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Vulnerability and Critical Control Point Assessment of the Feta Cheese Supply Chain in Greece towards Blockchain Implementation

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Abstract

As unique and culturally important commodities, food items designated with Protected Designation of Origin (PDO) play a pivotal role in the food supply chain by safeguarding the authenticity and uniqueness of regional delicacies. Within the PDO realm, Feta cheese, a culturally significant dairy product with strict geographic and production regulations, faces challenges like counterfeit products, threatening its authenticity. This study examines the PDO Feta cheese supply chain, focusing on "Olympos" producer and "Masoutis" retailer in Greece. This evaluation utilizes the Delphi Technique in combination with the design phases of HACCP, VACCP, and TACCP to thoroughly examine operations, vulnerabilities, and critical control points. The findings reveal numerous weaknesses and critical control points in the Feta cheese supply chain that require attention and serve as a foundation for enhancing PDO supply chains. Moreover, Blockchain Technology (BT) is proposed as a solution to enhance traceability. BT, with its decentralized and immutable ledger system, is seen as transformative in data management, fostering trust among stakeholders. It ensures transparent and auditable records throughout the supply chain, providing consumers with unprecedented authenticity transparency. The integration of BT holds promise for enhancing overall integrity and efficiency, benefiting all stakeholders.

Keywords: Food Supply Chain (FSC); Delphi Technique; Blockchain technology; sustainability; Protected Designation of Origin (PDO); digital transformation

1 Introduction

Ensuring the authenticity and originality of regional delicacies is of utmost importance in safeguarding Protected Designation of Origin (PDO) commodities. These products, which have strong ties to the cultural and geographical uniqueness of certain locations, possess a distinct reputation that ought to be conserved (Belletti & Marescotti, 2021). In addition, the PDO labeling serves to highlight both the distinct characteristics of these regional specialties and their increased economic merit and appeal in the market (Savelli et al., 2021).

Feta Cheese (FC), a unique and culturally important dairy product, has received considerable recognition in the fields of nutrition and food science, with its origins in Greece. FC has been designated as a Protected Designation of Origin (PDO) product within the European Union since 2002 (European Commission, 2002); therefore, it must meet certain criteria regarding its name, the origin of its raw materials, its inherent properties, the methods used to produce it, the specific geographical region in which it originates from, strict inspection requirements, and precise labeling specifications (European Commission, 1992).

The PDO FC Supply Chain (SC) holds substantial significance in the wider context of dairy production and local identity and demonstrates the meticulous focus and dedication to traditional methods in producing a product of high quality with distinct attributes (Bozoudi et al., 2018). However, the dairy production industry, which is subject to strict regulations, has occasionally faced the issues of food fraud; ensuring the uniqueness of PDO goods faces several difficulties within Food Supply Chains (FSCs), particularly in relation to the adopted procedures, administration, and governance. The complexities of these difficulties encompass several aspects, such as concerns over transparency, traceability, and efficiency (Aung & Chang, 2014). The intricacies manifest at every level of the Supply Chain (SC), starting with the procurement of raw materials to the ultimate product. Verifying the source, preventing tampering, and upholding quality requirements necessary for PDO certification become complex undertakings in a multinational industry (Brooks et al., 2021).

The critical factor in resolving the obstacles encountered by PDO SCs is the fundamental significance of agricultural and information systems. Longevity and viability of local economies are enhanced by resilient and sustainable agricultural systems, which also guarantee a constant high quality of raw materials (Del Baldo, 2022; Vasileiou et al., 2024). Blockchain Technology is considered an effective solution for enhancing the traceability and maintaining the integrity of PDO Feta cheese SC and similar high-value food products' SCs. The implementation of BT, distinguished by its distributed and immutable record-keeping system, offers a new approach to address issues related to transparency and trust in the SC (Vu et al., 2023).

This paper seeks to enhance understanding by conducting empirical research and operational analysis on vulnerability factors and potential solutions in relation to the adoption of BT in SCs of PDO FC in Greece. The subsequent Section encompasses the methodology employed in this study, while in Section 3 the results are discussed. Section 4 concludes the paper.

2 Methodology

The present research endeavors to examine the challenges of the PDO FC supply chain by implementing stringent methodologies in order to detect weaknesses and enhance the authenticity of this commodity. Furthermore, the FC SC of "Olympos" manufacturer and the "Masoutis" retailer, located in Greece, is examined in this study. The main focus is on analyzing the operations and technologies used in this specific supply chain. An evaluation is undertaken to assess the functioning, susceptibilities, and pivotal control points, including inadvertent and deliberate hazards. This incorporates the Delphi Technique with the design stages of the Hazard Analysis and Critical Control Points (HACCP), Vulnerabilities Assessment and Critical Control Point (VACCP), and Threat Assessment and Critical Control Point (TACCP) methodologies. The methodology utilized to collect the necessary information regarding the PDO Feta cheese SC is founded on the Delphi Technique, which is employed to gather and integrate expertise and perspectives from a group of experts or stakeholders, with the objective of making informed decisions (Hugé et al., 2010).

The examination of this research is conducted in a rigorous nine-step sequence as shown in Figure XX. A panel of experts with varied expertise in food safety, security, and SC management is initially assembled. 90 stakeholders were invited, of which 55 accepted the request. Following this, expert interviews, surveys, and questionnaires are utilized in conjunction with the Delphi Technique to investigate the complexities of the Feta cheese SC. This includes mapping the entire process, gaining an understanding of the technological ecosystem, identifying vulnerabilities, and identifying Critical Control Points (CCPs). This process is repeated iteratively until consensus is achieved. Consensus-building and group responses that ensue provide a forum for the collective expertise of the participants. Further iteration and refinement are subsequently implemented in order to establish and solidify expert recommendations. Subsequently, an initial assessment is conducted utilizing HACCP, VACCP, and TACCP analyses, with the respective objectives of identifying and mitigating unintentional hazards, food fraud-related vulnerabilities, and deliberate threats. Additional refinements are prompted by expert feedback, which guarantees accuracy and comprehensiveness. Revisions are made to the vulnerability assessment until consensus is reached. Consequently, on the basis of the insights obtained from HACCP, VACCP, TACCP, and the Delphi Technique, a final report and set of recommendations are formulated providing a meticulous examination of hazards, vulnerabilities, threats, CCPs, and mitigation strategies pertaining to both unintentional and deliberate risks.

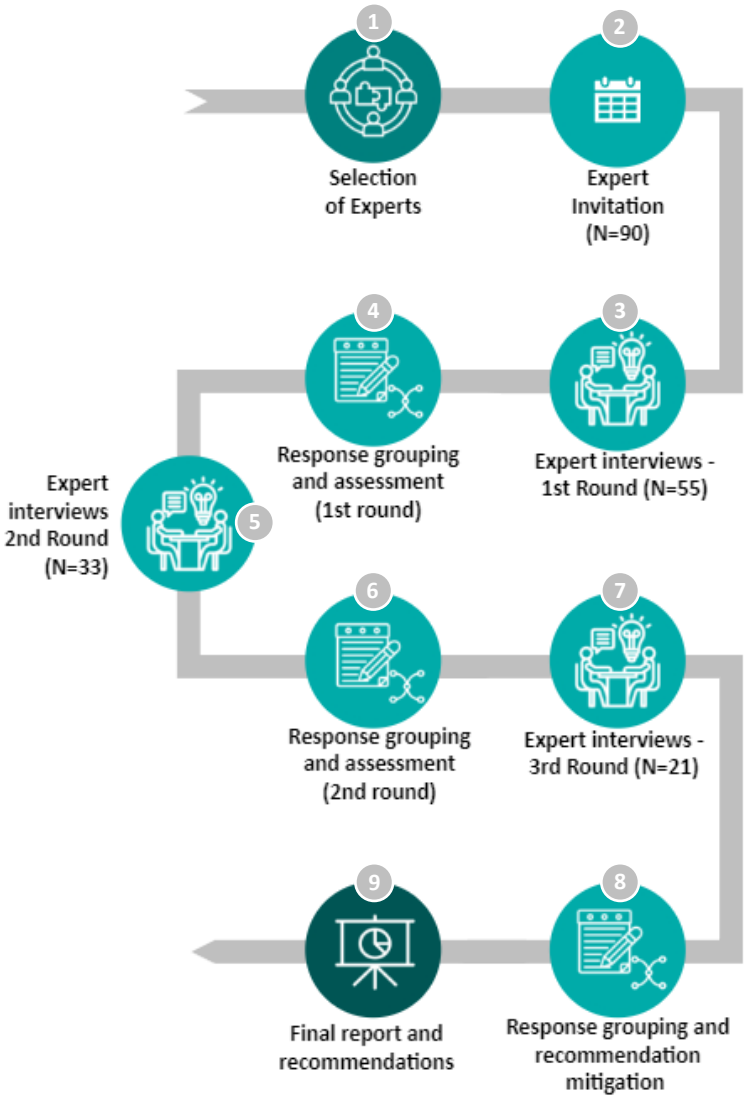

Figure 1 Steps of the methodology implemented in this study

3 Results and Discussion

Several consecutive steps comprise the PDO Feta cheese SC of "Masoutis" retailer and "Olympos" producer, each of which contributes to the product's journey from the farm to the final consumer. The procedure commences with the production of milk, which is stored in specialized iceboxes and is sourced exclusively from designated geographic regions. The collection of milk entails sample collection, pH and temperature analysis, and transport to the dairy processing facility. After pasteurization guarantees the safety of the milk, quality control and ERP system recording occur. The feta cheese manufacturing process is subject to stringent protocols, which include both pre-production and post-production quality assessments. The cheese is packaged, labeled, and placed in cold storage following the aging process. There are temperature-monitored transport and unloading inspections preceding distribution to the retailer. In the supermarket "Masoutis," where it is ultimately distributed to consumers, the PDO Feta cheese is subjected to quality control checks, temperature assessments, and visual examinations prior to being made available for purchase.

Weaknesses in the PDO Feta cheese SC of "Masoutis" retailer and "Olympos" producer, encompass low digitalization literacy among milk producers, and low level of automation processes, including

manual data entries during milk transportation raising concerns about potential unintentional errors. Additionally, authenticity control based on sampling faces challenges in ensuring the reliability of samples and information from external partners. Limited internet connectivity in rural areas where milk is collected by Olympos' Associate Transporters results in delays in updating essential SC data, impacting decision-making, traceability, and overall efficiency. Furthermore, low connectivity between the PDA software and GPS telematics poses interoperability challenges, hindering real-time monitoring crucial for data accuracy and control. What is more, scattered data generated through product distribution presents compatibility and accessibility challenges, impeding effective data utilization for decision-making, while the lack of digitalized critical information in retail stores contributes to traceability issues.

In response to these vulnerabilities, a comprehensive set of control measures is proposed. These include the implementation of training and support programs to enhance digital literacy among milk producers and the adoption of user-friendly digital tools to streamline data entry and communication. To address concerns about manual data entries during milk transportation, the suggested measures involve the implementation of automated data capture processes, such as IoT sensors in the icebox, along with the use of smart contracts to ensure immutability. Improved sampling protocols, third-party verification, and smart samplers tracking location are recommended to enhance authenticity control based on sampling. For the challenge of limited internet connectivity in rural areas, potential solutions include evaluating the feasibility of signal boosters or mobile network extenders and developing a validation system between truck drivers and producers to verify uploaded data. To tackle low connectivity issues between the PDA software and GPS telematics, the proposal includes the implementation of an integrated system to enable real-time monitoring and data synchronization. Finally, for challenges related to scattered data and lack of digitalized critical information in stores, the recommended measures involve the implementation of BT for enhanced transparency, traceability, and data integrity across the entire SC.

4 Conclusions

This research has undertaken a vulnerability assessment of FC SC of two major companies in Greece by utilizing the Delphi technique along with the design phases pf HACCP, VACCP, and TACCP. The examination of PDO Feta cheese SC identified many weaknesses and CCPs that provide possible hazards to the safety, authenticity, and excellence of this commodity. These limitations included a lack of knowledge about digital technology among milk producers, as well as difficulties with ensuring the accuracy and compatibility of data, and the centralized structure of ERP systems. Moreover, this study examined the practicality of using BT as a means of enhancing the capacity to track and disclose information inside the SC. Although BT holds significant potential in ensuring the genuineness of PDO Feta cheese, it also presents difficulties such as technological intricacies, integration problems, and regulatory factors. By identifying vulnerabilities and CCPs, stakeholders may proactively implement actions to mitigate risks and improve the resilience of this dairy product. Moreover, the possible integration of blockchain technology presents a favorable opportunity to improve transparency and traceability. However, its effective execution would need overcoming several obstacles and bolstering customer confidence.

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