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# Risk Management Model For Food Waste Reduction Among Restaurants

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***Abstract***

*The aim of this study is to examine and implement a food waste risk management model for food waste reduction among the Malaysian restaurants in Seri Iskandar, Perak. The food waste risk management model was segmented into food waste awareness, staff training, menu planning, and food waste monitoring. The study utilized a quantitative research approach and collected data from 190 Malaysian restaurants by incorporating the Five-point Likert scale. For data analysis, this study utilized the Smart PLS4.0. The findings show that the developed risk management model significantly and positively impacts food waste reduction. The study's findings can assist in fostering risk management strategies to lower food waste reduction, which further leads to lower food procurement and disposal costs.*

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## Introduction

Food waste is a pressing global issue with significant environmental, economic, and social implications. According to the United Nations Food and Agriculture Organization (FAO), approximately one-third of all food which produce for human consumption, is wasted annually (L. Brennan et al., 2021). This waste contributes to greenhouse gas emissions, deforestation, water scarcity, and other environmental problems. Restaurants have been recognized as the major contributors to food waste due to factors such as excessive portion sizes, overproduction, inefficient inventory management, and inadequate food handling practices (Dhir et al., 2020). Seri Iskandar, a town in Perak, Malaysia, is known for its vibrant culinary scene and many restaurants. Despite being a thriving culinary destination, the restaurant sector in Seri Iskandar faces challenges related to inefficient food waste management practices, leading to substantial wastage of resources and negative environmental impacts. The primary issues contributing to food waste in restaurants include overproduction, improper food storage,

inadequate inventory management, and lack of awareness and training among staff members (Teigiserova et al., 2020).

These factors result in excessive food spoilage, expiration of perishable items, and discarded leftovers. The consequences of food waste are multifaceted. First, it leads to significant economic losses for restaurant owners and operators, who must bear the costs of purchasing, preparing, and disposing of wasted food (Chen et al., 2020). Second, food waste contributes to environmental degradation, as the decomposition of organic waste in landfills releases methane, a potent greenhouse gas (Jeswani et al., 2021). The existing food waste management practices in Seri Iskandar's restaurants are often reactive and lack from a systematic approach to address the root causes of food waste. Therefore, there is a pressing need to develop a food waste risk management model specifically designed for restaurants in Seri Iskandar. Therefore, this study aims to examine the impact of food waste risk management on food waste reduction among Malaysian restaurants in Seri Iskandar. The outcomes of this study will provide valuable insights for restaurants in Seri Iskandar to implement practical food waste reduction strategies, leading to improved sustainability practices, reduced costs, and minimized environmental impact.

**Literature Review**

The literature review highlights the critical role of risk management strategies in reducing food waste among restaurants. Food waste monitoring, staff training, menu planning, and food waste awareness have been identified as effective factors in food waste reduction (Bhargava et al., 2020). However, it is essential to recognize each restaurant's context and specific challenges which may require tailored approaches to maximize the effectiveness of these risk management strategies. By adopting a comprehensive approach to food waste, restaurants can play a crucial role in achieving a more sustainable and environmentally responsible food system. Promoting food waste awareness among the restaurant staff and customers can foster a culture of waste reduction (Kapoor et al., 2021). Proper staff training is crucial in promoting sustainable practices and waste reduction in restaurants (A. Brennan et al., 2021; Dhir et al., 2020). Menu planning has a significant influence on food waste generation in restaurants. (Martin-Rios et al., 2020). Food waste monitoring systematically tracks and measures food waste generated during restaurant operations. By implementing waste monitoring systems, restaurants can identify areas of high waste generation, pinpoint specific food items that contribute most to waste, and devise targeted strategies for waste reduction. Previous studies have shown that effective food waste monitoring can significantly reduce overall food waste (Amicarelli et al., 2021; Borg et al., 2022). Therefore, this study aims to see the causal relationship between these variables as a risk management mode and food reduction.

**Conceptual Framework**

This study developed the conceptual framework to strengthen the impact of food waste risk management on food waste reduction. The independent variables, which are the primary variables include food waste awareness, staff training, menu planning, and food waste monitoring. Whereas the dependent variable is food waste reduction. Specifics regarding the conceptual framework are illustrated in Figure 1.

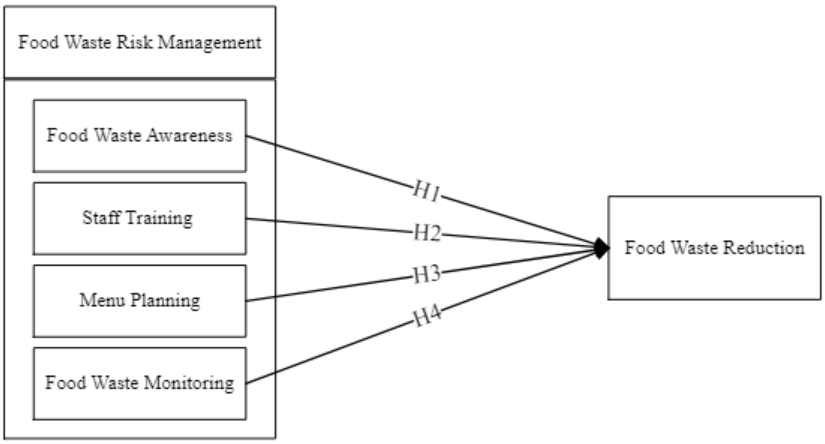


Figure 1: Conceptual Framework of the study

**Hypotheses Development**

Based on the conceptual framework, this study formulated a total of four hypotheses as follows:

$H_1$. Food waste awareness will significantly reduce food waste.

$H_2$. Staff training will significantly reduce food waste.

$H_3$. Menu planning will significantly reduce food waste.

$H_4$. Food waste monitoring will significantly reduce food waste among Restaurants.

**Research Methods**

The quantitative methodology is used to investigate a food waste risk management model to reduce food waste in restaurants in Seri Iskandar. Purposive sampling was utilized to select the restaurants for the study. This method ensures that restaurants of different sizes, types, and operational practices are included in the sample to make it representative. The sample size is determined through statistical power analysis. Data is collected through a structured questionnaire by incorporating the Five-point Likert scale. The gathered data is then analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS4.0 software. In PLS-SEM, the measurement model and structural model were assessed. The reliability and validity of the constructs are evaluated in the measurement model. The structural model is analyzed to test the research hypotheses and investigate the causal connections between the independent and dependent variables.

**Results**

**Demographic Characteristics of the Respondents**

To examine the demographic characteristics of the participants, descriptive statistics were employed. This section explains the four (04) important demographic aspects: 1) gender, 2) monthly income, 3) restaurant origination, and 4) type of restaurant, gathering data on these demographic characteristics will allow us to perform subgroup analyses and assess whether the effectiveness of the Food Waste Risk Management Model varies based on gender, income levels, restaurant origination, and type of restaurant.

**Respondents' Diversity Information**

Table 1 shows that 114 respondents were identified as male, which is 60% of the total 190 respondents. 76 respondents identified as female, which is 40% of the total number of respondents. This information can be used to understand the diversity of the respondents and how their gender may have influenced their views on food waste risk management.

Table 1: Statistic of Respondent Diversity

| Characteristic | Classification | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Gender | Male | 114 | 60 |
| | Female | 76 | 40 |
| | Total | 190 | 100 |

**Respondents' Monthly Income**

Table 2 shows the largest group (42.6%) has a monthly income of between RM0 and RM5000. The next largest group (27.4%) has a monthly income of between RM5001 and RM10,000. The remaining 30% of people are spread across the other three income ranges.

Table 2: Statistics of Respondents' Monthly Income (RM)

| Characteristic | Classification | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Monthly Income (RM) | 0 – 5000 | 81 | 42.6 |
| | 5001 – 10,000 | 52 | 27.4 |
| | 10,001 – 15,000 | 25 | 13.2 |
| | 15,001 – 20,000 | 18 | 9.5 |
| | 21,000 and above | 14 | 7.4 |
| | Total | 190 | 100 |

**Respondents' Restaurant Origination**

Table 3 shows the largest group (33.2%) were found between 0 and 5 years ago. This means that almost one-third of the restaurants in this group are relatively new. The next largest group (31.6%) was founded 6 and 10 years ago. The remaining 35.2% of restaurants were founded 11 years ago or more. This suggests that the restaurant industry in Seri Iskandar is relatively young.

Table 3: Statistics of Respondent's Origination (Years)

| Characteristic | Classification | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Restaurant Origination (Years) | 0 - 5 | 63 | 33.2 |
| | 6 - 10 | 60 | 31.6 |
| | 11 - 15 | 31 | 16.3 |
| | 16 - 20 | 20 | 10.5 |
| | 21 and above | 16 | 8.4 |
| | Total | 190 | 100 |

**Respondents' Restaurant Type**

Table 4 shows that the most common type of restaurant the respondent works in is Cafe, with 73 respondents (38.4%). The second most popular type of restaurant was fast food, with 39 respondents (20.5%). The third most popular type of

restaurant was a food truck, cart, or stand, with 30 respondents (15.8%). The fourth most popular type of restaurant was buffet style, with 28 respondents (14.7%). The least popular type of restaurant was a bistro, with 20 respondents (10.5%). A summary of respondent's type of restaurant statistics is given in Table 4.

Table 4: Statistics of Respondents' Type

| Characteristic | Classification | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Type of Restaurant | Bistro | 20 | 10.5 |
| | Buffet Style | 28 | 14.7 |
| | Cafe | 73 | 38.4 |
| | Fast Food | 39 | 20.5 |
| | Food Truck, Cart, Or Stand | 30 | 15.8 |
| | Total | 190 | 100 |

**Partial Least Square – Structural Equation Modelling (PLS-SEM)**

Partial least squares structural equation modeling (PLS-SEM) is a statistical method that analyses intricate causal connections between latent variables. By simultaneously conducting principal component analysis and regression analysis, PLS-SEM effectively addresses the issues of multicollinearity and measurement error (Hair Jr et al., 2020). Furthermore, PLS-SEM balances between covariance and variance, enabling the assessment of cause-and-effect relationships among variables even with moderate sample sizes. With such significance, the data analysis was performed using SmartPLS4.0 software. In SmartPLS4.0, the measurement and structural model were assessed. The findings of both measurement and structural model are provided in the following sections.

**Assessment of Measurement Model**

In measurement model, the internal consistency reliability, convergent validity, discriminant validity and goodness of model fit were checked. The results indicate that the internal consistency reliability, measured by Cronbach's Alpha exceeded the threshold value of 0.708. Specifically, the Cronbach's alpha values for each construct, including food waste monitoring (0.931), staff training (0.929), menu planning (0.957), food waste awareness (0.955), and food waste reduction (0.934), all demonstrated satisfactory levels of internal consistency. Furthermore, internal consistency reliability was also checked through composite reliability.The constructs had values above the threshold of 0.70. The composite reliability values for each construct were as follows: food waste monitoring (0.936), staff training (0.934), menu planning (0.958), food waste awareness (0.956), and food waste reduction (0.934). Then, this study confirmed the convergent validity through average variance extracted (AVE) values, which all exceeded the specified limit of 0.50. Specifically, the AVE values for the latent variables were as follows: food waste monitoring (0.745), staff training (0.825), menu planning (0.854), food waste awareness (0.847), and food waste reduction (0.835). A summary of the results is given in Table 11.

Table 11: Results of Internal Consistency Reliability and Validity

| Construct | Items | Cross Loading | Cronbach 's Alpha | Composite Reliability (CR) | Average Variance Extracted (AVE) |
|---|---|---|---|---|---|
| Food waste Monitoring | M1 | 0.776 | 0.931 | 0.936 | 0.745 |
| | M2 | 0.891 | | | |
| | M3 | 0.861 | | | |
| | M4 | 0.908 | | | |
| | M5 | 0.869 | | | |
| | M6 | 0.866 | | | |
| Staff Training | T1 | 0.934 | 0.929 | 0.934 | 0.825 |
| | T2 | 0.889 | | | |
| | T3 | 0.918 | | | |
| | T4 | 0.892 | | | |
| Menu Planning | MP1 | 0.941 | 0.957 | 0.958 | 0.854 |
| | MP2 | 0.921 | | | |
| | MP3 | 0.932 | | | |
| | MP4 | 0.934 | | | |
| | MP5 | 0.892 | | | |
| Food Waste Awareness | AW1 | 0.890 | 0.955 | 0.956 | 0.847 |
| | AW2 | 0.928 | | | |
| | AW3 | 0.921 | | | |
| | AW4 | 0.938 | | | |
| | AW5 | 0.924 | | | |
| Food Waste Reduction | FWR1 | 0.942 | 0.934 | 0.934 | 0.835 |
| | FWR2 | 0.935 | | | |
| | FWR3 | 0.918 | | | |
| | FWR4 | 0.858 | | | |

*AW: Food waste awareness, FWR: food waste reduction M: food waste Monitoring, MP: Menu Planning, T: Staff training*

After confirming convergent validity, discriminant validity was assessed using the HTMT (Heterotrait–Monotrait) ratio and Fornell and Larcker's (1981) criteria. Discriminant validity helps measure the amount of variation captured by the latent variables and examines the shared variance with other latent variables.These results show that the metrics have higher values for their corresponding endogenous variables than other variables, indicating the validity of the latent variables within each construct. To assess the discriminant validity, the HTMT (Heterotrait-Monotrait) ratio of correlations was calculated using a threshold value of 0.85 Chaokromthong and Sintao (2021) also suggested an appropriate value of 0.9. In this study, the HTMT ratio of correlation was computed, and the results indicated that all values were below the threshold limit of 0.888. This confirms the distinctiveness of each latent variable based on the statistical criteria inTable 12. In other words, the findings demonstrate that the latent variables in the measurement model are not highly correlated with each other, thus supporting their individuality and establishing discriminant validity.

Table 12: Result of Discriminant validity (HTMT Criterion)

| Variables | AW | FWR | M | MP | T |
|---|---|---|---|---|---|
| **AW** | | | | | |
| **FWR** | 0.765 | | | | |
| **M** | 0.652 | 0.764 | | | |
| **MP** | 0.624 | 0.843 | 0.609 | | |
| **T** | 0.838 | 0.849 | 0.802 | 0.722 | |

*AW: Food waste awareness, FWR: food waste reduction: M: food waste Monitoring MP: Menu Planning, T: Staff training*

After satisfying the discriminant validity, this study evaluated the goodness of model fit. The "standardized root mean square residual" (SRMR) is analyzed to evaluate the model fit. According to (Dirsehan et al., 2022) the criterion for overall model fit is that the SRMR value should be lower than 0.08. The results indicated that the SRMR value is (0.056), which is lower than 0.08. Therefore, the model fit criteria are satisfied.

**Assessment of Structural Model**

The structural model was analyzed to test the proposed hypotheses. The PLS algorithm was used to assess the hypothesis model. The study examined various hypotheses, including food waste monitoring, staff training, menu planning, and food waste awareness (HI, H2, H3, and H4). This process has the four key steps involved in path coefficient analysis; a statistical technique used to investigate causal relationships between variables. Firstly, the coefficient of determination (R square) measures the strength of the relationship between two variables by squaring their correlation coefficient. Secondly, the predictive relevance (Q square) assesses the predictive power of a variable by squaring the multiple correlation coefficient between the variable and all other variables in the model. Next, estimating path coefficients involves determining a variable's direct and indirect effects on another variable. Lastly, the effect size (F square) is calculated by squaring the F-statistic for the model, providing a measure of the overall effect size.

Using SmartPLS4.0, the structural model investigated the causal relationship between constructs (Novitasari et al., 2021). The Figure 2 revealed the findings of the structural model that includes value of $R^2$ (0.78) for food waste reduction, which indicates a substantial variance explained by the model. Additionally, the predictive relevance was assessed through $Q^2$, calculated via blindfolding to estimate parameters using the remaining data points. The $Q^2$ value for food waste reduction was found to be (0.64), demonstrating acceptable predictive relevance.

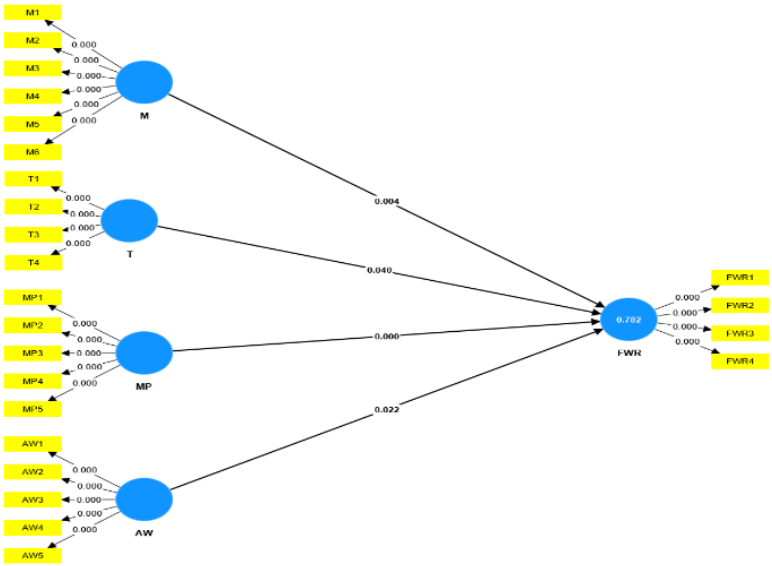


Figure 2: Predictive Relevance ($Q^2$)

Afterwards, the structural model was also utilized to assess and confirm the hypothesized links as proposed in the model determination process. The study examines four hypotheses. The first hypothesis, H1, suggests that food waste monitoring will significantly reduce food waste. The result shows a significant positive relationship between monitoring food waste and reduction (β = 0.176, S.E = 0.077, T-statistic = 2.288, and p = 0.022). Therefore, H1 is supported and accepted. The second hypothesis, H2, proposes that staff training significantly reduces food waste. The analysis indicates that H2 is significant at 0.004, with a T-statistic value of 2.872 (β = 0.197 and S.E = 0.069). Hence, H2 is also supported and accepted. The third hypothesis, H3, posits that menu planning significantly reduces food waste. The analysis reveals that the p-value is significant (p = 0.04, β = 0.206, S.E = 0.1, and T-statistic = 2.052). Thus, H3 is supported and accepted. The fourth hypothesis, H4, assumes that food waste awareness will significantly reduce food waste. The analysis indicates significant values for the p-value (p = 0, β = 0.438, S.E = 0.098, and T-statistic = 4.46). Consequently, H4 is supported and accepted. Overall, the findings demonstrate that food waste monitoring, staff training, menu planning, and food waste awareness significantly contribute to reducing food waste in restaurants at Seri Iskandar. A summary of the assessment of the structural model is given in Table 13.

Table 13: Assessment of Structural Model (H1-H4)

| $H_I$ | Hypothesis | β | S.E. | t | p | Remarks | Results |
|---|---|---|---|---|---|---|---|
| H1 | AW-FWR | 0.176 | 0.077 | 2.288 | 0.022 | Significant | Supported |
| H2 | T-FWR | 0.206 | 0.1 | 2.052 | 0.04 | Significant | Supported |
| H3 | MP-FWR | 0.438 | 0.098 | 4.46 | 0 | Significant | Supported |
| H4 | M-FWR | 0.197 | 0.069 | 2.872 | 0.004 | Significant | Supported |

*AW: Food waste awareness, FWR: food waste reduction M: food waste Monitoring, MP: Menu Planning, T: Staff training*

*Finally,* Table 14 presents the next step which is evaluating the effect size ($f^2$). This analysis assesses the impact of exogenous constructs on the endogenous latent variables by measuring the difference in $R^2$ when an exogenous construct is removed from the model (Hair et al., 2014). The $f^2$ values have standard interpretations: 0.02 suggests a weak impact, 0.15 indicates a moderate impact, and 0.35 reflects a strong impact of the exogenous latent variable (Chaokromthong & Sintao, 2021). The findings indicate a large effect size ($f^2$=0.456) for the exogenous latent variable "MP," making it the most significant factor influencing the endogenous variable "food waste reduction." On the other hand, for the exogenous variables "AW," "M," and "T," the results show a medium effect size ($f^2$=0.053, $f^2$=0.075, and $f^2$=0.046, respectively), implying their moderate impact on the endogenous variable.

Table 14: Result of Effect Size

| | FWR | Effect Size ($f^2$) |
|---|---|---|
| **AW** | 0.053 | Medium |
| **M** | 0.075 | Medium |
| **MP** | 0.456 | Large |
| **T** | 0.046 | Medium |

*AW: Food waste awareness, FWR: food waste reduction M: food Monitoring, MP: Menu Planning, T: Staff training*

## DISCUSSION

The risk management model and its various variables positively impact waste reduction. Food waste monitoring emerges as a powerful tool to combat food waste in restaurants. Through waste monitoring, restaurants can make data-driven decisions, optimize inventory management, and adjust portion sizes to minimize food waste generation. Staff training proves to be a crucial factor in promoting sustainable practices and waste reduction in restaurants. Menu planning emerges as a strategic approach to curbing food waste in restaurants. By offering flexible menu options and creatively utilizing surplus food, restaurants can optimize their food resources and minimize unnecessary waste. By raising awareness about food waste's environmental and economic consequences, restaurants can motivate staff and customers to take active measures to reduce waste.

## CONCLUSION

Addressing the food waste challenge in Seri Iskandar requires a collaborative and multi-faceted approach by involving all stakeholders to foster sustainable food waste reduction and promote a more sustainable and responsible food system. Thus, this study recognized the food waste risk management model that can contribute to food waste reduction effectively. The food waste risk management model was proxied by food waste monitoring, staff training, menu planning, and food waste awareness. Based on this, this study aimed to examine the impact of food waste risk management model on food waste reduction. To achieve this objective, this study formulated a total four hypotheses which further tested in PLS-SEM. The results indicated that food risk management model by including food waste monitoring, staff training, menu planning, and food waste awareness, has significantly positive impact on food waste reduction. By incorporating these recommendations into practice, restaurants can reduce food waste and contribute to the broader goal of achieving a more sustainable and environmentally conscious food service industry.

## FUTURE RECOMMENDATIONS

This research study offers several recommendations for future research. First, this study is conducted in restaurants of Malaysia. The future studies can replicate this model in other geographical contexts. Second, future studies should focus on assessing the long-term impact of risk management strategies on food waste reduction in restaurants. Understanding the sustainability and durability of waste reduction practices for a long period is essential for promoting continuous improvement and lasting change. Third, the identification of the barriers and challenges faced by restaurants in implementing risk management strategies is very crucial. Thus, future study can effectively identify the pertinent barriers to the implementation of risk management. Fourth, future research can conduct a comprehensive cost-benefit analyses of food waste reduction initiatives. This can assist restaurants in making informed decisions about investing in these strategies. Finally, this study has never utilized any moderating or mediating effect between the relationship of food waste risk management model and food waste reduction. The future studies can empirically validate this relationship by adding moderating or mediating effect.

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