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# The impact of ecological innovation on the food production quality: mediating role of environmental awareness

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## ABSTRACT

Eco-innovation is the necessary element for the production process and quality and the organization's success that needs researchers' and policymakers' emphasis. Hence, the current article investigates the impact of product eco-innovation, process eco-innovation, and organizational eco-innovation on the food production quality in the food industry in China. The present study also investigates the mediating impact of environmental awareness among the association of product eco-innovation, process eco-innovation, organizational eco-innovation, and quality of food production in the food industry in China. The article followed the survey questionnaires to gather the primary data. The study used the PLS-SEM to check the relationships among the constructs using SPSS-AMOS. The findings indicated that product eco-innovation, process eco-innovation, and organizational eco-innovation have a positive association with food production quality in the food industry in China. The outcomes also revealed that environmental awareness significantly mediates among product eco-innovation, process eco-innovation, organizational eco-innovation, and food production quality in the food industry in China. This study guides the policymakers in developing policies related to food production quality using eco-innovation and environmental awareness in the complete business process.

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Product eco-innovation; organizational eco-innovation; environment awareness; food production quality; food industry

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125; 128; Q50; Q58

## 1. Introduction

Food production includes all relevant to preparing food for users. It consists of processes to convert the raw material into ready-made food items for humans to use at home or the food processing units. Food production is based on a large number of agricultural commodities (products from both plants and animals). Agriculture provides humans with food products, including grains, spices, pulses, nuts, cereals,

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honey, milk, vegetables, fruits, chicken, egg, meat, etc. These items are either used directly for food purposes or used as raw materials to prepare other food items (Pichlak & Szromek, 2022). For the good health of humans, there is a need to preserve the nutritiousness of food dependent on food production quality.

If the food production quality is good, humans who collectively run society and provide human resources to run economic functions may have good health. These humans can actively and effectively perform social activities and economic functions. So, the food production quality must be evaluated and maintained for the country's survival on the world map, economic growth in the competitive world market, and human well-being at social and individual levels (Panghal et al., 2018). The quality of food production, because of its primary sources like plants and animals, is affected by the quality of the environment, including climate, soil condition, and water quality. As the economies are growing and the population is getting larger, there is increasing chemical use, energy consumption, machines, waste emissions, and continuous excessive resource consumption. So, the environmental quality is being damaged. (Ogunniyi et al., 2020).

Ecological innovation effectively deals with environmental issues and ensures food production quality. Eco-innovation refers to newness, value addition, or change in business processes, techniques, and products. It is meant to decrease the negative environmental impacts and encourage responsible and efficient use of natural resources. Adopting ecological innovation reduces the chances of pollution emissions and protects the product's quality in food production. Ecological innovation has three types: product eco-innovation (PEI), process eco-innovation (PREI) and organizational eco-innovation (OEI) (Barbieri & Santos, 2020). PEI is innovative in product design, functioning, reliability, and durability, which gives many more economic benefits and reduces negative environmental impacts. The food items that may affect the environment and the users' health need eco-innovation. The PEI makes it essential for firms dealing in food production to improve their knowledge and take steps to improve food production quality.

Process eco-innovation refers to the exploitation or application of production processes that are entirely new or have value addition. And these processes result in the decrease of environmental degradation relative to suitable alternatives. The eco-friendly changes and improvements in food production techniques also protect the quality of food products from being damaged by harmful substances (Nikolova-Alexieva et al., 2022). OEI is the novel organizational strategy implemented in a company's business resources, operations, workplace structure, or external relations to reduce environmental impacts. In the food production industry, the OEI adoption helps enhance the quality of food production effectiveness and improves the quality of food (Sanni & Verdolini, 2022).

The current study examines the influences of PEI, PREI, and OEI on environmental awareness and food product quality in China. China is a fast-growing economy and a large population. It is recognized as the largest country in purchasing power parity and the second-largest country in terms of nominal gross domestic product (GDP). China's nominal GDP is anticipated to reach \$19.91 trillion in 2022, with a \$30.38 trillion purchasing power parity. It shows how, by 2022, the economic growth rate will fall from 8.5% to 4.3%. (Shen et al., 2021). The economy has three major sectors, industry, agriculture, and services, with respective GDP shares of 40.5%, 7.

9%, and 51.6%. The Chinese production industry is closely associated with the agriculture sector but is also linked to the other two sectors.

Agriculture has vital importance for China, especially for food production. China alone provides food to 1.3 billion people, which accounts for 19% of the total population across the world, although it has only 7% of the earth's arable land. In China, about 75% of total cultivated land is under consumption for food crops (Wang et al., 2019). The three major crops of China are Rice, maize, and wheat. The production of these three crops provides more than 90 percent of the country's total food production. It is considered that China's more than 80 per cent crop production provides food to humans, whereas 20 per cent food to animals (Qin et al., 2021).

As the rate of urbanization and growth rate of people's income level is increasing and there is an improvement in people's lifestyle, there is a change in people's diet. Like people are moving from high-carbohydrate foods to energy-dense and high-protein foods. It is an increasing demand for animal-based food products (Q. Xu et al., 2019). Consequently, these circumstances put greater pressure on food production through agriculture improvement. In total, there is a need to increase 776 Mt grain by 2030 to meet food needs. This increased need shows a 36 percent increase in food production. So, it has become a country's priority to increase and sustain food production. The biggest hurdle to the lack of food production through agriculture (animals, crops, and trees) is increasing environmental pollution (Ren et al., 2021).

The internal food requirements and the need for food products to export to satisfy world food requirements, especially the need for nutrient food, are increasing. Nutrient food availability is a need of healthy societies and a sound economy in any country. Though the Chinese economy plays a considerable role in food production through agriculture, the production is not enough to meet nutrient food requirements (J. Xu et al., 2020). There is a need to pay heed to food production quality to achieve increased, nutritious, and cost-effective food production. Moreover, consumers must know how to recognize and attain quality food products. The Current study meets this need and focuses on food production quality. The study's objective is to examine the role of PEI, PREI, and OEI in food production quality. One of its objectives is to explore the mediating role of environmental awareness between PEI, PREI, and OEI and food product quality.

Despite there being ample literature on food production, this study has a great contribution to the literature. First, many studies have addressed the role of eco-innovation in food production quality. But then, few studies have looked deeply into PEI, PREI, and OEI for analyzing food production quality. So, the current study analyzing the nexus among PEI, PREI, and OEI, as the dimensions of eco-innovation and their impact on food production quality, makes a significant contribution to the literature. Second, in the previous literature, the relationship of environmental awareness to eco-innovation and food production quality has been analyzed. But little attention has been paid to the mediating role of environmental awareness between eco-innovation and food product quality. The present study, which examines the mediating role of environmental awareness between the eco-innovation dimensions like PEI, PREI, OEI, and food product quality, extends the literature. Third, very few studies have addressed the issue of food production related to eco-innovation in

China. The current study is distinguishing because of the analysis of the relationship between PEI, PREI, OEI, and food product quality in China.

The rest of the paper is composed of the following parts: The second part deals with the relationship between eco-innovation like PEI, PREI, OEI, and food product quality and establishes hypotheses in the light of past literature. The third part describes acquiring and analysing the empirical data to confirm the hypotheses. Then, the study findings are compared with previous similar literary workouts under appropriate discussion. Later, study implications are described, and the study conclusion and limitations follow these implications.

### **1.1. Literature review**

People and other living creatures rely on food to survive in the world. Food provides energy to living beings to perform their routine functions. Food quality affects humans' survival, their functioning, and the environment consisting of many other living things. If the food production quality is good, the food is full of nutrients and free of harmful substances. It maintains humans' health, keeps them active, and never affects natural resources. The quality of natural food production is much improved by eco-innovation, that is, to bring changes or newness in business processes, techniques, and products and, thereby, reduce environmental impacts (Kuntosch et al., 2020). The current study examines the role of PEI, PREI, and OEI in food production quality. Many previous studies, in different ways, have discussed the role of eco-innovation like PEI, PREI, and OEI in environmental awareness and food product quality. In further paragraphs, the relevant past literature is reviewed, and hypotheses for the relationship of eco-innovation like PEI, PREI, and OEI with environmental awareness and food product quality have been established.

### **1.2. Product eco-innovation and food production quality**

In the food industry, the end consumers or the food processing firms want not only innovation in the food items. Still, they require innovation in food items which helps improve environmental impacts along with economic benefits. This emphasizes food producers to provide good quality food production (Tabaeian et al., 2021). Leitão et al. (2020) state that the study implies that the firms in the food processing industry want to bring ecologically friendly innovation to the food products like grain, grain products, bread, rolls, buns, cakes, cookies and crackers, pastry, meat, and meat products, fish products, chicken products, beverages and drinks, herbs and spices, and vegetable oil, etc. In this situation, it becomes necessary to maintain the quality of food products that provide raw materials to the food processing industry. Hence, the food PEI positively contributes to food production quality. Sumrin et al. (2021), proclaim that the study claims that when food processing firms are active in maintaining eco-innovation in their products to respond to customer requirements, they need clean and good quality raw food materials from the basic food production units. This forces the food producers to control the environmental impacts of the food products

at the starting point, and their eco-friendly initiatives improve food production quality. Based on the above discussion, it can be hypothesized:

**H1:** PEI has a positive linkage to food production quality

### ***1.3. Process eco-innovation and food production quality***

The eco-innovation process promotes ecologically friendly changes, novelty, or value addition to techniques and methods applied for inventory handling or production. Reducing polluting factors during changed processes ensures the quality of food production (Chistov et al., 2021). García-Granero et al. (2020), investigate the influences of process eco-innovation on food production quality. This study took data from the Spanish agri-food sector and did a multidimensional analysis. Descriptive statistics, cluster analysis, and the chi-squared test were applied to findings about the relationship between process eco-innovation on food production quality. The authors find that the small-sized firms where the process eco-innovation is less likely to be implemented have not good quality food production. At the same time, large firms that can afford to implement process eco-innovation give better quality food production. Zhang et al. (2020), examine eco-innovation with four dimensions: product, process, organization, and marketing, and their impacts on food production quality. The data were acquired from 93 companies in the agri-food sector in Southeast Spain, and a partial least-squares technique was applied for data analysis. The study posits that the execution of process eco-innovation is useful to gain environmentally friendly goals and economic objectives. So, the food production quality can be improved. Based on the above discussion, the following hypothesis can be placed:

**H2:** PREI has a positive linkage to food production quality

### ***1.4. Organizational eco-innovation and food production quality***

OEI includes environmentally friendly innovation in inventory management, resources applied, the processes and business techniques to be followed, and marketing. When all the organizational departments perform effectively without causing pollution, the food production quality can be improved and maintained (Ali et al., 2021). Ratten (2018), explores OEI's role in food product quality and competitiveness. The semi-structured interviews were done to collect data from respondents in Australia's Barossa Valley wine region. The study implies that wine or other food products may have adverse environmental impacts. The execution of organization eco-innovation brings eco-friendly improvement or change in the resources, techniques, and products, which improves the effectiveness of the production process and overcomes the problems in food production. Hence, OEI enhances food production quality. Adrián Rabadán et al. (2020), investigate the relationship between OEI, technological eco-innovation, and food product quality. A survey was done of Spanish firms, and the information for the factors of interest was collected from the agri-food sector. The Qualitative Comparative Analysis (QCA) was applied for research purposes. The study implies that the firms implementing OEI improve the firm's internal operations

by applying eco-friendly technologies. Consequently, the food production quality gets improved. The above literature review helps to establish the following hypothesis:

**H3:** OEI has a positive linkage to food production quality

### ***1.5. Environmental awareness role between product eco-innovation and food production quality***

The PEI in the food industry enhances the knowledge of the users and all the firms concerned with food production about the environmental issues, the consequences, extremes, and the need to remove these issues. The developed environmental awareness triggers ecologically friendly initiatives in the food production units and improves food production quality (Sumrin et al., 2021). Severo et al. (2018), examine the relationship between PEI, environmental awareness, and food product quality. Quantitative and descriptive research method based on structural equation modelling was applied, and data for the concerned factors were acquired from 1123 participants from the regions of south Brazil over generations. The study implies that strategies to implement PEI enhance environmental awareness. The increase in environmental awareness enhances social responsibility, and the firms struggle to improve food production quality. So, environmental awareness serves as a link between PEI and food product quality. Ben Amara and Chen (2020), examine the relationship between PEI, environmental awareness, social responsibility, and food product quality. When some food processors have the policy to give eco-innovative food items, it creates environmental awareness among the general public. Environmental awareness enhances the customers' requirement for eco-friendly and full of nutrients agro-based food. Firms' response to customers' requirements results in improving food production quality. Based on the above discussion, the following hypothesis can be placed:

**H4:** Environmental awareness significantly mediators PEI and food product quality.

### ***1.6. Environmental awareness role between process eco-innovation and food production quality***

When the agro-production firms take care of firms, the environmental awareness resulting from this learning opens the way for firms to improve the food production quality by removing germs, bacteria, and dirty water and arranging for a suitable climate (Ben Amara et al., 2020). Triguero et al. (2018) investigate the relation between environmental awareness, process eco-innovation, and food product quality. The data for the process eco-innovation, environmental awareness, and food product quality were collected from the Spanish food and beverage manufacturing industry for the time from 2008 to 2014. The study reveals that when the firms continue to bring changes in the production processes to overcome the pollution emissions with the change in the circumstances and requirements, they have increased environmental awareness. The enhanced knowledge enables the firms to make effective decisions, and this leads the firms to attain higher-quality food production. García-Sánchez et al. (2021), demonstrate that process eco-innovation fosters environmental



awareness. Having the increased environmental awareness, the producers felt motivated and competent to combat harmful food substances while food manufacturing processes were underway. So, environmental awareness helps to connect the quality of food products and process eco-innovation. Based on the above discussion, the following hypothesis can be placed:

**H5:** Environmental awareness significantly mediates process eco-innovation and food product quality.

### ***1.7. Environmental awareness role between organizational eco-innovation and food production quality***

In OEI, eco-friendly innovation is maintained in the organizational resources, technologies, procedures, relations, and marketing strategies. The tendency to implement OEI keeps the firms aware of the environmental quality, the change in environmental features, the causes of these changes, and the competencies to overcome environmental pollution. When the firms apply their environmental knowledge, they produce higher-quality food (A Rabadán & Bernabéu, 2021). González-Moreno et al. (2019), highlight the relationship between environmental awareness, process eco-innovation, and food product quality. Using the random sampling technique, the questionnaire information for the factors included in the research was acquired from 279 food firms in Spain. The study claims that utilizing OEI helps identify and address issues that could lead to environmental damage. As a result, environmental awareness is raised, which enhances the quality of food production. So, environmental awareness improves the link between process eco-innovation and food product quality. Moslehpour et al. (2022), integrate the relationship between environmental awareness, process eco-innovation, and food product quality. The required data for the research about environmental awareness, process eco-innovation, and food product quality were acquired from Taiwan. The study proclaims that OEI encourages eco-innovation in all business departments and gives them a chance to increase environmental awareness, which assists in improving the food production quality. Based on the above discussion, the following hypothesis can be placed:

**H6:** Environmental awareness is a significant mediator between OEI and food product quality.

### ***1.8. Research gap***

The present article addresses many literary gaps as listed below: First, the previous studies have either checked the nexus between eco-innovation and food quality or are concerned with any of the PEI, PREI, and OEI for evaluation of food product quality. The current study, with simultaneous and detailed analysis of the nexus among PEI, PREI, OEI, and food product quality, removes the literary gap. Second, the direct relation of eco-innovation with food quality has been checked in previous literature. The present article, which tests the role of eco-innovation in food quality through environmental awareness, challenges the previous literature. Third, the previous



studies mostly discussed the eco-innovation role in food product quality for Spain, Brazil, Australia, the US, France, Egypt, the EU, Slovakia, and Canada. Still, it was required to investigate the eco-innovation and food quality relationships. The present study met this requirement. Finally, the study used the PLS-SEM to check the relationships among the constructs using SPSS-AMOS. So, it extends the literature.

## 2. Research methods

The article investigates the impact of PEI, process eco-innovation, and OEI on food production quality and also investigates the mediating impact of environmental awareness among the association of PEI, process eco-innovation, OEI, and food product quality in the food industry in China. The article followed the survey questionnaires to gather the primary data. The questionnaires have been taken from previously published studies such as PEI has six items taken from Yurdakul and Kazan (2020). The items, questions, and sources are given in Table 1.

In addition, the process eco-innovation (PREI) is measured with four items scale that is extracted from the article of Yurdakul and Kazan (2020). The items, questions, and sources are given in Table 2.

Moreover, OEI was measured with six items scale that is extracted from the article of Yurdakul and Kazan (2020). The items, questions, and sources are given in Table 3.

**Table 1.** Measurement scale of PEI.

Items	Statements	Sources
PEI1	'Our business develops products using less material'.	(Yurdakul & Kazan, 2020)
PEI2	'Our company develops products that can be recycled easily'.	
PEI3	'Our business develops products that cause the least amount of waste'.	
PEI4	'Our business develops products that minimize the damage caused by waste'.	
PEI5	'Our business develops products to minimize energy use'.	
PEI6	'Our business develops easily separable products'.	

Source: Author Estimations.

**Table 2.** Measurement scale of process eco-innovation.

Items	Statements	Sources
PREI1	'Our business develops less polluting production processes than its alternatives'.	(Yurdakul & Kazan, 2020)
PREI2	'Our business uses new technologies to save energy in production processes'.	
PREI3	'Our business has a recycling system in the production process'.	
PREI4	'Our business renews its production processes to meet the standards required by environmental laws'.	

Source: Author Estimations.

**Table 3.** Measurement scale of organizational eco-innovation.

Items	Statements	Sources
OEI1	'Our business uses an environmental management and audit system'.	(Yurdakul & Kazan, 2020)
OEI2	'Our business cooperates with businesses in the supply chain to avoid environmental damage'.	
OEI3	'Our business makes high R&D investments to reduce environmental impacts'.	
OEI4	'Our business has ISO14001 environmental standard'.	
OEI5	'The raw material suppliers of our business have the ISO14001 environmental standard'.	
OEI6	'Our business has a separate department for environmental protection'.	

Source: Author Estimations.

Similarly, environmental awareness (EAW) is measured with fifteen items scale that is extracted from the article of Jaciow et al. (2022). The items, questions, and sources are given in Table 4.

Finally, the food production quality (FPQ) is measured with seven items scale that is extracted from the article of Fortuin and Omta (2009). The items, questions, and sources are given in Table 5.

The researchers have selected the employees of the research and development department of the food industry in China. The study has chosen the top twenty food processing organizations based on income level. The employees are selected using simple random sampling. The surveys were sent through the mail. A total of 521 surveys were sent, but only 290 were received, representing around 55.66 per cent response rate. The study used the PLS-SEM to check the relationships among the constructs using SPSS-AMOS. It is an effective statistical tool that deals with complex models and is suitable for small and large data sets (Hair et al., 2014). It works in two parts: the first is assessing the measurement model, and the second is assessing the structural model. In assessing the measurement model, convergent and discriminant validity have been examined. The convergent validity has been examined using composite reliability (CR), Squared Shared Variance (ASV), factor loadings, Maximum Shared Variance (MSV), and average variance extracted (AVE).

**Table 4.** Measurement scale of environmental awareness.

Items	Statements	Sources
EAW1	'We are approaching the limit of the number of people the Earth can support'.	(Jaciow et al., 2022)
EAW2	'Humans can modify the natural environment to suit their needs'.	
EAW3	'When humans interfere with nature, it often produces disastrous consequences'.	
EAW4	'Human ingenuity will ensure that we do not make the Earth unlivable'.	
EAW5	'Humans are seriously abusing the environment'.	
EAW6	'The Earth has plenty of natural resources if we learn how to develop them'.	
EAW7	'Plants and animals have as much right as humans to exist'.	
EAW8	'The balance of nature is strong enough to cope with the impacts of modern industrial nations'.	
EAW9	'Despite our special abilities, humans are still subject to the laws of nature'.	
EAW10	'The so-called "ecological crisis" facing humankind has been greatly exaggerated'.	
EAW11	'The Earth is like a spaceship with limited room and resources'.	
EAW12	'Humans were meant to rule over the rest of nature'.	
EAW13	'The balance of nature is very delicate and easily upset'.	
EAW14	'Humans will eventually learn enough about how nature works to be able to control it'.	
EAW15	'If things continue on their present course, we will soon experience a major ecological catastrophe'.	

Source: Author Estimations.

**Table 5.** Measurement scale of food production quality.

Items	Statements	Sources
FPQ1	'We expect the sales volume of our current products in the coming three years to increase strongly'.	(Fortuin & Omta, 2009)
FPQ2	'The current position of our company compared to our main competitors can be characterized as very strong'.	
FPQ3	'Compared to our main competitors, our food quality is very high'.	
FPQ4	'Compared to our main competitors, our sales volume is very high'.	
FPQ5	'Compared to our main competitors, our growth rate is very high'.	
FPQ6	'Our company distinguishes positively from our competitors by a strong financial position'.	
FPQ7	'Our company distinguishes positively from our competitors by our good quality'.	

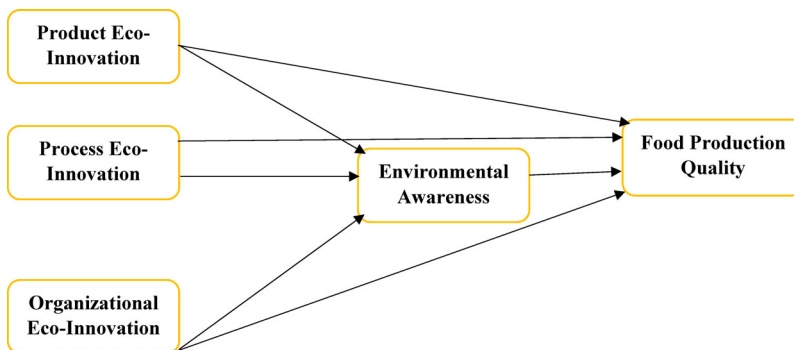
Source: Author Estimations.

In contrast, the discriminant validity has been examined using the Fornell Larcker criteria. In addition, model good fitness is also checked using the Tucker-Lewis index (TLI), comparative fit index (CFI), and root mean the square error of approximation (RMSEA). Finally, the structural assessment shows the association among variables using t-statistics and probability values. The study follows the reasoned action theory that explains the association among behaviors and attitudes within human action. This theory predicts individuals' behavior based on their pre-existing behavioural intentions and attitudes. The current study also examines the behavior of employees of the research and development department of the food industry in China in terms of adopting innovation to increase their product quality using their awareness of the environment. The reasoned action theory is used in the study to predict the employees' actions related to adopting the innovation by using their experience and behavior regarding environmental awareness to achieve high food production quality. Hence, the study has taken three predictors: PEI, process eco-innovation (PREI), and OEI. In addition, the study also used the mediating variable, such as environmental awareness (EAW). Finally, the study used food production quality (FPQ) as the dependent variable. These variables are presented in the shape of the theoretical framework mentioned in Figure 1.

### 2.1. Research findings

The study checks the correlation among items called convergent validity. The convergent validity has been examined using CR, and values should be more than 0.50, ASV value should be lower than AVE, factor loadings values should be higher than 0.40, MSV should be lower than AVE and AVE values should be larger than 0.50. The findings show the same results mentioned above. Hence, the convergent validity is valid. These outcomes are mentioned in Table 6.

The study checks the correlation among variables called discriminant validity. The discriminant validity has been examined using the Fornell Larcker criteria, and the standard criteria for the test are that the first value should be bigger than the rest of the values in the same column. The findings show the same results mentioned above. Hence, the discriminant validity is valid. These outcomes are mentioned in Table 7.



**Figure 1.** Theoretical model.  
Source: Authors Construction.

**Table 6.** Convergent validity.

Constructs	Items	Loadings	CR	AVE	MSV	ASV
Environmental Awareness	EAW1	0.460	0.898	0.579	0.335	0.441
	EAW2	0.462				
	EAW3	0.463				
	EAW4	0.448				
	EAW5	0.502				
	EAW6	0.476				
	EAW7	0.591				
	EAW8	0.807				
	EAW9	0.752				
	EAW10	0.674				
	EAW11	0.618				
	EAW12	0.746				
	EAW13	0.728				
	EAW14	0.636				
	EAW15	0.690				
Food Production Quality	FPQ1	0.761	0.902	0.649	0.557	0.416
	FPQ2	0.860				
	FPQ3	0.826				
	FPQ4	0.838				
	FPQ5	0.737				
Organizational Eco-innovation	OEI1	0.869	0.939	0.721	0.551	0.289
	OEI2	0.817				
	OEI3	0.972				
	OEI4	0.918				
	OEI5	0.821				
	OEI6	0.666				
Product Eco-innovation	PEI1	0.949	0.889	0.591	0.335	0.322
	PEI2	0.881				
	PEI3	0.480				
	PEI4	0.406				
	PEI5	0.839				
	PEI6	0.877				
Process Eco-innovation	PREI1	1.019	0.879	0.717	0.259	0.188
	PREI2	0.857				
	PREI3	0.614				

Source: Author Estimations.

**Table 7.** Discriminant validity.

	OEI	EAW	FPQ	PREI	PEI
OEI	0.849				
EAW	0.558	0.916			
FPQ	0.742	0.746	0.806		
PREI	0.371	0.509	0.455	0.847	
PEI	0.395	0.797	0.592	0.383	0.869

Source: Author Estimations.

The study also checks the model god fitness using TLI, and the standard value must be bigger than 0.90, CFI and the standard value must be bigger than 0.90, and RMSEA and standard value should be lower than 0.10. The findings show the same results mentioned above. Hence, the model is a good fit. These outcomes are mentioned in [Table 8](#).

**Table 8.** Model good fitness.

Selected indices	Result	Acceptable level of fit
TLI	0.901	TLI > 0.90
CFI	0.903	CFI > 0.90
RMSEA	0.001	RMSEA < 0.05 good; 0.05 to 0.10 acceptable

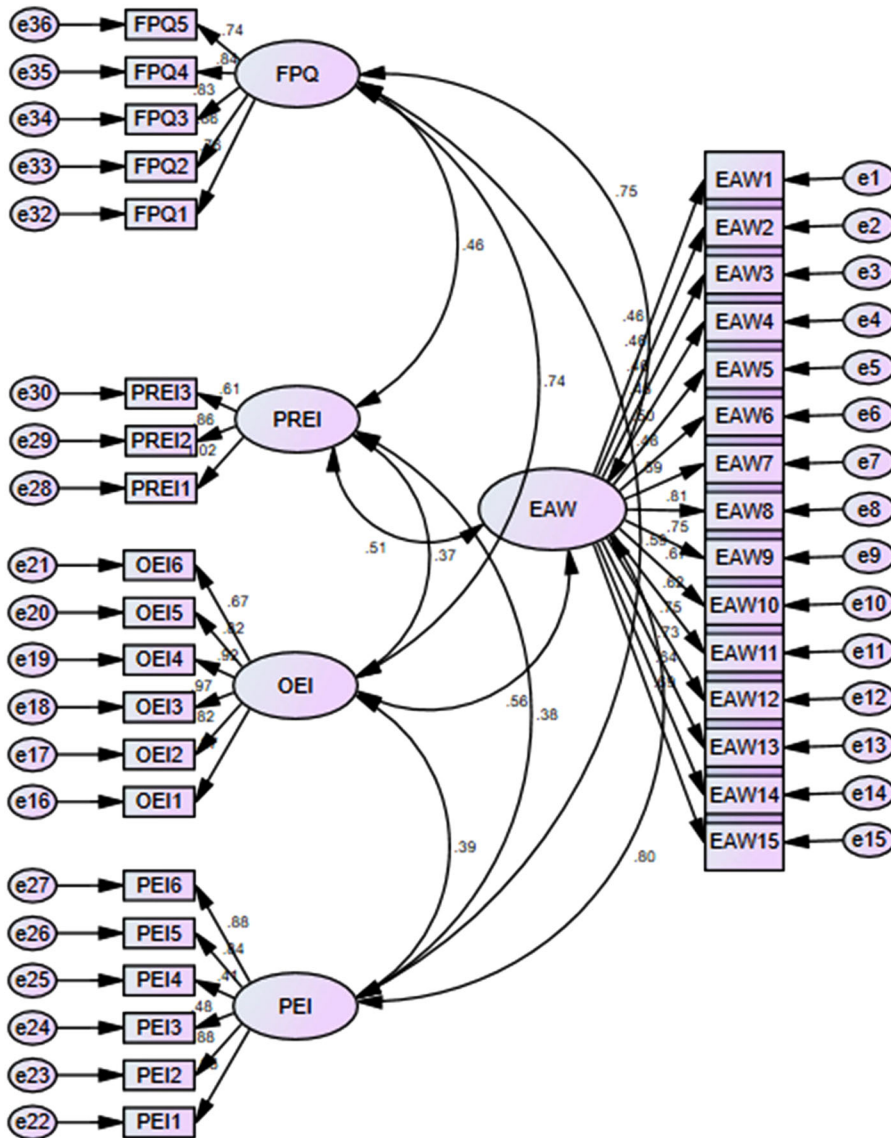
Source: Author Estimations.

The findings indicated that PEI, process eco-innovation, and OEI have a positive association with food production quality in the food industry in China and accept H1, H2 and H3. In addition, outcomes also exposed that eco-innovation, process eco-

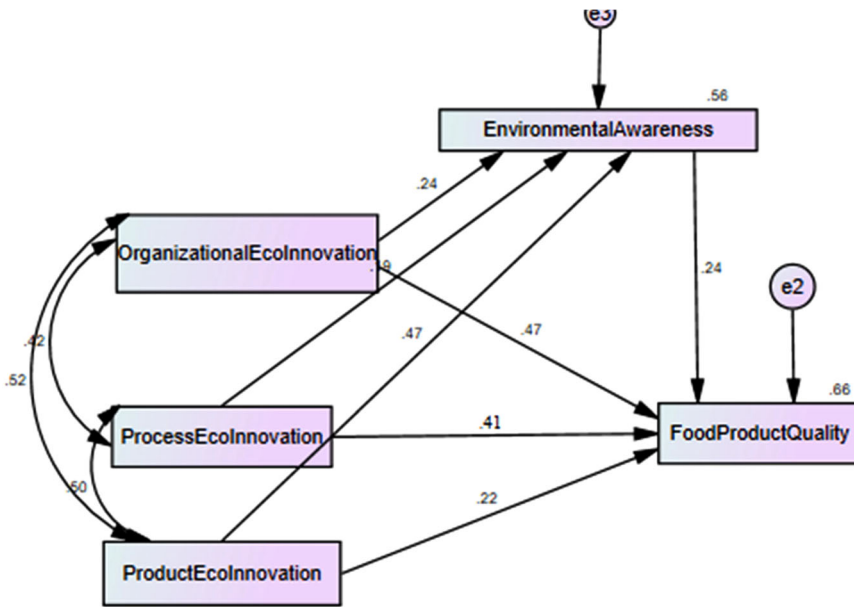
**Table 9.** Path analysis.

Relationships	Beta	S.E.	C.R.	<i>p</i>
Environmental Awareness <— Organizational Eco-Innovation	0.200	0.036	5.585	0.000
Environmental Awareness <— Process Eco-Innovation	0.162	0.036	4.439	0.000
Environmental Awareness <— Product Eco-Innovation	0.393	0.037	10.716	0.000
Food Product Quality <— Organizational Eco-Innovation	0.447	0.037	12.205	0.000
Food Product Quality <— Process Eco-Innovation	0.410	0.037	11.081	0.000
Food Product Quality <— Product Eco-Innovation	0.199	0.041	4.814	0.000
Food Product Quality <— Environmental Awareness	0.263	0.052	5.064	0.000

Source: Author Estimations.



**Figure 2.** Measurement model assessment.  
Source: Authors Construction.



**Figure 3.** Structural model assessment. Source: Authors Construction.

innovation, and OEI have a positive association with environmental awareness in the food industry in China. These outcomes are given in Table 9. (Figures 2 and 3).

The outcomes also revealed that environmental awareness significantly mediates among PEI, process eco-innovation, OEI, and food production quality in the food industry in China and accepts H4, H5, and H6. These outcomes are given in Table 10.

### 3. Discussions

The results showed that PEI has a positive linkage to food production quality. The increasing PEI adoption enables the firms to give quality food production. These results are in line with the previous study of Diez-Martinez et al. (2022). It shows that in Spanish companies, there is a requirement for green food products that cannot damage the health of the holders and users. It motivates food producers to take extra care to

**Table 10.** Mediation analysis.

Total Effects				
	PEI	PREI	OEI	EAW
EAW	0.236	0.394	0.291	0.000
FPQ	0.136	0.019	0.000	0.212
Direct Effects				
	SR	LSI	OEI	RC
EAW	0.416	0.334	0.281	0.000
FPQ	0.000	0.000	0.000	0.212
Indirect Effects				
	SR	LSI	OEI	RC
EAW	0.000	0.000	0.291	0.000
FPQ	0.226	0.029	0.000	0.000

Source: Author Estimations.

maintain the quality of the food products delivered to end consumers or subsequent customer firms. Hence, PEI improves food production quality. These results are also supported by the study of Loučanová et al. (2022). The study posits that in Slovakia, the firms involved in food production try to develop new products or want to bring changes to sterilize food items and remove their ecological impacts. They bring improvements to basic food production. The PEI brings improvement in food production quality. The results also agree with the study of Frigon et al. (2020), a study conducted in the Canadian wine industry. It examines the role of PEI in food production quality. When the customer firms and the end consumers are required to have eco-innovation in the food products, it is likely that food production is tried to be improved.

The results showed that PREI has a positive linkage to food production quality. These results are in line with the previous study of García-Granero et al. (2018), which shows that when the firms engaged in food production bring ecologically friendly innovation in the processes applied for food production, they can succeed in having food products in large quantity and better quality, even saving the extra costs. So, the process of eco-innovation drives high-quality food production. These results are also supported by the study of Munodawafa and Johl (2019) conducted using world economies data. This study implies that the methods which require the least amount of fuels, chemicals, toxic substances, etc., are applied in the process of eco-innovation for food preparation. These processes remove pollution emissions during production. Thus, food, while being produced, is away from harmful substances and is not likely to be damaged. Therefore, the process of eco-innovation improves the quality of food production. The results also agree with the study of Alos-Simo et al. (2020), which analyzes the role of process eco-innovation in food production quality in Spanish firms. The study shows that if eco-innovation is implemented in the whole process of food production at different stages, the quality of the food produced can be preserved.

The results showed that OEI has a positive linkage to food production quality. These results are in line with the previous study of Calle et al. (2020) in Spanish wineries. It highlights that the firms in the food industry have policies to apply ecologically friendly resources like seeds, fertilization, different types of technologies, and instruments. They overcome the creation of harmful substances. Thus, the quality of food production is maintained. These results are also supported by the study of Calle et al. (2021) for wine industries in Spain. It states that in OEI, innovation is brought into the production processes that can reduce pollution emission and their impacts on product quality. Hence, OEI leads to food production quality. The results also agree with the study of de Jesus et al. (2022). The effective execution of OEI helps the food producers to maintain the food production quality.

The results showed that environmental awareness significantly mediates PEI and food product quality. These results are in line with the previous study of Fernández et al. (2021). This previous study explains that in a country like Chile, some food processing firms are presenting eco-friendly products and carrying on eco-friendly products. It develops environmental awareness among the general public and food producers. This environmental awareness leads to improvement in food production quality. The results also agree with the study of Kuo et al. (2022). It highlights that in



the Taiwan hotel industry, the execution of PEI enhances environmental awareness, which in turn motivates the food producers to maintain product quality.

The results showed that environmental awareness is a significant mediator between PREI and food product quality. These results are in line with the previous study by Galliano et al. (2019), conducted in a French rural area. It states that the implementation of process eco-innovation creates assistance for the producers to overcome the damaging food substances while food production processes are going on because process eco-innovation enhances environmental awareness. So, environmental awareness builds a link between process eco-innovation and food product quality. These results are also supported by the study of Mady et al. (2022). The study implies that SMEs in Egypt tend to implement process eco-innovation to enhance their environmental awareness. This awareness enables the firms to improve food production quality.

The results showed that environmental awareness is a significant mediator between PEI and food product quality. These results are in line with the previous study of Arranz et al. (2019), which shows that there is the implementation of OEI in Spanish firms. It is useful for detecting and overcoming the things that may cause environmental pollution. This creates environmental awareness and, thereby, helps to improve food production quality. These results are also supported by the study of Bierwisch et al. (2021), written for EU firms. It shows that the firms tend to implement OEI motivates them to have environmental awareness, which is used to improve food production quality.

### **3.1. Theoretical implications**

The current study has made significant contributions to literature, and the authors can learn more to apply in their further literary work. The study explores the impacts of PEI, PREI, and OEI on food production quality. Many authors have addressed the eco-innovation role in food production quality without giving deep intention to PEI, PREI, and OEI. The current study removes this literary gap. The study makes a significant contribution to the literature for analyzing the mediating role of environmental awareness between PEI, PREI, OEI, and food product quality. Moreover, this is one of the first initiatives in which the authors have examined the role of PEI, PREI, and OEI in food production quality for China.

### **3.2. Empirical implications**

The current study has great significance to emerging economies like China, where environmental pollution is increasing at a high rate, and because of the increasing pollution, the quality of food seems to be getting spoiled. The current study guides the government, economies, and firms engaged in food production on how they should improve and maintain the food production quality. The study guides that through better policies, the firms' focus must be turned towards the need for PEI in order to improve food production quality. The study suggests that policymakers must create awareness for PREI and encourage it to be practiced in order to bring improvement in the food production quality. The study stated that with effective

policy-making, OEI should be encouraged so that the food production quality can be improved. This study guides the policymakers in developing policies related to food production quality using eco-innovation and environmental awareness in the complete business process. The study also provides a guideline that PEI must be encouraged to enhance environmental awareness, and thereby, the food production quality can be improved. The study guides that PREI must be encouraged to enhance environmental awareness. Thus, food production quality can be improved. The policymakers should encourage organizations for eco-innovation so that environmental awareness and, thereby, the food production quality may increase.

## **4. Conclusion**

The aim of the study was to examine the impacts of PEI, PREI, and OEI on food production quality. It was also to check the role of PEI, PREI, and OEI in environmental awareness for this purpose. The data were acquired through questionnaires about PEI, PREI, OEI, environmental awareness, and food product quality. The results showed that PEI, PREI, and OEI have a positive relation to food production quality. The results revealed that when there is a requirement for innovative products, and the food producers struggle for PEI, there is an improvement in food production quality. The results also showed that if the food production firms try to maintain eco-innovation in the production processes to improve the effectiveness, the quality of the food production increases. The results also indicated that food production might be costly, time taking, and not much effective, and the health quality of food production be damaged if the environmental aspects of firms are left ignored. And implementation of OEI helps overcome environmental concerns and improves food production quality. The study also concluded that environmental awareness mediates between PEI, PREI, OEI, and food product quality. The increase in the PEI requirements in the market and struggles for PEI in the economy enhance environmental awareness. This increasing environmental awareness enhances ecologically friendly improvement in food production techniques and improves food production quality. Similarly, the process of eco-innovation enhances environmental awareness, which in turn leads to improvement in food production quality. The study also showed that the execution of OEI enhances environmental awareness and, thereby, improves food production quality.

### **4.1. Limitations**

The present study also has some limitations, like other studies. In further literary work, authors may remove these limitations with their literary expertise. The current study emphasizes the role of PEI, PREI, and OEI in food production quality. Several other factors, like geographical features, green finance, agriculture funds, etc., also play a significant role in food production quality. The authors are recommended to examine these factors as well, along with the understudy factors for the analysis of food production quality. In this study, the mediating role of environmental awareness between PEI, PREI, and OEI and food production quality has been analyzed.

Environmental awareness also predicts PEI, PREI, OEI, and food product quality, so it can improve their relationship. That is why future scholars must analyze the moderating role of environmental awareness between PEI, PREI, OEI, and food product quality. The evidence for a relationship between PEI, PREI, OEI, and food production quality has been collected from China alone. In order to gain general results about the relation of PEI, PREI, and OEI to food production quality, evidential data should be acquired from different economies.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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