

Food Packaging Innovation to Extend Shelf Life and Reduce Food Waste in a Leading Company in Indonesia

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ABSTRACT

This research investigates the impact of food packaging innovations on shelf life extension and food waste reduction within a leading Indonesian food company. Employing a quantitative approach, the study incorporates a diverse sample of products subjected to various packaging technologies. Descriptive and inferential statistics reveal a statistically significant increase in shelf life by 50% and a substantial reduction in food waste by 40%. Consumer surveys underscore positive perceptions, with 80% expressing a preference for sustainable packaging. Economically, a 15% reduction in costs associated with product losses supports the business case for innovative packaging. These findings contribute empirical evidence to the discourse on sustainable food systems, emphasizing the practical effectiveness and economic viability of advanced packaging technologies.

Keywords: Food Packaging, Extend Shelf Life, Reduce Food Waste, Company, Indonesia

1. INTRODUCTION

Food waste in the global food industry is a complex issue with multiple causes. Inefficient management of operations within the food industry can lead to significant food waste. For instance, in a study conducted in a nectar factory in Lima, Peru, it was found that poor management of the operating processes was a major cause of food waste. The study applied a Green Lean Six Sigma Model to reduce raw material waste, resulting in a waste reduction of 2.23% [1].

Both upstream and downstream inefficiencies in the supply chain can lead to food waste. For example, in the beef supply chain, waste can occur due to inefficiencies in the product flow from farms to retailers [2]. Certain consumer behaviors can also contribute to food waste. For instance, lack of shopping planning, impulse buying, and excessive purchasing can all lead to food waste. In the context of tourism, it was found that tourists tend to waste more food than non-tourists [3].

Restaurants are a leading source of food waste. Factors such as lack of process flow rectification and identification of critical control points can contribute to food waste in this sector. Strategies such as redesigning flexible menus, offering employee training, reducing plate sizes, implementing a forecasting system, and implementing a lean inventory management system can help reduce food waste [4]. In the global aquaculture industry, shell waste from mollusk farming can account for up to 75% of total bivalve body weight. This waste often ends up in landfills or the sea, contributing to environmental problems [5].

In this context, the development and implementation of innovative food packaging solutions is a promising avenue to address these issues. The focus of this research is on a leading Indonesian food company that is at the forefront of exploring pioneering packaging technologies to extend the shelf life of its products and, simultaneously, reduce food waste. The management of food waste in Indonesia is a complex issue that intersects with various aspects of the country's economic growth and population increase. The challenges arise at different stages of the supply chain, from production

to consumption. One aspect of this issue is the impact of population growth on supply chain performance and economic growth. Research shows that increases in population growth can decrease the supply chain performance, which in turn contributes to the economic growth of Indonesia [6]. This implies that as the population grows, the demand for food increases, putting more pressure on the supply chain to deliver and manage food effectively. If not properly managed, this could lead to an increase in food waste.

Another aspect is the role of economic growth in environmental degradation. A study conducted in the Aceh Province of Indonesia found that while economic growth does not significantly contribute to environmental degradation, a high population growth does [7]. This suggests that as the economy and population grow, there could be more pressure on the environment, potentially leading to more food waste if not properly managed. Furthermore, the willingness to pay for water management in agriculture is a significant factor in ensuring sustainable food production [8]. Water availability is crucial in agriculture, and if not properly managed, it could lead to food waste.

In terms of food consumption, a study showed that the grains are consumed by most of the subjects (99.4%), while the oily seeds are consumed by the smallest number (2.0%) [9]. This indicates that the type of food consumed can also impact food waste management. If certain types of food are consumed more than others, it could lead to an increase in the waste of those less consumed. To address this issue, selected leading food companies have turned their attention to innovative food packaging as a strategic intervention [10]–[13].

The rationale for this research lies in the dual significance of its focus. On the one hand, it addresses the pressing need for sustainable practices in the food industry, aligned with global efforts to minimize the ecological footprint of food production. On the other hand, it also recognizes the economic need for companies to optimize their operations by minimizing losses associated with perishable goods. The main objective of this study is to conduct a comprehensive quantitative analysis of the effectiveness of food packaging innovations adopted by leading food companies in Indonesia. Specifically, this study aims to measure the extent to which these innovations contribute to the extension of product shelf life and the reduction of food waste. By achieving these objectives, the research is expected to provide actionable insights that can inform industry practices, guide policy decisions, and contribute to the broader discourse on sustainable food systems.

2. LITERATURE REVIEW

2.1 Introduction to Food Packaging Innovation

Food packaging has evolved from merely serving as a protective layer to a dynamic tool that plays a pivotal role in enhancing food preservation, quality maintenance, and waste reduction [14]–[17]. Innovations in food packaging have become increasingly sophisticated, encompassing a spectrum of technologies designed to address the complex challenges of a globalized food supply chain [18], [19].

2.2 Shelf Life Extension through Packaging Innovations

A considerable body of literature underscores the critical role of innovative packaging in extending the shelf life of perishable goods [18], [19]. Advanced barrier coatings, modified atmosphere packaging (MAP), and intelligent packaging systems are among the technological

innovations contributing to the preservation of food freshness. Studies have demonstrated that an effective packaging strategy can significantly retard the rate of food deterioration, leading to increased shelf life and reduced spoilage [20], [21].

2.3 Waste Reduction Strategies in Food Packaging

Reducing food waste is a global imperative, and packaging innovations offer a strategic avenue for achieving this goal. The literature reveals that packaging solutions, such as vacuum packaging and antimicrobial agents, can mitigate microbial growth, thereby reducing the likelihood of food spoilage. Additionally, intelligent packaging that provides real-time information on product freshness empowers consumers to make informed decisions, potentially reducing over-purchasing and subsequent waste generation [15], [22]–[25].

2.4 Consumer Perception and Acceptance

An integral aspect of packaging innovation is consumer perception and acceptance. Understanding how consumers respond to changes in packaging is crucial for the successful implementation of innovative solutions. Studies have explored factors influencing consumer attitudes towards sustainable packaging, highlighting the importance of clear communication and education regarding the environmental and economic benefits of these innovations [26], [27].

2.4 Economic Implications of Food Packaging Innovations

Economically, the adoption of advanced packaging technologies can result in significant cost savings for both producers and consumers. Research indicates that the initial investment in innovative packaging solutions can be offset by reduced losses due to spoilage, improved supply chain efficiency, and enhanced brand reputation. The economic viability of such innovations is a critical consideration for businesses aiming to balance sustainability with profitability [28], [29].

2.5 Regulatory Landscape and Standardization

The literature emphasizes the need for a supportive regulatory environment and standardized guidelines to facilitate the widespread adoption of food packaging innovations. Governments and international bodies play a crucial role in setting standards for sustainable packaging materials, ensuring safety, and promoting responsible practices within the industry [30].

2.6 Global Perspectives on Food Waste Reduction

The global nature of food supply chains necessitates an examination of food packaging innovations from a global perspective. Comparative studies across different countries and regions shed light on diverse approaches to reducing food waste through packaging. Lessons learned from successful implementations worldwide can inform strategies for the Indonesian food industry [31], [32].

2.7 Gaps in Current Research

While existing literature provides valuable insights into the benefits of food packaging innovations, there remain gaps that this research seeks to address. These gaps include a limited understanding of the long-term effects of certain packaging technologies, the need for more comprehensive studies across diverse food categories, and the importance of considering cultural and contextual factors in the adoption of these innovations.

3. METHODS

This study used a quantitative research design to systematically collect, analyze, and interpret numerical data. Quantitative methods enable rigorous measurement and statistical analysis of the impact of food packaging innovations on shelf-life extension and food waste reduction. This approach ensures objectivity, replicability, and generates strong empirical evidence. The research was conducted within the facilities of a leading food company in Indonesia, chosen for its commitment to exploring innovative food packaging solutions. Access to production areas, storage facilities, and relevant personnel will be facilitated to ensure a comprehensive understanding of the packaging process.

3.1 Sampling

The population for this study consists of a range of food products manufactured and distributed by the selected company. This included a wide array of perishable products that were subjected to different packaging innovations. A stratified random sampling technique was used to ensure representation across different food categories. Stratification is based on factors such as product type, packaging innovation and distribution channel. The determination of the sample size will be guided by statistical principles, taking into account the confidence level, margin of error, and variability in the population. The aim is to obtain a representative sample that allows statistically valid conclusions, 66 samples were involved in this study.

3.2 Variables and Measurements

The independent variable in this study is the food packaging innovation introduced by the company. These cover a range of technological features, including barrier coatings, modified atmosphere packaging, and antimicrobial agents. The main dependent variables are shelf-life extension and food waste reduction. Shelf life will be measured in days or weeks, while food waste will be measured in weight or volume. Control variables are factors such as storage conditions, transportation, and handling. These will be controlled to isolate the impact of packaging innovations on shelf life and waste reduction.

3.3 Data Collection

Data will be collected using a combination of methods, including surveys, product testing, and analysis of production and waste disposal records. Surveys will collect information on consumer perceptions and preferences related to packaging innovations.

For shelf-life extension, products with new packaging will be monitored over time, and routine testing conducted to determine the point of spoilage. Waste reduction will be assessed by comparing the volume of waste before and after the use of the new packaging.

3.4 Data Validation

To ensure data accuracy and reliability, multiple data sources will be cross-verified. In addition, statistical methods such as reliability tests will be applied to assess the consistency of data collected through surveys with the help of SPSS software.

4. RESULTS AND DISCUSSION

4.1 Overview of Data Collection

The study involved a thorough data collection process involving surveys, product testing, and analysis of production and waste disposal records. A representative sample of various food products from leading companies in Indonesia was carefully selected to cover a wide range of packaging innovations.

Descriptive Statistics

The descriptive statistics reveal interesting insights. For products with new packaging innovations, the average shelf life increased from 20 days (± 2 days) to 30 days (± 3 days). In terms of food waste reduction, the average weight of discarded products decreased from 500 grams (± 50 grams) to 300 grams (± 30 grams).

Inferential Statistics

Statistical tests, including t-tests, confirmed the significance of the differences in shelf life and waste reduction. The p values for shelf-life extension and waste reduction were both below 0.05, indicating statistical significance.

Hypothesis Testing

Hypothesis testing supports the effectiveness of food packaging innovations. The null hypothesis of no significant impact on shelf life extension and food waste reduction was rejected in favor of the alternative hypothesis. The calculated t-values for both hypotheses are well beyond the critical threshold, thus reinforcing these findings.

4.2 Findings on Shelf Life Extension

The quantitative analysis showed substantial shelf life extension. Products with the new packaging innovation showed, on average, a 50% increase in shelf life compared to products without the innovation. This statistically significant result underscores the efficacy of the adopted packaging technology in maintaining product freshness.

4.3 Findings on Food Waste Reduction

The data showed a noteworthy reduction in food waste. Products featuring the new packaging innovation experienced, on average, a 40% reduction in overall food waste compared to products that did not use the innovation. This statistically significant finding highlights the practical impact of advanced packaging technologies in reducing waste generation.

4.4 Consumer Perception and Acceptance

The survey results reflected positive consumer attitudes. Around 80% of respondents expressed a preference for products with sustainable packaging, indicating a strong alignment between consumer expectations and companies' adoption of green innovations. This underscores the importance of transparent communication on environmental benefits.

4.5 Economic Implications

Economically, the findings show a favorable relationship between packaging innovation and cost savings. Despite the initial investment, reduced spoilage losses and improved supply chain efficiency result in net economic gains. Companies experience, on average, a 15% reduction in costs associated with product loss.

Discussion

The quantitative results provide strong evidence of the positive impact of food packaging innovations on shelf-life extension and food waste reduction. Numerical values support the statistical significance of these results, emphasizing the practical effectiveness of selected companies' strategic adoption of advanced packaging technologies.

A 50% extension of shelf life means a substantial increase in product availability and a potential reduction in replenishment frequency. This not only contributed to operational efficiency but also improved consumer satisfaction. A 40% reduction in food waste is simultaneously in line with global sustainability goals, demonstrating the company's commitment to responsible and environmentally conscious practices.

Consumer perception emerged as a very important factor, with survey results showing a strong preference for sustainable packaging. The numerical value of 80% highlights the majority consensus among consumers, emphasizing the importance of transparent communication to build trust and brand loyalty.

Economically, the 15% reduction in costs associated with product loss underscores the business case for investing in innovative packaging solutions. Despite the initial investment, the long-term economic benefits position this innovation as not only environmentally sustainable but also economically viable.

Limitations and Future Research:

Despite the robust findings, there are some limitations that should be considered. The duration of the study may limit insights into long-term effects, and external factors may influence the results. Future research could explore broader social impacts and scalability across different industries.

5. CONCLUSION

In conclusion, the quantitative analysis provides robust evidence of the tangible benefits derived from food packaging innovations in the selected Indonesian food company. The significant extension in shelf life and reduction in food waste underscore the practical efficacy of advanced packaging technologies. Consumer preferences align with sustainability, emphasizing the importance of transparent communication. Economically, the reduction in costs associated with product losses highlights the dual impact of these innovations on environmental sustainability and economic viability. This research contributes not only to the company's strategic initiatives but also offers a compelling case for the wider adoption of innovative packaging solutions in the global food industry, ultimately fostering more resilient and sustainable food systems.

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