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Understanding Consumer Resistance to the Consumption of Environmentally-Friendly Agricultural Products: A Case of Bio-Concentrated Liquid Fertilizer Product

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Abstract

Methane fermentation digested sludge is a sustainable resource that is used as a liquid fertilizer. An innovative liquid fertilizer called Bio-Concentrated Liquid Fertilizer (Bio-CLF) was developed to solve the problems such as high transportation cost associated with current liquid fertilizer. As an innovation product, Bio-CLF inevitably creates remarkable resistance from consumers. Hence, we used the Innovation Resistance Theory (IRT) to determine the reasons for consumer resistance to Bio-CLF products. A total of 2,000 samples from three major cities, including Tokyo, were extracted via the Internet, and 703 samples were finally selected for analysis. Perceived risk, complexity, and attitude toward existing products were found to have a positive and direct impact on consumer resistance to Bio-CLF products, while motivation and purchase intention were found to have a negative and direct impact on consumer resistance to Bio-CLF products. Notably, Relative Advantage and Compatibility had a positive impact on motivation and indirectly influenced consumer resistance to Bio-CLF products, the results of which are inconsistent with IRT, as those characteristics could have a direct influence on resistance. Additionally, we opted to provide some advice that for market managers: (1) allocate a specialized corner for the Bio-CLF product and (2) place the Bio-CLF product alongside other green products. For producers: (1) disclosure of production information; (2) design of an attractive and clear label sheet; (3) proving the advantage of Bio-CLF and that the Bio-CLF product is a green product.

Keywords: Bio-Concentrated Liquid Fertilizer, environmental agricultural product, Innovation Resistance Theory, Structural Equation Modeling, consumer markets, resistance behavior

1. Introduction

Methane fermentation is a useful method for producing biogas as energy and digested liquid as fertilizer using local biomass resources, such as animal waste, farm and crop processing waste, kitchen food waste, slaughterhouse waste, and human excreta (Zackariah & Tanaka, 2019). The methane fermentation technology has many economic and sustainability benefits (Zhi et al., 2019). For example, Watanabe et al., (2012) revealed that the use of digested liquid can indirectly reduce greenhouse gas emissions. Additionally, the mobilization and extensive use of organic food waste as a renewable source for bioenergy production has high potential and can help to secure a safe energy supply (Pazera et al., 2015). Watanabe et al. (2012) also mentioned that the digested liquid from methane fermentation contains high levels of available crop nutrients. Based on the results of the field experiment by Li, Inamura, and Umeda (2003), the manure liquids could be utilized as a substitute for nitrogen fertilizer in rice cultivation under irrigated conditions. Therefore, the application of methane fermentation digested sludge as a liquid fertilizer in paddy fields has been suggested (Ryu, Suguri, Iida, & Umeda, 2010).

Currently, the utilization rate and spread efficiency of methane fermentation-digested sludge liquid fertilizer in Japan remain low. This is because most paddy field areas are small, resulting in high costs and problems regarding its use. These problems include handling and transportation (Haga, Tanaka, & Higaki, 1979).

Additionally, it is difficult to adjust the ingredients of the fertilizer. Liquid fertilizer has to be applied to paddy fields at 2-4 kg/m^2, and the liquid fertilizer contains a total nitrogen content of only 0.2-0.4%. Hence, the fertilizer has to be repeatedly transported from a facility to paddy fields (Ohdoi et al., 2013). In Japan, the liquid fertilizer is transported by a vacuum truck, and each vacuum truck can carry 2,500 kg each time. Further, the efficiency of the liquid fertilizer spreader is approximately 5 kg/m^2 per hour. Consequently, when a suitable period for fertilizer spread is approaching, farmers have to wait for the spreader. Based on these problems, farmers do not actively use digested liquid fertilizer, and methane fermentation facilities maintained by local governments have to spend a remarkable amount of time dealing with digested liquid and its discharge into the river (Note 1).

To solve these problems, Yabe (2019) developed a new technology based on liquid fertilizer derived from methane fermentation digested liquid, which is called Bio-Concentrated Liquid Fertilizer (Bio-CLF), as shown in Figure 1.

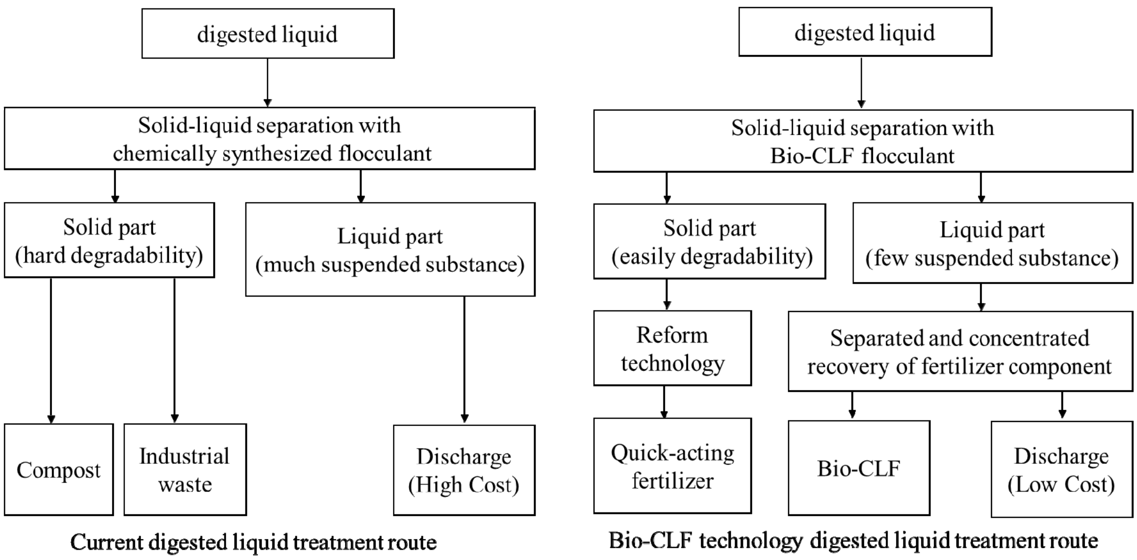

Figure 1. Comparative of current and Bio-CLF technology digested liquid treatment route

Source: Yabe (2019).

First, Yabe used flocculants derived from natural ingredients instead of the usual chemical flocculants, to separate methane fermentation digested liquid into solid and liquid parts. Second, Yabe used an ultrafiltration membrane to remove suspended substances from the liquid. Third, Yabe used ED to concentrate nitrogen and potassium from the liquid part. Accordingly, Yabe can adjust the fertilizer ingredients to fit the crops. At the laboratory level, Bio-CLF will help farmers save 2,000 yen/ton in spread cost, and allows its easy transportation as it is concentrated (Yabe, 2019). Additionally, compared with ordinary fertilizer, Bio-CLF can be spread in horticultural facilities and hydroponic soil cultivation (Note 2).

However, the Bio-CLF, as an innovation product, like other types of innovation products such as mobile phones, will inevitably create resistance from consumers. Determining the underlying reasons for consumer resistance to the use of Bio-CLF and modifying the product will help to improve the utilization rate of Bio-CLF and eventually contribute to the effective use of local biomass resources.

2. Literature Review

The Innovation Resistance Theory (IRT) was postulated by Ram (1987). According to Ram and Sheth (1989), "Innovation resistance is the resistance offered by consumers to an innovation, either because it poses potential changes from a satisfactory status quo or because it conflicts with their belief structure." Consumer resistance plays an important role in the success of innovation, as it can inhibit or delay consumer adoption (Hosseini, Delaviz, Derakhshide, & Delaviz, 2016). Resistance may also occur earlier than adoption after the innovation is launched, and ultimately, consumer resistance may lead to innovation failure in the market (Ma & Lee, 2019). Sheth (1981) argued that as most consumers have no a priori desire to change, we might learn more by understanding the reasons for innovation resistance rather than the reasons for adoption. Hence, it is meaningful to understand the underlying reasons for consumer resistance to innovation.

To date, IRT has been applied in many fields, such as the mobile phone industry (Abbas, Shahid Nawaz, Ahmad, & Ashraf, 2017; Hosseini et al., 2016; Kaur, Dhir, Singh, Sahu, & Almotairi, 2020), mobile banking (Laukkanen, 2016; Laukkanen, Sinkkonen, Kivijärvi, & Laukkanen, 2007; van Klyton, Tavera-Mesías, & Castaño-Muñoz, 2021), mobile wallet (Leong, Hew, Ooi, & Wei, 2020), mobile payment (Chung & Liang, 2020), online shopping system (Lian & Yen, 2014), hydrogen-electric motorcycles (Chen, Tsai, & Hsieh, 2018), food delivery applications (Kaur, Dhir, Ray, Bala, & Khalil, 2020), and home robots (Chiu, Lai, & Chu, 2020). However, research on "agricultural products," especially on "liquid fertilizer" is rare. Some related studies are presented below. Using the theoretical framework of IRT, Kushwah, Dhir, and Sagar (2019) found that the value barrier had a negative association with purchase intentions and ethical consumption intentions; ethical consumption and purchase intention were found to have a direct influence on choice behavior toward organic food. Tandon, Jabeen, Talwar, Sakashita, and Dhir (2021) showed that value and risk barriers are negatively associated with the stated buying behavior toward organic food.

However, to the best of our knowledge, research on consumer resistance to "liquid fertilizer," is lacking. Our study sought to address this gap by clarifying the underlying reasons for consumer resistance to Bio-CLF products.

2.1 The Model of IRT

Based on Ram (1987), consumer resistance to innovation can be viewed to be dependent on three sets of factors: innovation characteristics, consumer characteristics, and characteristics of propagation mechanisms. Among the three sets of factors, innovation characteristics have the power of expected resistance (Hosseini et al., 2016). However, consumer-dependent characteristics would generate resistance depending on how each consumer perceives the innovation carried out on each of these attributes (Ram, 1987). Consequently, we chose these two factors. The characteristics used in this study, based on Ram (1987) are shown in Figure 2.

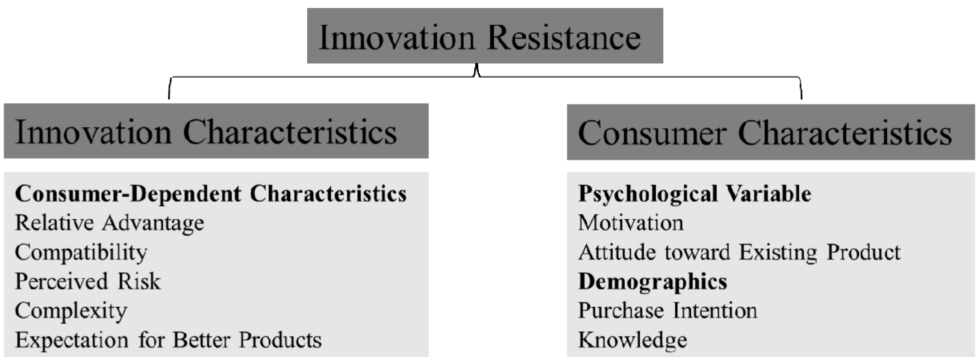

Figure 2. The model of innovation resistance

Note. Based on Ram (1987) and assembled by the authors.

Relative advantage represents the degree to which an innovation is perceived to be superior to current offerings (Plouffe, Hulland, & Vandenbosch, 2001). It is considered to be the dominant predictor of consumer adoption of innovation (Agarwal & Prasad, 1997).

Compatibility is an important consideration for a firm that sets its product specifications (Farrell & Saloner, 1985). It appears to have a significant impact on the willingness to adopt and the awareness of technologies (Mannan, Nordin, & Rafik-Galea, 2017).

Perceived risk was identified as one of the most important factors in the diffusion of innovation (Gerrard, Cunningham, & Devlin, 2006) and has been confirmed to be one of the main factors that directly influence the purchase intentions of consumers (Kim, Ferrin, & Rao, 2008).

Le, Hollenhorst, Harris, McLaughlin, and Shook (2006) revealed that complexity plays the most important role in the decision to adopt innovation. The complexity of the technology is still an important factor in determining consumer adoption (Min, So, & Jeong, 2019).

To provide a clear meaning for the term “Effect on Adoption of other Innovation,” it was replaced by the term “Expectation for Better Products” in some studies (Hosseini et al., 2016). In this study, we also used the latter term.

Resistance to innovation is dependent on the psychological characteristics of the consumer (Ram, 1987). In this study, we selected motivation because it was considered to provide more insights into consumer response variance to innovation (Barczak, Ellen, & Pilling, 1997).

The previous innovative experience of consumers also affects innovation resistance, and past experience plays an important role in shaping consumer perception and attitude formation (Ram, 1987). Hence, the attitude toward existing products was also selected in this study.

A green product is a product that is produced with the physical environment, such as air, water, and land in mind (Shrum, McCarty, & Lowrey, 1995). Gleim, Smith, Andrews, and Cronin, (2013) found that green product purchasing expertise plays a significant role in green purchasing decisions. Willingness to pay for organic food is positively related to organic food consumption (B. Chekima, K. Chekima, & K. Chekima, 2019). Moreover, the actual purchasing behavior of green products is positively influenced by their intention to buy green products (Testa, Sarti, & Frey, 2019). Hence, purchasing expertise and intention to buy green products are considered to influence consumer adoption of (or resistance to) Bio-CLF products, which are types of green products.

Knowledge of fertilizer raw material is also an important factor that influences consumer adoption (or resistance). This is because it strongly influences consumer green consumption (Pieniak, Aertsens, & Verbeke, 2010; Ritter, Borchardt, Vaccaro, Pereira, & Almeida, 2015).

3. Hypotheses

We propose our hypotheses based on the innovation resistance model of Ram (1987) and previous research findings. The hypotheses are as follows.

3.1 Direct Influence of Characteristics to Consumer Resistance

3.1.1 Perceived Risk

Perceived risk is the risk associated with adopting the innovation, and can be of several types: physical risk, functional risk (performance uncertainty), psychological risk and social risk (Ram, 1987). In this research, the Perceived risk is defined as the safety risk in the case of Bio-CLF products. Based on past research, perceived risk has a positive effect on resistance to smart home services (Hong, Nam, & Kim, 2020). Some studies confirmed that perceived risk has a negative influence on the intention to use or adopt an innovation product (Martins, Oliveira, & Popovič, 2014; Yang, Liu, Li, & Yu, 2015; Yiu, Grant, & Edgar, 2007). Based on these previous studies, we hypothesize the following:

Hypothesis 1: The higher the perceived risk of Bio-CLF, the higher the consumer resistance.

3.1.2 Complexity

A greater perception of complexity can lead to an aware individual refusing to acquire further information on new technologies and adopt these technologies (Vecchio, Agnusdei, Miglietta, & Capitanio, 2020). However, complexity in this study is defined as the process of purchasing the Bio-CLF product and whether it is easy to distinguish Bio-CLF products from their counterparts. Some studies have shown that complexity negatively affects the adoption of innovation products (Kousar, Sabri, Zafar, & Akhtar, 2017; Tan & Teo, 2000), which positively affects consumer resistance (Chouk & Mani, 2019; Mani & Chouk, 2018).

Hypothesis 2: The higher the perceived complexity of Bio-CLF, the higher the consumer resistance.

3.1.3 Motivation

Motivation is defined as “goal-directed arousal” that drives consumers need (Hosseini et al., 2016). Motivation for this research is defined as consumer motivation to purchase a Bio-CLF product. Ude and Diala (2015) found that there is a 0.446 increase in employee motivation for each one-point increase in support for innovation. Consequently, we hypothesize that motivation has a negative relationship with consumer resistance.

Hypothesis 3: The higher the consumer motivation regarding bio-CLF, the lower the consumer resistance.

3.1.4 Attitude toward Existing Products

Consumer experience with the use of a product affects consumer resistance to product innovation. For example, if consumers are satisfied with food irrigated using chemical fertilizer, liquid fertilizer, or organic fertilizer, they may consider that there is no need to buy food that was irrigated using Bio-CLF. This relationship was confirmed by (Hosseini et al., 2016), who found that the more positive the consumer attitude toward normal mobile phones, the higher the consumer resistance to mobile phones.

Hypothesis 4: The more positive the consumer attitude toward current food, the higher the consumer resistance to Bio-CLF food.

3.1.5 Purchase Intention

Purchase intention is based on whether a consumer has an intention to buy green rice, which consists of organic rice and rice grown without using or limited use of chemical fertilizers and pesticides. As mentioned above, if consumers have green product purchasing expertise, they may adopt and purchase Bio-CLF products, as Bio-CLF rice is also a type of green rice (strictly speaking, it is not defined as organic rice, but eco-friendly).

Hypothesis 5: The higher the consumer purchase intention toward green products, the lower the consumer resistance to the Bio-CLF product.

3.1.6 Knowledge

We use consumers' knowledge of organic fertilizer raw materials (Note 3) to measure knowledge. Understanding the information and gaining knowledge about green products will influence consumption behavior, as mentioned above.

Hypothesis 6: Consumers with knowledge of organic fertilizer raw materials will reduce their resistance to Bio-CLF.

3.2 Indirect Influence of Characteristics on Consumer Resistance

Previous studies have confirmed the relationship between compatibility, relative advantage, expectation of better products, and motivation. Reimer, Weinkauf, and Prokopy (2012) showed that the motivations for using different conservation practices were positively associated with relative advantages, compatibility, and observability (observing the practice's advantage). Compatibility and perceived relative advantages were associated with healthcare professionals' motivation to implement and continue a multidisciplinary primary care-based lifestyle intervention (Helmink, Kremers, Van Boekel, Van Brussel-Visser, & De Vries, 2012). The correlation between expectation and motivation was confirmed in a previous study (Wong, Cheung, & Wan, 2013). Additionally, Luo and Ye (2020) showed that tourists' expectations have a positive influence on motivation.

Consequently, relative advantage, compatibility, and expectation for better products may have an indirect influence on consumer resistance, as shown below.

3.2.1 Relative Advantage

A high level of perceived relative advantage means that innovation is considered to be a better option than its alternative based on an overall assessment made by the consumer (Wang, Yuen, Wong, & Teo, 2018). In this study, the relative advantage of Bio-CLF is defined as the advantage of Bio-CLF over chemical fertilizer. Consequently, we developed a hypothesis, according to (Reimer et al., 2012), by considering indirect influence.

Hypothesis 7. The higher the relative advantage of Bio-CLF, the higher the consumer motivation, which indirectly reduces resistance.

3.2.2 Compatibility

Compatibility is the degree to which society trusts that the invention is well matched with the old-style knowledge regarding "existing values, past experiences, and needs of the potential adopters" (Al-Rahmi et al., 2019). Compatibility helps the individual give meaning to the new idea, enabling it to be regarded as more familiar (Rogers, 2003). Joachim, Spieth, and Heidenreich (2018) showed that if a consumer perceives an innovation to be incompatible with past or existing products, compatibility barriers arise, and the compatibility barrier decreases the intention to adopt innovation. This means that compatibility decreases consumer resistance. The compatibility of Bio-CLF in this study is defined as the possibility of purchasing the Bio-CLF products instead of the more familiar and regularly-purchased products. Following the previous study (Reimer et al., 2012) and considering the indirect influence, we developed a hypothesis.

Hypothesis 8: The higher the perceived compatibility of Bio-CLF, the higher the consumer motivation, which indirectly reduces resistance.

3.2.3 Expectation for Better Products

In this study, we defined the expectation for better products as consumer expectations of future Bio-CLF products, which means that consumers wish Bio-CLF food will be more delicious, safer, and fresher with the progress of the Bio-CLF technology. Based on studies in different research contexts, positive attitudes toward organic food will positively influence consumer purchase intentions (Asif, Xuhui, Nasiri, & Ayyub, 2018; Bryła, 2016; Nuttavuthisit & Thøgersen, 2017; Slamet, Nakayasu, & Bai, 2016; Yadav & Pathak, 2016). In this study, the higher the consumer expectation of future Bio-CLF products, the higher their support for future Bio-CLF, and hence, the lower consumer expectation of the current Bio-CLF product and the higher their resistance to the current Bio-CLF product. According to Ram (1987) and Luo and Ye (2020), we developed another hypothesis.

Hypothesis 9: The higher the consumer attitude toward future Bio-CLF products, the lower the consumer motivation for the current Bio-CLF product, which indirectly causes higher consumer resistance to Bio-CLF products.

3.3 Research Model of Consumer Resistance to the Bio-CLF Product

Based on the hypothesis above, we constructed the theoretical model shown in Figure 3.

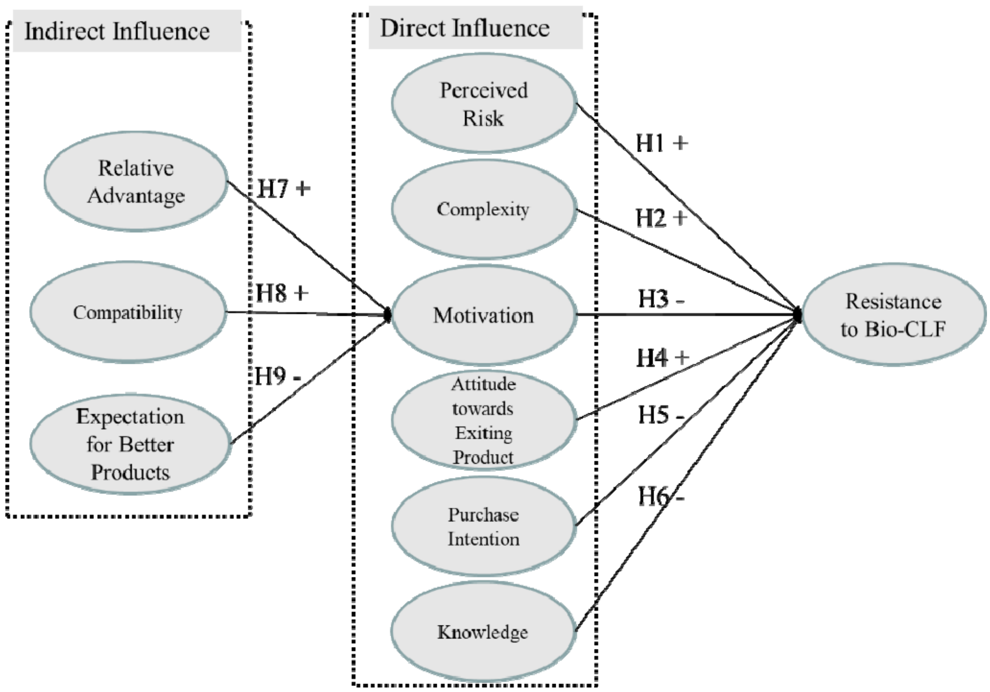

Figure 3. Hypothesized model of consumer resistance to the Bio-CLF product

Source: Authors.

4. Methodology

4.1 Data Collection and Sample Characteristics

We collected data through an Internet survey administered in Japan by the market-research company, Cross Marketing Inc. Data were collected from January 4 to 6, 2021. The target respondents were 20 years or older. The sample was collected from an individual enrolled in Cross Marketing Inc. Using random sampling, 1,000 in Tokyo, 500 in Osaka prefecture, and 500 in Fukuoka prefecture were finally stratified and extracted according to the age ratio of each local government.

To help respondents obtain an image of Bio-CLF, before questions, we used pictures to show the difference between the appearance of Bio-CLF and ordinary liquid fertilizer, and reveal the merits and demerits of Bio-CLF, and the materials of Bio-CLF. Under the pictures, we asked respondents, “Do you feel resistance to agricultural products cultivated using Bio-CLF in the pictures?” The consumers who answered “I don’t feel resistance.” were employed for the analysis.

Finally, 703 samples were used in our research. Males occupied 56.2% of the cohort, and mean age was 44 years old.

4.2 Questionnaire and Measures

To measure the latent variables, we designed a questionnaire by referring to Hosseini et al. (2016); this questionnaire contained 33 questions. A Likert scale from 1 to 5 was used to measure the constructed variables, where, 1 = strongly disagree and 5 = strongly agree. Item loading is usually considered high if the factor loading is above 0.7 (Hair, Black, Babin, & Anderson, 2010). Hence, 28 questions were finally selected, and the components of each construct are shown in Table 1.

Table 1. Factor loadings for the measurement items (N = 703)

Latent variables	**Measurement Items**	**Mean**	**Factor Loading**	**Cronbach's Alpha**
Motivation (*MOTIV*)	motiv1: Use Bio-CLF to produce food is a breakthrough technology.	3.31	0.88	0.87
	motiv2: Bio-CLF food seems to be good for health. As a result, I want to eat it.	3.09	0.78	
	motiv3 Many of these foods will be produced in the future. Thus, I want to be familiar with them.	3.21	0.82	
Attitude toward Existing Products (*ATTITUDE*)	attitude1: Foods cultivated in Japan meet national safety standards, so commercially available foods are sufficient.	3.22	0.71	0.85
	attitude2: There are organic food available; thus, if I am concerned about my health, I can buy them.	3.21	0.93	
	attitude3: There are organic foods available; thus, if I am concerned about the environment, I can buy them.	3.20	0.87	
Relative Advantage (*ADVANT*)	advant1: Bio-CLF is safe for the human body because it extracts fertilizer components from organic matter (such as kitchen waste).	3.26	0.81	0.92
	advant2: As organic matter (such as kitchen waste) for disposal is reused, Bio-CLF contributes to the waste disposal problem.	3.45	0.86	
	advant3: Food cultivated with Bio-CLF is friendly to the environment of the soil and water quality.	3.34	0.87	
	advant4: "Bio-CLF" is safe as a fertilizer and does not contain impurities because the nutrient components are extracted by a filtration device or electrodialysis.	3.28	0.89	
	advant5: Considering the quality of foods (non-chemical fertilizer) cultivated with Bio-CLF, the price that matches the quality is acceptable.	3.17	0.79	
Compatibility (*COMPA*)	compa1: Food cultivated with Bio-CLF matches the quality that I am looking for.	3.12	0.80	0.88
	compa2: I may buy it as a substitute for the food that I always buy.	3.24	0.87	
	compa3: I may buy it together with the food that I always buy.	3.32	0.88	
Expectation for Better Products (*EXPECT*)	expect1: We hope the technological development of Bio-CLF will progress and delicious foods will be produced.	3.39	0.92	0.95
	expect2: We hope the technological development of Bio-CLF will progress and safer foods will be produced.	3.44	0.91	
	expect3: We hope the technological development of Bio-CLF will progress and stronger and fresher foods will be produced.	3.43	0.92	
	expect4: I wish the Bio-CLF foods would become more widespread as this would enable them to be easily available for the ordinary family to purchase.	3.40	0.91	
Complexity (*COMPLX*)	complx1: I do not want to buy Bio-CLF food if they cannot be easily bought at supermarkets or online shops.	3.24	0.75	0.78
	complx2: If the Bio-CLF food is not easily identified according to the label (it is not clear at a glance), it is troublesome to purchase it.	3.09	0.75	
	complx3: Even if it is called organic food, specially cultivated food, or Bio-CLF cultivated food, the differences among them are not clear, and it is troublesome to separate them and purchase one.	3.13	0.72	
Perceived Risk (*RISK*)	risk2: I am worried the raw material ratio of Bio-CLF will be changed or the raw material itself will be changed.	3.03	0.75	0.80
	risk3: If I like Bio-CLF, I worry whether I will be able to buy it at the supermarket or online on a regular basis.	2.99	0.68	
	risk4: As Bio-CLF is a new technology, I would like to wait for a while to determine if there is any associated risk.	3.42	0.79	
	risk5: I need to know more information about Bio-CLF.	3.23	0.75	

Innovation Resistance (*RESIST*)	resist2: There is no point in buying Bio-CLF food because the usual food is sufficient.	2.90	0.79	0.84
	resist3: I have no intention of buying Bio-CLF food in the future.	2.65	0.83	
	resist5: I feel reluctant to switch from foods (or eat habit) I always buy.	2.78	0.78	
		Mean	**SD**	
Purchase Intention (*INTENTION*)	Have you ever purchased organic rice that is not cultivated with chemical fertilizers or cultivated with less chemical fertilizers? 1 = "I have bought it and I still buy it" or "I have never bought it before, but I want to buy it". 0 = else.	0.41	0.49	
Knowledge (*KNOW*)	Do you know what the raw materials for organic fertilizers, which are used in organic farming, are made of? 1 = "I know it.", or "I know to some extent.", 0 = else	0.19	0.40	

Note. Cronbach's alpha was 0.96. "Purchase Intention" and "Knowledge" are dummy variables. The factor loading of risk3 is 0.68, and half adjusted to 0.7, which was considered to be acceptable.

Source: Authors

The objective of our study was to analyze the causal relationships between innovation characteristic variables, consumer characteristic variables, and consumer resistance toward Bio-CLF products. Structural Equation Modeling (SEM) is a statistical technique for testing and estimating causal relationships based on statistical data and qualitative causal assumptions that can be used for analysis. Although the partial least squares (PLS) approach also fits our purpose, (Urbach & Ahlemann, 2010) suggested that when PLS approaches and SEM approaches can be applied, SEM should be used owing to the higher degree of validity of its results. Consequently, we used the SEM approach. We analyzed the data in R 4.1.0, and packages (GPArotation, lavaan, psych, psy, semPlot, semTools, tidyverse) were used.

5. Result

5.1 Validity and reliability analysis

The validity and reliability of the model are shown in Table 2, which proves that our measurement model returned a good model fit.

Table 2. The results of the validity and reliability of the model

Fit Index	Model Results	Reference Value*
χ^2	1731.74	-
df	369.00	-
χ^2/df	4.69	-
p-value	0.00	-
CFI	0.92	>0.90
TLI	0.91	>0.90
RMSEA	0.07	<0.08

Note. *Reference values adapted from CFI (Bentler & Bonett, 1980), RMSEA (Hair et al., 2010), and TLI (Hu & Bentler, 1999).

Table 3 shows the internal reliability of the model. The average variance extracted (AVE) was above 0.5 and construct reliability (CR) was above 0.7, which confirmed convergent validity and construct reliability according to (Hair et al., 2010). Half of the inter-correlations among the study constructs were smaller than the square root of the AVE values, which revealed that the discriminant validity of the model is acceptable. The results also revealed a high correlation between *ADVANT*, *COMPA*, *EXPECT*, and *MOTIV*.

Table 3. The results of correlation, convergent, and discriminant validity (N = 703)

	CR	AVE	*ADVANT*	*COMPA*	*RISK*	*COMPLX*	*EXPECT*	*MOTIV*	*ATTITUDE*	*RESIST*
ADVANT	0.94	0.71	**0.84**							
COMPA	0.89	0.73	0.95	**0.85**						
RISK	0.88	0.56	0.72	0.74	**0.75**					
COMPLX	0.79	0.55	0.63	0.60	0.75	**0.74**				
EXPECT	0.96	0.84	0.92	0.88	0.72	0.61	**0.92**			
MOTIV	0.85	0.68	0.94	0.94	0.71	0.58	0.84	**0.83**		
ATTITUDE	0.89	0.71	0.73	0.73	0.66	0.65	0.66	0.74	**0.84**	
RESIST	0.84	0.64	0.12	0.16	0.43	0.52	0.003	0.14	0.34	**0.80**

Note. The values in the diagonal (bold) represent the square root of AVE, and the off-diagonals represent the correlations.

5.2 Structural Model

The results of the structural model showed that most of the hypotheses were supported, except H6 and H9, which were not significant (see Table 4). We confirmed that *ADVANT* and *COMPA* significantly affected *MOTIV* and indirectly influenced *RESIST*. *MOTIV* had a significant negative effect on *RESIST*. The structural model explained 40.8% variance in consumer resistance to the Bio-CLF product.

Table 4. Direct and Indirect Influence of the Characteristics to RESIST

Direct/Indirect Influence	Hypotheses	Path	N = 703		
			β	p	Support
Direct	H1(+)	*RISK→RESIST*	0.31	0.000	YES
	H2(+)	*COMPLX→RESIST*	0.45	0.000	YES
	H3(-)	*MOTIV→RESIST*	-0.59	0.000	YES
	H4(+)	*ATTITUDE→RESIST*	0.29	0.000	YES
	H5(-)	*INTENTION→RESIST*	-0.07	0.079	YES
	H6(-)	*KNOW→RESIST*	-0.03	0.420	n.s
Indirect	H7(+)	*ADVANT→MOTIV*	0.62	0.000	YES
	H8(+)	*COMPA→MOTIV*	0.46	0.000	YES
	H9(-)	*EXPECT→MOTIV*	-0.11	0.121	n.s

Note. n.s. = not significant.

6. Discussion

In this study, we investigated the factors affecting consumer resistance to Bio-CLF products in Japan using IRT. Some factors were found to have a direct effect on *RESIST* as hypothesized, while some factors showed results that differed from those of the model of (Ram, 1987), which has an indirect effect on *RESIST*. The details are presented below.

6.1 Direct Influence Factors

H1 was supported. If consumers feel there is a risk associated with the purchase of the Bio-CLF product, they will resist it. This result is consistent with previous findings (Cheng, Lee, & Lee, 2014; Mohtar & Abbas, 2020; Ram, 1987). Hence, to reduce the degree of consumer resistance, it is useful to reduce consumers' perceived risk. For example, Bio-CLF food producers are suggested to disclose production information. For political makers, it is effective to have a monitoring system and a certification system. Certification systems affect consumer purchase behavior (Lee, Fu, & Chen, 2019).

H2 was supported. When consumers feel that it is complex to distinguish the Bio-CLF product from other green products or feel it is not easy to purchase this product from supermarkets or via the Internet, they will resist it. This result aligns with most available studies in different research contexts (Freeze & Schmidt, 2015; Hosseini et al., 2016; Kim & Bae, 2020; Mani & Chouk, 2018; Matsuo, Minami, & Matsuyama, 2018; Ram, 1987).

Consequently, it is important to reduce the complexity of the Bio-CLF product to reduce consumer resistance. To distinguish Bio-CLF products from other green products, setting a specialized corner for Bio-CLF products is a considerable notion. For producers, designing a label sheet that is attractive to consumers and enable consumers to easily recognize that the product is irrigated by Bio-CLF is reasonable.

These results support H3, which is consistent with previous studies (Hosseini et al., 2016; Ram, 1987). Hence, to reduce consumer resistance, it is useful to increase consumer motivation to purchase Bio-CLF products. Due to the relationship between relative advantage (*ADVANT*), compatibility (*COMPA*), and motivation (*MOTIV*), the suggestions for increasing consumer motivation are shown in the next chapter.

H4 was supported. The more consumers are satisfied with the current food, the higher the consumer resistance to Bio-CLF food. The relationship between *ATTITUDE* and *RESIST* has also been shown in a previous study, and the effect has been confirmed (Hosseini et al., 2016). In Japan, there were two levels of cultivation methods: "Conventional cultivation," which uses chemically synthesized pesticides and is the traditional cultivation method in Japan; and "Reduced pesticide cultivation," which uses less than half the amount of chemically synthesized pest (Nishimura, 2021). According to different cultivation methods, conventional food, pesticide-reduced food, organic food, etc. were defined and are now available in the market. Therefore, if consumers are satisfied with their current food, they may resist Bio-CLF food.

The results support H5. Consumers who have higher purchase intentions toward green products will be less resistant to Bio-CLF products. As mentioned above, green product purchasing expertise plays an important role in consumer purchase behavior (Gleim et al., 2013; Testa et al., 2019). Consequently, for supermarket managers, placing the Bio-CLF product alongside other green products, such as organic products, is a good approach to attract green consumers. Producers should ensure the Bio-CLF product appears appealing as a green product. For the Bio-CLF developer, advancing the Bio-CLF technology and acquiring JAS organic certification of Bio-CLF product are feasible.

6.2 Indirect Influence Factors

These results support H7 and H8, and are consistent with those of previous research (Helmink et al., 2012; Luo & Ye, 2020; Reimer et al., 2012; Wong et al., 2013). Based on the results, to reduce consumer resistance, it is important to improve consumer motivation to purchase Bio-CLF products. According to the definition of *ADVANT* and *COMPA* in this study, to improve consumer motivation to purchase Bio-CLF products, it is suggested that Bio-CLF product producers have the relative advantages of Bio-CLF over chemical fertilizer. For example, compared with chemical fertilizer, Bio-CLF contributes to the improvement of the environment due to the use of organic waste, such as waste milk, raw garbage, manure, etc. Compared with ordinary liquid fertilizer, it contains the adjusted ingredients that the crops need; hence, it may be more delicious. It is also necessary to show the compatibility of the Bio-CLF product with the current product. Taking Bio-CLF rice as an example, the producer should ensure that the quality matches the expectation of consumers. Hence, the creation of a certification system for Bio-CLF products to guarantee quality is suggested.

7. Conclusion

Although the fertilizer spread cost of farmers may be reduced and the use of Bio-CLF may expand with the development of Bio-CLF, this innovation suffers from consumer resistance. To date, IRT has been applied in many fields. However, research on "agricultural products," especially on "liquid fertilizer" is rare. The findings of this study fill this gap. In this study, we used IRT to determine the underlying reasons for consumer resistance to Bio-CLF products. A total of 2,000 samples were collected from three populous cities, such as Tokyo, and 703 samples were finally used for the analysis.

Perceived risk, complexity, and attitude toward existing products have a positive and direct impact on consumer resistance to Bio-CLF products, while motivation and purchase intention have negative and direct impacts on consumer resistance to Bio-CLF products. Notably, relative advantage and compatibility have a positive impact on motivation and indirectly influence consumer resistance to Bio-CLF products, which is inconsistent with the IRT model of (Ram, 1987).

To reduce consumer resistance to Bio-CLF products and expand the usage of Bio-CLF, we provide some advice for market managers, producers, political makers, and Bio-CLF developers. We suggest that market managers: (1) allocate a specialized corner for the Bio-CLF product and (2) place the Bio-CLF product alongside other green products. For producers, we suggest the: (1) disclosure of production information; (2) design of an attractive and clear label sheet; (3) proving the advantage of Bio-CLF and that the Bio-CLF product is a green product. For political makers, we suggest that it is effective to have a monitoring system and a certification system for Bio-CLF products. For Bio-CLF developer, advancing the Bio-CLF technology and acquiring JAS organic certification of Bio-CLF products are suggested for the future.

8. Limitations and Future Work

This study had certain limitations that should be addressed by future researchers. The first limitation was the lack of generalization of the study results. The study samples were obtained from three major cities; therefore, the representation of consumer resistance to Bio-CLF is limited. Future studies should use a wider research area. Second, the study used cross-sectional data, which failed to determine the dynamic nature of consumer behavior. Hence, future research should conduct a longitudinal study to overcome this limitation.

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Notes

Note 1. Taking kitchen food waste as an example, for the difference in cost between the case where methane fermentation digested liquid is used and the case where it is not used, the larger the scale of the methane fermentation facility, the larger the cost. The case when the processing scale of the facility is 100 tons/day, the difference in digested liquid treatment cost is 70.18 million yen/year.

Note 2. Ordinary liquid fertilizer contains suspended substance which may lead to clogging of the pipes in horticultural facilities. Hence, ordinary liquid fertilizer is mainly used to spray large-scale land-use crops.

Note 3. According to Japan Agricultural Standards, we defined the organic fertilizer raw materials as oil cake, livestock manure, bone meal, wood ash.

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