The Influence of Green Innovation on Environmental Performance of Food and Beverage Manufacturers in Thailand

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Abstract.

This study aims to examine green innovation and environmental performance and investigate the influence of green innovation on the environmental performance of food and beverage manufacturers in Thailand. Data were collected using questionnaires from 239 respondents. Mean, standard deviation, and multiple regression analysis were employed for data analysis. The results revealed that green innovation and environmental performance were at a high level. Green innovation accounted for 54.6 percent of the variance in the environmental performance of food and beverage manufacturers in Thailand.

The findings reflect that green innovation plays a crucial role as a key mechanism linking environmental policies to organizational practices. Food and beverage manufacturers in Thailand place importance on the practical application of green innovation in environmental operations through the adoption of clean technologies, energy conservation, and efficient waste management, together with clear environmental policies and management systems and the promotion of employee participation. As a result, organizations are able to reduce environmental impacts, use resources efficiently, and achieve a high level of environmental performance, reflecting a strong image of social responsibility and long-term organizational sustainability.

Keywords: Green innovation, Ennvironmental Performance, Food and Beverage Manufacturers

1. Introduction

At present, environmental issues have become a key agenda in the economic and social development of countries. The government has set directions and policies that emphasize balanced development alongside the sustainable conservation of natural resources. The Environmental Quality Management Plan B.E. 2566–2570 (2023–2027) emphasizes that all sectors should reduce environmental impacts, control pollution, and promote efficient resource utilization through the adoption of environmentally friendly innovations and technologies in operations (Office of Natural Resources and Environmental Policy and Planning, 2022). At the same time, the 13th National Economic and Social Development Plan highlights the transition toward sustainable economic development, the promotion of environmentally friendly industries, and the enhancement of competitiveness in the manufacturing sector under the concepts of the green economy and circular economy (Office of the National Economic and Social Development Council, 2022). In particular, the food and beverage industry, which plays a vital role in the national economy and consumes a large amount of resources, needs to adapt

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by adopting green innovation to enhance its environmental performance. In addition, the Fifth SME Promotion Plan encourages entrepreneurs to develop and apply green innovation to reduce environmental impacts and strengthen sustainable competitiveness (Office of Small and Medium Enterprises Promotion, 2023).

The food and beverage industry faces increasing environmental pressures from government regulations, consumer expectations, and corporate social responsibility, requiring organizations to adjust their operational practices in line with sustainable development principles (Kuo et al., 2022). In particular, the adoption of green innovation is essential for reducing environmental impacts and improving resource-use efficiency. Numerous studies indicate that green innovation plays a significant role in enhancing environmental performance, including waste reduction, pollution control, and efficient energy use (Ha et al., 2024). Moreover, green innovation serves as a mechanism linking organizational management practices—such as green supply chain management and green human resource management—with tangible environmental performance outcomes (Sobaih et al., 2020). For the food and beverage industry, which is one of Thailand's key industries and is characterized by high natural resource consumption, the adoption of green innovation is therefore crucial for reducing environmental impacts while simultaneously strengthening organizational competitiveness and long-term sustainability.

Although previous studies have emphasized the role of green innovation in environmental performance across various organizational and industrial contexts, including small and medium-sized enterprises in developing countries (Akhtar et al., 2024), empirical research focusing specifically on the Thai food and beverage industry remains limited. Furthermore, much of the existing literature has tended to examine green innovation primarily as a mediating or supporting variable in relation to other managerial factors, such as green human resource management or green intellectual capital (Asiaei et al., 2023), rather than directly investigating the impact of green innovation on environmental performance at the organizational level. Consequently, there remains a lack of systematic and clear empirical evidence explaining the causal relationship between green innovation and the environmental performance of food and beverage manufacturers in Thailand.

Therefore, the study entitled *The Influence of Green Innovation on the Environmental Performance of Food and Beverage Manufacturers in Thailand* is of significant importance in generating empirical knowledge that reflects the specific context of the Thai food and beverage industry. The findings are expected to clarify the role of green innovation as a key factor in reducing environmental impacts and concretely enhancing organizational environmental performance. Moreover, the results can serve as policy and managerial guidelines for entrepreneurs in formulating green innovation strategies aligned with sustainable development goals, strengthening competitiveness, and supporting the stable and sustainable long-term growth of Thailand's food and beverage industry.

2. Research Objectives

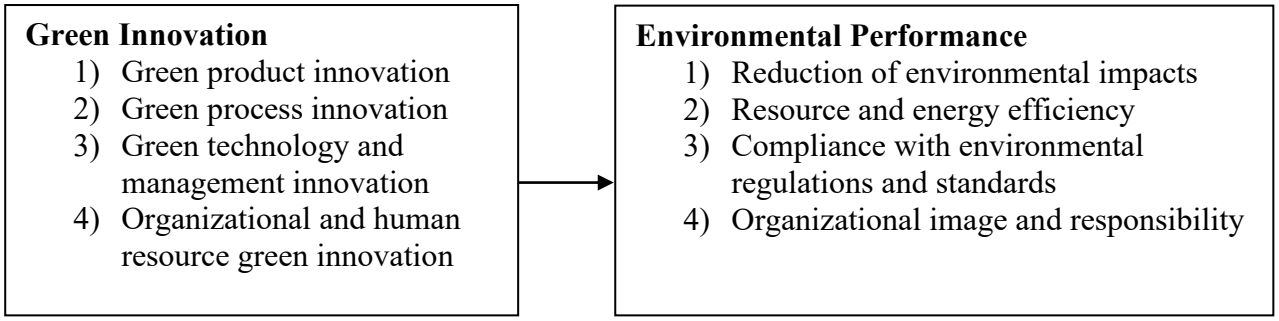
1) To examine green innovation and the environmental performance of food and beverage manufacturers in Thailand.

2) To investigate the influence of green innovation on the environmental performance of food and beverage manufacturers in Thailand.

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3. Conceptual Framework

Figure 1 Research Conceptual Framework



4. Methodology

Population and Sample

The population of this study consisted of business owners, executives, marketing managers, and business development managers of licensed food and beverage manufacturing plants operating in Thailand as of the end of 2025, totaling 593 factories (Department of Industrial Works, 2025). The sample size was determined using Yamane's (1973) formula for a known population size with a 95% confidence level. Accordingly, the required sample size was 239 factories.

Simple random sampling was employed to select respondents from business owners, executives, marketing managers, and business development managers of food and beverage manufacturing plants. This method was chosen to ensure that each unit in the population had an equal chance of being selected, thereby reducing sampling bias and enhancing the generalizability and reliability of the research findings.

Research Instrument

The instrument used for data collection was a questionnaire consisting of three parts:

Part 1: General information of the respondents. The questions were close-ended with multiple-choice responses.

Part 2: Questions related to green innovation, including:

1. Green product innovation
2. Green process innovation
3. Green technology and management innovation
4. Organizational and human resource green innovation

Responses were measured using a five-point Likert scale.

Part 3: Questions related to environmental performance, including:

1. Reduction of environmental impacts
2. Efficiency of resource and energy utilization

3. Compliance with environmental regulations and standards
4. Organizational image and responsibility

Responses were measured using a five-point Likert scale.

After developing the questionnaire, the quality of the instrument was tested in two aspects.

1. Content Validity: Content validity was assessed using the Index of Consistency (IOC), evaluated by three experts. The IOC values ranged from 0.67 to 1.00, with an overall IOC of 0.964 (Rovinelli & Hambleton, 1976).

2. Reliability: The validated questionnaire was pilot-tested with 30 respondents who had characteristics similar to the sample group. Cronbach's alpha coefficients were 0.882 for green innovation and 0.893 for environmental performance, indicating a high level of reliability (Cronbach, 1951).

Data Analysis and Statistical Methods

The data analysis was conducted as follows:

1. Descriptive statistics were used to interpret the levels of green innovation and environmental performance of food and beverage manufacturers in Thailand. The data were analyzed using mean and standard deviation.

2. Multicollinearity analysis was performed to examine the independence of the predictor variables using Tolerance and Variance Inflation Factor (VIF). The criteria were that Tolerance values must be greater than 0.10 and VIF values must not exceed 10 (Kim, 2019).

3. Inferential statistics were applied using multiple regression analysis to test the hypothesis regarding the effect of green innovation on the environmental performance of food and beverage manufacturers in Thailand.

5. Result

The findings corresponding to Objective 1, which aimed to examine green innovation and environmental performance of food and beverage manufacturers in Thailand, are presented in Tables 1 and 2.

Table 1 Means and Standard Deviations of Green Innovation

Green Innovation	$\bar{X}$	S.D.	Level	Skewness	Kurtosis
1) Green product innovation	3.42	.417	Moderate	-1.646	1.318
2) Green process innovation	4.08	.626	High	-.913	-.371
3) Green technology and management innovation	4.02	.573	High	-.734	-.635
4) Organizational and human resource green innovatio	3.92	.623	High	-.513	-1.269
Overall	**3.86**	**.372**	High		

Table 1 shows that overall green innovation was at a high level ($\bar{X}$ = 3.86, S.D. = 0.371). Among the dimensions, green process innovation had the highest mean ($\bar{X}$ = 4.08, S.D. = 0.626), followed by green technology and management innovation ($\bar{X}$ = 4.02, S.D. = 0.573), organizational and human resource green innovation ($\bar{X}$ = 3.92, S.D. = 0.623), and green product innovation, which had the lowest mean ($\bar{X}$ = 3.42, S.D. = 0.417). The skewness and

kurtosis values ranged between −2 and +2, indicating normal data distribution (Groeneveld & Meeden, 1984).

Table 2 Means and Standard Deviations of Environmental Performance

Environmental Performance	$\overline{X}$	S.D.	Level	Skewness	Kurtosis
1) Reduction of environmental impacts	4.13	.628	High	-.991	.381
2) Resource and energy efficiency	4.05	.614	High	-.795	-.449
3) Compliance with environmental regulations and standards	4.09	.558	High	-1.013	.313
4) Organizational image and responsibility	4.17	.527	High	-.911	.239
Overall	**4.11**	**.458**	**High**		

Table 2 indicates that overall environmental performance was at a high level ($\bar{X}$ = 4.11, S.D. = 0.458). The highest mean was found for organizational image and responsibility ($\bar{X}$ = 4.17, S.D. = 0.527), followed by reduction of environmental impacts ($\bar{X}$ = 4.13, S.D. = 0.628), compliance with environmental regulations and standards ($\bar{X}$ = 4.09, S.D. = 0.558), and resource and energy efficiency ($\bar{X}$ = 4.05, S.D. = 0.614). The skewness and kurtosis values fell within the acceptable range, confirming normality (Groeneveld & Meeden, 1984).

The findings corresponding to Objective 2, which aimed to examine the influence of green innovation on environmental performance of food and beverage manufacturers in Thailand, are presented in Table 3.

Table 3 Results of Multiple Regression Analysis of Green Innovation Affecting Environmental Performance

Independent Variable	b	SE_b	ß	t	p-value	Tolerance	VIF
(Constant)	.700	.199		3.525	.000		
Green technology and management innovation	.540	.052	.491	10.398**	.000	.728	1.373
Organizational and human resource green innovation	.189	.034	.256	5.626**	.000	.783	1.277
Green process innovation	.104	.033	.142	3.196**	.002	.820	1.220
Green product innovation	.078	.034	.097	2.299*	.022	.909	1.100
$R = 0.553$, $R^2 = 0.546$, SEest = 0.30868, F = 5.286, Sig. of F = 0.022, Durbin Watson = 1.991							

* Statistically significant at the 0.05 level ** Statistically significant at the 0.01 level

The tolerance values ranged from 0.728 to 0.909 and VIF values ranged from 1.100 to 1.373, indicating no multicollinearity among the independent variables. The Durbin–Watson statistic of 1.991 suggests no autocorrelation of residuals and confirms the suitability of the regression model.

The results of the standardized regression analysis indicate that four independent variables significantly influence the environmental performance of food and beverage manufacturers in Thailand. Ranked in descending order of effect size, these variables are: (1) green technology and management innovation, (2) organizational and human resource green innovation, (3) green process innovation, and (4) green product innovation. The adjusted coefficient of determination (Adjusted R^2) was 54.6%, indicating that green innovation explains 54.6% of

the variance in environmental performance, while the remaining 45.4% is attributable to other factors not included in the model. The standardized regression equation can be expressed as follows:

Y = 0.700 + 0.491 (Green technology and management innovation) + 0.256 (Organizational and human resource green innovation) + 0.142 (Green process innovation) + 0.097 (Green product innovation).

The standardized coefficient (β) for green technology and management innovation was 0.491, indicating that a one-unit increase in this dimension, holding other factors constant, is associated with an increase of 0.491 units in environmental performance, or an improvement of 49.1%.

Similarly, the standardized coefficient (β) for organizational and human resource green innovation was 0.256, suggesting that a one-unit increase in this dimension leads to an increase of 0.256 units in environmental performance, equivalent to a 25.5% improvement, ceteris paribus.

The standardized coefficient (β) for green process innovation was 0.142, indicating that a one-unit increase in green process innovation results in a 0.142-unit increase in environmental performance, or a 14.2% improvement, when other variables are held constant.

Finally, the standardized coefficient (β) for green product innovation was 0.097, implying that a one-unit increase in green product innovation is associated with a 0.097-unit increase in environmental performance, or a 9.7% improvement, ceteris paribus.

6. Conclusion

Green innovation among food and beverage manufacturers in Thailand is characterized by an integrated approach encompassing technology, processes, and organizational management. It extends beyond the mere adoption of clean technologies or technical waste reduction to include environmental policies, employee awareness and participation, and systematic communication of responsibility to stakeholders. The findings demonstrate that this integrated approach simultaneously enhances multiple dimensions of environmental performance, including impact reduction, resource efficiency, and sustainable corporate image. This highlights that green innovation functions as a strategic mechanism supporting organizational sustainability rather than merely an operational environmental activity.

Practical Recommendations

1. Food and beverage manufacturers should prioritize environmentally friendly product development by selecting safe and eco-friendly raw materials and adopting life-cycle-oriented product design.
2. Efforts should focus on reducing packaging usage and adopting recyclable or biodegradable packaging to minimize waste and environmental impacts.
3. Organizations should promote the use of systems and tools for continuous monitoring of energy and resource consumption to improve efficiency and reduce losses in production processes.

4. Environmental management should be systematic, with clearly defined policies, procedures, and monitoring and evaluation processes, including waste control in compliance with established standards.
5. Strict compliance with environmental laws and regulations should be emphasized, along with regular inspections and evaluations and the acquisition and maintenance of environmental certifications, to enhance credibility and support long-term sustainable growth.

Recommendations for Future Research

Future studies should examine green innovation across a broader range of dimensions, such as eco-design, sustainable packaging development, resource and energy efficiency, environmental management systems, and compliance with environmental laws and standards. In addition, mixed-method or qualitative research approaches are recommended to provide deeper insights into environmental management practices and success factors, enabling more effective policy formulation and practical application.

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