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Evaluating Consumer Intentions to Purchase Seafood Cultured with New Liquid Fertilizer: A Comparison of Logistic and Lasso Regression Models

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The deterioration of marine ecosystems due to intensified human activities has led to a significant decline in the availability of marine food sources. In response, some regions have implemented measures such as adding fertilizers to marine environments to promote the growth of seafood like clams. This study explores consumers' willingness to purchase seafood produced using Bio–Concentrated Liquid Fertilizer (Bio–CLF), a new eco-friendly fertilizer. An internet survey was conducted in Japan with 1,546 respondents, and the data was analyzed using logistic regression and LASSO regression to examine the influence of environmental awareness, knowledge of environmental solutions, and resistance to environmental innovations on purchase intention. The results indicate that consumers with higher environmental awareness and better understanding of environmental solutions are more inclined to purchase Bio–CLF cultured seafood. These findings suggest that effective communication and education about the benefits and scientific basis of such innovations are crucial. Recommendations for seafood marketers and government agencies are provided to promote sustainable seafood production and enhance organic waste recycling.

Key words: Consumer purchase intention, Environmental awareness, Environmental solutions, LASSO regression, Marine ecosystems

INTRODUCTION

The marine ecosystem has been deteriorating due to increasing human activities, leading to a gradual decline in the availability of marine food sources such as fish and shellfish. For instance, the catch of clams, a representative shellfish, has significantly decreased. According to the Ministry of Agriculture, Forestry, and Fisheries, clam harvests have dropped from approximately 30,000 tons in 2011 to less than 5,000 tons in 2020[1]. Similarly, the Japanese fisheries industry as a whole has experienced a decline, with fisheries production falling from 5.59 million tons in 2008 to 4.42 million tons in 2018, as reported by the Fisheries Agency[2].

In response to the worsening marine environment, various measures have been implemented to mitigate the impact. One such measure is the application of fertilizers to marine waters to support plankton growth, a crucial component of the marine food web. For example, in FY2022, Akashi City initiated a project to sow agricultural fertilizers in the surrounding sea to combat marine oligotrophication. Fermented chicken manure and chemical fertilizers were used, with the city covering the costs of fertilizers and monitoring, and fishermen providing their cooperation[3]. However, these initiatives are not widely recognized or understood by the general public.

Parallel efforts to promote the recycling of agricultural waste and kitchen scraps have led to the development of a new type of eco–friendly fertilizer known as Bio–Concentrated Liquid Fertilizer (Bio–CLF) (Yabe 2019b). This innovative fertilizer has found applications in traditional agriculture, hydroponics, and plant factories (Yabe 2019a). Researchers are now exploring broader applications for Bio–CLF, aiming to enhance waste recycling and achieve environmental improvements.

Despite these efforts, the acceptance and effectiveness of such eco-friendly innovations in marine environments remain underexplored. Existing studies have primarily focused on traditional agricultural applications, leaving a gap in understanding consumer attitudes toward seafood produced using these sustainable methods.

This study aims to address this gap by investigating the factors influencing consumer willingness to purchase seafood cultivated using Bio–CLF. Specifically, we assess awareness levels, perceptions of environmental impact, and resistance to new technologies among consumers. Understanding these factors is crucial for promoting sustainable marine practices and ensuring the acceptance of eco–friendly innovations in the marketplace.

To achieve these objectives, we employed both logistic regression and Lasso regression analyses to identify

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[1] Ministry of Agriculture, Forestry and Fisheries "The State of the Clam Situation." https://www.jfa.maff.go.jp/j/saibai/other/attach/pdf/asari–1.pdf (in Janpanese) Accessed on June 8, 2024
[2] Ministry of Agriculture, Forestry and Fisheries "2–1 Production Volume and Value by Fishery and Aquaculture Sector." https://www.jfa.maff.go.jp/j/kikaku/wpaper/r01_h/trend/1/sankou_2_1.html (in Janpanese) Accessed on June 8, 2024
[3] According to *Mainichi Newspapers*, 03/16/2022.

and evaluate the key determinants of consumer willingness. The findings of this research will provide valuable insights for policymakers, environmentalists, and the aquaculture industry. By identifying key drivers of consumer acceptance, this study contributes to the development of effective strategies for enhancing the sustainability of seafood production and supporting the broader goals of environmental conservation and resource management.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

Consumers' environmental awareness significantly impacts their willingness to purchase Bio-CLF aquaculture seafood. Mahmoud *et al*. (2022) found that consumer environmental awareness positively and significantly influences green purchasing decisions. They noted that the willingness of consumers to pay for green products has a strong predictive effect on their purchasing decisions, indicating that higher environmental awareness leads to a greater inclination towards purchasing green products. Similarly, Zameer and Yasmeen (2022) measured the impact of green innovation, environmental awareness, environmental issues, and knowledge of green products on green purchase intention, underscoring the crucial role of environmental awareness in sustainable consumption.

Regarding seafood products, Signes *et al*. (2023) found that environmental awareness is a key factor influencing consumers' preference for eco–labeled seafood products. Furthermore, a study in Japan by Uchida *et al*. (2014) yielded similar results, demonstrating the significant role of environmental awareness in purchasing decisions for seafood products.

These findings suggest that consumers' willingness to purchase seafood products is deeply influenced by their environmental awareness. Higher environmental awareness correlates with a stronger intention to purchase Bio–CLF cultivated seafood. This correlation provides a basis for hypothesizing that the level of consumer environmental awareness is related to their willingness to purchase Bio–CLF aquaculture seafood. Consequently, we hypothesize the following:

H1: The higher the level of environmental awareness among consumers, the stronger their willingness to purchase Bio–CLF products for aquaculture.

Consumers' understanding of environmental solutions has grown as they pay more attention to environmental protection and gain related knowledge. Fabiola and Mayangsari (2020) found that environmental knowledge and environmental concern are the determinant of green purchase intention on consumers. Newton *et al*. (2015) noted that while environmental issues are often seen as direct antecedents to environmental purchase intention, empirical results supporting this relationship are inconsistent. They discovered that intentional and accidental learning strategies mediate the relationship between environmental attention and environmental purchase intention, indicating that enhanced understanding of environmental solutions can increase the likelihood of purchasing green products. Hariyanto (2019) emphasized the importance of consumer understanding of environmental protection and its impact on their consumption behavior towards environmentally friendly products.

Moreover, research by Savari and Gharechaee (2020) suggested that environmental knowledge can significantly influence individuals' eco–friendly behaviors. Similarly, Liu *et al*. (2020) found that enhanced understanding of environmental risks positively impacts regional environmental behaviors. This implies that a better understanding of environmental solutions can enhance consumers' willingness to purchase green products. Therefore, consumers with a higher level of understanding of environmental protection solutions are more inclined to purchase Bio–CLF products. Thus, we propose the following hypothesis:

H2: The willingness of consumers to purchase Bio–CLF aquaculture aquatic products is positively related to their level of understanding of environmental protection solutions. The higher the level of understanding, the stronger the willingness to purchase.

Rogers (2003) refined the innovation adoption process into a series of cognitive steps, from understanding to attitude formation, leading to decision and execution confirmation. During these processes, consumers must not only accept the new features and performance of innovative products but also change their habits and challenge existing norms (Berchicci and Bodewes, 2005). Such changes may generate perceived risk depending on the consumers' perception of the new product (Kushwah *et al*., 2019). As a result, consumers often exhibit resistance towards innovation, which is a significant barrier to adopting new products (Laukkanen *et al*., 2007; Oreg, 2003). This resistance often leads to the postponement of product consumption until uncertainties are resolved (Molesworth and Suortti, 2002). Therefore, we propose the following hypothesis:

H3: The stronger consumers' resistance to Bio–CLF, the lower their willingness to purchase fertilizers.

METHODOLOGY

Logistic Regression Model

Logistic regression is a widely used statistical method for modeling binary outcome variables. In this study, we used logistic regression to model the likelihood of respondents' intention to purchase seafood products cultured with Bio–CLF. The logistic regression model estimates the probability of a binary outcome based on one or more predictor variables. Following the framework outlined by Cramer (2004), the model is specified as follows:

Suppose the probability of respondents' intention to purchase seafood products cultured with Bio–CLF can be expressed by the probability function $P(Z)$, as follows:

$$P(Z)=\frac{\exp Z}{1+\exp Z} \tag{1}$$

As Z varies along the real number axis, P monotonically increases between the bounds of zero and one, resembling a distribution function. In the logistic regression model, P represents the probability of a binary outcome, and the function of Z is expressed as follows:

$$Z = x^T \beta \quad (2)$$

Here β represents the coefficients, and x represents the independent variables. Empirically, the logistic model is represented as follows:

$$\log\left\{\frac{P}{1-P}\right\} = \beta_0 + \sum_{j=1}^{k} \beta_{ij} x_{ij} \quad (3)$$

LASSO Regression Model

To address potential issues of multicollinearity and enhance model interpretability, we employed Least Absolute Shrinkage and Selection Operator (LASSO) regression. As Ranstam and Cook (2018) highlighted, LASSO offers distinct advantages over standard regression methods by effectively reducing overfitting and enhancing model performance. Traditional regression methods often lead to overfitting due to the inclusion of too many variables and overestimation of the model's explanatory power. LASSO addresses these issues through shrinkage, minimizing prediction error by constraining regression coefficients towards zero, thus excluding non–essential variables from the model. By adding a penalty term to the loss function, LASSO regression can shrink some coefficients to zero, effectively excluding non–informative predictors. This technique not only facilitates variable selection but also improves prediction accuracy, making it particularly useful for identifying the most relevant variables influencing the intention to purchase Bio–CLF cultured seafood. The application of LASSO regression in this study refines the model by focusing on the most impactful predictors, providing a more parsimonious model with better generalization capabilities. The results from both logistic regression and LASSO regression are compared to evaluate the robustness and predictive performance of the models. Given that the logistic regression model failed the Hosmer-Lemeshow goodness–of–fit test, indicating poor model fit, LASSO regression was employed as a measure to improve model fit and predictive accuracy.

Data collection and sample characteristics

Data was collected via an internet survey conducted in Japan by Cross Marketing Inc. between January 4 and January 6, 2021. The survey targeted respondents aged 20 years and older. Using random sampling, a total of 2,000 participants were stratified and selected based on the age distribution of each local government. Participants who did not provide income information were excluded from the analysis, resulting in a final sample of 1,546 respondents.

To aid respondents in visualizing Bio–Concentrated Liquid Fertilizer (Bio–CLF), we presented images contrasting the appearance of Bio–CLF with ordinary liquid fertilizer. Following this, we detailed the advantages and disadvantages of Bio–CLF, along with its constituent materials. After these images, participants were asked questions about the use of Bio–CLF for aquaculture. The definitions of the main questions are shown in Table 1.

The dependent variable "*Intention*" is derived from the question: "Would you buy clams, oysters, or nori (seaweed) cultured by injecting slow–dissolving solidified 'Bio–CLF' into the seafloor if they were sold in supermarkets? There is no difference in taste from commercially available products." Responses were evaluated on a 4–point scale: "1" indicates "I'll buy it if it's the same price as the commercial product and bigger," "2" means "If it's the same price and the same size as the commercial product, I'll buy it," "3" stands for "I'll buy it if it's cheaper and bigger than the commercial product," and "4" indicates "I don't buy it." For the purposes of analysis, "Intention" is coded as 1 for responses 1, 2, and 3, and 0 for response 4.

Environmental Awareness Variables

The independent variable "*Lownutrient*" represents the response to the question: "Do you know that in recent years, closed sea areas such as inland seas and bays have been suffering from oligotrophication, a decrease in plankton levels due to a lack of nutrients, and this has had a major impact on the fishing industry?" Responses were evaluated on a 4–point scale, where "1" indicates "I don't know it at all" and "4" indicates "I know it very well."

The independent variable "*Clamcatch*" captures the response to the question: "Did you know that due to changes in the marine environment, the number of clams harvested decreased from more than 160,000 tons in 1983 to 7,000 tons in 2017?" Responses were evaluated on a 3–point scale, where "1" indicates "I don't know it at all" and "3" indicates "I know it very well."

Environmental Solutions Variables

The independent variable "*Fertilizeruse*" corresponds to the question: "Did you know that some municipalities spray chemical fertilizers and release septic-treated water to supply nutrients for plankton when flounder growth is poor?" Responses were evaluated on a 4–point scale, where "1" indicates "I don't know it at all" and "4" indicates "I know it very well."

The independent variable "*Slowdissolve*" pertains to the question: "Did you know that a university has developed a slow–dissolving solid (nutrient component) that is sunk to the seafloor to combat oligotrophication in closed systems such as inland seas and bays?" Responses were evaluated on a 4-point scale, where "1" indicates "I don't know it at all" and "4" indicates "I know it very well."

Resistance Variable

The independent variable "*Resistance*" represents the response to the question: "Just as we apply fertilizer when crops don't grow, do you have any resistance to dropping slow–dissolving solids (nutrient components) on the seafloor when shellfish, flounder, etc., don't grow due to nutrient deficiencies in the sea?" Responses were

Table 1. The definitions of the items in the questionnaire survey

Variable	Definition
Intention	Willingness to purchase clams, oysters, or nori cultured with Bio–CLF, measured on a scale from 1 to 4. Recoded as 1 for positive intentions (responses 1, 2, and 3) and 0 for negative intention (response 4).
Sex	0 = Female, 1 = Male.
Age	Year.
Marry	0 = No, 1 = Yes.
Family	Family members.
Income	Household income. 1 = under 2 million yen, 2 = above 2 million, under 4 million yen, 3 = above 4 million, under 6 million yen, 4 = above 6 million, under 8 million yen, 5 = above 8 million, under 10 million yen, 6 = above 10 million, under 12 million yen, 7 = above 12 million.
Lownutrient	Awareness of oligotrophication in closed sea areas, measured on a scale from 1 (“I don’t know it at all”) to 4 (“I know it very well”).
Clamcatch	Awareness of the decline in clam harvests from 1983 to 2017, measured on a scale from 1 (“I don’t know it at all”) to 3 (“I know it very well”).
Fertilizeruse	Awareness of municipalities using chemical fertilizers to support plankton growth, measured on a scale from 1 (“I don’t know it at all”) to 4 (“I know it very well”).
Slowdissolve	Awareness of a university-developed slow-dissolving nutrient solid used to combat oligotrophication, measured on a scale from 1 (“I don’t know it at all”) to 4 (“I know it very well”).
Resistance	Represents the response to the question about resistance to dropping slow-dissolving nutrient solids on the seafloor when marine life growth is poor. Evaluated on a 5-point scale: “1” (I’m not resistant at all) to “5” (I’m very resistant).

Note: 1) Sample size is 1,546.
2) In the questionnaire, respondents were asked about their “annual household income,” which was the same as the respondents’ annual household income.
Source: Author

evaluated on a 5–point scale, where “1” indicates “I’m not resistant at all” and “5” indicates “I’m very resistant.” For analysis, “*Resistance*” is coded as 0 for responses “1” (I’m not resistant at all) or “2” (I’m not resistant), and coded as 1 for responses “4” (I’m resistant) or “5” (I’m very resistant).

RESULTS

Descriptive Statistics

To provide an initial understanding of the data distribution and relationships between variables, we conducted descriptive statistics and cross–tabulations. The cross-tabulation analysis examines the association between the dependent variable “*Intention*” and various independent variables. The results are shown in Table 2.

Table 2 shown that the analysis reveals significant associations between the intention to purchase Bio–CLF cultured seafood and awareness of environmental issues. For instance, a higher awareness of oligotrophication (“*Lownutrient*”) is associated with a greater intention to purchase Bio–CLF cultured seafood. Similarly, respondents with higher awareness of the decline in clam harvests (“*Clamcatch*”) and the use of chemical fertilizers by municipalities (“*Fertilizeruse*”) also show a higher purchase intention. Additionally, those who are aware of the development of slow–dissolving solids for combating oligotrophication (“*Slowdissolve*”) exhibit a higher intention to purchase Bio–CLF cultured seafood. On the other hand, resistance to the use of slow–dissolving solids on the seafloor (“*Resistance*”) is negatively associated with purchase intention.

These initial findings suggest that awareness of environmental issues and practices significantly influences consumer attitudes towards Bio–CLF cultured seafood.

Regression Analysis

Following the descriptive analysis, we employed logistic regression and LASSO regression to further investigate the determinants of consumers’ purchase intention. This approach allows us to control for potential confounding variables and assess the robustness of the identified associations. The application of LASSO regression helps to mitigate issues of multicollinearity and improve model interpretability. It also serves as a complementary measure to address the poor fit observed in the logistic regression model, as indicated by the failure to pass the Hosmer–Lemeshow test. The results are shown as below:

Performance Metrics and Model Fit

Both models identified that “*Age*”, “*Lownutrient*”, “*Clamcatch*”, “*Fertilizeruse*”, “*Slowdissolve*”, and “*Resistance*” has significant impact on consumers’ purchase intention.

The performance metrics indicate that the Lasso

Table 2. Results of Cross–Tabulation by Consumers' Purchase Intention

Variables	Negative Purchase Intention (N = 481)	Positive Purchase Intention (N = 1065)	p value
Sex			
Male	240 (49.9%)	596 (56.0%)	0.03
Female	241 (50.1%)	469 (44.0%)	
Age			
Mean (SD)	43.90 (14.20)	46.20 (14.30)	0.004
Median [Min, Max]	44.00 [20.00, 79.00]	46.00 [20.00, 78.00]	
Marry			
Yes	268 (55.7%)	629 (59.1%)	0.24
No	213 (44.3%)	436 (40.9%)	
Family			
Mean (SD)	2.45 (1.33)	2.44 (1.24)	0.94
Median [Min, Max]	2.00 [1.00, 8.00]	2.00 [1.00, 8.00]	
Income			
Mean (SD)	3.27 (1.74)	3.49 (1.72)	0.03
Median [Min, Max]	3.00 [1.00, 7.00]	3.00 [1.00, 7.00]	
Lownutrient			
Mean (SD)	1.84 (0.61)	2.34 (0.62)	<0.001
Median [Min, Max]	2.00 [1.00, 4.00]	2.00 [1.00, 4.00]	
Clamcatch			
Mean (SD)	1.12 (0.38)	1.40 (0.57)	<0.001
Median [Min, Max]	1.00 [1.00, 3.00]	1.00 [1.00, 3.00]	
Fertilizeruse			
Mean (SD)	1.77 (0.54)	2.21 (0.54)	<0.001
Median [Min, Max]	2.00 [1.00, 4.00]	2.00 [1.00, 4.00]	
Slowdissolve			
Mean (SD)	1.77 (0.48)	2.16 (0.49)	<0.001
Median [Min, Max]	2.00 [1.00, 4.00]	2.00 [1.00, 4.00]	
Resistance			
Mean (SD)	3.03 (1.07)	2.64 (1.00)	<0.001
Median [Min, Max]	3.00 [1.00, 5.00]	3.00 [1.00, 5.00]	

Note:1) The p values indicate the result of t–test between the population means between the positive and negative purchase intention groups. And the p values associated with the categorical variables represent the results of Chi–square tests.

Regression model outperforms the Logistic Regression model in several key areas. The Area Under the Curve (AUC) for Lasso Regression is 0.835, showing better discriminatory power compared to 0.793 for Logistic Regression. Additionally, Lasso Regression achieves higher accuracy (0.783 vs. 0.741). While Lasso Regression has a lower sensitivity (0.365), it significantly improves specificity (0.972) compared to Logistic Regression. The kappa statistic for Lasso Regression is 0.399, indicating better agreement between observed and predicted classifications than Logistic Regression (0.322). Furthermore, Lasso Regression has a higher positive predictive value (PPV) of 0.854 and a comparable negative predictive value (NPV) of 0.772 relative to Logistic Regression.

In terms of model fit, Logistic Regression failed the Hosmer–Lemeshow goodness of fit test (p –value = 0.001), indicating a poor fit. The Hosmer–Lemeshow test was not directly applicable to Lasso Regression due to its regularization nature. However, Lasso Regression demonstrates higher explanatory power with an R^2 of 0.264 and an adjusted R^2 of 0.239, compared to Logistic Regression.

In conclusion, despite the Lasso Regression model's Hosmer–Lemeshow test results, its superior performance metrics—such as AUC, accuracy, and predictive values—suggest that it provides a better fit and predictive capability than the initial Logistic Regression model. Therefore, Lasso Regression appears to be a more robust and effective model for this analysis.

Interpretation of Lasso Regression Model Variables

The Lasso Regression model revealed significant predictors of this willingness. The intercept (0.975) rep-

Table 3. The results of logistic regression and lasso regression analysis

	Logistic			Lasso	
Variable	Coef.	SE	p value	Coef.	
ASC	–4.225	0.472	0.000	0.975	
Sex	0.240	0.128	0.061	.	
Age	0.009	0.005	0.044	0.001	
Marry	–	–	–	.	
Family	–	–	–	.	
Income	–	–	–	.	
Lownutrient	0.643	0.148	0.000	0.364	
Clamcatch	0.556	0.171	0.001	0.091	
Fertilizeruse	0.737	0.237	0.002	0.274	
Slowdissolve	1.485	0.279	0.000	0.552	
Resistance	–0.679	0.072	0.000	–0.427	
AUC		0.793		0.835	
Accuracy		0.741		0.783	
Sensitivity		0.385		0.365	
Specificity		0.901		0.972	
Kappa		0.322		0.399	
Pos Pred Value (PPV)		0.638		0.854	
Neg Pred Value (NPV)		0.765		0.772	
McFadden R^2/ R^2		0.223		0.264	
Adj.McFadden R^2/ *Adj.*R^2		0.215		0.239	
F–value		–		10.697	
F value p value		–		0.000	
Hosmer–Lemeshow test p value		0.001		–	
				Train	Test
N		1,546		1,237	309

Note:1) Variables "*Marry*", "*Family*", and "*Income*" were excluded from the final Logistic regression model based on the stepwise selection procedure using AIC.
2) In the LASSO regression model, the coefficient for Variables "*Sex*", "*Marry*", "*Family*", and "*Income*" is displayed as ".", indicating it has been shrunk to zero by the LASSO regularization. This means these variables does not significantly contribute to the model and is effectively excluded.

resents the baseline log–odds of willingness to purchase when all predictors are zero. *Age* (0.001) positively correlates with purchase intention, though the effect is minimal. Awareness of oligotrophication (*Lownutrient*, 0.364), the decline in clam harvests (*Clamcatch*, 0.091), municipalities using chemical fertilizers (*Fertilizeruse*, 0.274), and university–developed slow–dissolving nutrient solids (*Slowdissolve*, 0.552) all positively influence willingness to purchase. In contrast, resistance to dropping slow-dissolving solids on the seafloor (*Resistance*, –0.427) negatively impacts purchase intention. The importance of these variables are shown in Figure 1.

These results underscore the importance of environmental awareness and acceptance of innovative solutions in promoting consumer willingness to purchase Bio–CLF cultured products.

DISCUSSION

The findings of this study shed light on the potential market for Bio–CLF cultured seafood and highlight the significant role of environmental awareness in shaping consumer purchase intentions. The key variables, including "*Slowdissolve*," "*Resistance*," "*Lownutrient*," "*Fertilizeruse*," and "*Clamcatch*," were designed to capture respondents' awareness and attitudes toward marine environmental issues. The results indicate that higher awareness of these issues correlates with a greater intention to purchase seafood cultivated using Bio–CLF, as previous research suggested that environmentally conscious consumers are more willing to support sustainable products.

Environmental Awareness and Purchase Intention

Numerous studies have demonstrated that consumers' environmental awareness significantly influences their purchase intentions. For instance, Alhamad *et al.* (2023) analyzed responses from 527 consumers of eco–friendly products using a causal associative approach and found a positive relationship between environmental

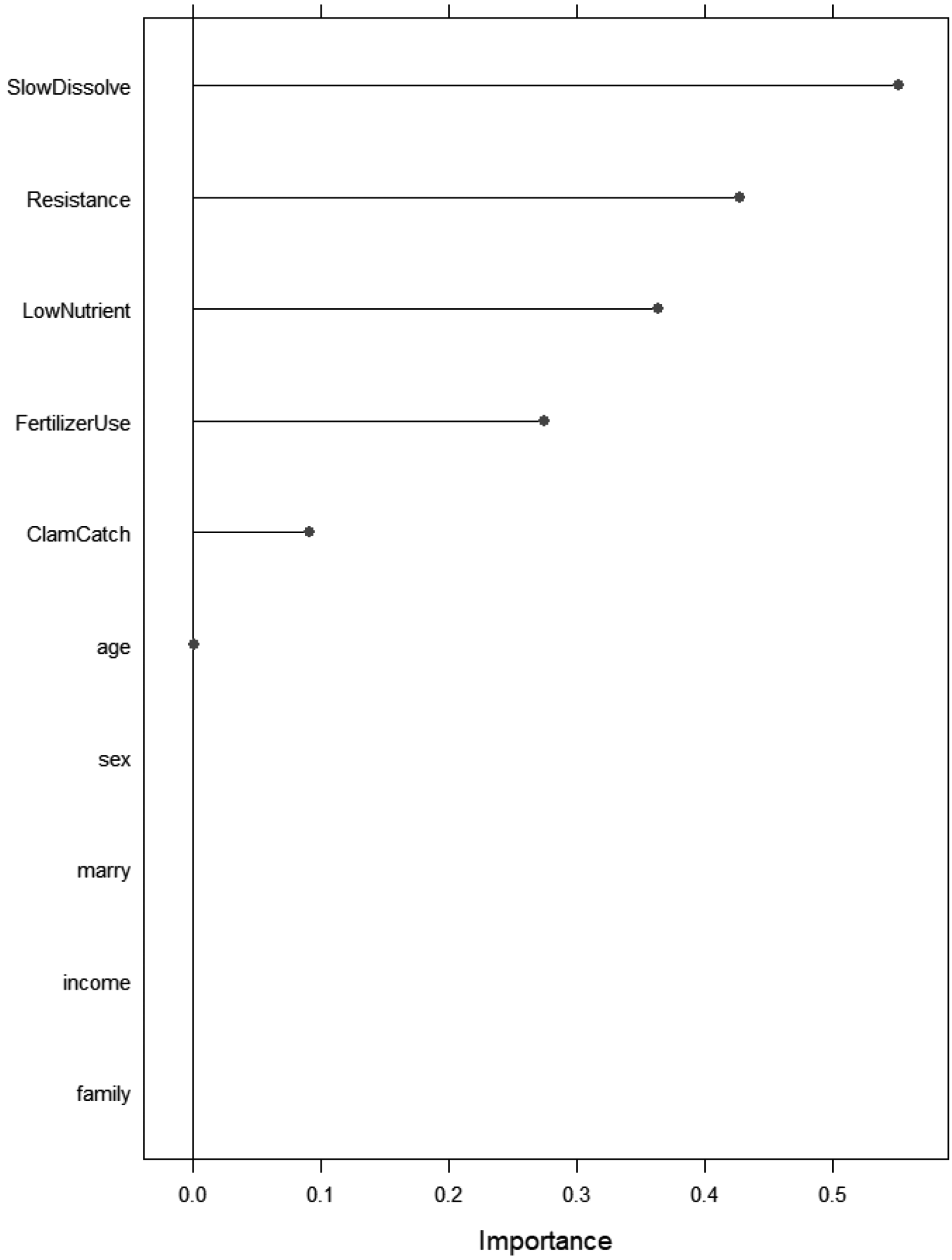

Fig. 1. The importance of independent variables

awareness and green purchase intention.

Environmental knowledge, defined as possessing facts about the natural environment, major ecosystems, and the relationship between people and the environment, has been shown to have a significant impact on consumer intentions towards environmentally friendly products (N. Kim and Lee 2023). Similarly, Chanda *et al*. (2023) identified that environmental knowledge indirectly impacts consumers' green product purchase intentions.

Further research supports these findings. García–Salirrosas *et al*. (2023) proposed a framework in Latin America during the COVID–19 pandemic, focusing on consumer behavior in terms of environmental awareness (EA), sustainable consumption (SC), social responsibility (SR), and environmentally responsible purchase intention (ERPI). Their results indicated that EA, SC, and SR positively influence ERPI, with gender and country of residence serving as moderating variables in these relationships.

In this study, the variables "*Lownutrient*," and "*Clamcatch*," were designed to reflect respondents' environmental awareness. The significant positive coefficients of these variables, as shown in Table 3, demonstrate the relationship between environmental awareness and the intention to purchase eco–friendly products. These findings are consistent with previous research, reinforcing the notion that higher environmental awareness correlates with a greater willingness to purchase sustainable products.

Perception of Environmental Solutions

The positive association between "*Slowdissolve*," and purchase intention, as well as "*Fertilizeruse*," and purchase intention , underscores the importance of educating consumers about innovative environmental solutions. Increasing public awareness about the benefits and effectiveness of these solutions can enhance acceptance and willingness to support such initiatives. As Shanmugavel and Balakrishnan (2023) noted, environmental knowledge significantly impacts individuals' intentions indirectly. Consumers are less likely to purchase innovative green products or pay a premium for them if they lack understanding about these products and their environmental benefits.

Wulandari *et al*. (2015) emphasized that existing environmental knowledge fosters positive attitudes and influences purchase intentions towards green products. Other studies have similarly highlighted the critical role of consumer knowledge in shaping purchase behavior (Alyahya *et al*. 2023; Y. Kim *et al*. 2016; Pieniak *et al*. 2010). Therefore, enhancing consumer education regarding environmental solutions like Bio–CLF can be a crucial strategy in promoting sustainable consumption.

Resistance to Environmental Innovations

The variable "*Resistance*" shows a negative association with purchase intention, indicating that consumers with higher resistance to using slow–dissolving solids in the marine environment are less likely to purchase Bio–CLF cultured seafood. This resistance may arise from a lack of understanding or skepticism about the safety and efficacy of such innovations, or a general unwillingness to introduce fertilizers into the marine environment. Wu *et al*. (2022) suggest that reducing consumers' perceived risk, such as through the disclosure of production information, can effectively lower consumer resistance. Additionally, Sadiq *et al*. (2021) found that consumers with higher environmental and health concerns are more likely to reduce resistance and adopt environmentally friendly products. Kushwah *et al*. (2019) indicated that marketers could highlight the health benefits of organic food products compared to conventional products to mitigate resistance due to perceived lower value.

Therefore, overcoming this resistance requires transparent communication and evidence–based information to build consumer trust. Providing clear, factual information about the safety and environmental benefits of Bio–CLF cultured seafood is crucial in reducing consumer resistance and promoting acceptance.

Implications for Marketing and Policy

The findings of this study provide valuable insights for both marketers and policymakers in promoting Bio–CLF cultured seafood.

Marketing Implications

For marketers, it is essential to educate consumers on the environmental benefits of Bio–CLF. Highlighting the advantages such as its non–polluting nature, eco–friendliness, and ability to enhance the utilization of organic waste can significantly enhance consumer acceptance. Effective communication strategies should emphasize the scientific basis for applying fertilizers to the marine environment, ensuring that consumers understand the safety and efficacy of this practice. However, given the current global sensitivity regarding marine pollution, especially in light of the controversy surrounding Japan's discharge of nuclear wastewater, these messages must be conveyed with extra caution. Transparent and evidence–based communication will be critical to build consumer trust and mitigate any potential concerns.

Policy Implications

For policymakers, there is a need to promote the recycling of organic waste and address the declining seafood harvests due to deteriorating marine ecosystems. One strategic approach could be the implementation of pilot projects that utilize organic fertilizers for cultivating seafood in selected areas of enclosed seas. These pilot projects can serve as a model for sustainable marine practices, demonstrating the feasibility and benefits of Bio–CLF in improving marine health and productivity. Additionally, government support in the form of funding, research, and regulatory frameworks can facilitate the adoption of such innovative practices, ultimately contributing to the sustainability of marine resources.

By integrating these marketing and policy recommendations, it is possible to advance the use of Bio–CLF, thereby promoting sustainable seafood production and contributing to the overall health of marine ecosystems.

Limitations and Future Research

This study has two main limitations.

First, the data was collected through an online survey, which may limit the generalizability of the findings. The conclusions are based on responses from individuals with internet access and registered with the survey company. Future research should incorporate various survey methods, such as face–to–face and postal surveys, to obtain a more comprehensive and representative dataset.

Second, the study focused on the newly developed eco-friendly liquid fertilizer, Bio–CLF. Despite detailed information provided, some respondents may have lacked familiarity with Bio–CLF, leading to inaccurate judgments. Future research should consider using more generalized fertilizers to gather broader data and provide more universally applicable policy recommendations.

Addressing these limitations will enhance the robustness of findings and contribute to more effective marketing strategies and policy frameworks for sustainable agricultural practices.

CONCLUSION

With the intensification of human activities, the marine ecosystem has been gradually deteriorating, leading to a yearly decline in the availability of marine products. To address this issue, some regions have implemented measures such as adding fertilizers to marine environments to promote the growth of seafood like clams.

This study investigates consumers' willingness to purchase seafood produced using this method. Through empirical analysis of responses from 1,546 consumers, we found that consumers with higher environmental awareness and better understanding of environmental solutions are more inclined to purchase seafood produced with the new eco–friendly fertilizer Bio–CLF.

Based on these findings, we propose several recommendations for seafood marketers and government agencies. These recommendations aim to promote the sales of seafood and enhance the recycling of organic waste.

AUTHOR CONTRIBUTIONS

Z. Wu designed the study. Z. Wu analyzed the data and wrote the manuscript. M. Yabe participated in the study design and supervised the study. Y. Takahashi and W. Wang assisted in editing the manuscript. Y. Takahashi approved the final version.

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