

Text Mining Analysis of Changes in Consumer Perceptions of Food Index

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Abstract

This study conducted a topic modeling analysis with the BERT model to identify the themes of the review texts on seafood written by consumers and compare them with the empirical analysis results from surveys. More specifically, this study analyzed the relationship between consumers' perceptions of seafood and the food index level, a subdomain of the PKNU Maritime Index. In particular, the correlation was explored to verify the relationship between the Korean consumers' evaluation of seafood concerning taste, nutrition, variety, price, and safety and the food index. The findings were as follows. First, consumers' perceptions of seafood were found to have a significant positive correlation with the food index. Second, the multiple regression analysis showed that, apart from the variety, the food index had a significant positive effect in the order of safety, nutrition, taste, and price. Such research findings showed that it is necessary to understand consumer perceptions of seafood, and the food index centered on the Northeast Asian Sea could be used as a foundation to improve consumer experience and satisfaction. This study further expanded the scope of existing marine humanities research by conducting text-mining analysis, providing theoretical and practical implications.

Keywords

PKNU Maritime Index

Food Index

Consumer Perceptions

Text Mining Analysis

BERTopic

1. Introduction

There are many factors that affect consumers' food preferences in the fast-paced modern society. Such changes in preferences are recognized as a critical aspect that affects the quality of life and health of consumers. The public's perception of the ocean can have a significant impact on the development of the marine industry, and consumer preferences for seafoods are an important factor that affects not only the economy of the island coastal regions that produce them, but also their culture. The advent of the digital age, in particular, have allowed consumers to easily access food-related information through various social media platforms, online reviews, and blog posts. A recent survey of 1,000 adult men and women aged 19 to 59 on "Consumer Attitudes Toward Meat and Seafood Consumption," which was conducted by the market research company Embrain (trendmonitor.co.kr), showed that uneasiness about domestic meat is increasing due to the outbreak of several livestock epidemics in Korea. Moreover, as concerns about seafood have grown due to the release of wastewater in Fukushima, many respondents displayed a tendency to avoid consuming Japanese seafood. This would likely lead to a decline in seafood consumption. Research on seafood consumption is emerging as one of the most important areas of research in the marine industry to effectively utilize the popularity of K-content, strengthen the competitiveness of Korean seafood, and open doors to new markets. Previous studies have mainly focused on Korean food and the images of food companies in relation to the influence of Hallyu (Bae et al., 2010) or empirically compared and analyzed consumers' food anxieties and their perception of alternatives, as well as consumption patterns (Kim et al., 2013). Since then, various studies have been conducted on various aspects of Korean food, including research that categorized consumer types and analyzed seafood preferences according to dietary lifestyles (Jung et al., 2016; Cho and Lee, 2023). Moreover, food in modern society has emerged as a critical area that directly impacts individual health and the environment. Food safety and quality, in particular, have been receiving increased attention from consumers. More recently, consumers' perception of food concerning local marine resources has been growing (Hyun et al., 2019), and consumers' food perceptions and choices are based on many factors. The variety of food provided by the food industry has led consumers to require more information, resulting in increased focus on the perceived value and quality of food (Gil and Seo, 2023). Analyzing such changes in consumer behaviors would provide critical insights for establishing policies for the food industry.

In addition, text mining techniques are used to extract and analyze useful information from large amounts of text data. Text analysis of consumer reviews, comments, and social media postings contributes to a deeper understanding of the change in consumer perceptions of food. This will also provide more insight as to which food or diet is in trend in society or in which ways consumers are interested in their health. This study aimed to gain insights into how consumers' perceptions of food have changed by region, generation, and individual experience by using the food index in the PKNU Maritime Index, which was compiled through a survey conducted in 2023 on the perception of maritime culture. This study used the topic modeling technique with the BERT model to collect and analyze various consumer opinion data from Coupang, Korea's biggest platform company, to identify the trends and patterns of consumer perception of food. It is significant at this stage that a food index is created using this data. This study, therefore, will analyze changes in consumer perception of food using text mining techniques, which will provide significant insights for policies for local food industries. This will provide a deeper understanding of the impact of the PKNU Maritime Index on consumers' choice and perception of food and lead to strategies for improved consumption of sustainable food. In other words, this study presents a new perspective on research changes in consumers' perception of food and contributes to future research and strategies in the food and marine industry.

2. Related Research

2.1 PKNU Maritime Index (Food Index)

The Ministry of Maritime Affairs and Fisheries has strived to narrow the physical and psychological gap between the public and the ocean by having monthly presentations on seafood, fishing villages as travel destinations, marine life, lighthouses, marine heritage, and uninhabited islands. It is crucial to inform the public of various maritime information and manage the public perception of the ocean and the sea. Accordingly, Pukyong National University has been compiling a comprehensive index of maritime culture through the “PKNU Maritime Index,” a nationwide survey of maritime cultural awareness conducted since 2017. This survey was conducted by the Initiative for College of Humanities Research and Education (CORE) at Pukyong National University from 2017 to 2018, and since 2019, has been succeeded by the Pukyong National University Humanities Korea Plus (HK+) Team to continue developing the maritime culture index. The PKNU Maritime Index has since been adjusted and developed under the “Study on the Dynamics of Humanities Network in Northeast Asian Sea Region.” In this research, an item related to Fukushima wastewater was added to reflect the social attention on the issue. The PKNU Maritime Index aims to identify differences in perceptions of the sea in terms of region, generation, and individual experience to understand the meaning of the sea to Koreans from a marine humanities perspective. The survey, which was conducted in July 2023 on 1,000 men and women in Korea who are 18 or older, will be used as primary data for marine humanities, marine education, and industry research and contribute to establishing the foundation and expanding the scope of marine humanities (HK+ Research Group, 2023). The comprehensive maritime perception index is a sum of the eleven subdomains: the familiarity index, knowledge index, experience satisfaction index, safety index, security index, food index, environment index, economy index, education index, policy index, and the Northeast Asian Sea index. The PKNU Maritime index, which represents the comprehensive Korean perception of the ocean, was 621.7 points (based on a scale of 1,100 points) in 2023, up 36.4 points from 585.3 points in 2019. Some of the subdomains, including the familiarity index (68.0 points), knowledge index (67.2 points), and experience satisfaction index (64.7 points), were also relatively higher, whereas the education index (37.3 points), food index (50.3 points), and security index (53.6 points) were relatively lower. The food index, which measures the perception of seafood by combining preference, necessity, and satisfaction regarding seafood consumption, was 50.3, and there was a general decline in the scores of all items, except for the degree of consuming uncooked seafood, such as raw fish or raw oysters. More specifically, respondents left relatively more “positive” responses, including “neutral,” to questions regarding seafood, excluding the items on seafood prices, frequency of seafood consumption, and safety. Nine items were used to measure the food index, including “I try to eat seafood at every meal,” “Seafood is much safer than other types of food,” “Seafood is much better for your health than other types of food,” “Seafood is cheaper than other types of food,” “Seafood is tastier than other types of food,” and “You should eat seafood once in a while for a healthy diet.”

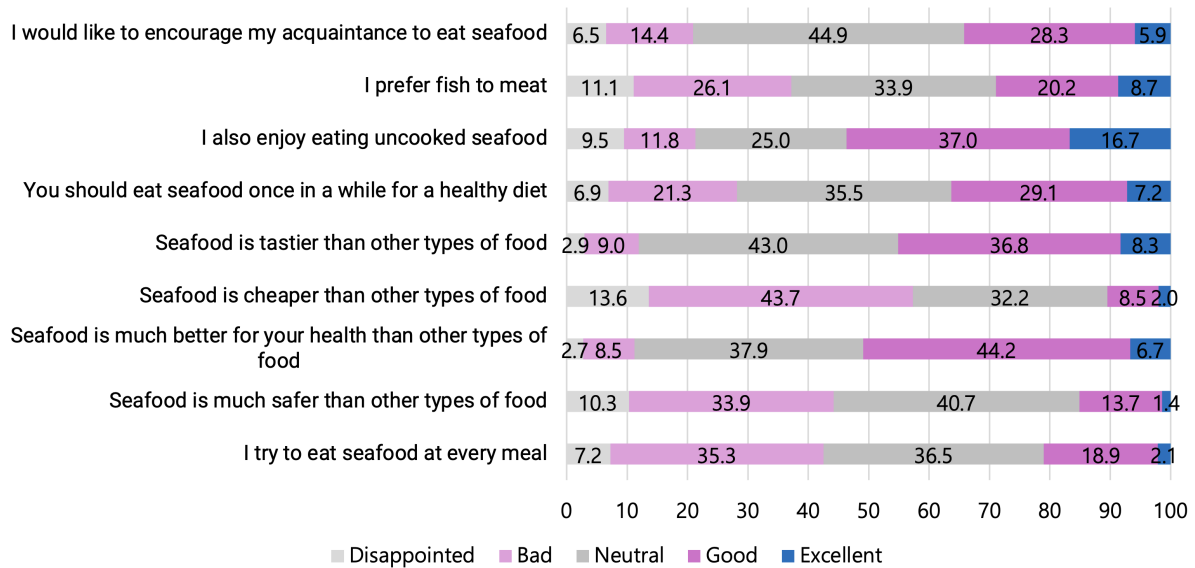


Fig 1. Food Index

2.2 Perceptions of Seafood

A detailed examination of consumers' perception of seafood (HK+ Research Group, 2023) showed that consumers were generally satisfied with the taste, nutrition, and variety of seafood but not the price. Regarding the radioactivity tests on imported seafood by the Ministry of Food and Drugs Safety in response to the release of wastewater from Japan's Fukushima nuclear power plant, 61.8% of the respondents considered the tests "untrustworthy." In comparison, only 15.3% deemed it "trustworthy." Regarding the frequency of seafood consumption, how often respondents eat seafood in a week, the most common response was "1-2 times," at 66.1%, up from 61.4% in 2019, followed by "3-4 times," at 16.2% and "rarely," at 15.4%, down from 18.3% in 2019. 2.3% of the respondents replied that they eat seafood every meal, and 84.6% were found to eat seafood once or more every week. The most common response to the most critical factor in purchasing seafood was its country of origin, at 49.4%, followed by safety at 36.9%. The "mackerel" was touted as the fish that represents Korea at 39.7%, followed by the "croaker" at 15.3% and the "hairtail" at 13.5%. Respondents were somewhat negative toward the seafood safety policies implemented by the government, with 27% replying that the policies were "untrustworthy" and 24.4% responding that they were "generally trustworthy." The most important factor when purchasing seafood was its "country of origin," with 49.4% of responses, which was up from 46.3% in 2019, followed by "safety" (36.9%), whereas factors such as "whether the seafood is fresh, frozen, or dried" and "whether the seafood is wild caught or farmed" ranked relatively lower at 8.3% and 5.4% respectively. Questions on the taste, nutrition, and variety of Korean seafood showed that consumers were generally satisfied with its taste, nutrition, and safety, with the exception of its price. More than half of the respondents, 63.6%, were found to buy seafood in "supermarkets," followed by "traditional markets" (15.2%) and "small supermarkets" (8.7%). Similar results were also found by trendmonitor (trendmonitor, 2023). The "release of wastewater in Fukushima" received national attention, with 72.9% showing interest in the issue. The perception was that 2023 would be the last year when seafood could be consumed safely due to the "release of wastewater in Fukushima," and as a result, a drastic drop in seafood consumption is expected in 2024 compared to that before the release, and anxiety will likely remain high despite what safety experts say. Male respondents were relatively more likely to trust the information that the "release of wastewater in Fukushima" is

safe and were more reassured about seafood that has been tested for radiation levels. Men also characteristically replied that they generally had little intention of eating less seafood due to the situation.

2.3 Research Hypotheses

This study presents the following hypotheses.

- <Hypothesis 1> The food index will positively affect consumers' perceptions of safety.
- <Hypothesis 2> The food index will positively affect consumers' perceptions of taste.
- <Hypothesis 3> The food index will positively affect consumers' perceptions of nutrition.
- <Hypothesis 4> The food index will positively affect consumers' perceptions of variety.
- <Hypothesis 5> The food index will positively affect consumers' perception of price.

Table 1. Frequencies of consumers' seafood awareness

Variable		Frequency	%
Seafood Intake Frequency	Rarely eating	154	15.4
	1-2 times	661	66.1
	3-4 times	162	16.2
	Every Meal	23	2.3
Seafood Safety System	Not Trusted at all	71	7.1
	Unreliable	199	19.9
	Normal	486	48.6
	Trustworthy	233	23.3
Importance when Purchasing Seafood	Very trusting	11	1.1
	Origin	494	49.4
	Safety	369	36.9
	Natural status	54	5.4
Where to Buy Seafood	Active, Frozen, Dried Seafood	83	8.3
	Traditional Market	152	15.2
	Supermarket	636	63.6
	Small Mart	87	8.7
Total	Fish Market	59	5.9
	Agricultural and seafood wholesale Market	44	4.4
	Other	22	2.2
		1,000	100

3. Research Methods

To test this study, the relationship between the food index from the PKNU Maritime Index, which was compiled by the Pukyong National University Humanities Korea Plus (HK+) Team, and the consumer perception of seafood. The samples included in the analysis were collected through a survey of 1,000 adult men and women in Korea from July 25 to July 31, 2023, through Macromil Embrain's panel using a structured questionnaire. The survey was balanced in gender, with 508 men and 492 women participants. The survey also encompassed all generations, as the age range of respondents was from 19 to 69 years old. By region, the survey covered all regions, including Seoul/Gyeonggi, Incheon, Chungcheong, Jeolla, Gyeongsang, Gangwon, and Jeju areas.

In addition, this study was conducted in two stages: validity analysis of the variables in the hypotheses and hypothesis testing. First, a validity analysis of the variables was conducted to verify that the variables in the hypotheses reflect what consumers consider important regarding seafood. Topic modeling techniques in text mining were used to analyze keywords in consumer reviews of seafood. This was followed by multiple regression analysis for hypothesis testing.

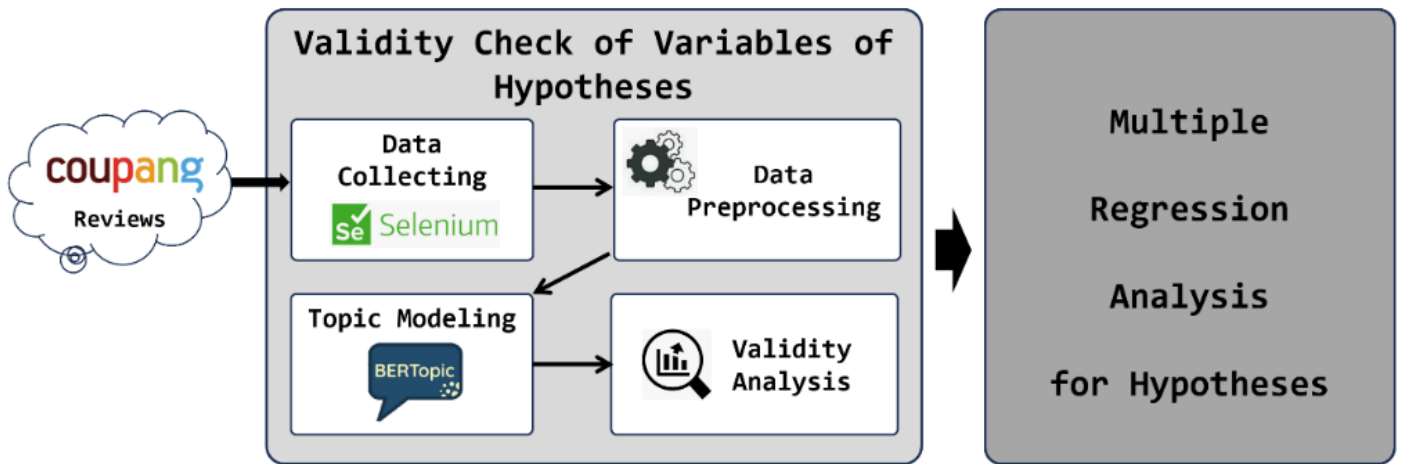


Fig 2. Food index analysis process

3.1 Data Collection

Consumer reviews of seafood were selected as data for analyzing the validity of the variables in the hypotheses, considering that the reviews reflect what consumers value in seafood. The data was collected using a crawler implemented with Selenium Library to collect consumer reviews of products searched using the keyword “seafood” in Coupang, a major e-commerce website in Korea. A total of 216,604 consumer reviews of seafood were collected using the crawler.

3.2 Data Processing

The collected 216,604 consumer reviews were preprocessed to omit content unrelated to the validity analysis of the variables and to improve the data quality. The preprocessing was conducted as follows. First, special characters and emoticons used in the reviews, such as “^^” and “ㄷㄷ,” as well as any numbers or units concerning product quantities, such as “10kg,” were removed. Next, information on dates, such as order dates, shipping dates, and prices, were deleted, as well as words unrelated to the analysis of consumer perception, including “strong points,” “shortcomings,” “purchase,” “motivation,” “evaluation,” “review,” “summary,” “weight,” “number,” and “outline.”

3.3 Topic Modeling

Topic modeling is a text mining technique used to identify topics from a substantial collection of documents and is frequently used in studies identifying topics or analyzing issues in review data. This study conducted a topic analysis to analyze the keywords from consumer reviews of seafood products and the relational information between the keywords. BERT (Bidirectional Encoder Representation from Transformers), a high-performance pretraining language representation provided by Google, was used for the topic modeling. As one of the advanced natural language processing techniques for extracting meaningful topics from textual data, BERT is highly efficient in natural language processing for understanding the meanings of complex text because it is a language model based on the Transformer architecture that processes contexts in both directions (Bard and Bainward, 2017). BERT separates textual data into sentences and fine-tunes a pre-trained natural language model to analyze texts on specific topics (Kang et al., 2013). BERT uses the sentence embedding method (sentence-transformers) that utilizes tokens, segments, and positions, and for this study, xlm-r-100langs-bert-base-nli-stsb-mean-tokens was used as the sentence embedding method. The Mecab

package was used to analyze Korean morphemes with BERT for the textual analysis. After the textual analysis using BERT was completed, BERTopic was utilized for the topic modeling. BERTopic provides topics grouped by related keywords, allowing users to identify the main topics for extensive text documents efficiently. This study used BERTopic to conduct topic modeling on the collected and edited consumer reviews on seafood. Whether the keywords from the hypotheses on consumers’ perception of seafood corresponded to the keywords that consumers value was compared and analyzed. The user reviews of seafood included words such as the names of the seafood, seafood dishes, and recipes, so the number of topics modeled using BERTopic was set to 30 to increase the number of topics to be analyzed so that the topics for the variables in the hypotheses could be identified. The topics were modeled so that each topic could include a maximum of six words.

4. Analysis Results

4.1 Topic Modeling Analysis Results

4.1.1 Analysis of Relationship between Topics

The relationship between the 30 extracted topics can be understood by examining the distance between the topics, as shown in Figure 3, and the similarity between the topics. The Intertopic Distance in Figure 3 shows that the 30 topics can be grouped into four groups. The largest group included words such as “satisfaction” and “date of purchase” concerning seafood since the analyzed data consisted of reviews of seafood. The next largest group included the words “think” and “sour,” which suggests that the opinions on and taste of seafood were key topics in the data. The Similarity Matrix between topics, shown in Figure 3, uses colors to indicate the relevance between the topics; the extracted topics are more relevant when the color has a darker hue.

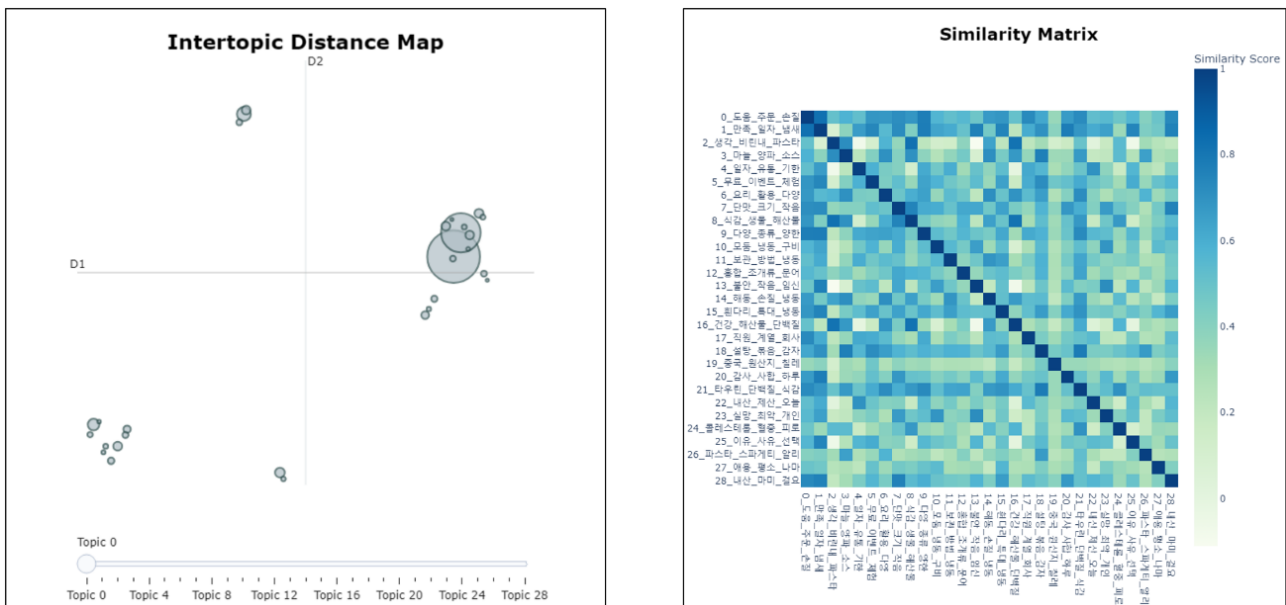


Fig 3. Distance between extracted topics and similarity between topics

4.1.2 Analysis of Topics Related to Safety

Since the safety of seafood can be determined by whether the food has gone bad or not, the most important keywords related to safety concerned temporal information, such as production year, month, and date or expiration dates, regional

information, such as the country or place of origin, and information on storage methods, such as freezing or refrigerating. Figure 4 shows the safety-related topics out of the extracted topics. Keywords found in Topic 4 included “date,” “distribution,” “expiration date,” “manufactured,” and “months,” all of which displayed the relevance of time-related keywords in consumers’ perceptions of the safety of seafood. Topic 10, which consists of keywords such as “freeze,” “refrigerate,” and “equipped,” concerned the storage and usage of seafood and illustrated that consumers were sensitive to safety issues related to the storage of seafood. Topic 19 included keywords such as “China,” “country of origin,” and “Chile,” which are information on the countries where the seafood originated, evidently showing consumers’ deeply invested interest in the safety related to the country of origin.

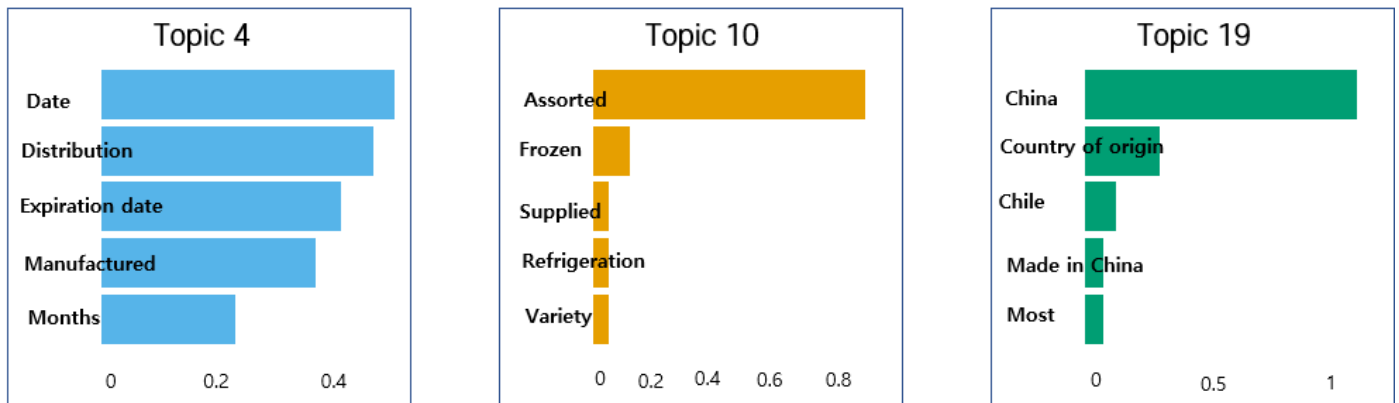


Fig 4. Topics related to safety

4.1.3 Analysis of Topics Related to Taste

Taste is a crucial keyword regarding food, and Figure 5 shows the taste-related topics out of the extracted topics. Taste-related topics were ranked highest out of the 30, indicating how much consumers value taste. Topic 2 had keywords such as “think,” “fishy smell,” and “sour,” and also displayed a relationship between taste and size, showing that consumers prioritized size as well as taste. Topic 8 was related to the texture, which illustrated that along with the taste of food, the texture and the satisfaction brought by it were also important for consumers.

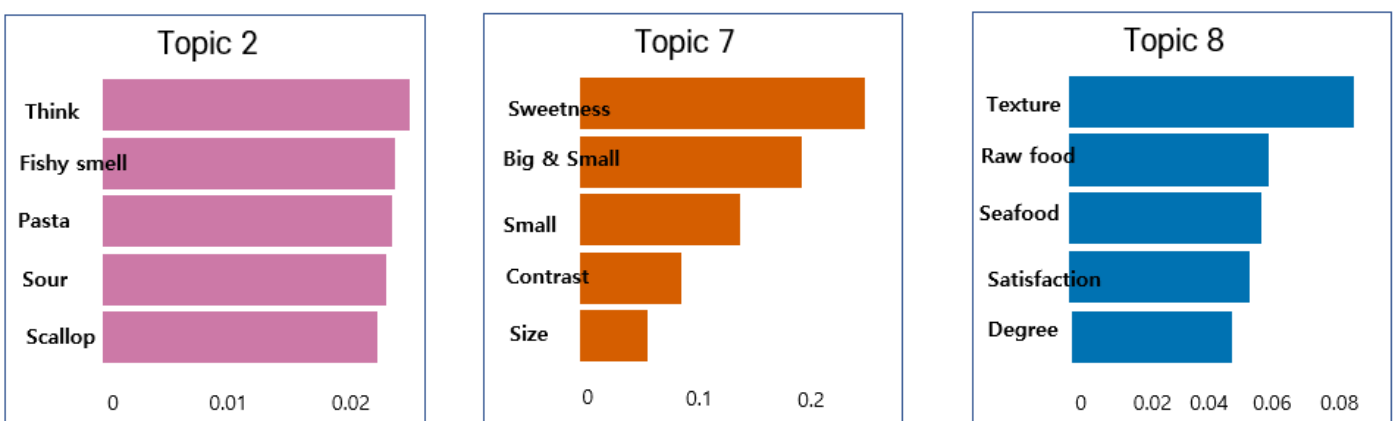


Fig 5. Topics related to taste

4.1.4 Analysis of Topics Related to Nutrition

Along with taste, nutrition is also an essential aspect of food. Figure 6 lists the topics related to nutrition from the consumer reviews. The first keyword in Topic 16 was “health,” which confirms what seafood consumers consider important. Moreover, through the keyword “protein,” it is possible to understand what nutrients consumers think they are consuming when eating seafood. Topic 21, with its keywords on nutrients, such as “taurin,” “protein,” “component,” “included,” and “texture,” confirmed that the feeling of eating the food and taste were important features for the consumers. Topic 24 included keywords on health indicators, such as “cholesterol,” “in blood,” and “fatigue,” along with the keyword “elevated,” indicating that consumers value the positive effects seafood will bring on the health indicators.

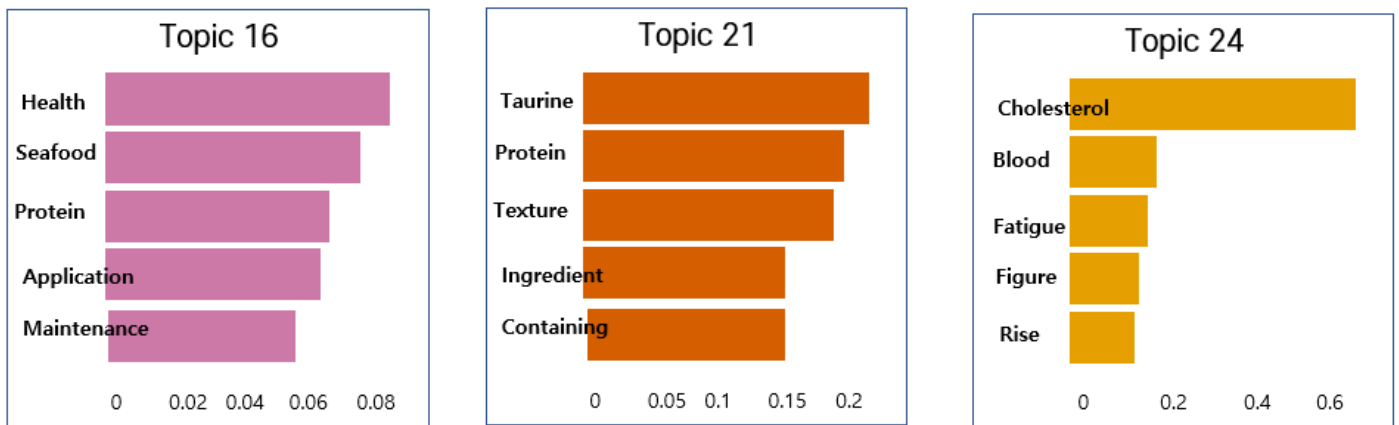


Fig 6. Topics related to nutrition

4.1.5 Analysis of Topics Related to Variety

As for the variety in seafood, the variety in the types of seafood, the variety in seafood dishes, and the variety in seafood processing can be considered. Figure 7 shows the topics related to the variety of seafood. First, Topic 6 includes keywords including “cooking,” “using,” “various,” and “types,” which showed how consumers value the variety of seafood dishes. Topic 9 consists of keywords on “size” and “types,” which show that consumers consider the variety of seafood types. Topic 14 has keywords such as “defrosting,” “cleaning,” “freezing,” “cooking,” and “washing” and concerns the variety in cooking methods, which also show how consumers value the recipes of the seafood they have purchased.

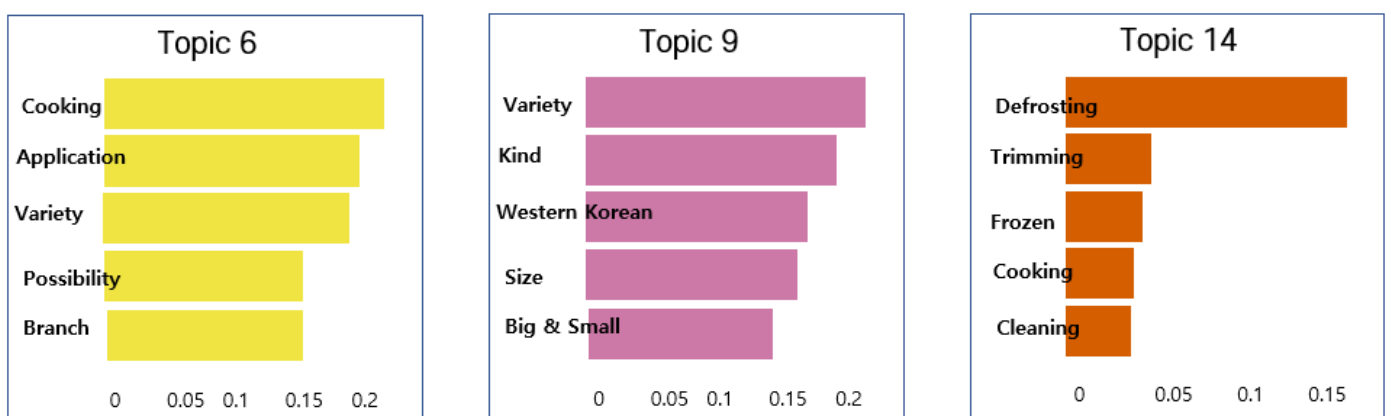


Fig 7. Topics related to variety

4.1.6 Analysis of Topics Related to Price

Price is a crucial issue consumers consider when purchasing seafood, and the relevant topics are shown in Figure 8. Topic 5 was a high-ranking topic among the 30 topics, which indicates the importance of price for consumers. Topic 5 includes keywords including “free,” “event,” and “promotion,” indicating how consumers are sensitive to promotional events, such as free deals and discounts. Topic 22 includes the keyword “I bought,” which shows that the reviewer purchased the reviewed product without receiving any promotions, suggesting that the consumers consider how genuine the reviews are. Topic 23 included keywords “disappointed” and “worst,” illustrating a very low level of satisfaction compared to the product's price.

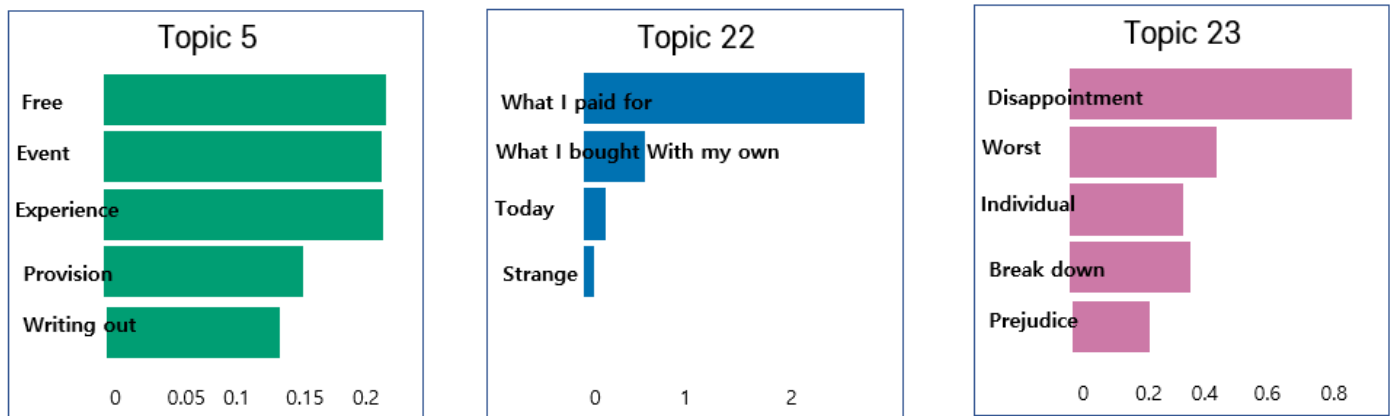


Fig 8. Topics related to price

4.2 Hypothesis Testing Results

Multiple regression analysis was conducted to examine the relationship between the food index, the presented independent variable, and the consumers' perception of seafood, the outcome variable. First, the descriptive statistics and correlation coefficient of each variable included in the study can be found in Table 2. The correlation coefficient between taste and nutrition (r) was .719, indicating a strong correlation. Next, there was a positive correlation between nutrition and variety, with a coefficient of .542, and variety and price, with .516. The results were similar to the correlation coefficient from an existing study conducted in 2019 (Yang and Kim, 2020). For the food index, a sub-domain of the 2023 PKNU Maritime Index, the average (median) was used, and the correlation coefficient between the main variables displayed a statistically significant correlation. The result was further verified using log transformation, as the distribution of the food index may be skewed to the right, possibly violating the assumption of normal distribution (Yoo and Joo, 2014). In addition, the variance inflation factor (VIF) was used to check for any multicollinearity problems, which showed that the VIF was less than 2, thus confirming that there were no multicollinearity problems.

Analysis of the hypotheses presented in this study showed that with the exception of the variety, the food index had a significant positive correlation with consumers' perceptions of safety, taste, nutrition, and price (refer to Table 3). The explanatory power of the regression model was 20%. Safety ($\beta=.184$, $p<.001$) had the most significant influence on the food index, followed by taste ($\beta=.153$, $p<.001$) and nutrition ($\beta=.121$, $p<.001$).

Table 2. Descriptive statistics and correlations

Variables	1	2	3	4	5	6
1. Food Index	1					
2. Safety Related System	.366**	1				
3. Flavor	.330**	.345**	1			
4. Nutrition	.333**	.360**	.719**	1		
5. Diversity	.255**	.291**	.516**	.542**	1	
6. Price	.265**	.363**	.171**	.225**	.271**	1
Mean	3.01	3.29	3.95	3.91	3.74	2.78
SD	.670	.817	.607	.611	.723	.843

Note. ** $p < .001$. Numbers in parentheses are Cronbach's alpha coefficients.

Table 3. Results of regression analysis

Variables	β	S.E	t	VIF
H 1	.184	.026	6.972**	1.298
H 2	.153	.046	3.311**	1.207
H 3	.121	.047	2.570*	1.307
H 4	.022	.033	0.667	1.540
H 5	.102	.025	4.140**	1.198
F=51.177***, R ² =.205, Adjusted R ² =.201				

Note. ** $p < .001$, * $p < .05$

5. Conclusion and Discussion

This study conducted a topic modeling analysis using the BERT model to analyze unstructured data on seafood collected through searches on the e-commerce website Coupang to understand the status of consumer perception and feelings concerning seafood, with the aim to explore consumption patterns of seafood sold online. This was accompanied by empirical research on consumers' perceptions and the food index. By testing the correlation and effects between these two variables, this study contributed to identifying ways to encourage more seafood consumption. The implications of the findings were as follows.

First, this study used the PKNU Maritime Index to analyze and apply the correlation between the food index and consumers' perception of seafood. First, the overall index for seafood declined from the previous survey, from 56.6 to 50.3 on a 100-point scale. Among the detailed questions, 80.5% of the respondents replied that the government should strengthen the seafood safety management system. This was similar to the results found from the analysis on the impact of the food index on consumer perceptions, which showed that the impact was most significant in the order of safety, taste, nutrition, and price. Accordingly, there is a concern that this could become a social issue when there is a lack of public consensus. However, this study deemed it unrealistic for consumers to stop consuming seafood. Moreover, food shopping is expected to have more varied effects in the Omnichannel environment, given that consumers now prioritize safety, nutrition, and taste in addition to lifestyles. More recently, convenience has become a popular trend in food culture, and consumers have preferred premium home meal replacement (HMR) products that are convenient but

also healthy and tasty. This trend is reshaping the consumer market, and companies should reflect such consumer perceptions and develop products and brands that align with such consumer trends.

Second, topic modeling analysis using the BERT model was conducted to examine the changes in the perceptions of seafood. This was an opportunity to discover the emotional variables experienced by consumers concerning their perception of seafood through text mining of unstructured data. Through this analysis, this study overcame the limitations of existing studies by identifying what factors can affect the emotions experienced by consumers during the consumption process. In other words, by conducting surveys and text mining analysis, this study systemized its findings, thereby creating foundations for phenomenological research of social culture and its changes.

However, this research only used two variables: the food index and consumer perceptions. Future studies should expand the research to Northeast Asia to conduct a more detailed comparative analysis using data from secondary surveys from Japan or China or through descriptive research (Jang and Park, 2014). Such approaches will likely be meaningful if the perceptions of Korean, Chinese, and Japanese consumers in Northeast Asia can be measured in a cross-sectional design, and the causality can be verified empirically at a comprehensive level. Additionally, in future research, it is necessary to compare regional awareness indices using purposive quota sampling to examine regional differences in maritime culture awareness surveys.

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