INTERNATIONAL UNIVERISTY OF LOGISTICS AND TRANSPORT IN WROCLAW

DOCTORAL DISSERTATION ABSTRACT

The Quality of Unit Packaging for Selected Frozen Products and the Expectations of the Client 5.0

AUTHOR:

mgr Patrycja Bill-Józefiak

SUPERVISOR:

prof. dr hab. inż. Zenon Zamiar

CO-SUPERVISOR:

dr Marcin Pawęska, prof. MWSLiT

The development of unit packaging quality for frozen products in the context of dynamic technological, social, and consumer-driven changes presents challenges for both the food industry and the science of quality management. The aim of this dissertation was to examine how the quality of unit packaging for selected frozen products influences consumers' purchasing decisions and satisfaction in the era of Industry 5.0, while simultaneously considering technological innovations and sustainable ecological solutions. The research is interdisciplinary, combining elements of engineering, logistics, marketing, quality management, and social sciences, which enables a multidimensional analysis of packaging performance across the entire frozen product value chain.

Two primary objectives were established in this dissertation: a cognitive objective and a utilitarian objective. The cognitive objective involves identifying the key quality attributes of unit packaging that determine purchasing decisions and consumer satisfaction, as well as understanding how the development of Industry 5.0 affects the perception of packaging quality. The utilitarian objective focuses on developing recommendations for companies designing and producing unit packaging, taking into account the expectations of the "Client 5.0" and the potential implementation of advanced, innovative, and sustainable technological solutions. Specific objectives include identifying packaging functions, exploring the potential of Industry 5.0 technologies, determining attributes influencing purchasing decisions, and evaluating best practices in the design and production of unit packaging.

The central research problem, which forms the starting point of this work, is formulated as follows: how does the development of Industry 5.0 influence the quality of unit packaging for frozen products and its alignment with the expectations of the Client 5.0, considering both technological and environmental aspects? Based on this main problem, four sub-problems were formulated: analyzing packaging functions and their impact on quality attributes; evaluating technological innovations and sustainable solutions in packaging design; identifying quality attributes critical for consumer purchasing decisions; and determining best practices and innovations in the unit packaging industry.

To address the research problems, appropriate hypotheses were formulated. The main hypothesis posits that the implementation of sustainable and innovative technological solutions in the design and production of unit packaging for frozen products significantly affects perceived product quality, thereby influencing the

satisfaction and purchasing decisions of Clients 5.0. The secondary hypotheses relate to packaging functions, the impact of Industry 5.0 technologies on functional and environmental quality, the significance of quality attributes for purchasing decisions, and the role of intelligent systems, ecological materials, and innovative solutions in the unit packaging sector.

A mixed-methods methodology was adopted to achieve the research objectives, integrating quantitative and qualitative approaches. This approach enables a comprehensive and multidimensional understanding of unit packaging quality for frozen products in the context of Industry 5.0, combining consumer perspectives with industry expert insights and technological analysis. Qualitative research included semi-structured individual and group interviews (IDI and FGI), comprising three focus groups representing different consumer segments, as well as in-depth interviews with manufacturers, packaging designers, and sustainability experts. This allowed for capturing opinions, preferences, environmental awareness, and perceptions of innovation across various respondent groups, forming a foundation for identifying key quality attributes of unit packaging.

Parallel quantitative research was conducted using an online questionnaire (CAWI) targeting frozen product consumers in Poland. The sample included individuals over 16 years of age who purchase frozen products, with a total of 388 respondents, ensuring representative results and enabling statistical analysis of the relationships between packaging attributes and purchasing decisions. The questionnaire covered perceptions of traditional, active, and intelligent packaging, willingness to pay for innovative solutions, and perceptions of ecological and marketing aspects. Data analysis allowed for determining the influence of specific packaging quality attributes on Client 5.0 purchasing decisions and for verifying hypotheses regarding the role of technological innovations and sustainable solutions in building perceived product value.

A case study was also conducted to examine selected technological innovations applied to food packaging with potential for the frozen product market. The study evaluated the adaptability of these technologies to cold chain requirements, considering functional, logistical, and environmental aspects. Insights from the case study informed practical recommendations for companies, highlighting directions for the development of unit packaging in line with Industry 5.0 principles, including food safety, process digitization, and the use of environmentally friendly materials.

Analysis of the impact of unit packaging on consumer purchasing decisions revealed that key quality attributes encompass functional, protective, logistical, visual, marketing, and environmental aspects. Respondents in both qualitative and quantitative studies emphasized product storage and transport safety, package seal integrity, ease of opening, and resealability. Equally important were packaging information elements, such as label readability, quality and ecological certifications, and visual appeal, which influence first impressions during purchase. Findings indicated that Clients 5.0 increasingly expect intelligent packaging solutions, including freshness indicators, interactive digital labels, and active technologies that extend product shelf life.

Qualitative research through focus groups and individual interviews highlighted that implementing Industry 5.0 technologies in the unit packaging sector enhances not only functional quality but also sustainability. Notably, respondents emphasized the potential for using biodegradable and recyclable materials, reducing plastic consumption, and implementing real-time product quality monitoring systems. Environmental aspects were highly valued in purchasing decisions, with willingness to pay higher prices increasing when packaging combines functionality with eco-friendly solutions.

Quantitative results confirmed significant correlations between perceived packaging quality and purchase decisions. Safety, functionality, and informational attributes, combined with marketing and visual elements, generate added product value in the eyes of Clients 5.0. Consumers responded positively to technological innovations, such as active and intelligent packaging, provided their use does not complicate product handling or incur substantial additional costs. Regarding sustainability, consumers increasingly prefer products with eco-friendly packaging, and the presence of ecological certifications enhances trust and purchase willingness.

Synthesis of qualitative and quantitative findings led to diagnostic and practical conclusions. First, key quality attributes of unit packaging derive from their protective, logistical, informational, marketing, ecological, and functional roles. Second, integrating Industry 5.0 technologies, such as intelligent quality indicators, automated monitoring processes, and product information digitization, significantly increases perceived value and can provide a competitive advantage. Third, implementing sustainable solutions, including ecological materials, recyclable packaging, and waste minimization, is critical for building a brand image aligned with Client 5.0 expectations.

Developing packaging practices in the spirit of Industry 5.0 also requires a systemic approach to managing the design and production process. This includes identifying consumer needs, monitoring technological trends, verifying materials and production processes, and continuously evaluating packaging impact on purchasing decisions. Companies effectively integrating these elements achieve higher consumer satisfaction and brand loyalty. Moreover, adopting best practices—such as process standardization, automated quality testing, and collaboration with sustainability experts—supports the creation of innovative and efficient unit packaging solutions.

Findings underscore the necessity of balancing technological innovation, functional performance, and environmental impact. Successful implementation of intelligent and eco-friendly solutions requires considering consumer expectations, technological feasibility, and business economics. Identified limitations include the focus of quantitative research on Polish consumers and the purposive selection of experts, which limits generalizability. The cross-sectional nature of the study precluded assessment of long-term effects of innovative packaging adoption or the costs of implementing sustainable materials and intelligent technologies.

Based on the findings, further research is recommended to encompass broader geographical regions, diverse food product categories, and economic aspects of implementing new technologies and materials. Pilot studies in real production environments, as well as evaluations of the economic, environmental, and functional efficiency of packaging innovations, are also warranted. Advancing research toward dynamic analysis of consumer interactions with intelligent packaging, including in e-commerce channels, will better clarify the real impact of innovations on purchasing behavior and user satisfaction.

Unit packaging quality for frozen products is a multidimensional phenomenon requiring the integration of consumer perspectives, industry expertise, and technological and environmental analyses. Implementing innovative and sustainable solutions aligned with Industry 5.0 significantly influences perceived product value, consumer satisfaction, and purchasing decisions. The results unambiguously confirm the dissertation’s main hypothesis: integrating innovative technological, material, and functional solutions in the design of unit packaging for frozen products substantially enhances product appeal in the eyes of Clients 5.0. The recommendations presented in this work provide practical guidance for companies striving to achieve high-quality unit packaging while responding to market needs and environmental challenges.

Keywords:
individual packaging, frozen products, packaging excellence, Customer 5.0, Industry 5.0, technological innovations, sustainable development, eco-friendly materials, smart packaging, purchase decisions