Issued After Complaints of Foreign Material in the Form of Metal Pieces." The company North Country Smokehouse, a Claremont, USA, recalled approximately 2,686 pounds of ready-to-eat sausage products that may have been contaminated with extraneous materials, specifically metal. The problem was discovered on March 18, 2019, by FSIS (Food Safety Inspection Service) inspection program personnel during a routine review of establishment consumer complaint records.

Also, the company Tyson Foods, Inc., a Rogers, Ark. establishment, recalled approximately 69,093 pounds of frozen, ready-to-eat chicken strip products that may have been contaminated with extraneous materials, specifically pieces of metal. The problem was discovered when FSIS received two consumer complaints of extraneous material in the chicken strip products.

(Food Safety Inspection Service, 2024) in their announcement- Perdue Foods LLC, a Perry, Ga. establishment, was recalling approximately 167,171 pounds of frozen, ready-to-eat chicken breast nuggets that may be contaminated with foreign material, specifically metal. The frozen, ready-to-eat chicken breast nuggets were produced on March 23, 2024, and contained vacuum-sealed plastic packages. The products were distributed to retail locations across the country and sold online directly to consumers. The issue came to light after the company received consumer complaints about metal wire found in the product and reported the matter to FSIS (rephrase Food Safety Inspection Service, 2024).

Thus, all these issues can negatively affect the company, including financial losses. High financial costs are incurred in product recalls, legal forums, loss of sales revenue, and so on, which are sustainable in the long run, affecting the overall profitability and sustainability of a business.

(U.S. Food and Drug Administration, n.d.) collected the data on recalled products annually.

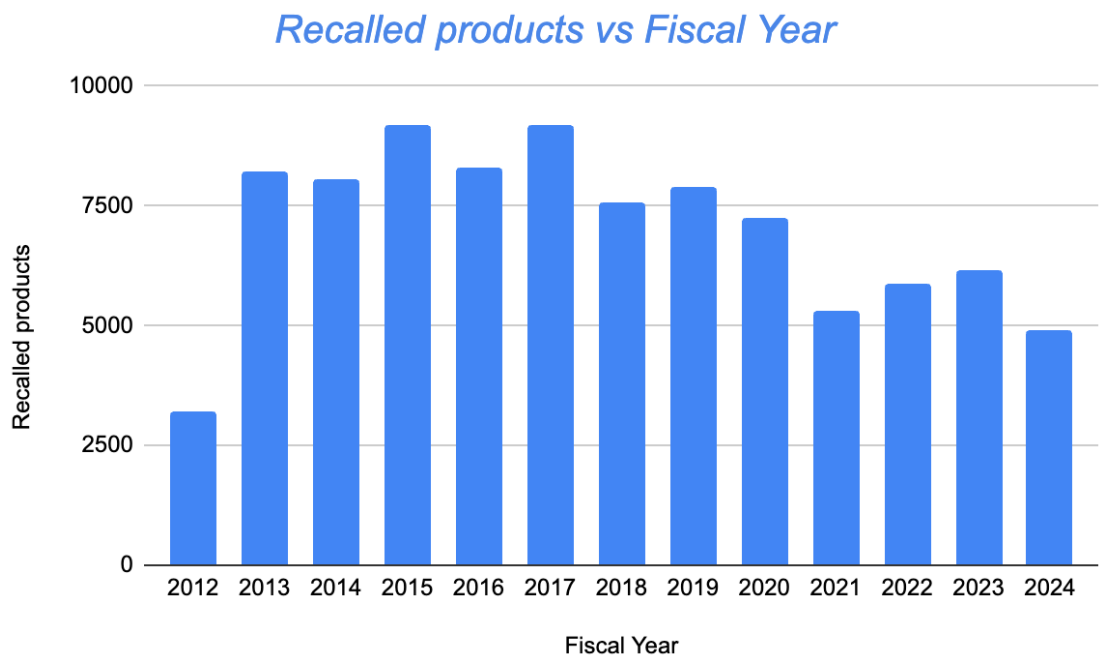


Figure 1. Recalled Products vs Fiscal Year

Source: (U.S. Food and Drug Administration, n.d.)

While the number of recalled products varies from year to year, a significant number of recalls still occur.

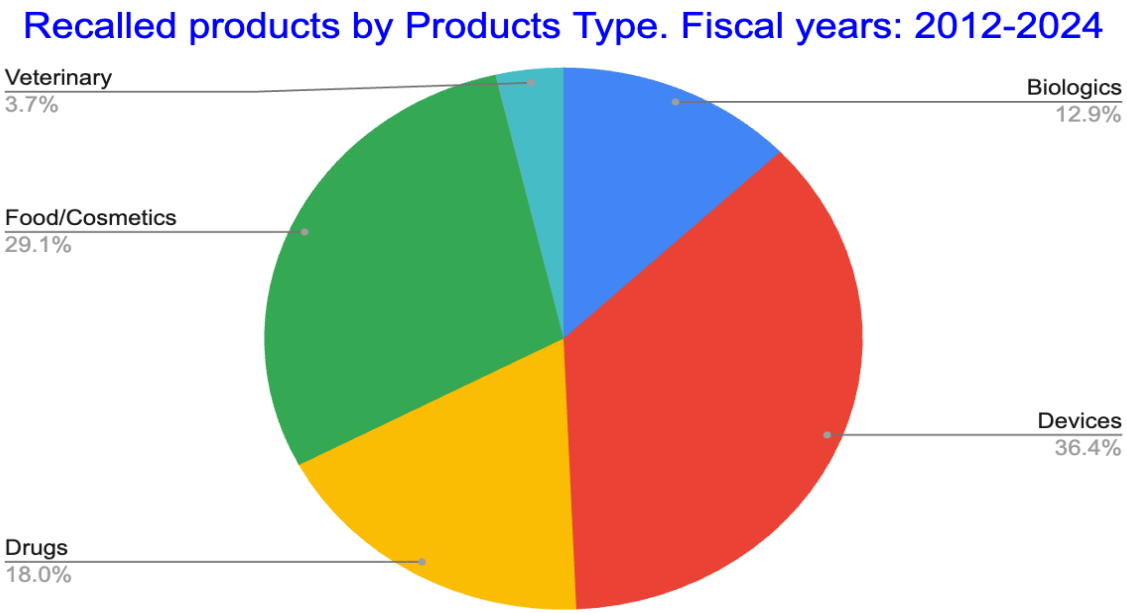


Figure 2. Recalled Products by Product Type

Source: (U.S. Food and Drug Administration, n.d.)

From this chart, food is one of the primary items that are recalled.

The Food Marketing Institute and Grocery Manufacturers Association emphasized in a report that product recalls 'can result in multi-million-euro costs' and may be significant enough to permanently shut down a company.

$ 10 MILLION
The average cost of a food recall, according to the Food Marketing Institute
the Grocery Manufacturers Association (GMA) in the US.

Figure 3. Report statement "Average losses due to recall products"

Source: (Yamato Scale, n.d.)

Not only are the recalls costly to a firm, but they also have long-term implications, such as the loss of reputation, which leads consumers to switch to other products.

55%
Percentage of people who would switch brands following a product
recall (according to research by Harris Interactive)

Figure 4. Report statement "Recalls can impact customer choice"

Source: (Yamato Scale, n.d.)

Reputation is a major factor in brand success, and the reputation of food brands is built on quality, trust, customer satisfaction, and safety. Recalls can lead to a loss of customer loyalty, damage to the brand, and exposure to expensive and damaging legal action for the company. Social media plays a major factor, and bad news spreads quickly to people.

## CHAPTER 3 FOOD SAFETY REGULATIONS AS CONSTRAINTS FOR FOOD PRODUCERS: INTERNATIONAL AND DOMESTIC PECULIARITIES

Moreover, for food companies to sell products to international markets, as well as in domestic markets, they must comply with applicable food regulations. The basis for these regulations is Codex Alimentarius (Latin for 'Food Code'), a collection of internationally recognized standards, codes of practice, and guidelines established by the Codex Alimentarius Commission (CAC). The CAC is a joint program by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). The Codex Alimentarius aims to protect consumer health and ensure fair practices in food trade.

In 1969, The Codex Alimentarius Commission (CAC) established a document titled "General Principles of Food Hygiene" (CXC 1-1969). This document outlines the essential hygiene principles applicable throughout the entire food chain, from primary production (farming) up to the point of sale to the final consumer.

There are some key points from this document:

- The core principle emphasizes a preventative approach to food safety based on scientific principles. This means identifying and controlling potential hazards throughout the food chain rather than simply reacting to problems after they occur;
- The Codex outlines general hygiene practices (GHPs) that food businesses need to implement to create a sanitary environment that minimizes the risk of food contamination. Examples of GHPs include:
- Proper sanitation and cleaning of food contact surfaces and equipment.
- Maintaining good personal hygiene for food handlers.
- Effective pest control measures.
- Appropriate storage conditions to prevent contamination and spoilage.

The Codex's General Principles of Food Hygiene (CXC 1-1969) provide the foundation for implementing the Hazard Analysis and Critical Control Points (HACCP) system.


Figure 5 HACCP stands for
Source: (Adobe Stock, n.d.)

HACCP stands for Hazard Analysis and Critical Control Points. It is a systematic and rigorous approach to hazard identification, risk assessment, and the control of identified risks in a food operation. HACCP was developed in the 1960s through a collaboration between NASA, the Pillsbury Company, and the U.S. Army Laboratories to ensure safe food for future space missions. NASA's engineering management approach, known as Critical Control Points, served as the foundation for this food safety system (rephrase Safe Food Alliance. (n.d.). The history of HACCP).

The HACCP (Hazard Analysis and Critical Control Points) system is a foundational program for those standards recognized by the Global Food Safety Initiative (GFSI).

Examples of GFSI-recognized standards that build upon the HACCP approach include the following standards: IFS, FSSC 22000, ISO 22000, and Global Gap.


Figure 6 GFSI-recognized standards
Source: Generated by ChatGPT

There are essential steps that need to be taken into consideration while implementing of HACCP requirements.

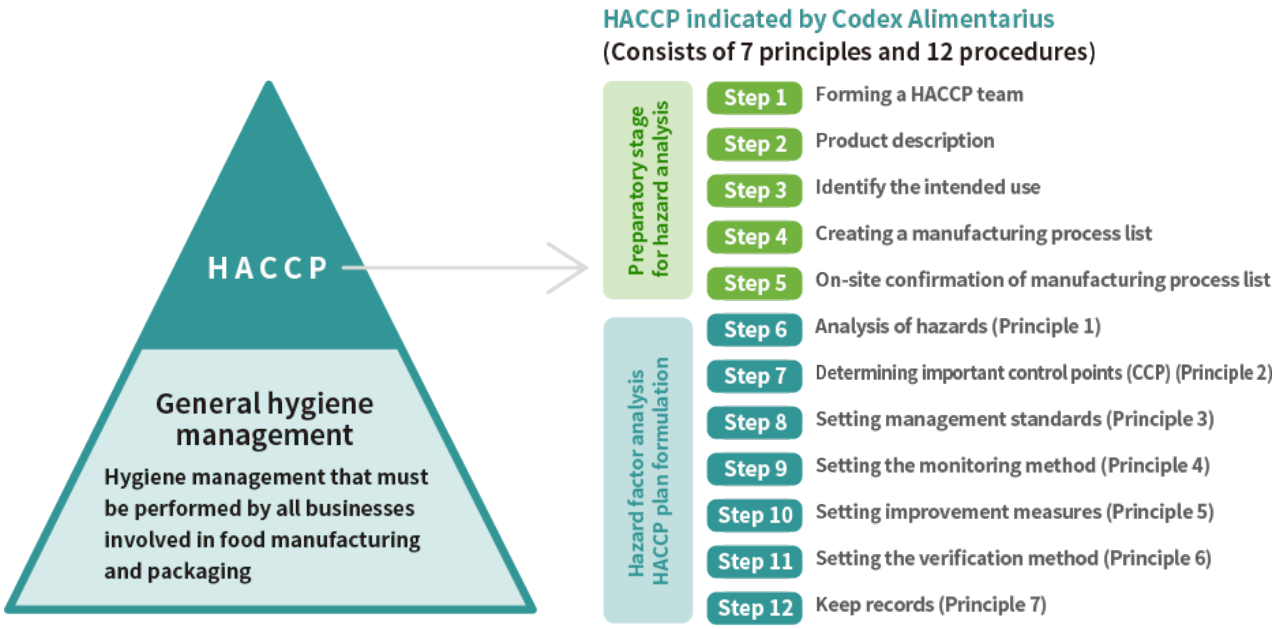


Figure 7 "7 Principles and 12 procedures as an essential step for HACCP implementation"
Source: (Google, n.d.)

- Establish a HACCP team (the team should include people from different disciplines who have expertise in food safety).
- Describe the food and its distribution: This includes understanding the ingredients, how the food will be processed and packaged, and how it will be distributed to consumers.
- Identify potential hazards: These can be biological, chemical, or physical hazards that could contaminate the food.
- Determine critical control points (CCPs): CCPs are the points in the process where hazards can be prevented, eliminated, or reduced to acceptable levels.
- Establish critical limits for each CCP: These are the specific parameters that must be met at each CCP to ensure food safety.
- Establish monitoring procedures: This includes how often CCPs will be monitored and how the data will be recorded.
- Establish corrective actions: These are the actions that will be taken if a CCP is not within its critical limits.
- Establish verification procedures: This includes how the HACCP system will be verified to ensure it is working effectively.

Establish record-keeping procedures: This includes documenting all aspects of the HACCP system, including the HACCP plan, monitoring data, and corrective actions.

For a company developing and implementing a HACCP system, there are costs associated with:

Training and Expertise: implementing HACCP effectively requires a team with knowledge and understanding of the system. Training personnel in HACCP principles and their specific role within the plan can be expensive.

Documentation and Record-Keeping: Developing a comprehensive HACCP plan requires thorough documentation of food processes, potential hazards, CCPs, monitoring procedures, and corrective actions. Maintaining accurate records of monitoring data and corrective actions adds to the ongoing cost.

Equipment and Technology: Depending on the complexity of business operations, HACCP may necessitate investments in equipment or technology to monitor CCPs effectively. For example, the company might need thermometers with data-logging capabilities or upgraded sanitation equipment.

External Audits and Certification (Optional): While not mandatory, some businesses seek certification against GFSI standards which build upon HACCP. These certifications often involve audits by external bodies, which incur additional costs.

Potential Operational Changes: Implementing HACCP may necessitate changes to existing processes to ensure proper control at CCPs. These changes could require adjustments to production lines, scheduling, or ingredient sourcing, potentially impacting initial costs.

Although developing and implementing an HACCP program involves costs, these expenses can be offset by avoiding the costs associated with non-compliance. For example, not having a HACCP system will limit its ability to sell in the wider market.  Moreover, the HACCP system can prevent huge financial losses by better identifying and controlling hazards before they contaminate food products. This proactive approach significantly reduces the risk of recalls, which can be incredibly expensive.

The benefits of a well-established HACCP program far outweigh the costs of development and implementation, especially when one considers the penalties associated with non-compliance.

In Ukraine, the State Service of Ukraine on Food Safety and Consumer Protection (SSUFSCP) is an institution responsible for supervising food processes and products. However, no statistics about

recalled Ukrainian food products produced in its territory currently exist. The costs of recalls and loss of sales associated with non-compliant products are still present and will negatively impact the responsible company.

The European Union upholds some of the world's highest food safety standards, supported by comprehensive EU legislation designed to ensure the safety of food and animal feed. A key component of these safety measures is the Rapid Alert System for Food and Feed (RASFF), which facilitates the exchange of information among member states. This system enables food safety authorities to respond quickly and effectively to public health risks arising from the food supply chain (rephrase of European Commission. (n.d.). Rapid Alert System for Food and Feed (RASFF).

Although Ukraine participates in the European Commission's Rapid Alert System for Food and Feed, it is not currently a network member.  (State Service of Ukraine on Food Safety and Consumer Protection, n.d.) was posted on their late report on the website of the State Service of Ukraine on Food Safety and Consumer Protection (SSUFSCP) on April 20, 2021. This update warned people about mislabeled canned fish exported from Great Britain to the Netherlands. These samples were also sent to Ukraine.

Following the Global Food Safety Initiative (GFSI) and implementing and complying with global food safety standards, including the HACCP principles, will help the company avoid product recalls and mitigate the financial costs of producing unsafe food.

In Ukraine, it is obligatory to implement the HACCP system requirements for the food industry according to order № 590 from 01.12.2012 of the Ministry of Agrarian Policy and Food of Ukraine.

## CHAPTER 4  THE CASE STUDY OF IMPROVEMENT FSMS FOR “SMACHNI TRADYZII”, LLC

Throughout my 20 years of experience, I have worked with many food companies that approached me for assistance with implementing a Food Safety Management System (FSMS) according to the ISO 22000 standard. In my capstone project, I aim to improve both documentation and equipment that are part of FSMS for LLC 'SMACHNI TRADYZII', the company that produces semi-finished

products, to make it more effective and help them avoid product recalls and lose their reputation. I will use the production of varenyky with potato filling as an example.

After investigating their actual documentation, I would like to take into consideration the major documentation that impacts the Food Safety Management System (FSMS), such as flow-chart, hazards analysis of the process of semi-finished products, and HACCP plan where we can find out which critical control points the company defined for its process.

**4.1 The flowchart of the production of semi-finished products (varenyky with potato filling)**

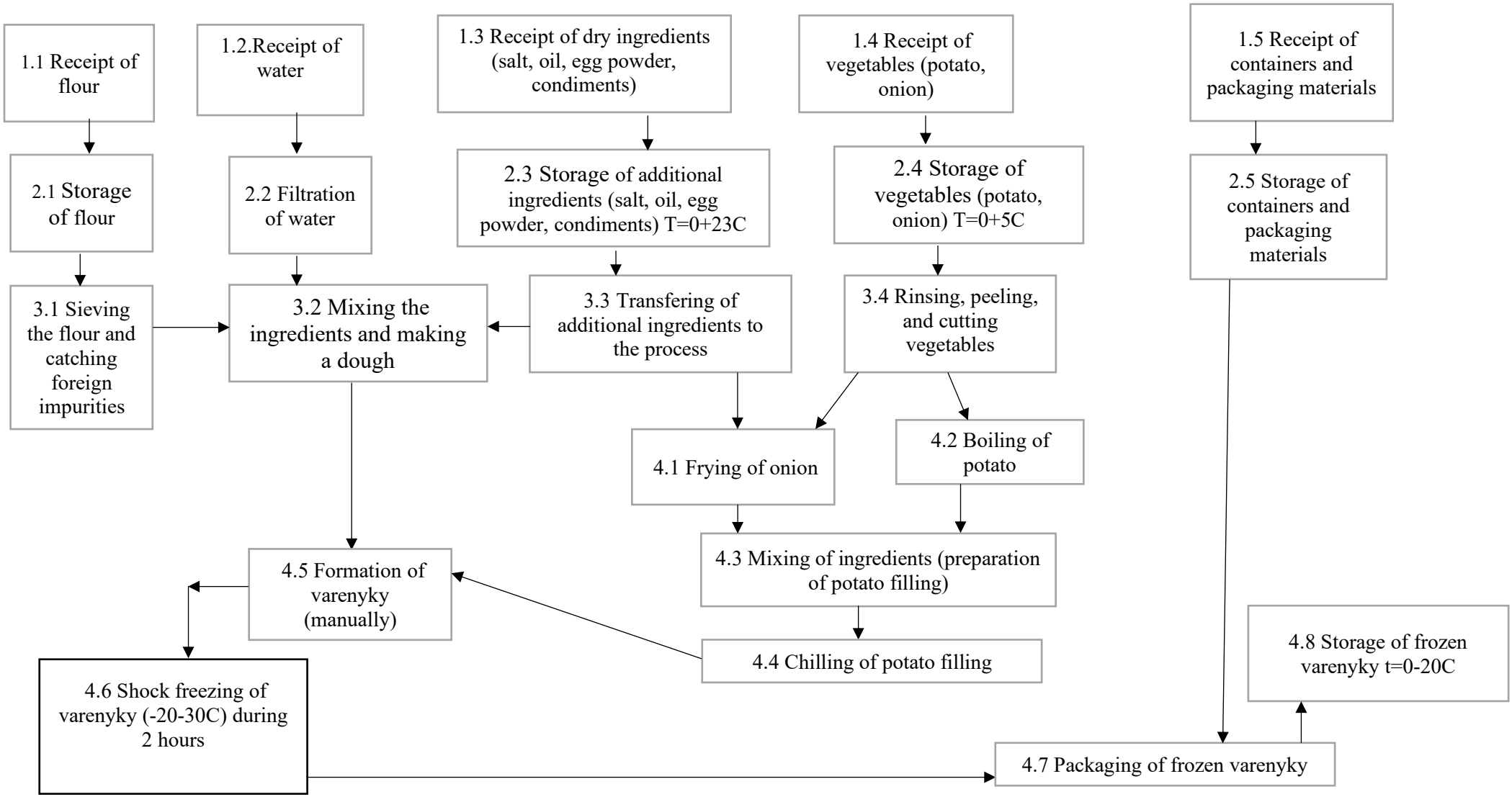


Figure 8 The flowchart of the production of semi-finished products (varenyky with potato filling)
Source: developed by LLC 'SMACHNI TRADYZII'

According to standards ISO 22000, the flow diagrams shall be clear, accurate, and sufficiently detailed to the extent needed to conduct the hazard analysis. Moreover, the flow diagrams shall include the following:

a) the sequence and interaction of the steps in the operation;

b) any outsourced processes;

c) where raw materials, ingredients, processing aids, packaging materials, utilities, and intermediate products enter the flow;

d) where reworking and recycling take place;

e) where end, intermediate, by-products, and waste are released or removed.

The flowchart mentioned above consists of the sequence and interaction of the steps in the operation, also revealing that the company does not use any outsourced processes, so all work can be done by its employees and its facilities the whole technological process. Also, we can follow the traceability of all raw materials and ingredients, and packaging materials used for the technological process of producing semi-finished products (varenyky with potato filling) until the end of finished products.

### 4.2 Hazards analysis of the process of semi-finished product (varenyky with potato filling)

The next crucial step in implementing a Food Safety Management System (FSMS) and identifying critical control points in the production line is conducting a hazard analysis based on the described flowchart and the actual production process. Throughout the hazard analysis, we will examine each step of the production process to identify physical, chemical, and biological hazards that could affect food safety.

Microbiological hazards in Hazard Analysis Critical Control Point (HACCP) systems refer to the presence of harmful microorganisms that can contaminate food and cause illness, such as bacteria, viruses, parasites, and fungi. Chemical hazards in Hazard Analysis Critical Control Point (HACCP) systems refer to the presence of harmful chemicals that can contaminate food, potentially causing illness or injury. The main categories of chemical hazards include:

1) Naturally Occurring Chemicals – mycotoxins, marine toxins, plant toxins, allergens;
2) Intentionally Added Chemicals - food additives, pesticides and herbicides, veterinary drugs;

3) Unintentionally Added Chemicals - industrial chemicals, cleaning agents, packaging materials; processing aids.

4) Contaminants from equipment and environment - lubricants and fuels, chemicals can transfer from one food product to another, particularly in facilities that handle allergens or use shared equipment.

Physical hazards in Hazard Analysis Critical Control Point (HACCP) systems refer to foreign objects or physical materials in food that can cause harm or injury to consumers. The main categories of physical hazards include metal, glass, wood, plastic, stone, bone, jewelry, personal items (hair, fingernails), and other foreign objects (paper, cardboard, feathers, or insects).

Table 1 Hazards analysis of the process of semi-finished product (varenyky with potato filling)

Source developed by LLC 'SMACHNI TRADYZII' (fragment)

| Process stage | Potential hazards | Risk factor | Preventive measures | Control points (CP) | Critical control points (CCP) |
|---|---|---|---|---|---|
| 3.1 Sieving the flour and catching foreign impurities | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Metallomagnetic impurities and foreign impurities or the barn pests | Adherence to schedules for planned and preventive repairs and maintenance of equipment, application of magnets, inspection of sieves and magnets | | CCP 1 |
| 4.6 Shock freezing of varenyky (-20-30C) during 2 hours | Microbiological hazard | Non-compliance with the temperature conditions of shock freezing | Control of temperature regimes during shock freezing<br>Temperature control of the varenyky in the thickness of the product | | CCP 2 |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard (absence) | - | - | | |

The full hazards analysis of the process of semi-finished product (varenyky with potato filling) is attached in Appendix A.

So, the hazards analysis of the technological process of the production of varenyky with potato filling revealed two critical control points:

- in stage "3.1 Sieving the flour and catching metal impurities" concerning the physical hazard. These hazards impose risk factors such as metal magnetic impurities and foreign impurities or barn pests which can enter the production process and cause harm or injury to consumers. To eliminate this hazard the company has to adhere to schedules for planned and preventive repairs and maintenance of equipment, application of magnets, and inspection of sieves and magnets. Otherwise, foreign impurities can lead to non-conformity in the final products.
- in stage "4.6 Shock freezing of varenyky (-20-30C) for 2 hours" concerning microbiological hazard. The risk factor is non-compliance with the temperature conditions of shock-freezing. Under frozen conditions, varenyky are well-preserved, and this process helps to inactivate all harmful microorganisms. Therefore, controlling the temperature during shock freezing and monitoring the internal temperature of the varenyky ensures the production of a safe final product.

## 4.3 HACCP PLAN FOR THE FROZEN SEMI-FINISHED PRODUCTS (VARENYKY WITH POTATO FILLING)

The next important document in the FSMS is the HACCP plan, which identifies the critical control points that must be regularly monitored. There are strict requirements for the HACCP plan, and it should contain the following information:

Determined Critical Control Points (CCPs)

Established Critical Limits

Implemented Monitoring Procedures

Defined Corrective Actions

Established Verification Procedures

Documentation and Record Keeping

| Number of CCP | Process stage | Hazard | Critical limits | Monitoring | | | | | Corrective actions | Verification | Records reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | What | By means | Where | Who | Frequency | | | |
| CCP 1 | 3.1 Sieving the flour and catching metal impurities | Physical hazard | Absence of foreign impurities | Magnets and sieves | Visual | in the equipment where magnets and sieves | Mechanic | Before and after every shift | In case of detecting foreign impurities in the dough, the process must be stopped, and the condition of the magnets and sieves must be checked. The technological process cannot be continued without cleaning or replacing the sieves and checking the strength of the magnets. | Developed company's Verification Procedure | The records of monitoring the cleaning or replacement of sieves and checking the strength of the magnets. |
| CCP 2 | 4.6 Shock freezing of varenyky | Microbiological hazard | T=(-20-30C) for 2 hours | Temperature | Pyrometer | in the thickness of products | Technologist | Every batch during the freezing | In case of detecting temperature deviations within the thickness of the products, they are | Developed company's Verification Procedure | The records of monitoring of the temperature in the thickness of |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | redirected for re-freezing to correct the internal temperature | | the products. Corrective action plan. |

Table 2 HACCP PLAN FOR THE FROZEN SEMI-FINISHED PRODUCTS (VARENYKY WITH POTATO FILLING)

Source developed by LLC 'SMACHNI TRADYZII'

# CHAPTER 5. IMPROVEMENT OF FOOD SAFETY MANAGEMENT SYSTEM (DOCUMENTATION)

After thoroughly investigating current Food Safety Management Systems and consulting reputable sources, I have identified areas that require improvement. Both the documentation and the actual technological process have drawbacks. The company does not adequately address the control of physical hazards in its technological process.

Physical hazards such as foreign material contamination in the food supply chain present significant risks, including:

- Consumer Health Risks. Ingesting food debris may cause one to cut or break their teeth, choke if the food particles block the airways, or suffer an illness if the particle has pathogens on it. Such events may lead to serious health effects, for example, the individual may require a hospital or may even die based on the type of contaminant and the level of vulnerability of the consumer.
- Regulatory Compliance. Sanitary measures prescribed by governmental authorities, as well as protecting statutes, dictate rigorous compliance with established food protection norms and anti-contamination safeguards. Non-compliance with these regulations has penalties such as fines, legal consequences, recall, and even shutdown.
- Supply Chain Disruption. Contamination incidents are capable of causing traffic interruptions of products in the supply chain, resulting in shortages of products, delays, and high operating costs. These disruptions can be systemic and could impact almost everyone in the industry chain.
- Damage to Brand Value. Contamination by foreign material has been known to cause severe loss since it affects the image of a company and the trust people have in its products. Recalled products' information quickly circulates through the media; conventional and social media and negatively affects the company's reputation.

The documentation and technological process of the company LLC 'SMACHNI TRADYZII' do not address any measures to control impurities that may be present in salt. Credential technological sources such as the (Studfile, n.d.) of the Ukrainian National University of Food Technology and International Food Safety standards require that all raw materials, including salt, are handled in a way that minimizes risks. These practices involve the removal of impurities that could compromise the

product's safety. This is aligned with broader food safety principles found in international regulations like ISO/TS 22002-1 “Prerequisite programmes on food safety Part 1: Food manufacturing,” which also emphasize controlling contamination at all stages of food production.

There are two potential methods for handling salt before it is introduced into the technological process. The first method involves removing impurities from the salt and evenly distributing it in the dough. In this process, the salt is dissolved, filtered, and allowed to settle. Since salt dissolves more quickly at a temperature of 30ºC with stirring, the salt solution is added during dough kneading. The amount of salt added is determined according to the recipe, based on its density as measured by the unit.

The second way is passing salt through the sieve and metal detector.

Sieving: This step ensures a uniform particle size by removing oversized particles or foreign debris. In salt preparation, for instance, a sieve separates larger salt crystals from finer ones before further processing. This process not only maintains product consistency but also helps prevent equipment blockages and downtime.

Metal Detection: After sieving, salt typically passes through a metal detector. This is crucial because metal contaminants, which may come from various sources like machinery wear, can cause damage to processing equipment and pose serious safety risks if they end up in the final product. Metal detectors in food production are designed to detect contaminants made of ferrous metals, non-ferrous metals, and stainless steel.

In this stage, as a salt preparation step before its submission to the technological process, I defined it as a control point. I will depict the hazard analysis extract and how it would be added.

Table 3. Extract of hazard analysis based on an author’s recommendation

| **Process stage** | **Potential hazards** | **Risk factor** | **Preventive measures** | **Control points (CP)** | **Critical control points (CCP)** |
|---|---|---|---|---|---|
| The preparation of salt before its submission to the technological process | Microbiological hazard (absence) | | | | |
| | Chemical hazard (absence) | | | | |
| | Physical hazard | Non-compliance with technological instructions for the salt preparation (depends | Control of sieve integrity and regular checks of the magnetic detector, either for | CP | |

| | | | | | |
|---|---|---|---|---|---|
| | | on the way supplying salt in the process dry or solution) | cleaning metal impurities or verifying the strength of the magnets. | | |

Source: developed by author.

The next improvement I recommend for the company's Food Safety Management System is the installation of a metal detection system for the final products. While the technological process currently lacks a stage for salt preparation, this can be addressed by enhancing the inspection of the final products.

Detecting foreign impurities in final products is essential for ensuring product safety and quality, particularly in the food industry. Advanced technologies are used to identify and remove these impurities, including:

1) X-ray Inspection Systems (TDIPackSys, n.d.) are highly effective at detecting dense foreign materials, including metals, glass, stones, bones, and hard plastics. They work by capturing images of products and identifying any anomalies in density compared to the standard product. These systems are commonly used in food production to ensure no harmful foreign bodies reach consumers.
2) Metal Detectors (Cassel Inspection, n.d.) are widely used to detect metallic contaminants (both ferrous and non-ferrous) in products. Metal detectors are a cost-effective solution and are typically deployed in high-speed production environments, making them ideal for catching metallic impurities in food products.
3) Hyperspectral Imaging and Infrared Systems (Baranyi, Hui, & Kiss, 2012), these technologies detect foreign objects based on their spectral signatures. They are especially useful for identifying contaminants that differ in color or reflectance compared to the product, such as plastics or organic materials. These systems are advantageous in scenarios where traditional X-rays or metal detectors might miss certain impurities.
4) Related to our flowchart of production of frozen semi-finished products varenyky with potato filling, I would additionally install the X-ray inspection between stage 4.7 Packaging of frozen varenyky and 4.8 Storage of frozen varenyky t=0-20C.

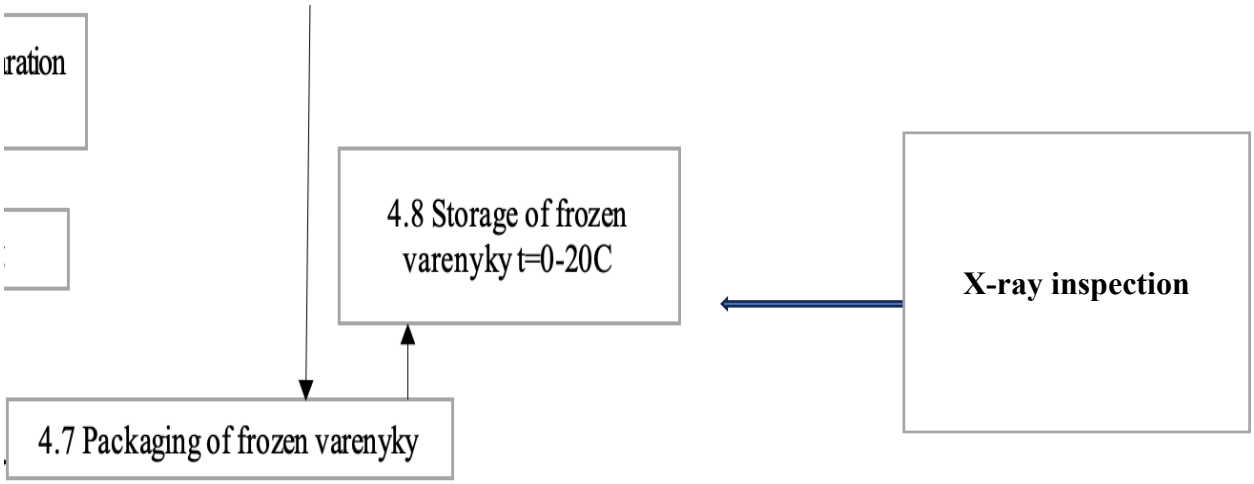


Figure 9 Extract of flow chart based on an author's recommendation

Source: developed by author

X-ray inspection is a one of the option for preventing foreign impurities in the final products, and I would recommend that the company alter the main document of the Food Safety Management System as Plan (HACCP) in the new version, incorporating the third CCP (CCP3).

Table 4. Extract of HACCP plan based on an author's recommendation

| Number of CCP | Process stage | Hazard | Critical limits | Monitoring | | | | | Corrective actions | Verifi-cation | Records reference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | What | By means | Where | Who | Frequency | | | |
| CCP 3 | Checking the final products against foreign impurities | Physical hazard | Absence of foreign impurities | Control of X-ray with mock foreign impurities | Visual | X-ray | Mechanic | After every batch | If the X-ray does not detect mock foreign impurities, it is necessary to separate the last batch of products and keep them until the machine is working properly. After fixing the X-ray, the stored products need to undergo X-ray inspection once more. | Developed company's Verification Procedure | The records of monitoring mock foreign impurities |

Source: developed by author.

## CHAPTER 6 IMPROVEMENT OF FOOD SAFETY MANAGEMENT SYSTEMS (ADDITIONAL EQUIPMENT)

Thus, one of the option alternatives for preventing foreign impurities in the final product is installing an X-ray machine that has the following benefits (TDIPackSys, n.d.):

- detects a wide range of contaminants: X-ray machines can detect a variety of foreign objects, including metal, glass, stone, bone, and some plastics. This makes them versatile for quality control in the food production and packaging industries.
- Density-Based Detection: X-ray machines are effective at identifying contaminants based on density differences from the surrounding product. This allows for the detection of non-metallic contaminants that may be missed by metal detectors.
- Non-Destructive Testing: X-ray inspection is a non-destructive method, meaning it does not alter or damage the product being inspected.
- Internal Defect Detection: X-ray systems can also detect internal defects in products, such as cracks, voids, or inconsistencies in density, which metal detectors cannot detect.
- Packaging Inspection: X-rays can inspect the integrity of packaging, ensuring that seals are intact and that there are no contaminants within the sealed packages.

On the one hand, it is a huge sum of money for Ukrainian businesses to purchase new equipment, on the other hand, it is a guarantee that the company can produce safe products that do not affect people's health.

For instance, the Texas grand jury charged Paul Kruse, former president of Blue Bell Creameries, with wire fraud and conspiracy for allegedly covering up the sale of Listeria-contaminated ice cream in 2015 (U.S. Food and Drug Administration, 2020). Kruse is accused of hiding the contamination and misleading customers, resulting in multiple recalls. Blue Bell pleaded guilty to distributing contaminated food and agreed to pay $19.35 million in penalties. The company temporarily closed its plants in 2015 to improve safety practices. (Lucas, 2019) reported that Tyson Foods recalled almost 12 million pounds of chicken strips

over contamination fears on May 6, 2019. The main key points of this recall were six complaints from consumers who found pieces of metal in the product. These tendencies of increasing awareness among consumers may lead to recall of the products, and even lawsuits in Ukraine as well.

## Methodology of scenario analysis

The company LLC 'SMACHNI TRADYZII' provided me with their financial statements, where I saw that their net income from product sales is 30000,00 hryvnia (~$ 700) for the quarter. This is much less than the amount needed to purchase new equipment. The commercial offer in the Ukrainian market (Appendix B) provides the cost of a new X-ray of about 72,000 euros. Thus, this price is unaffordable for LLC 'SMACHNI TRADYZII' from the Ukrainian manufacturer. My recommendation for the company LLC 'SMACHNI TRADYZII' is to buy a new X-ray from a foreign supplier, (Alibaba.com, n.d.) which costs ~$ 27000.

The company can take a loan or lease. This will make it possible to distribute payments over several months or years, reducing the burden on the company's cash flows.

The scenario analysis aims to assess the Value-in-Use (VIU) of purchasing X-ray equipment for LLC 'SMACHNI TRADYZII' by quantifying avoided losses due to product returns and lawsuits. Using financial data from the company's quarterly income statements, we modeled various loss scenarios as percentages of net income. Avoided losses were calculated based on a 90% reduction in returns and legal risks attributed to the improved product quality ensured by the X-ray equipment. Costs were analyzed using the foreign supplier's offer of ~$27,000 for the equipment, with payments distributed over five years at an estimated 5% annual interest. The analysis included scenarios ranging from minimal (10% of net income) to catastrophic losses (150% of net income plus a potential lawsuit). For each scenario, we calculated the net annual benefit and the break-even period to illustrate the financial impact and feasibility of the investment.

The scenario analysis evaluates the Value-in-Use (VIU) of purchasing X-ray equipment for LLC 'SMACHNI TRADYZII' by quantifying avoided losses due to product returns and lawsuits.

The key formulas used for the calculations are:

1. **Annual Losses Due to Returns or Lawsuits:**
$$\text{Annual Losses} = (\text{Net Income per Quarter} \times 4) \times \text{Loss Rate (\% of Net Income)}$$
2. **Avoided Losses with Equipment (90% Reduction):**
$$\text{Avoided Losses} = \text{Annual Losses} \times 90\%$$
3. **Net Annual Benefit:**
$$\text{Net Annual Benefit} = \text{Avoided Losses} - \text{Annual Payment for Equipment}$$
4. **Break-Even Period:**
$$\text{Break-Even Period} = \frac{\text{Total Equipment Cost}}{\text{Avoided Losses}}$$

The analysis uses data from the company's quarterly net income of 30,000 UAH (~$700). Five scenarios are modeled, with loss rates ranging from 10% to 150% of net income. Costs are calculated using a foreign supplier's equipment price of ~$27,000, distributed over five years with a 5% annual interest, resulting in an annual payment of ~$5,550.

| Scenario | Annual Losses Due to Returns or Lawsuits ($) | Avoided Losses with X-Ray Equipment (90% Reduction) ($) | Annual Equipment Payment ($) | Net Annual Benefit ($) | Break-Even Period (Years) |
|---|---|---|---|---|---|
| Low Avoided Losses (10% of Net Income) | 280 | 252 | 5550 | -5298 | 107 |
| Medium Avoided Losses (30% of Net Income) | 840 | 756 | 5550 | -4794 | 36 |
| High Avoided Losses (50% of Net Income) | 1400 | 1260 | 5550 | -4290 | 21.5 |
| Critical Avoided Losses (100% of Net Income) | 2800 | 2520 | 5550 | -3030 | 10.7 |
| Catastrophic Avoided Losses (150% of Net Income + Lawsuit) | 8200 | 7380 | 5550 | 1830 | 3.7 |

**Results of scenario analysis:**

According to the calculations (Table above), different scenarios were analyzed. The analysis reveals that in low-risk scenarios (10% loss rate), annual losses are $280, and avoided losses amount to $252. The net annual benefit is negative (-$5,298), with a break-even period of 107 years. As the loss rate increases, the benefits become more significant. In medium-risk scenarios (30% loss rate), annual avoided losses rise to $756, reducing the break-even period to ~36 years. In high-risk scenarios (50% loss rate), avoided losses of $1,260 per year shorten the break-even period to ~21.5 years. For catastrophic scenarios (150% loss rate plus a $5,000 lawsuit), avoided losses reach $7,380 annually, yielding a positive net benefit of $1,830 and a break-even period of just ~3.7 years.

This analysis underscores the importance of investing in X-ray equipment to mitigate financial risks associated with product returns and lawsuits. The formulas used provide a structured approach to calculating the financial impact, highlighting how higher risk levels significantly enhance the equipment's value. This evidence supports a strong case for attracting investor support and financing to ensure the company’s sustainability and growth.

# CHAPTER 7. CONCLUSION

Ensuring food safety is paramount for the sustainability and reputation of food manufacturers. This capstone project examined the Food Safety Management System (FSMS) improvements needed for LLC 'Smachni Tradytzii' to align with ISO 22000 standards. By analyzing the production process of varenyky with potato filling, the project identified critical control points and proposed enhancements, including updated HACCP plans and the integration of advanced equipment like X-ray machines to detect foreign impurities.

The findings underscore the necessity of implementing robust FSMS measures, not only for regulatory compliance but also to protect consumer health, maintain brand integrity, and prevent financial losses associated with recalls and legal liabilities. The case study highlights that investing in food safety measures is not an optional expense but a strategic investment in the company's long-term success.

While the financial burden of acquiring advanced equipment may pose a challenge for small manufacturers like LLC 'Smachni Tradytzii,' the costs of non-compliance—both tangible and reputational—far outweigh the initial investment. By adopting the recommended improvements, the company can enhance its production quality, build consumer trust, and strengthen its position in a competitive market.

**APPENDIX A.**

| Process stage | Potential hazards | Risk factor | Preventive measures | Control points (CP) | Critical control points (CCP) |
|---|---|---|---|---|---|
| 1.1 Receipt of flour | Microbiological hazard | No appropriate input control of documentation with microbiological indicators in flour (Salmonella would be a hazard to be recognized at the receipt of the flour) | Incoming control of purchased products: Control of the availability of accompanying documents Visual inspection: Packaging integrity, labeling, expiration date control Organoleptic assessment | CP | |
| | Chemical hazard | No appropriate input control of documentation with safety indicators in flour. (including allergens) | Incoming control of purchased products: Control of the availability of accompanying documents Visual inspection: Packaging integrity, labeling, expiration date control Organoleptic assessment | CP | |
| | Physical hazard | The presence of foreign impurities in flour | Incoming control of purchased products: Control of the availability of accompanying documents Visual inspection: Packaging integrity, labeling, expiration date control | CP | |
| 1.2. Receipt of water | Microbiological hazard | Non-compliance with biological indicators in water | Testing water from the water supply system for compliance with microbiological indicators | CP | |
| | Chemical hazard | Non-compliance with chemical indicators in water | Testing water from the water supply system for compliance with sanitary and toxicological indicators | CP | |
| | Physical hazard | The presence of foreign impurities in water | Testing water from the water supply system for foreign impurities | CP | |

| | | | | | |
|---|---|---|---|---|---|
| 1.3 Receipt of dry ingredients (salt, oil, egg powder, condiments) | Microbiological hazard | No appropriate input control of documentation with microbiological indicators in additional ingredients | Incoming control of purchased products:<br>Control of the availability of accompanying documents<br>Visual inspection:<br>Packaging integrity, labeling, expiration date control<br>Organoleptic assessment | CP | |
| | Chemical hazard | No appropriate input control of documentation with safety indicators in additional ingredients including allergens. | Incoming control of purchased products:<br>Control of the availability of accompanying documents<br>Visual inspection:<br>Packaging integrity, labeling, expiration date control<br>Organoleptic assessment | CP | |
| | Physical hazard | The presence of foreign impurities in additional ingredients in flour | Incoming control of purchased products:<br>Control of the availability of accompanying documents<br>Visual inspection:<br>Packaging integrity, labeling, expiration date control | CP | |
| 1.4 Receipt of vegetables (potato, onion) | Microbiological hazard | No appropriate input control of documentation with microbiological indicators in vegetables (Salmonella and other enteric pathogens, C. botulin and spore forming pathogens) | Incoming control of purchased products:<br>Control of the availability of accompanying documents<br>Visual inspection:<br>Packaging integrity, labeling, expiration date control<br>Organoleptic assessment | CP | |
| | Chemical hazard | No appropriate input control of documentation with safety indicators in vegetables | Incoming control of purchased products:<br>Control of the availability of accompanying documents<br>Visual inspection:<br>Packaging integrity, labeling, expiration date control<br>Organoleptic assessment | CP | |

| | | | | | |
|---|---|---|---|---|---|
| | Physical hazard | The presence of foreign impurities in vegetables | Incoming control of purchased products: Control of the availability of accompanying documents Visual inspection: Packaging integrity, labeling, expiration date control | CP | |
| 1.5 Receipt of containers and packaging materials | Microbiological hazard | Non-compliance with microbiological indicators in containers and packaging materials | Incoming control of purchased materials: Control of the availability of accompanying documents Visual inspection: Integrity of packaging, labeling | CP | |
| | Chemical hazard | Failure to comply with established requirements for chemical indicators in containers and packaging materials | Incoming control of purchased materials: Control of the availability of accompanying documents Visual inspection: Integrity of packaging, labeling | CP | |
| | Physical hazard | The presence of foreign impurities in containers and packaging materials | Incoming control of purchased materials: Control of the availability of accompanying documents Visual inspection: Integrity of packaging, labeling | CP | |
| 2.1 Storage of flour | Microbiological hazard | In case of non-observance of storage temperature regimes, spoilage of products is possible, which leads to the development of a microbiological factor. | Control of temperature regimes of product storage | CP | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Violation of sanitary norms and rules during flour storage | Control of compliance with sanitary norms and rules during flour storage | CP | |

| | | | | | |
|---|---|---|---|---|---|
| 2.2 Filtration of water | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Violation of the periodicity of replacing the filter material | Control of periodicity compliance of replacing the filter material | CP | |
| 2.3 Storage of additional ingredients (salt, oil, egg powder, condiments) T=0+23C | Microbiological hazard | In case of non-observance of storage temperature regimes, spoilage of products is possible, which leads to the development of a microbiological factor. | Control of temperature regimes of product storage | CP | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 2.4 Storage of vegetables (potato, onion) T=0+5C | Microbiological hazard | In case of non-observance of storage temperature regimes, spoilage of products is possible, which leads to the development of a microbiological factor. | Control of temperature regimes of product storage | CP | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard (absence) | - | - | | |
| 2.5 Storage of containers and packaging materials | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |

| | | | | | |
|---|---|---|---|---|---|
| | Physical hazard (absence) | - | - | | |
| 3.1 Sieving the flour and catching foreign impurities | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Metallomagnetic impurities and foreign impurities or the barn pests | Adherence to schedules for planned and preventive repairs and maintenance of equipment, application of magnets, inspection of sieves and magnets | | CCP 1 |
| 3.2 Mixing the ingredients and making a dough | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 3.3 Transfering of additional ingredients to the process | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 3.4 Rinsing, peeling, and cutting vegetables | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and | Control of personnel hygiene and environmental | CP | |

| | | | | | |
|---|---|---|---|---|---|
| | | requirements for a hygienic environment | hygiene requirements of the production process | | |
| 4.1 Frying of onion | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 4.2 Boiling of potato | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 4.3 Mixing of ingredients (preparation of potato filling) | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 4.4 Chilling of potato filling | Microbiological hazard | Sporeforming pathogens - the cooling of the potato must be controlled. | Control of time for chilling of potato filling | CP | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and | Control of personnel hygiene and environmental | CP | |

| | | | | | |
|---|---|---|---|---|---|
| | | requirements for a hygienic environment | hygiene requirements of the production process | | |
| 4.5 Formation of varenyky (manually) | Microbiological hazard | Non-compliance with the requirements for personal hygiene | Control of periodicity cleaning hands and changing the gloves and sanitary uniform. | CP | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 4.6 Shock freezing of varenyky (-20-30C) during 2 hours | Microbiological hazard | Non-compliance with the temperature conditions of shock freezing | Control of temperature regimes during shock freezing<br>Temperature control of the varenyky in the thickness of the product | | CCP 2 |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard (absence) | - | - | | |
| 4.7 Packaging of frozen varenyky | Microbiological hazard (absence) | - | - | | |
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard | Non-compliance with the requirements for personal hygiene and requirements for a hygienic environment | Control of personnel hygiene and environmental hygiene requirements of the production process | CP | |
| 4.8 Storage of frozen varenyky t=0-20C | Microbiological hazard | In case of non-observance of storage temperature regimes, spoilage of products is possible, which leads to the development of a microbiological factor. | Control of temperature regimes during product storage | CP | |

| | | | | | |
|---|---|---|---|---|---|
| | Chemical hazard (absence) | - | - | | |
| | Physical hazard (absence) | - | - | | |

# COMMERCIAL OFFER FOR NEW X-RAY

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Київ 22.07.2022

## КОМЕРЦІЙНА ПРОПОЗИЦІЯ

1. **Назва:**

Інспекційна система на основі X-Ray від Loma Systems(Великобританія)

2. **Загальна специфікація цін:**

| *Поз.* | *Кіл-ть* | *Назва* | *Ціна, Євро.* |
|---|---|---|---|
| | 1 | **Loma X5C** (розмір продукту ВхШхД: 110x280x280 мм) | |
| | | **ВСЬОГО** (шеф-монтаж, наладка, навчання персоналу, ПДВ, доставка, гарантія 1 рік) | **62 100,00** |
| | 1 | **Loma X5 SpaceSaver** (розмір продукту ВхШхД: 180x480x500 мм) | |
| | | **ВСЬОГО** (шеф-монтаж, наладка, навчання персоналу, ПДВ, доставка, гарантія 1 рік) | **71 900,00** |
| | | **Опції: Додаткові конвейери з захистом X5c / X5SS** | 5 500.00 / 7 000,00 |

3. **Термін поставки: 12-13 місяців**
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