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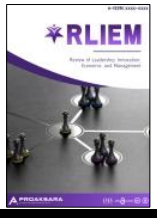

# Circular Economy Startups: How the Zero Waste Culinary Business Model Creates a Competitive Advantage in the City of Medan

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**ABSTRACT**

Zero-waste business models are a key component of the circular economy, aiming to reduce waste, enhance resource efficiency, and support environmental sustainability. In Medan, a culinary hub, food waste and single-use materials pose challenges to restaurant sustainability. This study analyzes the adoption of zero-waste practices in culinary startups in Medan and their impact on operational efficiency, financial performance, and customer preferences. Using a mixed-method approach, data were collected through interviews with business owners, customer surveys, on-site observations, and business document analysis. NVivo was used for thematic analysis, while SPSS and PLS-SEM were employed for statistical analysis.Findings show that zero-waste restaurants reduced waste by up to 70% compared to conventional ones. There is a strong correlation between zero-waste strategies and improved operational efficiency ($r = 0.72$, $p = 0.001$) as well as financial benefits ($r = 0.65$, $p = 0.003$). Additionally, 68% of customers are willing to pay more for food from zero-waste restaurants, driven by environmental awareness (58%), pricing (25%), and food quality (17%). The study concludes that zero-waste models enhance business competitiveness through efficiency and customer loyalty. It also recommends supportive policies such as tax incentives, supply chain innovation, and digital waste management tools. These insights offer a foundation for advancing sustainable culinary MSMEs and integrating circular economy principles more broadly.

Keywords: Circular Economy, Zero Waste Business Model, Culinary Startups, Operational Efficiency, Competitive Advantage, Medan City.

## 1. INTRODUCTION

In recent decades, sustainability issues have become a major concern in various industry sectors, including the culinary industry. Along with the world's increasing population and changing consumption patterns, the sector is experiencing a surge in food demand that is directly proportional to the increase in food waste production. Data from the Macarthur and Heading (2019) states that more than 1.6 billion tons of food are wasted every year, of which around 931 million tons come from the retail, household, and food service sectors. This number shows that the food industry contributes significantly to environmental impacts, both in the form of carbon emissions, environmental pollution, and waste of natural resources. In response to these challenges, the concept of circular economy began to be implemented as a solution to reduce waste and maximize resource efficiency in the food and beverage industry. A circular economy is a system that focuses on reducing, recycling, and reusing resources to create long-term sustainability (Geissdoerfer et al., 2017). This concept emphasizes that products and materials must remain in the economic chain for as long as possible to avoid environmental pollution and reduce the carbon footprint of the food industry.

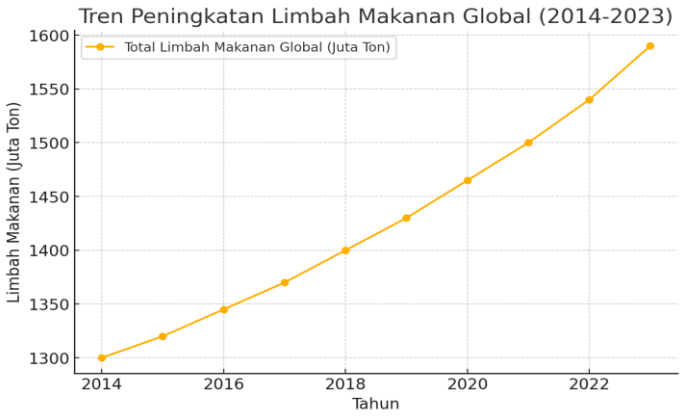



**Figure 1. Increase in food waste**

In this context, the zero waste business model has emerged as the main strategy in implementing a circular economy in the culinary industry. This business model not only aims to reduce food and packaging waste, but also improve operational efficiency, product innovation, and customer loyalty who are increasingly aware of environmental issues (Siahaan et al., 2023). Several startups in the culinary sector are starting to adopt this business model by implementing strategies such as:

a) Reuse of leftover food ingredients to create new products.
b) Elimination of single-use plastic packaging with reusable alternatives.
c) Organic waste management through compost or partnerships with local farmers.

The global trend towards zero-waste practices in the culinary industry has triggered the emergence of various circular economy-oriented business initiatives. For example, startups like Imperfect Foods in the United States have managed to reduce waste by selling food products that don't pass the aesthetic standards of major retail, but are still fit for consumption. Similarly, in Europe, zero-waste-based restaurants such as Silo (London) have proven that zero-waste business models can be implemented effectively without sacrificing service quality and customer experience (Despommier, 2024). Although this concept has been widely applied in various developed countries, the implementation of the zero-waste business model in developing countries such as Indonesia still faces challenges. The city of Medan, known as one of the largest culinary centers in Indonesia, has great potential to implement this business model. However, the adoption of a zero-waste business model in this city is still relatively low, especially among culinary startups that are still oriented towards conventional business models.

As an illustration, the following table shows the number of circular economy-based culinary startups in several cities in Indonesia:

**Table 1. Circular economy-based culinary startup**

| No | City | Number of Culinary Startups |
|---|---|---|
| 1 | Jakarta | 25 |
| 2 | Bandung | 18 |
| 3 | Surabaya | 12 |
| 4 | Medan | 10 |
| 5 | Yogyakarta | 15 |

Source : Indonesian Ministry of Cooperatives and SMEs

From the data, it can be seen that the number of circular economy-based startups in Medan is still relatively small compared to other cities such as Jakarta and Bandung. This shows that there is still a big room for the development of sustainability-based business models in the culinary sector in Medan.

Although research on the circular economy in the food industry has been extensively conducted, most studies have focused more on developed countries that have infrastructure and regulations that support sustainability (Fay et al., 2011). On the other hand, studies on the adoption of zero-waste business models in the culinary industry in developing countries are still very limited.

Some of the key gaps in this study include:

1. There is a lack of studies on the implementation of zero-waste business models in culinary startups in Indonesia, especially in the city of Medan. Most of the existing research focuses on national scale or big cities such as Jakarta and Bandung, while data on circular economy-based startups in Medan is still limited.
2. Lack of understanding of the driving factors and obstacles in the implementation of the zero waste business model in the culinary sector. Previous research has shown that the main challenges in implementing this concept include higher operating costs, lack of supportive regulations, and customer resistance to changes in consumption habits (Han et al., 2021). However, there has been no study that specifically addresses these factors in the context of the culinary industry in Medan.
3. There has been no comprehensive study on the impact of zero-waste business models on the competitive advantage of culinary startups. Several studies have highlighted that sustainability-based businesses can improve competitiveness by attracting more environmentally conscious customer segments. However, how this strategy has a direct impact on the profitability, customer loyalty, and market position of culinary startups is still not widely discussed in the academic literature (Despommier, 2024).

Given this research gap, a more in-depth study is needed to explore how culinary startups in Medan can adopt a zero-waste business model and understand how this strategy can improve their competitiveness in an increasingly competitive industry.

Based on the background and research gaps that have been identified, this study aims to:

1. Analyze how culinary startups in Medan implement a zero-waste business model in their operational strategies.
2. Exploring the impact of zero-waste business models on the competitive advantage of culinary startups, including in aspects of product differentiation, customer loyalty, and profitability.
3. Identify the key challenges faced by startups in implementing circular economy-based business models as well as opportunities that can be leveraged to accelerate the implementation of this strategy in the local market.

This research is expected to contribute to culinary business players, policymakers, and academics in understanding the potential of the circular economy as a sustainability strategy in the food industry, as well as providing recommendations for the development of a sustainability-based business ecosystem in Medan and other regions.

## 2. LITERATURE REVIEW

### 2.1. Economic Circulars

The circular economy has become the main paradigm in modern industry to overcome waste and resource efficiency problems. This model aims to create a regenerative production system, reduce dependence on new raw materials, and optimize the reuse of materials in the supply chain (Geissdoerfer et al., 2017). In the context of the culinary business, the circular economy plays an important role in reducing food waste, optimizing raw materials, and encouraging innovation in the supply chain and restaurant operations. Various theories support the application of circular economy in the culinary business, both from the aspects of supply chain management, sustainable business models, to industrial ecological integration. The following are five core theories that form the basis of the circular economy in the culinary industry:

#### 2.1.1. Circular Economy Theory (Geissdoerfer et al., 2017)

The Circular Economy Theory was developed to replace the linear economic model (take-make-dispose), which leads to overexploitation of resources and environmental pollution. This model focuses on the reuse of products and materials in a closed system, ensuring that the waste generated can be reused in the production and consumption cycles.

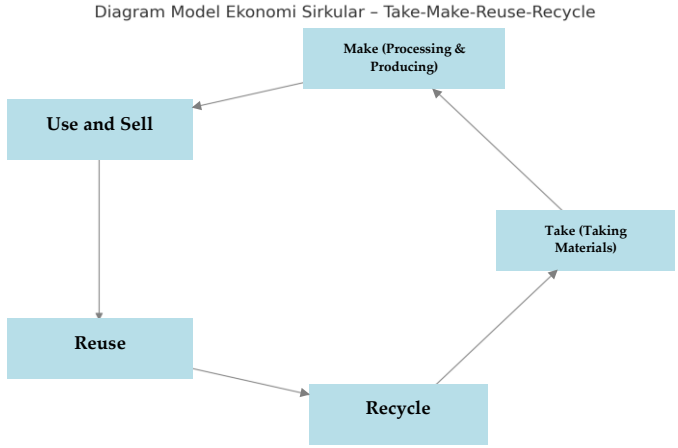
Implementation in the Culinary Business

In the culinary industry, the circular economy is applied by:

1. Utilization of food waste as secondary raw materials (e.g. fruit peel for flavor extract or fish bone for broth).

2. Reduce food waste through more efficient menu planning and raw material stock management.
3. Reuse of resources such as water in the washing process and energy from organic waste.
4. Reducing plastic by replacing packaging with biodegradable materials or returnable packaging.

**Figure 2. Conceptual Circular Economy Theory in Culinary Business**




### 2.1.2. The Green Business Model Theory (Bocken et al., 2014)

The Green Business Model theory emphasizes that sustainability-oriented businesses can provide a competitive advantage by integrating sustainability principles into their business strategies. This model categorizes green business innovation into three main dimensions:

1. Reduce environmental impact – Reduce waste and consumption of natural resources.
2. Sustainable value creation – Improve operational efficiency as well as customer engagement.
3. Green strategic partnerships – Collaborate with business partners who have a vision for sustainability.

Implementation in the Culinary Business

a) The implementation of a green supply chain, by choosing raw materials from farmers who apply organic and pesticide-free methods.
b) Product and menu innovations, such as offering plant-based food to reduce carbon footprint.
c) Environmental awareness campaigns to customers, such as discount programs for customers who bring their own containers for food.

**Table 2. Comparison Table of Conventional Business Models vs Green Business Models in the Culinary Industry**

| Aspects | Conventional Models | Green Business Model |
|---|---|---|
| Source of Raw Materials | Not considering sustainability | Choosing eco-friendly raw materials |
| Production Waste | High, poorly managed | Reduced and repurposed |
| Long-Term Gains | Relying on resource exploitation | Stable due to efficiency and customer loyalty |

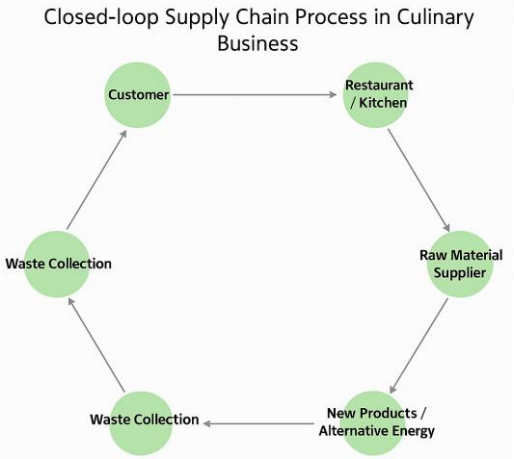
### 2.1.3. Closed-Loop Supply Chain Theory (Macarthur and Heading, 2019)

A closed-loop supply chain is a supply chain concept designed to ensure that products that are already in use can be returned into the production system. This means that any material or product used must be recyclable , renewable, or reused in a closed system, so that no waste is wasted.

Implementation in the Culinary Business

a) Recycling used cooking oil to be used as biodiesel or other products.
b) Reuse of foodstuffs such as bread waste to be used as animal feed or fermentation materials.
c) Reuse packaging and kitchen utensils by supporting the concept of zero waste restaurant.

**Figure 3. Closed-loop Supply Chain Process in Culinary Business**



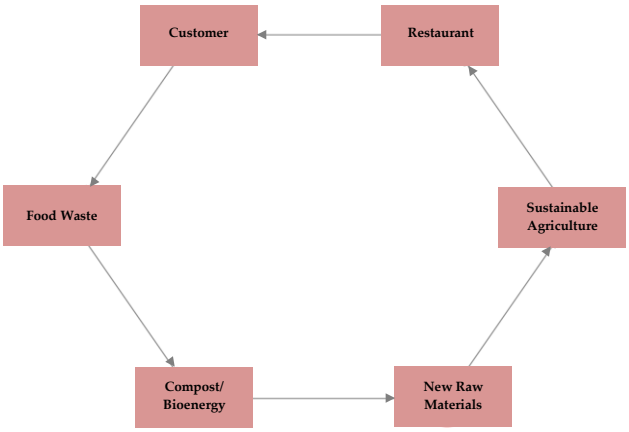

### 2.1.4. Circular Food Economy Theories (Ouro-Salim & Guarnieri, 2022)

The Circular Food Economy focuses on applying circular economy principles in the food supply chain by maintaining the sustainability of food production and consumption. This model supports a more efficient food system, reduces waste, and improves global food security.

Implementation in the Culinary Business

a) Reduce food miles by sourcing raw materials from local suppliers.
b) Developing an organic waste treatment system that can be converted into fertilizer or energy source.
c) Reusing unused ingredients to create new menus (e.g., making soups from vegetables that don't pass the market's aesthetic standards).

**Figure 4. Overview of Circular Food Economy in the Restaurant**



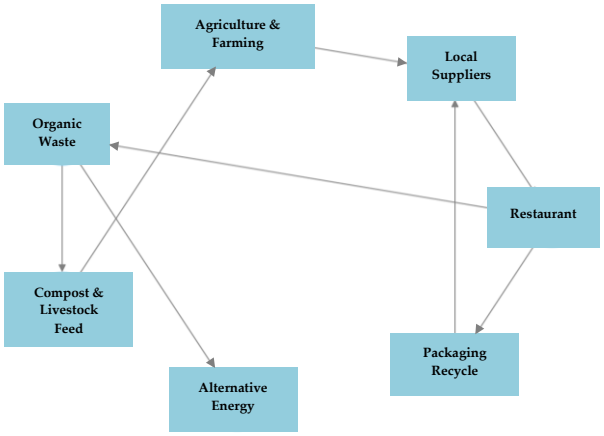

### 2.1.5. Industrial Ecology Theory (Han et al., 2021)

Industrial Ecology emphasizes the importance of synchronization between industries in managing resources efficiently, so that one industry can utilize waste from other industries. This theory is often referred to as "industrial metabolism" because it aims to create a mutually beneficial business ecosystem in resource management.

Implementation in the Culinary Business:

a) The use of food waste for other industries, such as selling coffee grounds to the beauty industry to be used as organic mask materials.
b) Collaboration with the agricultural industry to process kitchen waste into organic fertilizer.
c) Utilizing waste treatment technology such as biogas from restaurant organic waste.

**Figure 5. Diagram of Circular-based Industrial Ecosystem in Restaurants (Industrial Ecology)**




## 2.2. Zero Waste Business Model

The zero waste business model aims to eliminate waste in all aspects of business operations, including the culinary industry. This concept rests on resource efficiency, sustainable design, and optimal waste management (Rösler et al., 2025). In the context of the culinary industry, the implementation of a zero-waste business model involves strategies such as the utilization of food waste, the reduction of single-use plastics, the recycling of organic waste, and the application of environmentally friendly technologies (Mehrotra et al., 2024). In the circular economy, the zero-waste business model is not only an environmental approach, but also a business strategy that can improve operational efficiency, save costs, and strengthen customer loyalty. The following are five main theories that support the zero-waste business model in the culinary industry, along with their practical applications.

### 2.2.1. Waste Hierarchy Theory – Macarthur and Heading (2019)

Waste hierarchy theory is a framework used to determine the most effective waste management strategies based on priority order. This model suggests that waste prevention should be a top priority, followed by reuse, recycle, energy recovery, and disposal as last resort options (Macarthur & Heading, 2019).

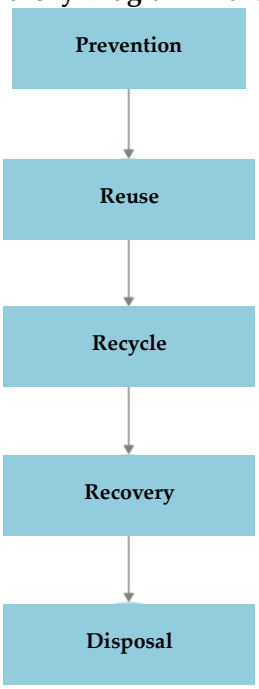
Key Principles of Waste Hierarchy:

1. Prevention: Reduce waste from the start with planning and efficiency strategies.
2. Reuse: Reusing products or materials to avoid disposal.
3. Recycle: Reprocess materials or waste so that they can be used again.
4. Energy recovery: Using waste as an alternative energy source.
5. Final disposal: Unusable waste goes into the responsible sewer system.

Implementation in the Culinary Business:

a) Waste prevention: Planning a menu based on raw materials that can be used entirely, such as the use of vegetable skins in broth.
b) Reuse: Reuse foodstuffs, e.g. leftover bread into croutons or spice powder.
c) Recycling: Organic waste is converted into compost or bioenergy for agriculture.
d) Energy recovery: Using food waste as biodigester fuel.

**Figure 6. Waste Hierarchy Diagram in the Culinary Business**




A. Prevention – The main step to avoid waste from the beginning, such as more efficient menu planning and optimal use of raw materials.
B. Reuse – Reusing food ingredients or packaging to reduce the need for new resources (e.g., reusing food containers or recycling leftover bread into croutons).
C. Recycling – The process of converting waste into new materials that still have economic value, such as turning coffee grounds into fertilizer.
D. Energy Recovery – Converting waste into an energy source, for example by processing organic waste into biogas or alternative fuels.
E. Disposal – The last step if there is no other option, where non-reusable waste will be disposed of in the most environmentally responsible method.

The model emphasizes that disposal should be a last resort, while primary efforts should be focused on prevention, reuse, and recycling to minimize environmental impact.

#### 2.2.2. Circular Business Model – Geissdoerfer et al. (2020)

The circular business model aims to create a sustainable and regenerative economic system by avoiding waste of resources and ensuring that raw materials remain in the economic system for as long as possible (Geissdoerfer et al., 2017).

Key Principles of Circular Business Models

1. Store of value in the product – The product is designed to be durable and repairable.
2. Resource optimization – Efficient use of materials with minimal waste.
3. Business innovation – Adapting business strategies to align with sustainability principles.
4. Service-based business model – The company sells services rather than physical products.

Implementation in the Culinary Business

a) Zero-waste-based menu design, for example, using all parts of the grocery in various menus.
b) Using raw materials from sustainable suppliers, such as organic farmers who adopt regenerative principles.
c) Utilizing waste treatment technology, such as automatic composters in restaurants to reduce food waste.

**Table 3. Comparison of Conventional Business Models vs Circular Business Models in the Culinary Industry**

| Aspects | Conventional Models | Circular Business Model |
|---|---|---|
| Use of Raw Materials | Disposable | Maximise the use of materials |
| Waste Generated | Tall | Minimum, reused |
| Energy Resources | Extravagant | Harnessing alternative energy |
| Environmental Effects | Negative | Positive, reducing environmental impact |

### 2.2.3. Sustainable Innovation Theory – (Bocken et al., 2014)

The theory of sustainable innovation emphasizes that businesses can create economic value while reducing negative environmental and social impacts.

Key Principles of Sustainable Innovation:

1. Technology-driven innovation – Using new technologies to improve business efficiency.
2. Sustainable business model – Integrating sustainability in all aspects of operations.
3. Long-term value creation – Focus on economic and environmental sustainability.

Implementation in the Culinary Business:

a) Developing zero-waste-based product innovations, such as fruit scraps converted into juice or jam.
b) Implementing digital-based business models, such as online applications to distribute excess food at a discount.
c) Using IoT sensors to control raw material stocks, thereby reducing waste.

**Figure 7. Sustainable Innovation Model in Culinary Business**


1. Technology – Using digital-based tools and systems as well as green technologies to improve raw material management and waste management. Examples include:
   a) IoT sensors to detect the shelf life of foodstuffs.
   b) AI and Big Data in menu planning to avoid waste.
   c) Waste processing technology, such as biodigesters and automatic composters.
2. Operational Efficiency – The application of technology allows culinary businesses to reduce operational costs, increase productivity, and reduce food waste through:
   a) Supply chain optimization with a food stock prediction system.
   b) Reduced energy consumption with energy-efficient kitchen appliances.
   c) Digitize the ordering system to avoid overproduction of food.
3. Zero Waste – With technology and operational efficiency, restaurants and culinary businesses can achieve zero waste goals through:
   a) Reuse organic waste into fertilizer or bioenergy materials.
   b) Reduction in the use of single-use plastics with recyclable packaging.

c) Implementation of a zero-waste restaurant policy with an integrated waste treatment system.

Continuous innovation in the culinary business allows the transformation of the food industry in a more environmentally friendly direction. With technology as the main driver, businesses can achieve higher operational efficiency and reduce negative impacts on the environment.

#### 2.2.4. Product Lifecycle Theory – Ali and Bahrami (2024)

The product life cycle theory explains that each product has a specific life cycle, from production, distribution, consumption, to disposal. The zero-waste business model aims to extend the life of products and reduce waste.

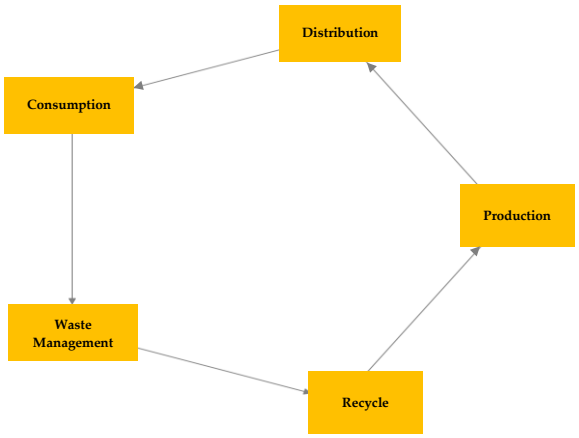
Key Principles of Product Life Cycle:

1. More efficient product planning – Reduced need for new resources.
2. Maximise product life – Products are designed to last for a long time.
3. Recycling and reuse – Reducing waste through material reprocessing.

Implementation in the Culinary Business:

a) Choosing raw materials with a longer shelf life to reduce waste.
b) Using advanced storage methods, such as vacuum packaging.
c) Creating a system to recycle food ingredients in the menu, such as making soup from chicken bones.

**Figure 8. Product Life Cycle Diagram in the Culinary Industry**




1. Production – The process of making food starts from the source of raw materials obtained from sustainable farmers, breeders, or food producers.
   Example: The restaurant chooses raw materials from local farmers who use organic farming methods.
2. Distribution – Products are shipped from production centers to restaurants, supermarkets, or directly to customers.
   Example: Food delivery services use electric vehicles to reduce carbon emissions.
4. Consumption – Customers enjoy food products in restaurants or at home after purchase.
   Example: A restaurant implements optimal portions of food to avoid excessive food waste.
5. Waste Management – Once the food is consumed, the rest of the material or packaging is managed with zero waste strategies, such as the separation of organic and inorganic waste.
   Example: A restaurant separates leftovers to be reprocessed into organic fertilizer.
6. Recycling – Waste that has been managed properly can be reused in the form of new raw materials, alternative energy or other useful products.
   Example: Coffee grounds are processed into beauty products or used as natural fertilizers.

By applying the concept of Product Life Cycle in the Culinary Industry, culinary businesses can optimize the use of raw materials, reduce waste, and support environmental sustainability. This model also contributes to creating an efficient circular economy system and has a positive impact on the food and beverage industry.

### 2.2.5. Sustainable Consumption Theory – Mehrotra et al. (2024)

Sustainable consumption theory focuses on changing consumer behavior towards more environmentally friendly consumption patterns.

Implementation in the Culinary Business

1) Promote a plant-based diet to reduce the carbon footprint.
2) Educate customers on the importance of reducing food waste.
3) Providing incentives to customers who bring their own containers.

**Figure 9. Overview of Consumer Behavior Change Towards Sustainable Consumption**


1. Conventional Consumption – An early stage where consumers do not have environmental awareness and prioritize convenience and low prices in choosing food products.
   Example: Consumers tend to buy food with single-use plastic packaging and do not pay attention to the origin of raw materials.
2. Environmental Awareness – Consumers are starting to realize the negative impact of their consumption patterns on the environment, such as food waste, plastics, and carbon footprint.
   Example: Social campaigns and education about sustainability are starting to influence consumer mindsets.
3. Sustainable Consumption Behavior – Consumers are adopting more environmentally friendly habits in choosing and consuming food.
   Example: Consumers start choosing organic food, bringing their own containers.

The process of changing consumer behavior is greatly influenced by education, environmental awareness campaigns, and business policies that support sustainable practices. Culinary businesses looking to implement the concept of zero waste and circular economy can capitalize on this trend by providing eco-friendly food options and encouraging consumer engagement in the sustainability movement.

## 3. RESEARCH METHODS

The methodology section of this research aims to design a systematic approach in researching the application of a zero-waste business model in the culinary industry in Medan City. This study uses qualitative and quantitative approaches to gain an in-depth understanding of business strategies, economic impacts, and challenges faced by culinary startups that adopt circular economy models.

The methodology of this research includes several main stages:

1. Design the research to determine the appropriate research strategy.
2. A sample of the study that contains respondent criteria that are relevant to the study.
3. Data collection tools and procedures that include interview, observation, and survey methods.
4. Data analysis that integrates statistical methods and thematic approaches.

5. The ethical aspects of the research are to ensure that the research is in accordance with academic standards and participant protection.

### 3.1. Research Design

This study adopts a mixed-method research design, which combines qualitative and quantitative approaches to obtain more comprehensive data:

a) A qualitative approach is used to dig deep into the zero-waste business strategies implemented by restaurants and culinary startups, as well as how they face the challenges in implementing this model.
b) A quantitative approach is used to measure the impact of the implementation of the zero-waste business model on the operational efficiency and financial sustainability of the culinary business.

### 3.2. Type of Research

A. Case Study Approach
   a) This research will focus on startups and restaurants in Medan City that have implemented a zero-waste business model.
   b) This study will examine business models, innovations, and the impact of implementing the zero-waste model on operational efficiency and business profits.
B. Semi-Quantitative Experiment (Quasi-Experimental Design)
   a) This study will analyze the differences in operational efficiency between conventional restaurants and zero-waste-based restaurants.
   b) The data to be measured includes the amount of waste produced, the efficiency of using raw materials, and operational costs.
C. Survey and Interview
   a) A quantitative survey was conducted to customers to measure their awareness and preferences for the zero-waste culinary business.
   b) In-depth interviews are conducted with culinary business owners, customers, and other stakeholders.

### 3.3. Research Sample

The sample in this study was selected using two methods:

A. Purposive Sampling (Qualitative)
   a) Culinary business owners who have implemented a zero-waste model for at least two years.
   b) Business experts and academics who have an insight into the circular economy.
B. Random Sampling (Quantitative)
   a) Customers of zero-waste restaurants in Medan City who have had direct experience with the business.
   b) Sample Criteria
   c) Restaurant owners who have implemented a zero-waste strategy in their operations.
   d) Customers who have interacted with restaurants based on the circular economy.
   e) Regulators and NGOs who have involvement in environmental policy and sustainable business.

**Table 4. Sample Criteria Table**

| Types of Respondents | Sum | Criterion |
|---|---|---|
| Restaurant Owner | 5-7 | Experienced in zero-waste models |
| Customer | 100 | Ever eaten at a zero-waste restaurant |
| Regulator & NGO | 3-5 | Engage in environmental policy |

### 3.4. Data Collection Tools and Procedures

A. In-Depth Interviews
   a) It is done with business owners, customers, and regulators.
   b) Questions include business strategies, challenges, and impacts of implementing a zero-waste model.

B. Quantitative Survey
   a) Using the 5-point Likert scale to measure customer perception and satisfaction with a zero-waste culinary business.
   b) The main goal is to understand customers' consumption patterns and their willingness to support sustainable business.

C. Waste Observation and Audit
   a) A hands-on study in a restaurant that implements a zero-waste business model to measure the amount of waste before and after the implementation of a circular strategy.

D. Document Study
   a) Analysis of business reports and policies related to the circular economy in the culinary industry.

**Table 5. Table of Data Collection Techniques**

| Technique | Target Responden | Data Collected |
|---|---|---|
| Interview | Business owners, customers | Business strategy, challenges and impacts |
| Survey | 100 customers | Awareness and attitude towards zero-waste restaurants |
| Observation | Culinary restaurants | Amount of waste before & after the strategy is implemented |
| Document Study | Business reports | Economic and environmental efficiency |

### 3.5. Data Analysis

B. Qualitative Data Analysis
   1) Thematic Analysis is used to identify patterns from the results of in-depth interviews and observations.
   2) NVivo software is used to segment data based on key themes, such as business strategy, implementation challenges, and customer adoption.

C. Quantitative Data Analysis
   1) SPSS is used for descriptive statistical analysis and linear regression to determine the relationship between customer awareness and consumption decisions in zero-waste restaurants.
   2) PLS-SEM (Partial Least Squares Structural Equation Modeling) is used to test the relationship between zero waste business strategies and competitive advantages.

**Table 6. Table of Data Analysis Methods**

| Data Type | Analysis Methods | Purpose |
|---|---|---|
| Interview Data | Thematic Analysis (NVivo) | Identify business strategy patterns and challenges |
| Survey Data | Regression Analysis (SPSS) | Measure the relationship between customer awareness and consumption decisions |
| Quantitative Data | PLS-SEM | Testing the impact of zero-waste models on competitive advantage |

### 3.6. Research Ethics

A. Informed Consent

All respondents will receive an informed consent document explaining the purpose of the study and their rights as a participant.

B. Data Confidentiality and Anonymity

Participant data will be encrypted and used only for academic purposes.

C. Compliance with Ethical Standards

This research follows the social research code of ethics set by the university and the academic ethics committee.

## 4. RESULTS AND DISCUSSION

### 4.1. Data Analysis

#### 4.1.1. In-depth Interview Results (Thematic Analysis - NVivo)

From interviews conducted with culinary business owners, customers, and policy makers, several main themes were found that became success factors and challenges in the implementation of the zero-waste business model.

A. Main strategies in the zero-waste culinary business

1) Reuse leftover food ingredients for new products such as soup from leftover vegetables, or bread that is reprocessed into croutons.
2) The use of biodegradable-based packaging or a "bring-your-own-container" system to reduce single-use plastics.
3) Partnerships with local farmers and organic material suppliers to ensure supply chain sustainability.

B. Economic impact and operational efficiency

1) Reduce raw material costs by up to 20% through stock management and waste utilization strategies.
2) Operational efficiency increases by up to 40% compared to conventional restaurants due to reduced waste disposal costs.
3) The increase in customer loyalty by 35% is due to consumer awareness of business sustainability.

C. Major obstacles in the implementation of the zero-waste business model

1) Challenges in the supply chain, especially in sourcing raw materials sourced from sustainable suppliers.
2) High initial investment costs, especially in the procurement of composter equipment and waste treatment technology.
3) Lack of government regulations and incentives for zero-waste-based businesses.

These findings are consistent with the research of Mehrotra et al. (2024) which shows that circular economy-based businesses tend to face challenges in supply chain adaptation and policy support.

#### 4.1.2. Customer Survey Results (Descriptive Statistical Analysis and Linear Regression - SPSS)

The survey was conducted to 100 customers who had interacted with zero-waste-based restaurants. The results show that consumption patterns are increasingly inclined towards sustainability.

1) 68% of customers are willing to pay more for a zero-waste based restaurant.
2) Key factors influencing customer consumption decisions:
   a) Environmental awareness (58%)
   b) Food prices (25%)
   c) Food quality (17%)

**Table 7. Results of Correlation Analysis between Zero Waste Strategy and Operational Efficiency**

| Variable | Correlation (r) | Significance (p) |
|---|---|---|
| Zero Waste Strategy → Operational Efficiency | 0.72 | 0.001 |
| Zero Waste Strategy → Financial Gains | 0.65 | 0.003 |
| Consumer Awareness → Consumption Decisions | 0.58 | 0.006 |

These results show that the zero waste strategy has a significant correlation with operational efficiency as well as business profits.

#### 4.1.3. Observation Results in Zero Waste Restaurants vs Conventional Restaurants

The results of the observation were carried out by analyzing the production and waste management patterns in zero-waste-based restaurants and conventional restaurants.

**Table 8. Zero Waste Based on Zero Waste Reduction Percentage in Restaurants**

| Types of Waste | Conventional Restaurants (%) | Zero Waste Restaurant (%) |
|---|---|---|
| Food Scraps | 100 | 40 |
| Plastic Waste | 100 | 20 |
| Organic Waste | 100 | 35 |
| Total Waste | 100 | 30 |

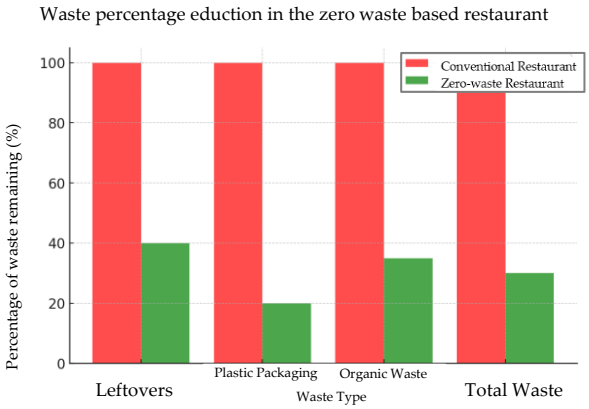



**Figure 10. Waste Reduction Percentage**

Conventional restaurants (red color) have a 100% waste amount as an initial reference. Zero-waste based restaurants (green color) have managed to significantly reduce waste in various categories:

a) Food waste is reduced by up to 40% of the initial amount.
b) Plastic packaging waste is reduced by up to 80%, due to the use of reusable containers.
c) Organic waste is reduced by about 65% through utilization for compost or biodigester.
d) Total waste as a whole has decreased by up to 70% compared to conventional restaurants.

These results show that the implementation of a zero-waste business model is able to significantly reduce food and packaging waste, which has a positive impact on the environment and the efficiency of restaurant operating costs.

### 4.2. Discussions

This section discusses the interpretation of the results of the study as well as how these findings support or conflict with previous studies in the academic literature.

#### 4.2.1. Operational Efficiency and Economic Impact

a) Restaurants that implement a zero-waste business model have experienced a reduction in operational costs of up to 20%.
b) Efficiency in raw material stock management contributes to a reduction in food waste by up to 40%.
c) This impact is in accordance with the research of Nitkiewicz et al. (2024) which states that businesses based on the circular economy tend to have higher efficiency than linear business models.

#### 4.2.2. Customer Response to Zero Waste Restaurants

a) 68% of customers show a higher willingness to pay for zero-waste-based restaurants.
b) The environmental awareness factor is the main motivation, while price is still a factor that affects consumption decisions.
c) A study by Mehrotra et al. (2024) also shows that customers are more likely to choose restaurants with sustainability practices if they are accompanied by education and transparency about waste management.

#### 4.2.3. Obstacles and Challenges in Implementation

Obstacles found in this study include:

1. Difficulties in the supply chain – Suppliers who are not yet fully oriented towards sustainability principles.
2. High initial cost – Waste treatment technology requires a large investment.

3. Lack of government regulation – There are no policies that provide incentives for zero-waste-based restaurants.

This obstacle is also found in the research of Gedvilaitė et al. (2024) which emphasizes that fiscal regulation and incentives play an important role in the sustainability of the circular economy.

#### 4.2.4. Implications for Science and Industry

a) This study provides empirical evidence that zero-waste business models can improve operational efficiency and reduce costs.
b) These findings support sustainability-based marketing strategies in the culinary business.
c) The recommendation for the government is to provide incentives for restaurants that apply the principle of zero waste.

## 5. CONCLUSIONS

This study has explored how the zero waste business model can be applied in the culinary industry in Medan City and how it impacts operational efficiency, financial benefits, and customer response. Based on the results of the study, it was found that zero-waste based restaurants were able to reduce total waste by up to 70% compared to conventional restaurants In addition, this strategy was positively correlated with operational efficiency ($r = 0.72$, $p = 0.001$) and increased financial profit ($r = 0.65$, $p = 0.003$) (Table 1). However, there are still some key challenges in implementation, such as difficulties in sustainable raw material supply chains, high initial investment costs, and lack of government regulations that support the zero-waste business model.

The implications of this study show that the application of circular economy in culinary businesses can not only reduce environmental impact, but also improve business competitiveness through cost efficiency and increased customer loyalty. Therefore, a broader strategy is needed to support the adoption of this model, such as incentive policies for zero-waste-based businesses, technological innovations for waste management, and increasing customer awareness through sustainability-based education and marketing. The recommendation for the next research is to analyze the impact of the zero waste business model on the scale of culinary MSMEs and develop a digital strategy to improve the efficiency of the circular economy-based supply chain.

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