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CONTRIBUTION TO THE IMPLEMENTATION OF THE HACCP SYSTEM WITHIN THE ORANGE NECTAR WORKSHOP

Laila EL ARCHI

Master's Thesis

Supervisor

Asst. Prof. Dr Fatih YIĞIT

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The thesis titled CONTRIBUTION TO THE IMPLEMENTATION OF THE HACCP SYSTEM WITHIN THE ORANGE NECTAR WORKSHOP prepared by LAILA EL ARCHI and submitted on 24.01.2024 has been **accepted unanimously** for the degree of Master of Science in Industrial Engineering department.

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I hereby declare that this thesis meets all format and submission requirements for research Master's thesis.

I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Laila EL ARCHI

Signature

DEDICATION

In the name of Allah, the Most Gracious, the Most Merciful.

I dedicate this thesis to the pivotal forces that have shaped my academic journey and fuelled my aspirations.

To my parents, the pillars of my strength, whose unwavering belief in me and approval to study abroad have been the wind beneath my wings. Your sacrifices and encouragement have sculpted the path to this achievement.

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ABSTRACT

CONTRIBUTION TO THE IMPLEMENTATION OF THE HACCP SYSTEM WITHIN THE ORANGE NECTAR WORKSHOP

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This thesis focuses on implementing the Hazard Analysis and Critical Control Points (HACCP) system in orange nectar production, emphasizing the integration of prerequisite programs and adherence to the 12-step HACCP methodology. The goal is to design a tailored HACCP system for orange nectar production, incorporating prerequisite programs for general food safety and following the Codex Alimentarius Commission's 12 steps. Expected outcomes include enhanced control over critical points, improved product safety, reduced contamination risks, compliance with regulations, and increased consumer confidence. This research contributes practical insights for applying HACCP in the fruit beverage industry, specifically in orange nectar production. While limited to a specific timeframe, geographic location, and industry context, the study aims to establish a comprehensive framework for enhancing orange nectar safety and quality.

Keywords: HACCP, Prerequisite Programs, Orange Nectar, Food Safety, Quality Control.

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ABBREVIATIONS

COPAG	:	Taroudant Agricultural Producers Cooperative
HACCP	:	Hazard Analysis and Critical Control Points
GHP	:	Good Hygiene Practices
FDA	:	Food and Drug Administration
EPA	:	Environmental Protection Agency
QM	:	Quality Management
QA	:	Quality Assurance
ISO	:	International Organization for Standardization
NIPPP	:	The National Industrial Pollution Prevention Program
NASA	:	National Aeronautics and Space Administration
CFP	:	The Conference on Food Protection
CCP	:	Critical Control Point
PRP	:	Prerequisite Program
PS	:	Partially Satisfactory
S	:	Satisfactory
NS	:	Non-Satisfactory
NEPS	:	The Number of Partially Satisfactory Response
NES	:	The Number of Satisfactory Responses
NENS	:	The Number of Non-Satisfactory Responses
NTCE	:	The Total Number of Checklist Elements
G	:	Gravity
F	:	Frequency

D	:	Detectability
NCRM	:	Non-Conformity Raw Materials

1. INTRODUCTION

In today's global food industry, ensuring the safety and quality of our food is paramount, placing increasing pressure on companies to meet heightened customer expectations. For the citrus sector, particularly in juice and nectar production, the focus has shifted from simple fruits to more sophisticated products. This growth presents new challenges to consumer health, necessitating robust safety systems.

In response to these challenges, the Taroudant Agricultural Producers Cooperative (COPAG) has decided to implement the Hazard Analysis Critical Control Point (HACCP) for continuous self-monitoring, building on previous initiatives. Our project is dedicated to contributing to this effort, specifically focusing on implementing the HACCP system in the orange nectar workshop.

The goal is to enhance safety and quality assurance in the production process, aligning with the cooperative's commitment to providing consumers with safe and high-quality orange nectar products.

The HACCP system, recognized globally as a standard for food safety, is based on scientific principles and risk management. Its flexibility and adaptability to different food production processes make it a valuable tool. The success of HACCP hinges on the commitment of both management and staff to its implementation and ongoing maintenance.

The thesis is structured into three main parts: assessing the company's current status regarding preliminary programs, preparing for the implementation of HACCP, and conducting a detailed HACCP study. The first step involves evaluating the company's compliance with general principles of food hygiene, specifically Good Hygiene Practice (GHP). It aims to identify strengths, weaknesses, and deviations. The second step encompasses implementing a quality management system using the HACCP approach, involving an examination of the production line, identification of crucial hazards, and the creation of HACCP plans for groups of products with similar production processes and hazards.

The thesis is designed to provide a comprehensive analysis of the implementation of preliminary programs and the HACCP system within the COPAG cooperative. It begins with an introduction that contextualizes the research objectives, followed by a literature review exploring existing knowledge and research related to HACCP and preliminary programs. The body of the thesis comprises detailed discussions of the HACCP system and preliminary programs, emphasizing their implementation processes, benefits, and practical applications. The final section presents data and results obtained from the implementation of the HACCP system and preliminary programs at COPAG, providing insights into their effectiveness and improvements in food safety practices. The thesis concludes with a comprehensive summary and conclusion, highlighting key findings, implications, and recommendations for future research and practice.

2. LITERATURE REVIEW

The literature review section of this thesis explores the implementation of a HACCP system in the food industry. It provides an overview of existing research and publications, aiming to establish a theoretical foundation for understanding key concepts, approaches, and factors related to successful HACCP implementation in ensuring food safety and customer satisfaction.

To ensure the credibility and relevance of the review, a comprehensive search strategy is employed to gather peer-reviewed articles, academic journals, industry reports, and reputable sources. Relevant search terms include "HACCP," "food industry," "food safety," "customer satisfaction." And “the citrus sector”.

2.1 THE FOOD INDUSTRY

The food industry is a vital and multifaceted sector that profoundly impacts our society. It encompasses various stages, including agriculture, production, distribution, and consumption. This globalized industry connects a complex network of stakeholders, such as producers, suppliers, retailers, and consumers. It not only satisfies our basic sustenance needs but also influences factors such as health, culture, economy, environmental sustainability, and food safety. The food industry's reach extends from farm to fork, shaping our dietary choices and impacting socioeconomic factors on a global scale.

Sun and Anwar employ a product variety model to investigate the factors influencing optimal product quality, considering that higher-quality products increase consumer utility but are more costly to produce. It explores the interplay between the parameters of the consumer utility function and the firm's cost of production to determine the most advantageous product quality for a company [1]. The study's theoretical analysis reveals a structural connection between a firm's unobserved product quality and its observed sales revenue, which enables the estimation of product quality within an industry. To put the theory into practice, the researchers use firm-level data from China's food processing and food manufacturing industries during the years 2005 to 2007.

Through empirical analysis, they establish that product quality in both industries has shown a positive trend over time, with the probability distributions of product quality shifting towards higher quality between 2005 and 2007. Furthermore, the probability distributions of product quality growth rates also demonstrate positive means in 2007, affirming the continued improvement in product quality within these sectors. However, despite the observed improvements, the paper acknowledges that there is still considerable room for enhancing product quality further, especially considering media reports and general perceptions regarding the quality of certain Chinese-made products, particularly in the food industry. It is important to note that the authors declare no known competing financial interests or personal relationships that could potentially influence the reported findings in this paper, ensuring the integrity of the research. Overall, the study provides valuable insights into understanding and estimating product quality within industries, highlighting the potential for ongoing improvements while emphasizing the significance of consumer utility and production costs in determining optimal product quality.

2.1.1 Food Safety

Food safety is incredibly important for public health and consumer trust. It involves protecting our food from contamination and hazards to ensure its quality and safety. Researchers and policymakers are working together to find effective ways to maintain the integrity of the food supply chain and keep consumers safe.

Food safety is a fundamental human right since food is essential for survival. Sadly, many people worldwide are exposed to unsafe food, leading to illnesses and fatalities. The food supply chain faces various challenges related to microbial, chemical, personal, and environmental hygiene. Both intentional and unintentional contamination in the past has caused tragedies and economic disasters, underscoring the need for improved governmental and individual efforts to ensure food quality and safety. Recent outbreaks, mainly due to microbial agents, disproportionately affect vulnerable populations like children, the elderly, and the sick. To address these issues, rapid and accurate pathogen detection is crucial, with advanced diagnostic technologies replacing traditional methods. Collaborative efforts among all stakeholders, including food producers, distributors, handlers, vendors, consumers, and government agencies, are essential to effectively ensure food safety and prevent foodborne illnesses in the 21st century. Medical providers also play a crucial role in promoting safe diet therapy under proper supervision, further safeguarding public and individual health. Furthermore, safe food not only satisfies basic human needs but also plays a pivotal role in supporting national economies, trade, tourism, nutrition security, and sustainable development. However, as the global food chain becomes more complex due to globalization and population growth, it brings both opportunities and challenges for food safety. Stakeholders must assume responsibility, and government agencies such as the FDA and EPA are instrumental in enforcing food safety laws. By collaborating closely, stakeholders can achieve meaningful food safety on a global scale, directly impacting public health and nutrition. [2]

In another article foodborne pathogens pose a significant public health burden, causing an estimated 600 million cases and over 400,000 deaths globally each year [3]. Vulnerable populations, such as children under five, the elderly, and immunocompromised individuals, are most affected. Food safety incidents and outbreaks also have a considerable economic impact, estimated at 7 billion annually in the US. As a result, preventive controls and monitoring systems have become a priority, leading to the development of new tools for detecting and preventing pathogens in the food chain. These tools have evolved rapidly, including rapid testing methods and the application of genomics and metagenomics. It's crucial to take a holistic approach to food safety, considering the entire food chain from farm to fork. The review highlights the importance of implementing new tools in detection and prevention, recognizing the rapid evolution of technologies in this field, and addressing regulatory data gaps, particularly in developing countries. Policy makers and regulatory agencies should stay updated with the latest scientific knowledge to ensure effective food safety measures are in place.

Diogo Thimoteo da Cunha assume that Foodborne illnesses remain a global concern, and the foodservice industry plays a vital role in preventing such illnesses and safeguarding consumer health. However, there is conflicting research on effective strategies for enhancing food safety in this industry [4]. This study focuses on behavior-based approaches and emphasizes the importance of cultivating a proactive food safety culture and creating an improved environment. Training should address practical issues, communication, and motivation. Developing effective education processes, regulations, and policies, along with strong leadership, can contribute to fostering a proactive food safety culture in the foodservice industry.

2.1.2 Customer Satisfaction

In the realm of food safety, customer services play a pivotal role in shaping public perceptions, trust, and satisfaction. Effective customer service practices not only ensure the safety and quality of food products but also contribute to fostering long-term relationships between consumers and food establishments. In this chapter, we will explore various articles that delve into the significance of customer services in the context of food safety, examining their impact on public perception, trust, and overall satisfaction with food establishments.

Suchánek and Králová investigates customer satisfaction, loyalty, product knowledge, and business competitiveness from the perspective of food-industry customers. The research uses a questionnaire to study the relationships between these factors and their influence on customer satisfaction. The results indicate that product knowledge directly affects customer expectations and product competitiveness, while customer loyalty influences product knowledge [5]. Additionally, customer expectation is influenced by customer satisfaction, and the rate of repeat purchases plays a significant role in these relationships. Furthermore, the study suggests that the correct pricing of a product, relative to its quality, does not impact other research factors. It also explores the influence of product knowledge on customer satisfaction and business competitiveness, with loyalty playing a significant role in this relationship. The research emphasizes the importance of product knowledge in enhancing competitiveness and customer expectation. It suggests that marketing tools, like product tastings, can increase customer product knowledge, leading to improved customer satisfaction and higher competitiveness. Additionally, the study highlights the impact of perceived product quality on competitiveness and emphasizes the need to inform customers about product details to enhance loyalty and competitiveness. The findings indicate that the relationship between customer satisfaction, loyalty, and competitiveness is complex, necessitating continuous efforts to improve customer knowledge and perceptions of products for long-term success.

Another study made in India indicates that the fast-food market is experiencing rapid growth due to changing habits and the widespread adoption of technology. Many brick-and-mortar stores are embracing digital platforms to cope with technological disruptions. Online retailers, empowered by aggregators, strive to synchronize product demand and supply through technological innovations [6]. Customer retention is a significant challenge in this competitive industry, making customer satisfaction a potential solution to retain customers in a market with numerous alternatives and low switching costs. This study explores factors influencing customer satisfaction in the tech-enabled Indian fast-food industry through a structured questionnaire. The findings reveal five key factors, namely "Quality," "Customer service," "Price," "Delivery," and "Time," with "Quality" being the most significant, assisting service marketers in devising effective online retailing strategies for fast food customers. The study also investigates the differences in customer satisfaction between online and brick-and-mortar fast-food experiences. Data from 260 respondents across various locations, age groups, and occupational profiles in India were analyzed using Principal Component Factor analysis. The research identified five significant factors affecting customer satisfaction in online fast-food consumption. "Quality" emerged as the most crucial factor, encompassing food and service quality. "Customer Service" was the next vital factor, emphasizing the importance of responsiveness in online service marketing. "Price," "Time," and "Delivery" were also found to significantly influence customer satisfaction, highlighting the importance of correctly pricing services and ensuring timely delivery and quality assurance. The study provides insights for fast-food businesses operating online to focus on key factors, like quality and customer service, to increase customer loyalty and market share.

One more final study made by Chen, Riantama, and Chen mentions that The COVID-19 pandemic has severely impacted fast-food businesses, leading to a sharp decline in sales. Customer satisfaction is crucial for sustainable enterprise development but understanding it in the fast-food industry has been challenging. Text reviews on social media now play a significant role in customers' purchasing decisions [7]. This study aims to explore differences in customer voices from social media reviews during the COVID-19 outbreak and proposes a new method to collect data while reducing interpersonal contact. The text mining scheme, which includes LASSO and decision trees, identifies essential factors for increasing customer satisfaction from unstructured online reviews. Experimental results can help companies adapt to similar epidemic situations in the future, promoting sustainable development. This study proposes a text mining scheme to discover customer satisfaction from social media comments, especially during the COVID-19 outbreak when collecting data without interpersonal contact is crucial. The scheme utilizes natural language processing techniques and data mining approaches, including LASSO and decision trees, to identify essential factors for customer satisfaction from unstructured online reviews. The results indicate that food quality, service quality, and promptness are the leading factors for fast-food customer satisfaction, both during the pandemic and in normal situations. Online customer reviews offer valuable insights, and this text mining approach can help managers make informed decisions and adapt to market changes. The study suggests that monitoring and managing online reviews are critical for businesses to survive and succeed in the current market, particularly in the hospitality industry. Further research can explore different feature selection methods and apply the text mining scheme to other industries heavily influenced by customer reviews in social media.

2.2 PREREQUISITE PROGRAMS

Prerequisite programs form the bedrock of safety and quality assurance in the food industry. These foundational initiatives, including hygiene, sanitation, and employee training, play a crucial role in establishing a reliable framework.

Yeboah focused on assessing the prerequisite programs related to food safety in hotels in Accra, with a specific focus on the Ga-West municipality [8]. The study also aimed to explore the influence of gender and educational background on food safety practices in ten selected hotels. Prerequisite programs were defined as crucial practices and conditions for ensuring food safety, essential before and during the implementation of an HACCP program. The research utilized a cross-sectional descriptive survey design, surveying 150 hotel staff through questionnaires to gather primary data. The findings indicated satisfactory attitudes and behaviours among hotel food-handlers in Ghana concerning food safety knowledge, personal hygiene, and cleaning procedures. However, areas such as food handling, serving, and supply/storage showed unsatisfactory practices. Men predominantly engaged in hotel food preparation (54%), and while no significant gender differences were observed in food safety knowledge and attitudes, individuals with higher educational backgrounds demonstrated better understanding of food safety and hygiene. The study underscores the importance of strengthening food safety education and training, particularly for those with lower levels of education, to enhance overall food safety systems in Ghanaian hotels. Continuous education and training for food handling personnel, especially those with lower educational backgrounds, are crucial to address potential risks in food handling, ensuring the health and safety of the public.

Another study realised by Suliman and Mustafa conducted between February 2018 and August 2020, focused on evaluating the implementation of Hazard Analysis and Critical Control Points (HACCP) prerequisite programs (PRPs) in poultry meat portioning operations (POs) in Khartoum State. Out of 33 POs, 12 were selected, with 6 each from traditional and modern systems, covering the three localities of Khartoum State. Data was gathered using a standardized observational checklist. Results revealed a significant difference in the location of operations between traditional and modern systems ($p=.049$). While good hygiene and manufacturing practices showed minor differences in favor of the modern sector, a significant distinction was noted in the separation between clean and dirty areas ($p=.010$). However, no significant differences were observed in facilities for cleaning, disinfecting hands, cleaning tools near workstations, hand-cleaning facilities at wash basins, foot dip stations, and toilet facilities between the two types of operations. The study concluded that the current implementation of HACCP PRPs in traditional poultry portioning operations did not meet international standards. Therefore, it is recommended that all food operations, including traditional systems, adhere to HACCP PRPs to ensure compliance with international standards. [9]

One more study aimed to assess the implementation of a management system based on Prerequisite Programs (PRPs) in a honey extraction establishment in Tandil, Buenos Aires, Argentina, during the honey harvest period (January to March) [10]. A checklist was developed to evaluate compliance with PRPs, covering 35 requirements divided into seven blocks. The overall compliance observed was 83%, with notable non-compliances mainly associated with written programs and records. The flow diagram and description of the honey extraction process were identified as incomplete. Despite these shortcomings, microbiological indicators for honey samples (n = 80) and food contact surfaces indicated acceptable performance of the implemented PRPs. Only one honey sample did not meet microbiological requirements according to Argentine legislation. Most food contact surfaces exhibited microbial loads below 10 CFU/cm². The study concludes that while the general level of PRP implementation was satisfactory and the final product met microbiological standards, there is a need for improvement in written documentation. The checklist used in this study is recommended as a valuable tool for identifying areas for improvement in food safety management systems, emphasizing the importance of a well-documented system for auditability.

2.3 HACCP

Hazard Analysis and Critical Control Point (HACCP) stands as a cornerstone in the food industry, offering a systematic and proactive approach to identify and mitigate potential hazards in the production process. By prioritizing preventive measures, HACCP ensures food safety, regulatory compliance, and consumer confidence. Its application not only guards against foodborne illnesses and contamination but also minimizes the risk of costly recalls and reputational damage. In essence, HACCP is a vital tool for enhancing public health, operational efficiency, and trust in the dynamic landscape of the food industry.

Food hygiene is a vital aspect of ensuring food safety throughout the entire process, from production to consumption, [11]. Inadequate food hygiene can result in foodborne illnesses and even fatalities, often stemming from improper storage, reheating, or cross-contamination. To mitigate these risks, regulatory bodies such as the FDA and USDA mandate the implementation of hazard analysis and critical control points (HACCP), a preventive approach in food production processes. One crucial element in guaranteeing food safety is comprehensive food hygiene training. This training focuses on preventing microbial contamination across the entire food chain. Reinforcing hygiene messages consistently in the workplace is essential to maintain appropriate food handling practices. Moreover, establishing a conducive physical and social environment that encourages proper food handling behaviours can contribute significantly to improved food hygiene standards. To ensure the effectiveness of food hygiene training, it is crucial to integrate training activities closely with the workplace and emphasize practical skills and assessment methods rather than relying solely on knowledge-based courses conducted separately.

Knowledge alone does not always translate into changes in food handling practices, underscoring the importance of implementing reliable evaluation techniques. Collecting baseline data is particularly significant as it provides a foundation for future comparisons and analysis of food hygiene practices. By prioritizing food hygiene and implementing HACCP, stakeholders in the food industry can enhance food safety, minimize the risk of foodborne illnesses, and ultimately safeguard the health and well-being of consumers.
Implementing effective food safety management systems, such as HACCP, is crucial for food companies in ensuring product quality and safety [12]. This study examines the financial impact of HACCP adoption and finds that it positively affects firm profitability, manufacturing productivity, asset turnover, and market growth. The findings highlight the importance of HACCP certification and provide practical implications for food companies in managing product safety. This study focuses on two aspects of HACCP certification in operations management, analysed through institutional theory. Firstly, it examines the short-term advantages of implementing HACCP and finds that it leads to immediate improvements in firm profitability, sales growth, asset turnover, and production costs reduction. Secondly, it explores the lag effect of HACCP implementation, suggesting that the benefits continue to manifest over time.

Another article conducted by Okpala and Korzeniowska emphasizes the importance of continuous improvement and implementation of hazard analysis and critical control points (HACCP) in the agro-food industry to ensure food hygiene quality safety. Quality management (QM), including elements like quality assurance (QA) and control, plays a vital role in enhancing agro-food product quality. The article discusses the assurance of food hygiene quality safety standards, HACCP implementation, QA control systems, and challenges faced in implementing food safety management systems. The combined efforts of HACCP and QA control points contribute to improved quality and safety levels, with a focus on sustaining and maintaining them. In the agro-food industry, maintaining moral values is essential for effective quality management (QM). Food processors must adhere to food quality safety standards, and various good practices aim to ensure high levels of food product hygiene and consumer safety. The combined efforts of HACCP and QA control points further enhance and sustain food quality and safety. ISO22000, Kosher, and Halal standards play significant roles, along with supplementary essentials like process control and personnel training. Research is needed to explore the alignment of good practices with Kosher and Halal standards. The COVID-19 pandemic has highlighted the importance of stringent food safety practices throughout the food supply chain. [13]

Farag examines the challenges and benefits of implementing Hazard Analysis and Critical Control Points (HACCP) in the production of three authentic Egyptian cheese varieties. The benefits of HACCP implementation include improved food safety, resource utilization, productivity, quality, security, inspection rates, and international trade cooperation. Egypt has a significant cheese consumption rate, and the review provides detailed graphics and tables outlining the manufacturing flow, critical control points, hazards, control limits, monitoring, and corrective measures for each cheese variety. Hazard Analysis and Critical Control Points (HACCP) plans have been effectively used to reduce food hazards and prevent foodborne illnesses in food manufacturing processes. This study focused on developing HACCP plans for three unique Egyptian cheeses: Domiati, Karish, and Ras. The plans considered factors such as raw material safety, equipment hygiene, and personnel practices. However, it is important to note that each HACCP plan is specific to the product and plant, and this generalized study provides a foundation but may not ensure the complete safety of the discussed cheeses without plant-specific adaptations. [14]

This one more study focuses on the global concern of foodborne diseases and the need for effective food safety and quality management. It evaluates traditional and modern approaches to improving the Hazard Analysis and Critical Control Points (HACCP) system, incorporating innovations like artificial intelligence, automation, and novel freezing techniques. The study identifies various factors contributing to food contamination, including chemical, biological, and physical contaminants, and emphasizes the importance of implementing measures such as ISO 22000, water quality management, and proper food labeling. By embracing these advancements, the food, agricultural, and pharmaceutical industries can enhance product safety and quality. HACCP is an approach that uses preventive methods to safeguard food and consumers from hazards, employing scientific techniques for food preparation and storage. Foodborne illnesses and deaths can be significantly reduced through proper HACCP application and other safety measures. The study highlights both traditional and modern approaches to improving HACCP, food safety management, and quality in the food and agricultural sectors. Modern technologies such as light technologies, novel freezing, artificial intelligence, and automation have been developed to facilitate the detection and control of contaminants in food safety management. [15]

2.4 THE CITRUS SECTOR

The citrus sector is a significant component of the global agricultural industry, focusing on the cultivation, production, and trade of citrus fruits. Citrus fruits are known for their refreshing taste, vibrant colors, and high nutritional content. Some of the most commonly cultivated citrus fruits include oranges, lemons, limes, grapefruits, and tangerines.

Badenhorst discusses in his article the microbiological safety of fresh fruit in South Africa, highlighting a lack of independent verification and dependence on producers, implementers of food safety systems, and auditors. Common pathogens like Salmonella, E. coli, and Listeria monocytogenes in fruit production environments are mentioned. Based on samples exported to Indonesia, the study found minimal contamination, emphasizing the need for consumer education on food safety, particularly for higher-risk fruit varieties like melons. It underscores the importance of robust food safety programs, including good agricultural practices and HACCP-based systems, for effective risk management during production and packing. Environmental microbiological testing is recommended for accurate risk assessment, with melons, avocados, and berries identified as higher-risk compared to citrus fruits. The study suggests periodic testing based on specific indicators in the production environment, highlighting the limited value of routine microbiological testing. While acknowledging the role of microbiological testing in produce safety programs, the study emphasizes that relying solely on testing is insufficient. It points out the lack of independent verification in South Africa, trusting food safety auditors and producers. Consumer education is crucial in mitigating microbiological risks, especially with high-risk products like melons. [16]

Under the project Support for Environmental Assessment and Management (SEAM), the initiative is executed by the Reduction of Milk Losses at Miser Company for Dairy and Food in Mansoura, Egypt, operating within the framework of the National Industrial Pollution Prevention Program (NIPPP). NIPPP's focus is on introducing and promoting cost-effective improvement measures with swift implementation by factories, emphasizing economic benefits, especially those with short pay-back periods. The approach includes waste minimization through enhanced quality control procedures at Edfina Company for Preserved Foods in Alexandria, Egypt, resulting in annual savings of LE 382,622 from interventions costing LE 65,200. Quality control training and the adoption of the Hazard Analysis and Critical Control Point (HACCP) system are expected to improve product quality and yield additional savings, with an anticipated LE 550,000 in the short term. The project's broader emphasis is on pollution prevention, targeting the reduction of production costs, losses of valuable raw materials, on-site treatment costs, energy and water costs, as well as solid and liquid waste volumes. Furthermore, the initiative aims to enhance overall operating efficiency, generate income through waste reuse and recycling, ensure safety for employees, comply with legislation, and improve the company's image. This comprehensive approach is designed for easy replication in sister factories to achieve similar savings and ensure legislative compliance while enhancing the company's image. [17]

This comprehensive study performed by Allam et al delves into the intricate landscape of food safety considerations faced by organic food producers and processors, emphasizing the critical role of applying Hazard Analysis and Critical Control Point (HACCP) principles and implementing good hygiene practices (GHP) to meet stringent food safety and process hygiene criteria. Conducted across five European countries (Croatia, Estonia, Germany, Italy, and Poland) with 316 producers and processors, the research evaluates their knowledge and experience with HACCP systems. The study identifies varied needs and expectations, emphasizing the necessity for assistance, particularly in document and record preparation, to address specific food safety issues and apply HACCP principles effectively. While basic knowledge of HACCP is prevalent among operators, a lack of understanding of its principles is noted. Additionally, the study employs a developed questionnaire to assess the food safety knowledge, needs, and expectations of organic stakeholders in these countries, extending the questionnaire's applicability to other nations for tailored strategies. Areas requiring assistance include hazard analysis, document preparation, and addressing labeling and claims concerns. Varied needs and expectations among primary producers and processors underscore the need for targeted training programs. The study's outcomes, alongside recognized limitations, pave the way for future research and the development of training programs to elevate food safety standards in the organic food production and processing sector. [18]

In conclusion, this literature review highlights the importance of food safety and customer satisfaction in the food industry and in the citrus sector. Implementing HACCP ensures quality management and safe food production. Prioritizing customer feedback and continuous improvement drives consumer trust and business success. By combining these strategies, food businesses can thrive in a competitive market and enhance overall public health.

3. METHODOLOGY

In outlining our methodology, we will focus on two key elements: prerequisite programs and Hazard Analysis and Critical Control Point (HACCP). Prerequisite programs establish fundamental conditions for food safety, laying the groundwork for the implementation of HACCP. We will provide definitions for each of the prerequisite programs, outlining their fundamental role in creating the basic conditions for food safety. Our approach will include also a brief historical overview of HACCP, highlighting its evolution and significance in ensuring food safety. We will then delve into the step-by-step implementation process of HACCP, emphasizing its systematic and preventive nature. This methodology aims to provide a concise yet comprehensive understanding of how these essential components work together to enhance food safety in our research context.

3.1 PREREQUISITE PROGRAMS

3.1.1 Definition

Prerequisite or preliminary programs are the prerequisites for maintaining an appropriate hygienic environment production chain [19]. These programs must be in place before the HACCP system is applied.

3.1.2 Prerequisite Programs

Prerequisite programs are generally divided into six sections:

a. Premises hygiene.

b. Transport and storage hygiene.

c. Equipment hygiene.

d. Personnel hygiene.

e. Sanitation and pest control.

f. Withdrawal and recall procedures.

3.1.2.1 Premises hygiene

The premises encompass every aspect of the facility and its immediate environment. This includes the exterior area, roads, drainage systems, the design and construction of the building, the path that products take through the facility, as well as the sanitary quality of water, steam, and ice. To ensure compliance, we scrutinize program documents which outline the specific measures that need to be put in place to guarantee optimal conditions are upheld. These documents specify the areas that require inspection, the tasks that need to be carried out, the individuals responsible, the frequency of inspections, and the records that need to be maintained. [20]

3.1.2.2 Transport and storage hygiene

Establishments must ensure that ingredients, packaging materials and other materials received from outside are transported, handled, and stored in a way that prevents conditions likely to lead to food contamination. This necessitates the implementation of a robust control and management program encompassing all elements outlined in this section, with careful maintenance of corresponding records. Raw materials, ingredients, and packaging materials acquired from external sources must be managed with a focus on sanitation. Establishments are required to enact proactive measures to forestall any contamination of these materials, whether through direct or indirect contact with potential contaminants. [20]

3.1.2.3 Equipment hygiene

Establishments are required to utilize equipment specifically designed for food production, and it must be installed and maintained in a manner that precludes conditions conducive to food contamination. Additionally, establishments must establish an effective program to oversee and manage all aspects outlined in this section. They must also diligently maintain the requisite records associated with these operations. [20]

3.1.2.4 Personal hygiene

Establishments must implement a comprehensive program for personnel management, encompassing all facets covered in this section. They must also initiate and uphold the pertinent records. The primary goal of this personnel program is to guarantee the adoption of sound food handling practices. This involves providing production personnel with the essential, ongoing training they require. [20]

3.1.2.5 Sanitation and pest control

Establishments are required to establish a robust written sanitation program that effectively governs and oversees all aspects outlined in this section. Additionally, they must generate and uphold the requisite records for compliance. [20]

a. Sanitation program

After each use, it is imperative to sanitize both equipment and facilities, and for larger pieces of equipment, disassembly for thorough cleaning and inspection is recommended. In cases where a closed-circuit cleaning system is employed, regular dismantling for inspection is essential. Before use, all equipment must be entirely free of residues and any foreign matter. This rigorous cleaning protocol ensures optimal safety and quality in food production.

b. Pest control program

Establishments must implement a satisfactory pest management program to control and manage all elements covered by this section and shall create and maintain the necessary records.

3.1.2.6 Withdrawal and recall procedures

The written withdrawal and recall program should outline the specific procedures that the company would follow in the event of a product recall. These procedures are designed to facilitate the swift and efficient removal of a particular food item from the market. They must be capable of being activated promptly at any given time. The ultimate goal of these recall procedures is to ensure that the recall process is executed as effectively and expeditiously as possible. [20]

3.2 HACCP

3.2.1 Definition

Hazard Analysis and Critical Control Points (HACCP) is a food safety management system that focuses on identifying and controlling potential hazards in the food production process. HACCP is also a recognized worldwide as the most effective managing system in which food safety is addressed through the analysis and control of biological (microbes & toxins), chemical, and physical hazards in food manufacturing, storage, distribution, and consumers consumption, [21]. Many foods regulatory agencies in several countries require mandatory application of specific HACCP programs for different foods, such as meat, juice, dairy products, infant formula, seafood, canned foods, etc. In addition to food industries, HACCP has been increasingly applied to other industries, including pharmaceuticals and cosmetics [15]. The goal of HACCP is to prevent, eliminate, or reduce hazards to an acceptable level before the food product reaches the consumer. HACCP is a preventive approach to food safety that emphasizes controlling the process rather than testing the final product.

3.2.2 History of HACCP

The HACCP concept was first developed in the 1960s by the U.S. National Aeronautics and Space Administration (NASA), working with Pillsbury, to ensure crumb- and pathogen-free food that had extensive shelf-life properties for space travel [22]. The Pillsbury company had a problem with making sure food was safe for astronauts in space. Their usual quality control methods didn't work. They teamed up with scientists from Natick Research Laboratories and NASA to create a new way to make sure the food was safe. Instead of destroying the food for testing, they focused on preventing problems and keeping careful records throughout the whole process. This new system became the basis for HACCP. In 1971, Pillsbury food company introduced the initial HACCP system at the Conference on Food Protection (CFP), a gathering sponsored by the Food and Drug Administration (FDA). This pivotal event led to the establishment of a training program, guided by Pillsbury Food company scientists. The program's objective was to educate FDA inspectors in the intricacies of inspecting canned foods, employing the innovative HACCP methodology. This marked a significant milestone as it represented the inaugural educational application of the HACCP framework. As the late 1980s approached, a number of food safety companies recognized the importance of HACCP and began offering comprehensive training programs for the development and implementation of HACCP plans. These initiatives, coupled with the dissemination of scientific literature on HACCP, played a pivotal role in establishing HACCP as the preeminent non-destructive food safety system. By 1998, a watershed moment occurred in the realm of food safety when it became mandatory for the majority of food businesses to attain a food safety certification adhering to HACCP guidelines. Some smaller enterprises, constrained by financial resources, were granted an exemption from this requirement. Subsequently, in 1993, the National Advisory Committee of Microbiological Criteria for Foods (NACMCF) undertook a significant revision of the HACCP guidance standard. [23]

This revision encompassed the incorporation of five preliminary steps to augment the original seven principles, imparting substantial refinement to the hazard analysis process. Presently, HACCP stands as a globally acclaimed and universally acknowledged system, serving as a linchpin in the ongoing effort to augment food safety across domestic and international food production.

3.2.3 Advantages of HACCP

a. The HACCP system places a stronger emphasis on prevention rather than analyzing the finished product.
b. It provides better tools to meet consumer demands for ensuring the sanitary quality of food products.
c. It can be applied throughout the entire food chain, from primary production to consumption, and its implementation should be guided by scientific evidence of risks to human health. This increases consumer trust in the industry.
d. The application of the HACCP system can assist regulatory authorities in their inspection tasks and promote international trade by strengthening confidence in food safety.
e. It enables more efficient resource utilization, leading to cost savings for the food industry and swift responses to food safety issues.
f. It enhances the level of accountability and control within the food industry.
g. It encourages significant employee involvement in understanding and ensuring food safety, providing them with an additional source of motivation for their work.

3.2.4 HACCP Plan

For the development of an HACCP system, the method established and internationally recommended by the HACCP working group of the Codex Alimentarius consists of twelve steps or phases. The first five are referred to as "preliminary steps," while the subsequent steps correspond to the seven "HACCP Principles." The sequence of these twelve steps must be followed, as it ensures the coherence and rigor of the implemented system. [24]

Step 1: Assemble the HACCP Team and Defining the Scope of Study:

The first crucial step in implementing Hazard Analysis the HACCP is to assemble a multidisciplinary team with specific expertise and relevant experience in the product under consideration. It is imperative that the execution of HACCP is not the sole responsibility of an isolated quality manager, but rather the collective effort of a diverse team, specifically dedicated to food safety. In cases where such an experienced team cannot be locally sourced, it is advisable to seek input from external experts such as microbiologists, consultants, or suppliers. [24]

Each member of the HACCP team bears responsibilities for the success of this initiative. Namely, every member must:

a. Contribute to the development of management rules and operational guidelines and commit to adhering to them.
b. Actively engage in group work.
c. Practice active consensus-building.
d. Embrace the methodology proposed by the facilitator.
e. Contribute to the team's efforts outside of meetings.

The competencies of the HACCP team members must cover four specific areas, namely:

a. The product.
b. The process.
c. The equipment.
d. The hazards.

<u>Scope of Study:</u>

Once the HACCP team has been established, one of their initial tasks is to define the scope of their study. It is essential to:

a. Limit the study to a specific product (or category of product) and/or a particular process.
b. Define the type(s) of hazards to be considered, which may include biological, chemical, physical, functional, regulatory, etc.
c. Identify the link in the food chain that is the focus of the study.

Ultimately, the HACCP system should encompass:

a. All of its products (or categories of products).

b. All of its processes.
c. All primary-level confidence hazards (biological, physical, and chemical).

Step 2: Describe the Product

The multidisciplinary team must provide a comprehensive description of the raw materials, ingredients, and finished products. This is essential for effectively assessing how product-related factors contribute to the origins of the studied hazards, as well as identifying the elements necessary for their control. For a raw material or ingredient, it is necessary to specify its nature, the percentage it represents in the finished product, the conditions of its preparation, any treatments it undergoes, the conditions of its storage, and its physico-chemical characteristics (pH, water activity, acidity, etc.). For a finished product, it is crucial to define its physico-chemical characteristics (formulation, volume, shape, structure, texture, pH, Brix, preservatives, etc.), as well as its packaging and labeling, storage and distribution conditions, shelf life, and any instructions regarding its use. [24]

Step 3: Identify the Intended Use and Consumers

This step complements the previous information and focuses on the normal or intended use that the consumer will make of the product. It is crucial to identify the profile of the end consumer and take into account vulnerable population groups such as infants and young children, pregnant women, the sick, and the elderly. [24]

Step 4: Construct Flow Diagram to Describe the Process

The production flow diagram should outline the sequence of all manufacturing steps from the arrival of the raw materials at the facility to the release of the finished product onto the market. This diagram should be created by the HACCP team. When applying the HACCP system to a specific operation, it is important to examine the steps both preceding and following the operation in question. It is possible to use the same operation diagram for multiple products when the transformation steps for these products are similar. [24]

Step 5: On-Site Confirmation of Flow Diagram

The HACCP team is responsible for confirming the production operations by comparing them to the established production flow diagram for each step and during operating hours. If necessary, they should make adjustments. The confirmation of the operation diagram should be conducted by one or more individuals with sufficient knowledge of the process of transformation operations. [24]

a. After these first five preliminary tasks have been completed, the following seven principles of HACCP has to be applied.

Step 6: Conduct a Hazard Analysis (Principle 1):

Once the production flow diagram has been completed and verified, the HACCP team proceeds to the next phase of the study: hazard analysis. The team must compile a list of all hazards that can reasonably be anticipated at each step.

A hazard is defined as: "A biological, chemical, or physical agent or condition of food with the potential to cause harm to health." (According to the Codex Alimentarius).

Hazard analysis must be conducted for all existing or new products (or categories). Indeed, any changes in raw materials, formulations, processing and preparation methods, packaging, distribution, and/or product use will necessitate a review of hazard analysis.

The HACCP team should then proceed with a risk analysis to determine which hazards are of such a nature that their elimination or reduction to acceptable levels is crucial for the safety of the food product. When conducting risk analysis, the following factors should be considered, to the extent possible:

a. Probability of a hazard occurring and the severity of its health consequences.
b. Qualitative and/or quantitative assessment of the presence of hazards.
c. Survival or proliferation of dangerous microorganisms.
d. Appearance or persistence of toxins, chemicals, or physical agents in the food.

Control measures applicable to each hazard must be considered to effectively manage these hazards. [24]

Step 7: Determine Critical Control Points (CCPs) (Principle 2)

A critical control point (CCPs) is defined as a step, or procedure where a health hazard can be prevented, eliminated, or reduced to an acceptable level through appropriate control measures. The identification of critical control points requires a logical approach. To facilitate this process, the Codex Alimentarius provides a decision tree (see appendix 1, figure 4). At each step, one must sequentially address each question in the specified order for any hazard for which occurrence or introduction should be considered, and for any identified control measure. The decision tree should be applied with flexibility and common sense, while maintaining an overview of the production process, in order to avoid unnecessary and costly duplication of CCPs as much as possible. [24]

Step 8: Establish critical limits for each CCP (Principle 3)

For each CCP, the multidisciplinary team must establish monitoring procedures to ensure the control of hazards at critical points. To achieve this, each control measure must lead to the definition of critical limits that differentiate acceptability from non-acceptability. These are expressed through observable or measurable parameters for which limit values and/or tolerances must be established. Parameters could include, for example, temperature, time, water content, residual chlorine content, pH, sterilization or pasteurization standards, etc. Critical limits can be derived from regulatory texts (such as freezing temperature) or from good manufacturing practice guidelines. However, it is essential to ensure their validity in relation to the control of hazards identified at the corresponding critical points. [24]

Step 9: Establish a Monitoring System for Each CCP (Principle 4)

Monitoring, as defined by the Codex Alimentarius, is "the act of conducting a planned sequence of observations or measurements to assess whether a CCP is under control." Manufacturers use monitoring to demonstrate that the HACCP plan is being implemented. It provides them with records to demonstrate that the manufacturing conditions comply with the HACCP plan. The monitoring procedures are used to determine if control measures are being implemented and to ensure that critical limits are not exceeded. [24]

The monitoring specifications for each CCP should provide information regarding:

What**:** The specific CCP to be monitored.

How**:** The method of monitoring.

When**:** The frequency of monitoring.

Who**:** The person responsible for monitoring.

Step 10: Establish Corrective Actions (Principle 5)

Corrective actions are predefined actions established by the multidisciplinary team that must be immediately implemented when the monitoring system reveals a deviation indicating the loss or absence of control at a CCP. This may involve sorting a batch of product, revising a procedure, water treatment, resterilization, repasteurization, or simply rejecting the product. Corrective actions should be documented in appropriate records, and the person responsible for their execution should be clearly identified. They should also specify the actions to be taken regarding products that were manufactured during the out-of-control period. [24]

Step 11: Establish Verification Procedures (Principle 6)

The verification procedure is defined as: "The application of methods, procedures, analyses, and other assessments, in addition to monitoring, to determine if there is compliance with the HACCP plan." Verification involves using audit techniques for the HACCP system and its associated documents, complemented by random sampling and analysis (chemical, physical, or microbiological) of intermediate or finished products, or intensified at certain critical points. Additionally, verification must be carried out systematically whenever a new situation arises. This includes cases such as a modification of the process, equipment, or an official standard, as well as the emergence of new scientific or epidemiological information concerning the product. [24]

Step 12: Establish Documentation and Record Keeping (Principle 7)

Effective and accurate record-keeping is crucial for the implementation of the HACCP system. HACCP procedures relating to each step must be documented, and these documents should be compiled into a manual. Records may include, for example:

a. Ingredients
b. Product safety
c. Processing
d. Packaging
e. Storage and distribution
f. Records of deviations
g. Changes made to the HACCP system.

The success of implementing an appropriate HACCP program depends on the appointed leaders' ability to discern deviations and their promptness in responding to these deviations. [24]

4. APPLICATION

4.1 PRESENTATION OF THE COPAG COOPERATIVE AND ITS BUSINESS SECTOR.

4.1.1 Birth of the COPAG Agricultural Cooperative

The COPAG -TAROUDANT cooperative "Coopérative des Primeurs et d'Agrumes de Taroudant", was created by the general assembly of May 07, 1987, taking advantage of the Moroccan government's policy of liberalizing exports, 39 farmers in the Taroudant region felt the need and necessity to form a cooperative in order to control their agricultural products from production to a more advanced stage of distribution. Thus, was born the "COPAG" cooperative, whose share capital was set at 4 600 000dhs divided into 4600 shares of 1000 DH each. In figure 1 we can see the logo of the company.

Figure 4.1: COPAG.

4.1.1.1 Field of activity

Plant Production:

a. 6,400 ha of citrus,

b. 500 ha of Primeurs,

c. 1,000 ha of bananas.

Animal Production

a. Holstein herd: 85,000 head, including 60,000 dairy cows.

Forage area:

a. 9,500 ha of forage maize,

b. 1,500 ha of alfalfa,
c. 500 ha of forage sorghum.

4.1.1.2 Cooperative products

a. Milk: UHT jaouda (whole, semi-skimmed, skimmed), fresh pasteurized milk, linea (for diabetics), growth (for small children) ...
b. Fermented milk: plain raib, leben...
c. Yoghurt: perly, ghilal, cremy, muscly, le nature, linea, bnine...
d. Milky juices: soif, raibi jaouda, ghani (for small children), mixy...
e. Nectars: Nectary, mon jus...
f. Desserts: gourmand, flan jaouda...

4.2 PROJECT REALIZATION METHODOLOGY

4.2.1 Project Presentation

This work aim is to contribute to the implementation of the HACCP system in the fruit nectar production workshop within the company COPAG cooperative. This project was chosen for several reasons:

a. The importance of this system in guaranteeing safe, wholesome food,
b. To comply with the requirements of European legislation on food hygiene legislation,
c. To meet the needs of the cooperative, which is currently preparing to implement ISO 22000 standard, which requires the implementation of the HACCP system as a prerequisite.

4.2.2 Process Followed

To carry out this project, we divided the work into two main stages:

a. Assessment of the (PRPs) that form the basis for setting up the HACCP system, in order to deduce the cooperative's situation in relation to the requirements of GHP as defined by the Codex Alimentarius Commission and the by the Food Safety Enhancement Program (FSEP),
b. Application of the 12 steps of the HACCP approach to the fruit nectars.

4.2.2.1 Evaluation of prerequisite programs

Before putting the HACCP system in place at your facility, it's important to establish basic hygiene practices. These practices serve as a foundation, allowing the HACCP team to focus on specific food safety risks related to orange nectar production. This way, we don't have to spend time addressing broader environmental hazards. To make sure we're following the right hygiene standards, we first have to reviewed existing programs. We used a checklist based on Codex Alimentarius standards to guide us.

4.2.2.2 Application of the HACCP plan

To assist in the implementation of the HACCP plan, a collection and analysis of the company's data were conducted, based on the application of the twelve steps of the HACCP approach as already explained in the methodology section. The study results will be presented in tabular form.

4.3 CONTRIBUTION TO THE IMPLEMENTATION OF THE HACCP SYSTEM WITHIN THE ORANGE NECTAR PRODUCTION UNIT

4.3.1 Evaluation of Prerequisite Programs

4.3.1.1 Compliance analysis

In the figure 2, we highlight the six essential sections of prerequisite programs.

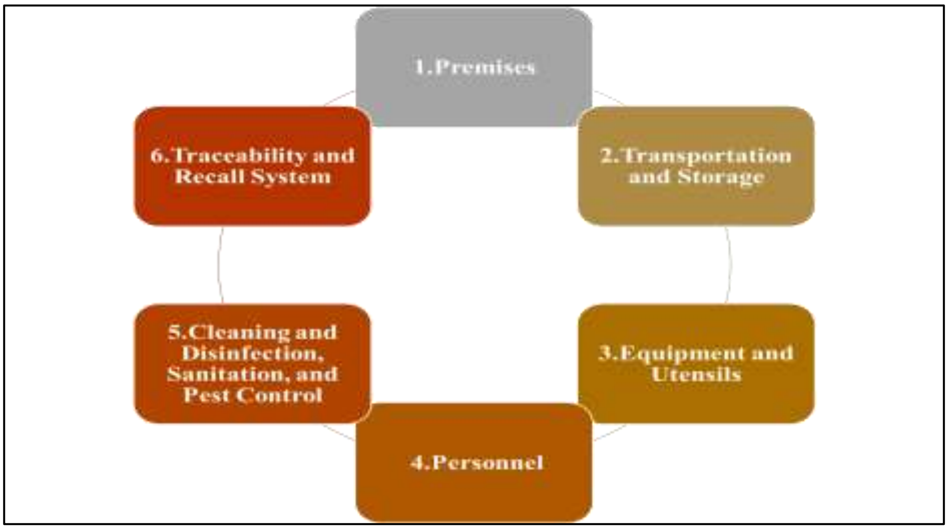

Figure 4.2: The Six Critical Categories of this Framework.

During the assessment of prerequisite programs, a thorough inspection and on-site examination of the facility were conducted. This allowed for an immediate and balanced understanding of the operational realities within the fruit nectar production unit. To accomplish this, an evaluation framework rooted in Codex Alimentarius requirements, coupled with the Food Safety Improvement Program , was utilized and customized to align with the specific activities of the unit under scrutiny. Each of these categories was further dissected into a set of assessment criteria (Refer to appendix A: Table A.1). Responses to the checklist were categorized as 'Satisfactory (S)', 'Partially Satisfactory (PS)', and 'Not Satisfactory (NS)'. This evaluation was carried out through daily tours spanning three weeks, covering the production zones for juice concentrate, evaporation, pasteurization, finished product storage, as well as the changing rooms and sanitary facilities.

4.3.1.2 Results

The information gathered from the evaluation grid will be translated into numerical data and subsequently transformed into a visual representation.

i. Calculation of the satisfaction percentage for each category and graphical representation

Once the evaluation grid was filled out, the degree of compliance with the requirements of general hygiene principles for each prerequisite program was quantified. This standard outlines the method for calculating the satisfaction percentage using the following formula.

$$\text{Category satisfaction} = \frac{((NES * 1) + (NEPS * 0,5) + (NENS * 0))\times 100 = category\ score}{(NTCE * 1) = Maximum\ category\ Score} \qquad (4.1)$$

The designations of the terms in the formula and the grading system based on the degree of satisfaction for each category are illustrated in the table 1:

Table 4.1: The Grading System Assigned to the Requirements of the Prerequisite Programs (PRP).

Abbreviations	Designations	Assigned Score
NES	The number of satisfactory responses	1
NEPS	The number of partially satisfactory responses	0.5
NENS	The number of non-satisfactory responses	0
NTCE	The total number of checklist elements	1

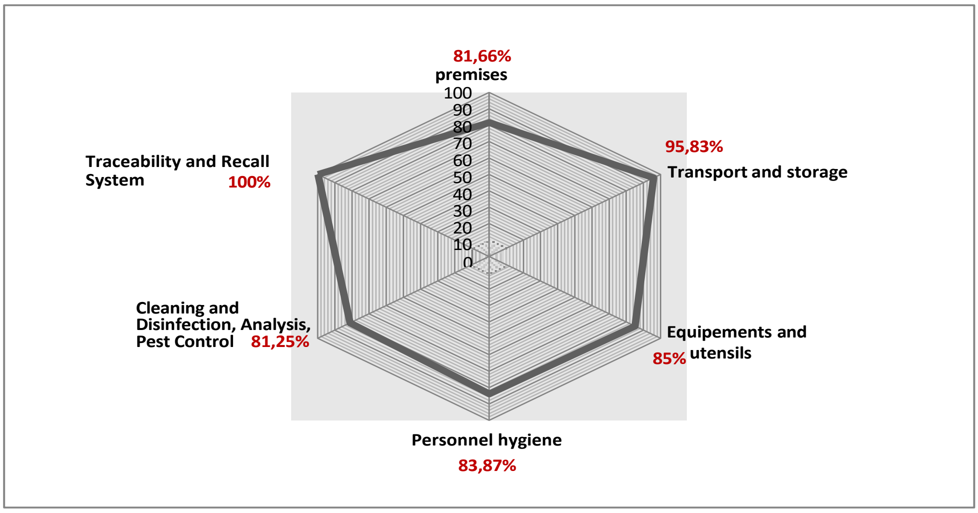

Figure 4.3: A Radar Chart Depicting the Results of the PRP Diagnostic Assessment.

The results of the calculation of satisfaction percentages for each section or category are presented in the table 2 and in the figure 3 as a radar chart.

Table 4.2: The Results of the Calculation of Satisfaction Percentages.

Category Name	NES	NEPS	NENS	Total Checklist Elements (NTCE)	Satisfaction (%)	Target (%)	Deviation (%)
Premises	23	3	4	30	**81.66**	**100**	**18.34**
Transport and Storage	11	1	0	12	**95.83**	**100**	**4.17**
Equipment and Utensils	8	1	1	10	**85**	**100**	**15**
Personnel Hygiene	24	4	3	31	**83.87**	**100**	**16.13**
Cleaning and Disinfection, Analysis, Pest Control	6	1	1	8	**81.25**	**100**	**18.75**
Traceability and Recall System	13	0	0	13	**100**	**100**	**0**

ii. The Discussion of the Obtained Results

Based on the radar chart in the figure 3, the bold line represents the satisfaction percentage of the fruit nectar production unit within the Copag cooperative in relation to the PRP requirements. The results indicate that the 6th category fully complies with the requirements at 100%, while the other categories exhibit varying levels of non-compliance and deviations:

a. 18.34% for the first category: Premises,

b. 4.17% for the second category: Transport and Storage,

c. 15% for the third category: Equipment and Utensils,

d. 16.13% for the fourth category: Personnel Hygiene,

e. 18.75% for the fifth category: Cleaning and Disinfection, Analysis, Pest Control.

iii. Action Plan: Corrective Actions for Improving PRPs (Prerequisite Programs)

In order to address the non-conformities identified in the prerequisite programs, we have proposed corrective actions, some of which are currently being implemented. We are waiting to apply the remaining actions to fully correct the detected deficiencies possible.

a. Premises

The non-conformities identified in this section relate to physical separation within different parts of the workshop, as well as walls, ceilings, floors, lighting, doors, ventilation, and sanitary facilities (see Table 3).

Table 4.3: Corrective Actions Proposed for Improving Preliminary Programs at the Facility Level.

Non-conformities	Action Plan
Physical Separation	
The orange reception area is directly connected to the juice processing line, specifically to the section for unloading, sorting, and initial washing of the oranges. Electric pallet trucks transporting the crates of oranges enter directly into the juice processing area.	Maintain physical separation between the orange reception area and the juice crushing line. Pallet trucks should not extend beyond the orange reception area. It must be distinctively separated from the juice processing line.
Walls and Ceilings	
There are openings between the walls and the ceiling for the entry of water and steam pipes into the concentrated juice production area, as well as in the areas of juice clarification and evaporation.	Close these openings, which can allow insects and birds to enter and potentially serve as a source of contamination. Alternatively, install a mesh and a mosquito net that prevents the passage of birds and insects.

Table 4.3: Corrective Actions Proposed for Improving Preliminary Programs at the Facility Level "Table Continued".

Floor	
The floor in the juice extraction area is not entirely smooth and has cracks, making it difficult to clean.	Maintain the flooring in this area to facilitate cleaning and prevent water from accumulating in these cracks.
Lighting	
The lighting intensity in the juice extraction unit is somewhat low.	Add additional, higher-intensity bulbs to ensure more favorable conditions for processing.
Doors	
The door to the juice clarification area is constantly open to the outside of the unit, which leads to the entry of dust and could facilitate the entrance of birds, insects, and pests.	Raise awareness among the staff about the importance of closing the door after each entry and exit. Ideally, we recommend replacing this door with an automatic closing one to prevent this issue.
Ventilation	
Presence of some dust deposits in high and hard-to-reach areas for cleaning. Accumulation of unpleasant odors.	Provide well-functioning air extractors to prevent the accumulation of dust and bad odors.
Sanitary Facilities	
The presence of toilets within the juice extraction area. Lack of hot water at the handwashing stations to ensure proper personal hygiene.	Replace these toilets with others that will be located away from this area to avoid any possible contamination. Alternatively, limit the use to only the toilets located in the locker room, as they are more than sufficient (26 toilets). Additionally, provide washbasins within the unit to replace those in the toilets. Supply the sink faucets with hot water to ensure satisfactory personal hygiene for the staff.

b. Transportation and Storage

In this section, the inspection of the transportation means revealed that only the trucks used for waste transport require maintenance to meet the requirements of good transportation practices. The diagnostic result is presented in Table 4.

Table 4.4: Corrective Action Proposed for Improving Preliminary Programs at the Transportation Level.

Non-conformities	Action Plan
Some trucks specifically used for the disposal of orange waste after crushing are in poor condition, leading to leakage of remaining juice in the factory during transportation. This situation promotes bacterial proliferation and attracts insects.	Replace these trucks with others that are better suited for transporting this type of waste or maintain and thoroughly clean them if replacement is not readily feasible.

c. Equipment and Utensils

The inspection of the equipment and utensils section has revealed a non-compliance regarding the cleaning of the equipment, as presented in Table 5.

Table 4.5: Proposed Corrective Action for the Improvement of Prerequisite Programs at the Equipment and Utensils.

Non-conformities	Action Plan
Some equipment cannot be disassembled during cleaning, which reduces the effectiveness of the cleaning process and makes certain parts inaccessible for thorough cleaning.	Adapt the cleaning techniques to this specific equipment by using suitable cleaning tools that can reach the hard-to-clean areas. Additionally, a cleaning schedule for the equipment should be posted in the production area.

d. Personnel Hygiene

In this section, non-compliances were identified related to sanitary practices, staff behavior, work attire, and hygiene training. The diagnostic results are presented in Table 6.

Table 4.6: Corrective Actions Proposed to Improve Prerequisite Programmes in Terms of Staff Hygiene.

Non-conformities	Action Plan
Staff Behavior	
Some employees do not organize their lockers in a way that ensures separation between personal belongings and work clothes.	Raise awareness and provide training to the staff on the importance of separating work clothes from personal belongings.
Workwear	
Interns are taking their lab coats home outside of the factory.	It should be prohibited for interns to take their lab coats home. Work clothes should be used exclusively and solely within the establishment.

Table 4.6: Corrective Actions Proposed to Improve Prerequisite Programmes in Terms of Staff Hygiene "Table Continued".

Hygiene Training	
The workers are not properly trained on GHP.	Raise awareness and provide regular and ongoing training to the staff on good manufacturing practises. Establish and enforce an internal regulation regarding the use of premises such as locker rooms and toilets. It should be posted and known by all staff members.

e. Cleaning and Disinfection, Sanitation, and Pest Control

In this section, the identified non-conformity relates to the absence of on-site microbiological sampling to assess the cleanliness of surfaces and production materials (see table 7).

Table 4.7: Corrective Action Proposed to Improve Prerequisite Programmes For Cleaning and Disinfection, Sanitation, and Pest Control.

Non-conformities	Action plan
Absence of microbiological sampling on site to monitor the cleanliness of surfaces and production materials.	The effectiveness of the sanitation and cleaning program must be monitored through on-site microbiological sampling and sensory inspection of the areas and equipment.

4.3.1.3 Conclusion

The evaluation of the six sections of the prerequisite programs implemented in the fruit nectar production unit has allowed us to deduce an approximation of the unit's status in relation to the hygiene requirements and good production practices of the Codex Alimentarius and the (PASA). An action plan has been developed to address the non-conformities. The cooperative has already taken steps to implement these actions, especially in the following areas:

i. Infrastructure: closing openings responsible for bird entry, closing toilets directly open to the production line.

ii. Personnel training: training sessions have been conducted, covering the following aspects: personal hygiene and cleaning/disinfection program.

4.3.2 Contribution to the Implementation of The HACCP Plan

This section outlines the implementation of the HACCP approach within the fruit nectar production unit, with a specific emphasis on orange nectar (Nectary). The study was dedicated to identifying potential microbiological, chemical, and physical hazards that could affect the product throughout its journey, from raw material processing to final shipment. To achieve this, a thorough adherence to the 12 steps of the HACCP approach was maintained.

Step 1: Definition of the scope of study and formation of the HACCP team:

<u>Scope of Study:</u>

Application of the HACCP method to the orange nectar production line, from the reception of raw materials to the packaging of the finished product, while considering risks of biological, chemical, and physical nature.

<u>HACCP Team:</u>

The HACCP team must have a thorough understanding of the product, processes, equipment, and risks related to the safety of the company's products. In this context, the team within the COPAG cooperative consists of several members, each of whom is responsible for executing tasks within their area of expertise under the supervision of the Quality Management Director. The director validates all actions deemed necessary to be taken.

Step 2: Product Description:

Step 2 involves crafting a detailed product description by compiling all available information provided. This encompasses specifics about raw materials, composition, applied thermal treatments, packaging, and any other pertinent details crucial for accurate product identification (refer to Table 8).

Table 4.8: Product Description Sheet for "Nectary".

Commercial Name	Nectary orange.
Product Definition:	A fermentable but non-fermented product obtained by adding water, sugar, pulp, and flavorings to orange juice obtained from concentrate.
Production Origin:	Production takes place at the fruit nectar production unit within the Copag cooperative located in Taroudant.
Raw Material:	Various varieties of oranges: Maroc late, Clémentine, Nour, Navel, Salustania, and Sanguine...

Table 4.8: Product Description Sheet for "Nectary" "Table Continued".

Composition of the Finished Product:	Up to 60% juice, 6% sugar, pulp, flavors, and water**.**
Thermal Treatments	Evaporation, Pasteurization: 89 to 94°C / 18s.
Packing and packaging	Size: ¼ and ½ Capacity: 200g and 450g, Volume: 250 ml, 500 ml, Material: White food-grade cardboard on the inside, waterproof, suitable for room temperature, refrigeration, and freezing conditions of the finished product, Paper Type: Recyclable, Disposal: Disposable.
Identification	Quality of Marking: Clear and legible, using an inkjet printer that provides the following information: Lot Identification: Production Date: day/month/year, Production Time, Expiration Date: day/month/year, Filling Machine Code: for example (B). Label Information: Product Nature: Fresh orange juice nectar, Composition: Up to 60% juice, water, 6% sugar, pulp, and flavoring. Nutritional Value: per 100g, Energy Value: 54Kcal Proteins: 0.4g Carbohydrates: 13g Fats: 0g Vitamin C: 28mg. Net Weight: 200g or 450g, Storage Temperature: <6°C.

Table 4.8: Product Description Sheet for "Nectary" "Table Continued".

Storage Conditions:	**Store at room temperature, away from heat. After opening, store in the refrigerator at (4°C ± 2) and consume within 5 days.**
Use By Date	30 days
Physicochemical characteristics	Chemical Properties: pH: 3.80 - 3.90 Brix: 11.7 ±2 Sugar: 6% Physical Properties: Net Weight: 200g and 450g
Microbiological Characteristics	Stability Test: This product has been found to be stable after being subjected to incubation at temperatures of 10°C, 20°C, and 30°C for a period of 15 days.
Organoleptic Characteristics	Color: Orange, characteristic of oranges. Taste: Slightly acidic, sweet, free from any sharpness. Texture: Liquid, with suspended pulp giving it a characteristic appearance of natural juice. Odor: Characteristic of oranges, without any abnormal odor.

Step 3: Determine Intended Use

The objective of this step is to present the expected use of the product once its description has been provided.

Table 4.9: The Description of the Intended Use of "Nectary" Orange Along With its Consumption Mode.

Product name	**Nectary orange**
Destination	Human consumption
Target consumer	This is a product intended for every consumer: Non-diabetic (as it is a sweetened beverage with 6% sugar added). Those without any issues related to acidic foods. Except for infants (as their digestive system may not be sufficiently robust).

Table 4.9: The Description of the Intended Use of "Nectary" Orange Along With its Consumption Mode “Table Continued”.

Consumption mode	Meant to be consumed while fresh. It is advisable to store it at a temperature not exceeding 6°C, especially after opening the packaging, in order to preserve its organoleptic and nutritional characteristics.
Forbidden use	In the case of reaching the expiration date.

Step 4: Establish a Production Flowchart:

At this stage, we have developed the production flowchart for orange nectar, detailing the entire production process from the reception of raw materials to the final product (appendix, Figures 5 and 6). This flowchart will be further detailed in the next step of the HACCP plan.

Step 5: On-Site Confirmation of the Production Flowchart:

The on-site verification of the production flowchart, developed by the HACCP team, aims to ensure that this flowchart, which will be used to conduct the hazard analysis, accurately represents the considered production process. The verification was conducted by constantly comparing the course of transformation operations with the established operations flowchart. The confirmation of the operations flowchart was carried out by HACCP team members possessing sufficient knowledge of the course of transformation operations. Below, the different stages of the flowchart and the progression of operations leading to the production of orange nectar will be described.

a. Preparation of Orange Concentrate

Storage in Cold Rooms: After arriving at the factory, the oranges, assumed to be harvested at the right level of ripeness, are typically stored for a few days under conditions that minimize spoilage (adequate refrigeration). They can be stored for 5 to 6 days.

Reception: The oranges received at the fruit nectar production unit mostly consist of discrepancies (such as variations in size, color, etc.) from oranges intended for export. These oranges come from the packaging unit owned by the cooperative, which is located within the same factory. They have already undergone a series of checks to determine the pesticide levels, any rot, mold, or other defects. Only those that are healthy and ripe are accepted and immediately placed into the processing line.

Washing and Sorting: The accepted oranges are unloaded and washed with chlorinated water, then rinsed with dechlorinated water to remove any sources of contamination, including yeasts, molds, mud, and small leaves. Sorting is done simultaneously with washing by the workers who remove damaged and/or non-standard oranges, as well as any remaining leaves or impurities. After this step we have two scenarios:

a. Either the oranges are of small caliber, meaning the maximum equatorial section diameter of the fruit is small according to the marketing standards applicable to oranges destined for packaging and export ($d < 53$ mm). In this case, the next step will be brushing followed by washing.
b. Or the oranges are of large caliber. In this case, before proceeding to the brushing step, a rasping is first done to puncture the secretory cells of the epidermis for the extraction of essential oils. This is because the standards require an essential oil content of less than 0.02% by volume of the final juice. The oils are collected in circulating water, then separated by settling.

Brushing and Washing: In this stage, the oranges are rinsed using water sprays that remove any remaining raspings. They pass through a device that provides vibration and rotation to the oranges to enhance and optimize the washing process. At the exit of this device, the oranges pass under a brush to remove any remaining raspings.

Juice Extraction: After brushing, the oranges are conveyed to the extractor using an elevator. Initially, the oranges pass over a knife that separates them in half. Then, each half is placed between two extraction discs, which, through a double rotating motion in opposite directions, allow the pressing of the carpels without risking the bursting of the seeds containing bitter compounds. Control of the pressure and speed of movement of the extraction discs adapts to the thickness of the peel. At the end of the pressing, the peels are conveyed using a spiral that revolves around a central axis along a conduit for the evacuation of residues outside the unit.

Refinement: Refinement involves the simple sieving of raw juice at the exit of the extractor using a sieve that separates the seeds and pulp from the juice. The separated pulp and seeds are combined with the epidermis that was removed during the extraction stage and transported by trucks designated for waste disposal.

Cooling and Storage: The juice, after refinement, is pumped to a plate heat exchanger for cooling. The plate heat exchanger uses both conductive and convective modes through the wall separating the juice and cold water. This lowers the juice temperature to around 4 to 6 °C. After cooling, the juice is stored in suitable storage tanks for further processing.

Clarification: Clarification involves destabilizing the cloudiness in the juice caused by suspended particles: larger elements consisting of cellular debris or clusters of cells, pulp, and seeds. Clarification is achieved through a mechanism combining two effects: centrifugation (which serves to refine the content of fine pulp in the juice, standardize the quality, and regulate the excess essential oil content in the juice) and settling. The result is a juice containing only fine and calibrated pulp, with a controlled percentage.

Evaporation: The juice passes through evaporators to extract water and obtain a high-quality orange juice concentrate. The evaporator operates under vacuum conditions, which are maintained through a barometric condenser connected to the evaporator of the final effect, and a vacuum pump. Evaporation aims to remove the maximum amount of water from the juice, leading to an increase in the Brix level up to 65% of dry matter and the production of concentrated juice. This operation is carried out by a continuous system in which the product is subjected to three different temperature and pressure effects. The temperatures in the evaporator system are as follows: 1st effect: 90°C, 2nd effect 70°C, 3rd effect 60°C.

Each effect essentially consists of:

Vertical tubular bundles,

A steam/liquid separation chamber (effect),

A circulation pumps.

Cooling and Storage: The concentrate from the evaporator is rapidly cooled to a temperature between 5 and 10°C. It will then either proceed directly to subsequent processing steps, or it will be frozen and stored in large bulk storage tanks, allowing it to be preserved for up to 2 years. These tanks are placed in a cold room at a temperature of (-18°C), and the site is commonly referred to as a "tank farm". Storing concentrate in tank farms is the standard practice in the industry, as well as bulk transportation and distribution in the markets.

b. Preparation of 'Nectary' Orange Nectar from Orange Concentrate:

The process of preparing nectar begins with:

Water Supply and Mixture Preparation:

a. Supply water to the tank designated for mixing.
b. Prepare the mixture: This involves adding the basic ingredients according to the specific internal formulation for orange nectar at the cooperative. The added ingredients are:

i. Orange concentrate,
ii. Pulp: This is imported pulp that has undergone specific treatments to allow for better preservation and give the nectar the characteristic appearance and texture of a natural product.
iii. In some cases, pH correctors are added. This can be citric acid if the juice has a pH higher than 3.85, or sodium bicarbonate if the pH is very acidic (below 3.7).

Addition of Syrup: The syrup added to the previous mixture is prepared by mixing water and sugar to achieve a sugar concentration of approximately 6% in the final product. The addition of sugar to reach the required levels for preservation must consider the amount of sugar already presents in the juice. It is important to reach the minimum required level to prevent bacterial growth.

Pasteurization: Pasteurization is the heat treatment process used to deactivate and inhibit natural enzymes and microorganisms that may exist in the product (Nectary). This thermal treatment also extends the product's shelf life. Pasteurization occurs in three stages:

a. Heating the nectar to 40°C in tubular heat exchangers, followed by a deaeration process in a vacuum pipeline system. This operation aims to prevent the production of foam,

but more importantly, to prevent the oxidation of ascorbic acid (Vitamin C) and compounds responsible for the nectar's flavor.

b. Raising the temperature of the nectar to 65°C in preparation for pasteurization.
c. Pasteurization of the nectar at a temperature ranging from (89 to 94°C/ 18s) in a tubular system allowing for thermal exchange between hot water (89 to 94°C) and the nectar heated to 65°C.

Cooling: The nectar is then immediately cooled (between 4 to 6°C) through tubular heat exchangers to preserve its taste and nutritional qualities.

Storage and Flavoring: Once cooled, the nectar is pumped into storage tanks with a capacity of 20 to 30 tons. At this stage, flavors are added because it has been observed that these flavors can be destroyed due to pasteurization if they were added in-line before or during the pasteurization process.

Packaging: Empty individual containers for the finished product move along a conveyor belt. The filling of these containers with pasteurized and cooled nectar is done using a dosing head for swift filling.

After filling, the packaging is sealed tightly to prevent the entry of air and any potential sources of contamination. It is then marked using an inkjet printer to identify the batch number which specifies the production date, time, and expiration date.

Storage and Shipping: The finished products are palletized and stored at a temperature not exceeding 6°C to preserve their quality until they are ready for shipment.

Step 6: Identify and Analyze Hazards (Principle 1):

In the application of our HACCP plan for hazard identification and analysis, we followed the following approach:

a. Hazard Identification: This step sets the foundation for the entire study. It is therefore crucial to give it special attention. Significant effort was dedicated to this part of the study. We focused primarily on biologically, chemically, and physically reasonably foreseeable hazards. Allergenic hazards were not detected. The study conducted did not only limit itself to identifying these hazards but also aimed to determine their origins and causes for each stage of the process. This was done to cover as many scenarios as possible and conduct the study in the most comprehensive way.
b. Evaluation of each hazard along the entire orange nectar production chain: This was done following the methodology described below. Initially, hazards were considered of three essential types:

Biological: contamination (introduction or presence of hazard), proliferation (increase of hazard), persistence (survival or non-elimination of hazard),

Chemical,

Physical. During the hazard analysis, we used the (Material, Environment, Equipment, Method, and Manpower) rule to determine their causes.

c. Estimation of hazard criticality based on three parameters:

The severity from a consumer health perspective,

The frequency of hazard occurrence,

Its detectability.

Table 10 presents the scoring system that was assigned for hazard assessment: [The specific table data may be included for further details].

Table 4.10: Rating System Used to Assess Hazards.

Scale	Gravity: G	Frequency: F	Detectability: D
1	Non-existent	Low Visible	To the naked eye
2	Inconvenience	Medium	Through simple examination
3	Out of specification	Frequent	Through detailed examination
4	Dangerous	Very frequent	Through analysis
5	Fatal	All the time	Undetectable

The criticality was calculated as follows:

$$\text{Criticality index } (\boldsymbol{C}) = \text{Gravity G} * \text{Frequency F} * \text{Detectability (D)} \qquad (4,2)$$

NB :

Maximum = 125 points.

Minimum = 1 point.

The company has set a threshold of 27 points for a hazard to be considered.

At each stage of the transformation process, an analysis of potential biological, chemical, and physical hazards was carried out. In Table 11 we have limited ourselves to those stages of the manufacturing diagram which were deemed essential to control and where the hazard presents a high level of risk priority.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar.

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Receipt of oranges	Biological	Contamination by pathogenic microorganisms (Staphylococcus aureus, fecal coliforms). Proliferation of yeasts and molds (Aspergillus, Fusarium, Penicillium, etc.).	Cross-contamination due to: insects, birds, rodents, etc.	4	1	3	12	Ensure proper handling conditions for oranges.
			Lack of personal hygiene and inappropriate clothing of the staff	4	2	2	12	Raise awareness and train the workers on GMP (Good Manufacturing Practices).
			Excessive waiting time at room temperature and at a relative humidity conducive to their multiplication.	4	2	3	24	Proceed with the rapid storage of oranges at a temperature ≤ 20°C and at a relative humidity ≤ 70% to prevent the development of yeasts and molds.
	Chemical	Residues of phytosanitary products (pesticides, insecticides, etc.).	Non-compliance with good agricultural practices (GAP) in "phytosanitary treatment" (Failure to adhere to the proper quantity of pesticides or insecticides to be sprayed).	4	2	4	32	Raise awareness and provide training for farmers on Good Agricultural Practices (GAP).
								Establish a set of specifications with suppliers.
								Conduct residue analysis of pesticides in an external and competent laboratory.
	Physical	Wood, Stone, Leaves, Thread, Impurities, Glass and metal debris, Personal belongings.	Lack of control over foreign bodies during the packing of oranges at the suppliers.	3	3	2	18	Adhere to the requirements outlined in the specifications
								Select suppliers carefully.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Storage of oranges in cold storage rooms.	**Biological**	Proliferation and development of pathogenic germs (Yersinia, etc.) and spoilage microorganisms (yeasts and molds).	Non-compliance with the storage temperature of oranges.	4	1	4	16	Maintain the cold chain.
			Break in the cold chain.					Ensure the reliability of the continuous temperature monitoring system for storage.
			Lack of hygiene in the cold storage rooms.					Cleaning and disinfection of cold storage rooms should be carried out at regular intervals.
First sorting of the oranges.	**Biological**	Contamination by pathogenic microorganisms (Staphylococcus aureus) and by total coliforms and fecal coliforms (Escherichia Coli).	Non-compliance with hygiene rules by employees	3	2	4	24	Raise awareness and provide training for the staff on GMP
			Inadequate cleaning of the sorting mat.	3	1	3	9	Implement the cleaning and disinfection program for the equipment.
	Chemical	Contamination by residues from cleaning products.	Inadequate rinsing of the conveyor belt.	3	1	3	9	Adhere to the cleaning and disinfection program for the equipment.
		Contamination by grease, lubricants, and maintenance products.	Use of non-food-grade maintenance products such as grease and lubricants.	3	1	3	9	Use food-grade maintenance products.
	Physical	Wood, stones, leaves, thread, impurities, metals, personal objects, etc.	Lack of vigilance during the sorting of oranges.	3	1	3	9	Raise awareness among workers about the importance of this operation in ensuring a healthy and compliant product.
								Implement strict instructions to ensure effective sorting.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar “Table Continued”.

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
First washing of the oranges.	**Biological**	Contamination by bacteria: (total and fecal coliforms: E.coli), Salmonella, Staphylococcus aureus.	Fecal contamination (in the presence of E. coli) due to non-compliance with hygiene rules by workers (failure to wash hands with soap or a bactericide after using the toilet).	3	2	3	18	Raise awareness among workers about the importance of washing hands with water and disinfectant soap after each visit to the sanitary facilities.
			Inappropriate frequency of water replacement in the washing tank.	3	1	2	6	Replace the water in the washing tank at a frequency appropriate to the load of oranges with impurities.
			Salt washing equipment in poor condition and not properly maintained.	3	1	3	9	The equipment used for washing oranges should be designed to facilitate their cleaning.
			Lack of personal hygiene among the staff.	3	2	2	12	Adhere to Good Manufacturing Practices
			Oranges damaged by scratches (nails, sharp rings, etc.).	3	2	2	12	Handle the oranges carefully during washing.
	Chemical	High dosage of chlorine in chlorinated water (>1.2 ppm after dechlorination).	Failure to adhere to the recommended dosage for treating the well water used at the cooperative.	3	1	4	12	Adhere to the recommended dosage for chlorination of well water (≤1.2 ppm).
			Absence of effective control at the laboratory level.					Conduct tests for chlorine residues after each treatment.
		Toxic chemical substances: heavy metals (Pb, Cd, Hg, etc.), nitrates, nitrites, etc.	The water table is contaminated.	4	1	4	16	Conduct toxicological analyses of the well water once a month.
			Contamination through water pipes and storage tanks.					

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
First washing of the oranges.	**Physical**	Sand, dust, limestone...	Clogging of the filters used to prevent the passage of impurities into the water after treatment, which will be used for washing the oranges.	3	2	3	18	Regenerate the filters used periodically (every 4 days).
			Pipes clogged with limestone.	2	1	3	6	Treat the water pipes with an acidic detergent, pH < 6 (once a month) to solubilize mineral material and remove limestone deposits.
Second sorting of the oranges.	**Biological**	Contamination by pathogenic germs (total and fecal coliforms, Shigella).	Employees not washing hands after using the restroom.	3	2	4	24	Raise awareness among workers about GHP.
	Physical	Presence of foreign bodies: stones, leaf debris, lost jewelry pieces, etc.	Lack of vigilance during the sorting of oranges.	3	1	3	9	Rigorously monitor the sorting process.
								Control the lighting effectively.
								Prohibit wearing jewelry.
Grating of the oranges.	**Biological**	Contamination by and proliferation of pathogenic microorganisms, especially mesophiles that thrive at room temperature between 15 and 45°C. An example is the total aerobic mesophilic flora.	Raw material initially contaminated with germs whose proliferation is facilitated by room temperature and contact between the oranges.	3	2	4	24	Select suppliers of high-quality raw materials.
								Practice rapid grating to avoid excessive waiting time at room temperature.
			Contact with a dirty grater loaded with microorganisms	4	1	3	12	Effectively implement the cleaning and disinfection plan for the equipment.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

<table>
<tr><th rowspan="2">Step</th><th rowspan="2">Nature of danger</th><th rowspan="2">Description of danger</th><th rowspan="2">Cause</th><th colspan="4">Monitoring</th><th rowspan="2">Control measures</th></tr>
<tr><th>G</th><th>F</th><th>D</th><th>C</th></tr>
<tr><td>Brushing and second washing of the oranges.</td><td>Biological</td><td>Proliferation of pathogenic mesophilic bacteria</td><td>The room temperature at which brushing and washing take place is optimal for the development of these germs, which thrive between 15 and 45°C.</td><td>4</td><td>1</td><td>4</td><td>16</td><td>Conduct a quick brushing/washing to reduce the risk of bacterial proliferation.</td></tr>
<tr><td rowspan="5">Juice extraction.</td><td>Biological</td><td>Possibility of introducing bacteria and insects through the air.</td><td>The entrance of the extractor is open to the open air.</td><td>3</td><td>3</td><td>3</td><td>27</td><td>Implement a closed system for juice extraction.</td></tr>
<tr><td rowspan="2">Chemical</td><td rowspan="2">Residues of phytosanitary products (pesticides, insecticides, etc.).</td><td>Insufficient washing of the oranges.</td><td rowspan="2">3</td><td rowspan="2">1</td><td rowspan="2">4</td><td rowspan="2">12</td><td>Adhere to the procedure for washing oranges.</td></tr>
<tr><td>Contact between the peels containing these residues and the pulp at the extractor level.</td><td>Establish a set of specifications with suppliers.</td></tr>
<tr><td rowspan="2">Physical</td><td rowspan="2">Foreign bodies: debris from orange leaves, stones, fragments of peels.</td><td>Poor sorting,</td><td rowspan="2">3</td><td rowspan="2">2</td><td rowspan="2">3</td><td rowspan="2">18</td><td>Raise awareness among employees about the importance of properly sorting the oranges.</td></tr>
<tr><td>Inadequate juice extraction system.</td><td>Monitor the pressure and speed of the extraction discs to adapt to the thickness of the peel.</td></tr>
<tr><td>Refinement of juice.</td><td>Biological</td><td>Proliferation of germs initially present in the raw material.</td><td>Use of poor-quality raw material with bacterial contamination (for example, spoiled).</td><td>3</td><td>1</td><td>4</td><td>12</td><td>Develop specifications sheets for the raw material, including all necessary characteristics for identification and quality assessment. Select suppliers.</td></tr>
</table>

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Refinement of juice.	**Biological**	Contamination of the juice by pathogenic bacteria, spoilage bacteria, or insects at the refining stage.	Contact with a sieve that is not properly cleaned and disinfected.	3	1	3	9	Proper cleaning and disinfection of the production facility, and verification of the effectiveness of the cleaning process.
			Introduction of bacteria and insects through the air	4	2	4	32	Implement a covered sieve.
	Chemical	Residues from cleaning and disinfection products.	Insufficient washing and/or disinfection of the production line.	3	1	3	9	Wear appropriate attire for the tasks and handling. If necessary, use a head covering and a face mask, and change them regularly to prevent hair and hair particles from falling.
	Physical	Foreign bodies of human origin (hair, hair particles, etc.).	Failure to adhere to GHP and good production practices.	3	1	3	9	Wear suitable attire for the tasks and handling. If necessary, use a head covering and a face mask.
Cooling	**Biological**	Proliferation of bacteria, yeasts, and molds (Aspergillus, Fusarium).	Elevation of the juice temperature due to a problem in the operation of the plate heat exchanger.	3	1	2	6	Maintain the heat exchanger and implement a system to monitor the temperature of the juice at the outlet of the exchanger.
Storage of pure juice under refrigerated conditions.	**Biological**	Proliferation of pathogenic bacteria (Listeria Monocytogenes, which can persist even at a temperature of 4°C and production of mycotoxins by molds such as Aspergillus and Fusarium.	Insufficient cleaning and disinfection of the storage tank.	3	1	3	9	Adhere to the cleaning and disinfection program for storage chambers.
			Failure to comply with the storage temperature (approximately ≤ 4°C).	3	2	3	18	Ensure the maintenance of the appropriate temperature for juice storage (≤ 4°C).

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Storage of pure juice under refrigerated conditions.	**Chemical**	Residues from cleaning and disinfection products.	Insufficient rinsing of the storage tank.	3	1	3	9	Adhere to the cleaning and disinfection program: apply sufficient rinsing of the storage tank.
Clarification	**Biological**	Bacterial contamination.	Contaminated clarifier.	3	1	4	12	Clean the clarifier after each production cycle.
	Physical	Presence of seeds (which can release a bitter taste in the juice if they burst). Presence of pulp in the juice (risk of clogging in the later stages of processing).	Problem with centrifugation or settling in the clarifier.	3	2	2	12	Maintain and monitor the performance of the clarifier's operation.
Evaporation	**Biological**	Proliferation of pathogenic microorganisms.	High water activity (aw > 0.85) due to a problem in applying temperature and pressure parameters in the three-effect evaporation system (temperature and/or pressure drop).	4	1	4	16	Seek assistance from a qualified and experienced technician. Monitor and control temperature and pressure variations in evaporation with vigilance and expertise.
	Chemical	Residues from cleaning and disinfection products.	Insufficient rinsing of the three vapor/liquid separation chambers (effect).	3	1	3	9	Adhere to the cleaning and disinfection program for the evaporation system.
Cooling	**Biological**	Proliferation of pathogenic microorganisms.	Extended cooling time before freezing.	4	1	4	16	Implement rapid cooling to prevent microbial proliferation.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Storage of juice concentrate in cold rooms (-18°C).	Biological	Proliferation and persistence of spoilage microorganisms, Pathogens (yeasts and molds : Aspergillus, Fusarium)	Lack of hygiene in the cold rooms.	3	1	3	9	Cleaning and disinfection of cold rooms should be carried out at a regular and appropriate frequency.
			Incorrect refrigeration.	3	1	3	9	Ensure continuous monitoring and control of temperature variations in the cold rooms.
			Interruption of the cold chain					Adhere to the cold chain.
								Limit the duration of cold room openings.
			The plastic bags used for packaging juice concentrate for refrigeration are contaminated or not properly sealed to prevent the entry of air, which promotes bacterial proliferation.	3	2	3	18	Use single-use, clean bags exclusively for packaging juice concentrate in the cold rooms.
								Ensure that these bags are properly sealed and do not allow any air entry.
								Ideally, implement an aseptic vacuum filling system to guarantee an ideal seal.
	Chemical	Contamination of orange juice concentrate by cleaning solvents, detergents, and biocides.	Inadequate rinsing of cold rooms after applying cleaning solvents, detergents, and biocides.	3	1	3	9	All cleaning chemicals must be compatible with food use.
								Apply thorough and effective rinsing.
								Provide training for the staff.
			Presence of leaks in the bags used for packaging juice concentrate in the cold rooms.	3	2	3	18	Ensure the quality of the bags used for packaging orange juice concentrate.
		Odors from disinfectant products.	Use of cleaning chemicals that are not food-grade or compatible (scented).	2	1	3	6	All cleaning chemicals must be food-grade and should not be scented.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring G	F	D	C	Control measures
Preparation of syrup.	Biological	Development of pathogenic microorganisms, osmophilic bacteria that tolerate high sugar concentrations in the syrup, as well as yeasts and molds.	Improper handling of ingredients (sugar).	3	1	2	6	Handle the ingredients under appropriate conditions.
			Use of water with poor microbiological quality.	3	1	4	12	Conduct bacteriological and physicochemical analyses of the water before using it in the mixture.
			Cross-contamination with equipment (contact with an unsanitized salt mixer).	3	1	3	9	Ensure proper cleaning and disinfection of production equipment.
	Chemical	Residues from cleaning and disinfection products.	Insufficient rinsing of the mixer product	3	1	3	9	Follow the cleaning and disinfection schedule for the equipment.
	Physical	Implementation of measures to prevent foreign objects from entering the mixer (dust, stones, metal, etc.).	Non-compliance with good hygiene and manufacturing practices.	3	1	3	9	Raise awareness among the staff about good hygiene and manufacturing practices
Syrup Storage	Biological	Possible contamination of the syrup by molds or fungi (Mucor).	Non-compliance with storage conditions (cooling, hygiene, and sealing of the storage unit).	3	2	4	24	Ensure proper storage conditions for the syrup (thermal insulation of the storage tank, adherence to the tank cleaning schedule).

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Preparation of the orange nectar blend (Nectary).	**Biological**	Contamination by pathogenic microorganisms.	Use of water or contaminated.	4	1	4	16	Microbiological analysis of water, Ensure the quality of ingredients through careful selection of suppliers and by taking samples for microbiological analysis at the internal laboratory of the cooperative.
			Salt reactor poorly maintained or in disrepair.	3	1	3	9	Clean the reactor regularly (after each production shutdown).
	Physical	Introduction of foreign bodies into the reactor (dust, stones, metal...).	Failure to comply with good hygiene and manufacturing practices.	3	1	3	9	Raise awareness among the staff about good hygiene and manufacturing practices, Prohibit the wearing of accessories during the handling of ingredients.
Storage of the mixture.	**Biological**	Proliferation of pathogenic microorganisms and spoilage in the mixture.	Insufficient acidity to inhibit certain pathogenic bacterial, viral, and parasitic agents that can survive and remain infectious in an acidic environment.	3	3	4	36	Adhere to the nectar preparation formulation. (pH < 4)
		Proliferation of pathogenic microorganisms and spoilage in the mixture.	Non-respect de la température de stockage (≤4°C).	3	1	3	9	Maintain the refrigeration of the nectar mixture (°T≤4) in the storage tank (ensure thermal insulation of the tank).
	Chemical	Contamination by cleaning and disinfection products.	Insufficient rinsing of equipment after cleaning and disinfection.	3	1	3	9	Master the cleaning and disinfection instructions for the nectar storage tank.

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar "Table Continued".

Step	Nature of danger	Description of danger	Cause	Monitoring				Control measures
				G	F	D	C	
Storage of the mixture	**Physical**	Contamination by foreign bodies: Dust, sand, plastic, wood...	Failure to adhere to hygiene rules by the personnel preparing the nectar.	3	1	3	9	Raise awareness and provide training to the personnel on Good Manufacturing Practices
Pasteurization of the nectar	**Biological**	Contamination by pathogenic microorganisms (thermo-resistant bacteria).	Insufficient cleaning and disinfection of the pasteurization equipment.	4	1	3	12	Ensure that the cleaning program for the pasteurization equipment is followed.
		Persistence of spores and thermo-resistant pathogenic germs,	Non-compliance with the pasteurization criteria: (89 to 94°C / 18s).	4	2	4	32	Review and adhere to the pasteurization temperature and duration,
		Partial destruction of enzymes (pectinases).						Ensure the reliability of the monitoring system for temperature variations in the pasteurizer.
Storage of the nectar in tanks after pasteurization	**Biological**	Microbial contamination.	Contamination due to damaged pipes carrying the nectar from the pasteurizer outlet to the temporary storage tank or due to improper cleaning of the tank.	4	1	4	16	Adhere to the cleaning and disinfection program for the passages carrying the nectar from the pasteurizer outlet to the storage tank to prevent cross-contamination.
	Chemical	Chemical residues from the walls of the pipes.	Failure to follow the cleaning/ disinfection procedure.	3	1	3	9	Adhere to the cleaning/ disinfection procedure.
	Physical	Presence of hair, hair fall.	Failure to comply with Good Manufacturing Practices	3	1	2	6	Raise awareness among the staff about Good Manufacturing Practices (BPH),

Table 4.11: Analysis of the Hazards Associated with the Production of Orange Nectar “Table Continued”.

Step	Nature of danger	Description of danger	Cause	Monitoring G	F	D	C	Control measures
Packaging of the nectar.	**Biological**	Contamination by pathogenic agents.	Lack of sealing in the packaging closure.	4	3	3	36	Set up the machine at startup, Perform packaging seal checks every half-hour during production.
			Use of contaminated steam for sealing the packaging jar (made of cardboard) for the juice.	4	1	4	16	Use steam generated from potable water that has undergone bacteriological checks.
			Absence of sterilization of the packaging.	2	5	4	40	Sterilize the packaging using peroxide to prevent any possible cross-contamination.
	Chemical	Unpleasant odor in the finished product.	Presence of volatile substances and impurities in the steam used for packaging sealing.	3	1	3	9	Use steam generated from well-treated and free from any impurities potable water.
	Physical	Metallic residues.	Failure to comply with Good Manufacturing Practices	4	1	3	12	Implement a metal detector at the exit of the finished product.
Storage of the finished product.	**Biological**	Development of pathogenic bacteria, yeasts, and molds.	Storing the finished product at a temperature ≥6°C, Inadequate storage conditions.	3	2	33	118	Monitor the temperature of the storage room, Adhere to the "Best Before" date (30 days).

Step 7: Identify Critical Control Points (CCPs) for hazards (Principle 2):

The identification of CCPs was carried out using the decision tree proposed by the Codex Alimentarius (see appendix, figure 4). At each step, we answered each question successively in the order specified, for any hazard for which the occurrence or introduction is conceivable. The results obtained are represented in Table 12.

Table 4.12: Results of CCP Determination.

Process step.	Nature of the hazard.	Description of the hazard.	Q1	Q2	Q3	Q4	CCP (yes/no)	CCP number
Pasteurization of the nectar	Biological	Persistence of pathogenic microorganisms (thermo-resistant bacteria). Partial deactivation of enzymes.	YES	YES	___	___	YES	**CCP°1**
Storage of the nectar in tanks after pasteurization.	Biological	Contamination by pathogenic microorganisms at the level of the tank or in the pipes carrying the nectar from the pasteurizer to the temporary storage tank.	YES	NO	YES	NO	YES	**CCP°2**
Packaging of the nectar	Biological	Contamination by pathogenic agents due to contact with contaminated packaging or due to a sealing problem with the packaging.	YES	NO	YES	NO	YES	**CCP°3**

Step 8: Establish Critical Limits for Each CCP (Principle 3):

After identifying the various CCPs, critical limits were defined and validated to prevent any loss of control. The results are presented in Table 13.

Table 4.13: Establishing Critical Limits for Each Critical Control Point (CCP).

Step	**Control measure**	**Critical limit**
CCP°1 Pasteurization of the nectar -Persistence of pathogenic germs: thermoresistant bacteria, -Partial deactivation of enzymes.	Review and adhere to the pasteurization scale, Install a pressure gauge in the hot water loop of the pasteurizer and a gauge at the output of the finished product to monitor the critical limits of the pasteurization CCP, Update the preventive maintenance schedule for the pasteurization system.	Pasteurize the juice at a temperature (from 89°C to 94°C for 18 seconds).

Table 4.13: Establishing Critical Limits for Each Critical Control Point (CCP)" Table Continued".

Step	Control measure	Critical limit
CCP°2 <u>Storage of pasteurized nectar in tanks</u> -Contamination by pathogenic microorganisms at the tank or in the pipelines transporting the nectar from the outlet of the pasteurizer to the temporary storage tank	Adhere to the cleaning and disinfection program for the storage tank and pipelines: Cleaning with 2% concentration sodium hydroxide (NaOH) at a temperature of 80°C followed by rinsing with potable water, Circulation of 1% concentration nitric acid (HNO3) at a temperature of 75°C followed by rinsing with potable water, Application of a disinfectant (Oxonia or divosane) to eliminate any potential source of contamination after cleaning, Final rinse with potable water.	-Sodium hydroxide (NaOH): [OH-] = 2%, T = 80°C for 10 minutes. -Nitric acid (HNO3): [HNO3-] = 1%, T = 75°C for 10 minutes. -Disinfectant (Active Oxonia or divosane): Concentration: 0.4%, Contact time: 10 minutes. -Agitator and circulation pressure for cleaning liquids: P = 4 bars.
CCP°3 <u>Packaging of the nectar</u> Contamination by pathogenic agents.	Sterilize the packaging using hydrogen peroxide (H2O2) to prevent any possible cross-contamination, -Adjust the machine at startup, -Perform packaging seal checks every half hour during production.	30% < [H2O2] < 49%.

Steps 9 and 10: Implement a monitoring system for CCPs and corrective actions in case of deviations (Principles 4 and 5):

After determining the critical limits, the next step is their monitoring and identifying corrective actions to be taken when monitoring reveals a deviation or loss of control over a given critical limit. The established monitoring system and proposed corrective measures for our example regarding the production of orange nectar are presented in Table 14:

Table 4.14: Establishing Monitoring System and Proposed Corrective Measures.

Critical point	Monitoring method					Corrective actions
	"What" (Object)	**Critical limit**	**How" (Mode)**	**"When" (Frequency)**	**Who" (Responsible)**	
CCP 1: Pasteurization of the nectar	Pasteurization scale.	Pasteurization scale: 89°C < Temperature < 94°C / 18 seconds.	Monitor the nectar pasteurization system using an automated system to detect any loss of control over the pasteurization scale.	During each cycle of nectar pasteurization.	Monitoring by automated system (APT Flex Tubular 14T).	Stop the nectar flow to the storage tank using the automation system, Clean the entire pasteurization circuit, Repasteurize the nectar
CCP°2: Storage of nectar in tanks after pasteurization.	Temperature and concentration of cleaning and disinfection agents, Contact time between these agents and the circuit to be cleaned, Circulation and agitation pressure of these agents.	Sodium hydroxide: T = 80°C and $[OH^-]$ = 2%. Nitric acid: T = 75°C and $[HNO_3^-]$ = 1%. Disinfectant (Active Oxonia or divosane): Concentration: 0.4%, Contact time: 10 minutes. Agitator pressure: P = 4 bars.	Verify the concentrations and temperatures of the cleaning products before their use by taking samples for laboratory analysis, Ensure the performance of the Clean In Place (CIP) control system through systematic checks.	Before each start of the cleaning cycle	Laboratory technician, CIP control system technician.	Empty the tank, Adjust the cleaning and disinfection parameters (concentration, temperature, agitation pressure, and contact time with the system to be cleaned), Ensure the reliability of the CIP control system.
CCP 3: Packaging of the nectar	Sterilization of the packaging.	$[H_2O_2] > 30\%$ and $[H_2O_2] < 49\%$, Temperature (H_2O_2) = 68°C.	Monitor the sterilization parameters of the packaging: (concentration and temperature of hydrogen peroxide).	Every 4 hours.	Packaging operator.	Stop, Adjust the concentration, or change the hydrogen peroxide, Adjust the sterilization temperature, Restart.

Step 11: Establish a verification system for the HACCP plan (Principle 6):

The HACCP team within the Copag cooperative has developed its procedure to assess and, if necessary, verify the operation of its applied HACCP programs for the quality control of orange nectar. This includes:

a. Utilizing the results of analyses carried out by competent authorities (such as pesticide residue analysis),
b. Analyzing customer complaints,
c. Leveraging the results of analyses performed at each critical control point... Furthermore, this verification will be updated whenever there is a change in the process, equipment, standard, control method, etc.

Step 12: Establish a document system (Principle 7):

The HACCP system requires the establishment and retention of documents. Therefore, the HACCP team has created an HACCP manual that compiles all the team's work results, including product specifications, production diagrams, hazard analysis tables and determination of Critical Control Points (CCPs), non-conformity form, monitoring system records, HACCP plan documentation form, and more.

5. DISCUSSION AND CONCLUSION

The study was conducted to address the food safety requirements within the juice production unit at the COPAG Taroudant cooperative. It represents a contribution to the implementation of the HACCP system while adhering to the Codex Alimentarius requirements. Meeting the HACCP system requirements involves the development of an HACCP plan.

The initial phase of this work involved the implementation of prerequisite programs (diagnosis and action plan). An inspection and physical examination conducted within the establishment to assess these programs provided a snapshot, offering a realistic evaluation of both positive and negative conditions in the fruit juice production unit. Based on this assessment, an action plan was established, partially executed, including personnel training and corrections to certain infrastructure deficiencies, pending the implementation of the remaining actions, especially those requiring investment. This was aimed at ensuring ongoing control of the prerequisite programs, as any failure in these programs inevitably leads to a collapse of the entire HACCP system.

The second part focused on studying the orange nectar production chain (Nectary) according to the HACCP plan while complying with Codex Alimentarius requirements. Hazard analysis revealed three CCPs:

a. CCP.1 - Pasteurization of Nectar: This critical control point focuses on the pasteurization process, acknowledging the potential risks associated with the persistence of thermoresistant pathogenic germs or the partial deactivation of enzymes during this crucial phase.
b. CCP.2 - Storage of Nectar in Tanks after Pasteurization: The storage of nectar in tanks post-pasteurization emerges as another critical control point, emphasizing the risk of contamination by pathogenic microorganisms either within the tank or in the pipelines transporting the nectar from the pasteurizer to the temporary storage tank.
c. CCP.3 - Packaging of Nectar: The final critical control point involves the packaging of nectar, recognizing the inherent risks of contamination by pathogens. This contamination can arise from contact with packaging materials that may be contaminated or from potential sealing issues during the packaging process.

To control these identified critical points, control measures were established, including setting critical thresholds, and implementing an effective system for pasteurization control to eliminate germs affecting the safety and wholesomeness of the finished product.

Currently, the orange nectar production unit within the COPAG cooperative has actively and effectively committed to implementing the HACCP system, involving all stakeholders in its successful completion. To ensure the success of this time-consuming and resource-intensive task for all involved parties, the following recommendations are made:

i. Production management should sensitize stakeholders and ensure the implementation of good manufacturing practices in the production chain.
ii. Workers should actively engage in the application of the HACCP approach by efficiently carrying out their tasks, which is crucial for the success of the HACCP system.
iii. Continued upgrading of various prerequisite programs (facilities, equipment, transportation, storage, maintenance, etc.).
iv. Effective implementation of the documentation system.
v. Periodic evaluation of the project's progress in line with HACCP system requirements.

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APPENDIX A

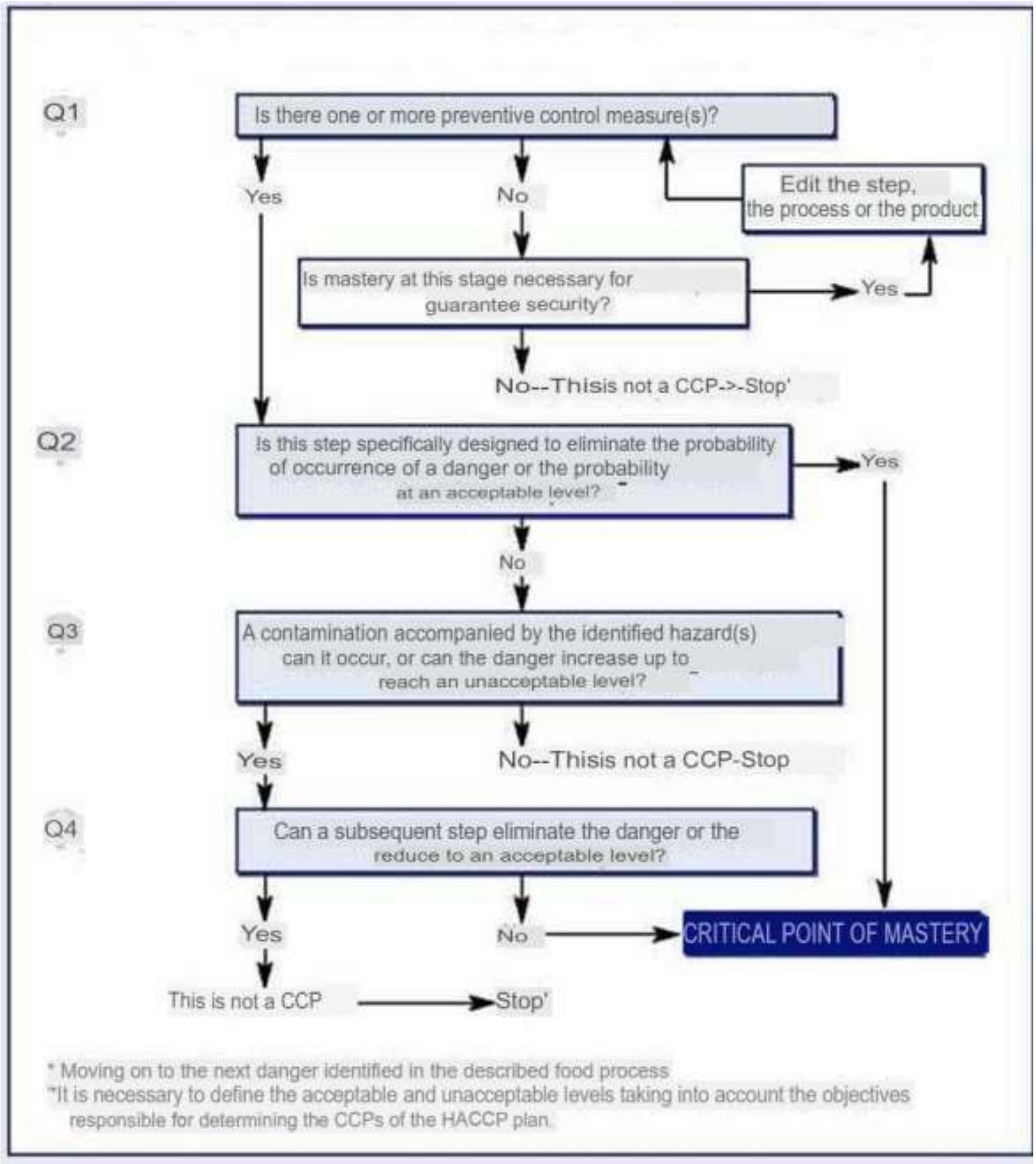

Figure A.1: Decision Tree for the Identification of Critical Control Points.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius.

	Elements of PRP	**S**	**PS**	**NS**	**Observations**
1	Hygiene of Premises				
1.1	Exterior of the Building				
1.1.1	Factory located in an area free from unpleasant odors, smoke, dust, and cultivated land.	X			
1.1.2	Absence of garbage deposits around the perimeter or stagnant water.	X			
1.1.3	Area not prone to flooding.	X			
1.1.4	Access roads and nearby areas are drivable.	X			
1.1.5	Appropriate drainage system.	X			
1.2	Interior of the Building				
1.2.1	Design and construction, rational organization of premises.				
1.2.1.1	The materials of the floors, walls, ceilings are durable, smooth, easy to clean.			X	The floor in the juice extraction unit is not completely smooth and has cracks, making it difficult to clean.
1.2.1.2	The walls have a light color.	X			

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
1.2.1.3	Sufficient lighting throughout the building.		X		The lighting intensity in the juice extraction unit is a bit low.
1.2.1.4	The building is ventilated in such a way that heat, steam, odor, and condensation do not accumulate.			X	Natural ventilation in the nectar production unit is not sufficient; it should be supplemented with effective artificial ventilation (installation of fans) to prevent the accumulation of unpleasant odors.
1.2.1.5	Physical and operational separation of incompatible activities.	X			The processing areas are separated from the maintenance workshops, and the processing zones (juice extraction, concentrate preparation, nectar blend preparation, and packaging) are separated from each other.
1.2.1.6	The premises should be designed according to the principle of 'forward flow'; successive work operations must ensure a progression of the product forward, without going back, at least processed to more processed, from less sanitary to more sanitary, from more delicate to less delicate.	X			
1.3	Sanitary facilities.				
1.3.1	Toilets, cafeterias, and locker rooms				

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
1.3	Sanitary facilities.				
1.3.1	Toilets, cafeterias, and locker rooms				
1.3.1.1	The toilets, cafeterias, and locker rooms are separated from the processing areas and do not open directly into them.		X		
1.3.1.2	The doors of the toilets are clear, smooth, and washable.	X			
1.3.1.3	The number of toilets is proportional to the number of employees.	X			The number of toilets is quite sufficient; the cooperative is equipped with 26 toilets in the locker rooms, not to mention the toilets in the hallways and even in the juice extraction unit (which is recommended to be closed to avoid any potential source of contamination).
1.3.2	Facilities for handwashing, sanitary facilities, and equipment sanitation.				
1.3.2.1	The toilets are equipped with handwashing facilities providing potable water, liquid soap, disposable hand towels, or hand dryers, equipped with easily cleanable bins.		X		Absence of hot water to ensure proper personal hygiene.
1.3.2.2	The processing areas are equipped with sinks with faucets activated by a non-manual system.	X			

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	**S**	**PS**	**NS**	**Observations**
1.3.2.4	Presence of sanitation facilities for equipment.	X			
1.4	Water quality control.				
1.4.1	Use of cold and hot drinking water in food processing, handling, packaging, and storage areas.	X			
1.4.2	Presence of water storage and distribution facilities ensuring protection against contamination.	X			Storage of water in tanks to protect it from contamination and ensure its availability.
1.4.3	The water supplying the boilers and any water subjected to chemical treatment are monitored and controlled to achieve the desired concentration and prevent contamination. Records on water treatment include the following information: treatment method, sampling site, analysis results, analysts, and date.	X			Bacteriological and physico-chemical analyses of well water, chlorinated water, and decolorized water are performed daily.
1.4.4	No intercommunication between potable and non-potable water networks.	X			
1.4.5	If filters are used, they are kept in good condition and are hygienically maintained.	X			The filters used for water filtration are periodically regenerated to prevent clogging and contamination.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Obseravtions
2	Hygiene related to transport and storage.				
2.1	Transport.				
2.1.1	Transport vehicles.				
2.1.1.1	Inspection of vehicles upon reception and before loading.		X		Some trucks, specifically used for the disposal of orange waste after crushing, are in poor condition, leading to leakage of residual juice at the factory during transport. An inspection of these trucks should be carried out before loading.
2.1.1.2	The vehicles are cleaned after each transport.	X			
2.1.2	Temperature control.				
2.1.2.1	The transport temperature poses no risk of alteration or deterioration of ingredients and finished products.	X			
2.2	Storage.				
2.2.1	Ingredients and packaging materials.				
2.2.1.1	The frozen ingredients are stored at a temperature that poses no risk of thawing, and the refrigerator is equipped with monitoring means.	X			The negative cold rooms are always maintained at a temperature of -18°C or lower, and their temperature level is displayed by the control system operated through computers.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	**S**	**PS**	**NS**	**Observations**
2.2.1.2	The ingredients and packaging materials are handled and stored in a manner to prevent any damage and contamination.	X			
2.2.2	Non-food chemicals				
2.2.2.1	The chemicals are stored in areas that pose no risk of cross-contamination with food or food contact surfaces and packaging materials.	X			The cleaning products are stored in a closed store with no direct access to the processing area and ingredient or packaging material storage rooms. The store is managed by a responsible person who handles the distribution of these products according to the sections.
2.2.2.2	The chemicals are distributed and handled only by authorized personnel.	X			The cleaning and disinfection products are handled only by cleaning personnel.
2.2.3	Storage of finished products.				
2.2.3.1	The finished products are stored in conditions suitable for preventing any deterioration. The finished products are stored in conditions suitable for preventing any deterioration.	X			The finished product is stored at a temperature not exceeding 6°C at most, as it is a fresh juice that has undergone pasteurization treatment.
2.2.3.2	Returned, non-compliant, or suspicious products are stored in a separate area.	X			A return service handles returned products, either by recycling them if recycling is possible or by disposing of these products if they pose a risk to the consumer.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
3	Hygiene of equipment and utensils				
3.1	General design and installation of the equipment				
3.1.1	The materials of the equipment and utensils resist corrosion	X			The equipment and food surfaces are constructed from stainless steel.
3.1.2	The equipment is accessible for cleaning, sanitation, maintenance, and inspection.		X		Some equipment does not disassemble during cleaning, reducing the effectiveness of cleaning and making certain parts inaccessible for thorough cleaning.
3.1.3	The equipment must always be clean and compliant with the sanitation program.	X			The equipment is rinsed with water during production and sanitized according to the sanitation program at the end of production. Sodium hydroxide is used to solubilize organic contaminants, and acid is used to dissolve mineral precipitates.
3.1.4	Equipment for non-edible materials is not used for edible materials.	X			
3.2	Maintenance of the equipment.				
3.2.1	Calibration of the equipment.				

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
3.2.1.1	A list of all control devices must be compiled, indicating their purpose as well as the calibration methods.	X			The calibration technician has a list of all control devices from various units, along with the schedule for their calibration.
3.2.2	Maintenance of the equipment.				
3.2.2.1	The operator has implemented an effective preventive maintenance program that ensures the proper functioning of equipment that could affect food safety. This program is adhered to and poses no physical or chemical hazards. It includes the following: A list of equipment requiring regular maintenance. Procedures and maintenance frequencies: equipment inspection, adjustment, and replacement of parts in accordance with the manufacturer's manual or an equivalent document, or based on operating conditions that may affect the equipment's condition. The rationale for each activity.			X	Update the preventive maintenance schedule for the workshop in accordance with the control measures outlined in the HACCP study of the workshop, and schedule a presentation for the HACCP team for validation.
4	Personal hygiene.				
4.1	Individuals: their state of health.				

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius “Table Continued”.

	Elements of PRP	**S**	**PS**	**NS**	**Observations**
4.1.1	The staff must undergo medical screening upon hiring.	X			Anyone who may have access to the processing area undergoes a medical check.
4.1.2	The staff must undergo medical checks at least once a year.	X			
4.2	Hygiene training.				
4.2.1	Implementation of a hygiene training program for the staff.	X			
4.2.2	Anyone entering the processing area must be made aware of hygiene practices.	X			
4.3	Sanitary practices.				
4.3.1	Infectious diseases.				
4.3.1.1	Staff in contact with the product or food surfaces must report any skin infection or infectious disease.	X			Anyone suffering from an illness is required to consult the occupational health physician.
4.3.2	Injuries.				
4.3.2.1	Staff in contact with the product or food surfaces must report any open wound.	X			Anyone injured declares their injury for treatment, protects it with a bandage, and wears gloves.
4.4	Clothing hygiene.				
4.4.1	Workwear.				

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
4.4.1.1	Workwear must be suitable for the job.	X			Staff working in the negative cold room handling area wears a suit to protect the body from the cold in the room. Personnel in the processing area wears disposable plastic aprons to protect their gowns (workers involved in equipment cleaning) and ear protection helmets. Maintenance personnel wears safety suits and shoes.
4.4.1.2	Shoes must be cleaned upon each entry into the processing area.		X		Boots are cleaned at the end of the production only.
4.4.1.3	A minimum frequency for changing clothes must be established for each position.	X			All staff changes their clothes twice a week (on Monday and Thursday).
4.4.2	Accessories				
4.4.2.1	Gloves and face masks must be available to employees when necessary.	X			Gloves and face masks are provided for employees.
4.5	Staff flow				
4.5.1	Changing rooms.				
4.5.1.1	Personal belongings must be kept separate from work clothes in the lockers.		X		Some employees do not organize their lockers to ensure separation between personal belongings and work clothes.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
4.5.2	Organization of workstations.				
4.5.2.1	Differentiation of activities should be possible through the choice of colors for clothing.	X			Staff in the juice extraction line wears green gowns. Personnel responsible for cleaning the processing areas wears white gowns. The hygiene team wears light blue gowns.
5	Cleaning and disinfection, analysis, and pest control.				
5.1	Sanitation program.				
5.1.1	Establish a sanitation program.				
5.1.1.1	Installations and equipment must be sanitized after each use and before resuming activity or changing products	X			Cleaning of the juice extraction line occurs after each shutdown (3 times/24h). The pasteurization installation is sanitized in the following sequence: first, the base, then with acid, and finally rinsed with potable water after each shutdown.
5.1.1.2	Large equipment pieces must be disassembled for cleaning.		X		No disassembly of large equipment pieces during cleaning.

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	S	PS	NS	Observations
5.1.2	Adherence to the program.				
5.1.2.1	The effectiveness of the cleaning program must be verified through on-site microbiological sampling and sensory inspection of areas and equipment.			X	Lack of on-site microbiological sampling to monitor the cleanliness of surfaces and production materials.
5.2	Pest Control Program.				
5.2.1	Establish a pest control program.				
	Food and equipment must be protected from contamination by the chemicals used.	X			Chemicals are applied in areas that do not have direct access to processing or storage areas.
5.2.2	Adherence to the program.				
5.2.2.1	The effectiveness of the program must be checked by inspecting the areas to ensure the absence of insects and pests.	X			An inspection of the treated areas and baits is conducted after treatment using appropriate chemical products.
	Traceability and Recall System.				
6.1	Recall System.				
6.1.1	Every product must be identified with the production date or a lot identification code.	X			
6.1.1.2	The establishment must maintain a file of complaints related to hygiene and sanitation.				

Table A.1: Evaluation Grid for the Audit of Prerequisite Programs According to the Codex Alimentarius "Table Continued".

	Elements of PRP	**S**	**PS**	**NS**	**Observations**
6.1.1.4	The roles and responsibilities of each team member must be clearly defined.	X			
6.1.1.5	The program must describe, step by step, the procedures to follow during a recall.	X			The establishment has established a control sheet for non-conforming products specifying its objective, scope, identification, and isolation of non-conforming products, as well as the different steps to follow during a recall.
6.1.1.6	The program must describe the control measures for what will be done with the recalled products.	X			
6.2	Identification and storage of non-conforming products.				
6.2.1	Each lot of non-conforming products must be easily identifiable.	X			Any non-conforming product or lot is identified with a red label and red tape for easy recognition.

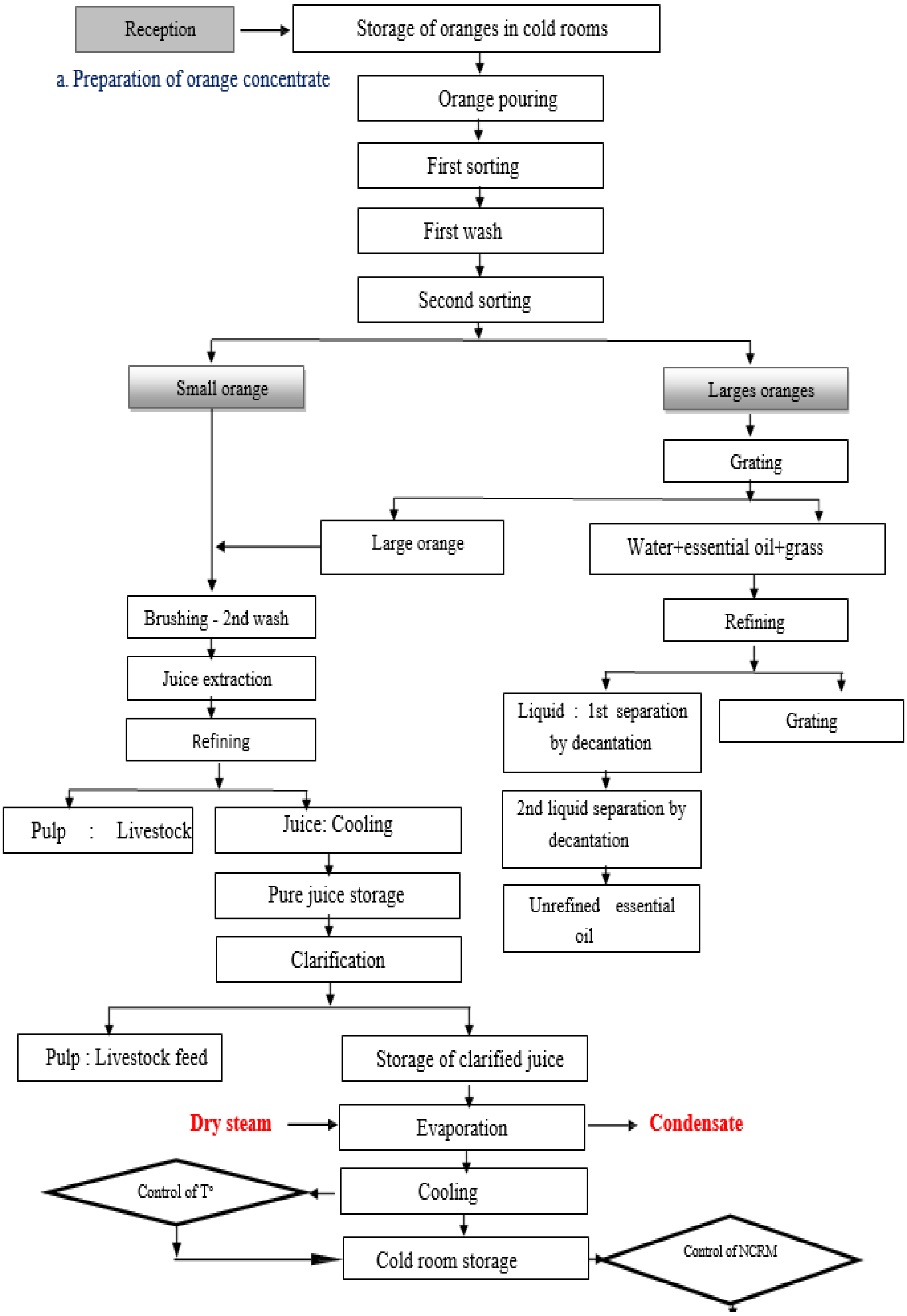

Figure A.2: Manufacturing Flowchart " Preparation of Orange Juice Concentrate.

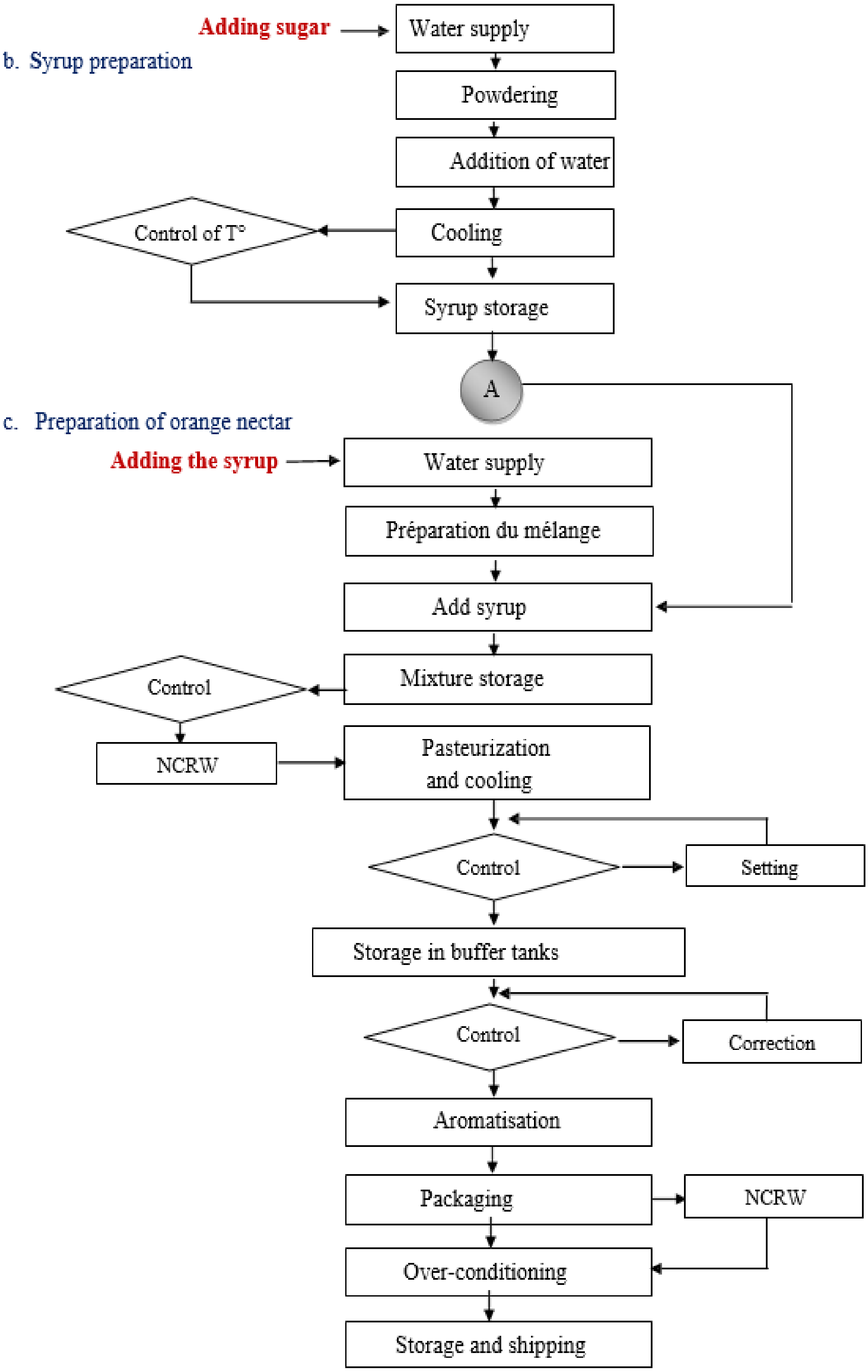

Figure A.3: Diagram of Syrup and Orange Nectar Preparation.