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A Study on the Subjectivity Perception Type of Irradiated Foods Using the Q Methodology

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Abstract:

Education and promotion of food irradiation are important factors for the activation of irradiation foods. In order for education and publicity to be effective, it is necessary to know the type of consumer's perception. The purpose of this study is to investigate consumers' perception of irradiated foods, using a Q methodology that studies people's attitudes through subjective perceptions. The Q method used in this study is a research method that objectifies subjective responses of respondents, and it is used in human behavior research. Statistical methods such as correlation coefficient and factor analysis are used for type search. It was found that there are three types of consumers' recognition. Type 1 appears primarily in young female consumers, which is a 'safety suspicion type'. Type 2 is an older female who accepts the necessity of the food irradiation treatment on the premise of securing safety, and named 'necessity recognition type'. Type 3 is the elder female, named "dubious type", who does not have such a positivity as the purchase of the irradiated food immediately because of the negative image of the radiation, but agreed with the basic necessity of the food irradiation treatment. In order to activate the irradiated food, it is necessary to eliminate the misperception about the irradiation. The results of this study investigated consumer's perception type that is needed to maximize the effects of education and publicity. Furthermore, it shows the possibility of utilizing Q method in radiation related research.

Keywords: Irradiation food, Q method, subjectivity, factor analysis, concourse.

I. INTRODUCTION

Food Irradiation refers to a food treatment process in which gamma rays or electron rays are irradiated to prevent the growth of microorganisms or insects in food and to prevent sprouting. Since the discovery of radioactive material in 1896, it has been suggested that irradiation can kill microorganisms in food. Later in 1921, irradiation was patented in the United States as a means of solving meat parasitic contamination problems. This is the starting point of the irradiation. Gamma rays, which are most widely used in industry, can be continuously treated in a packed state due to strong permeation force, so that secondary contamination caused by repackaging after sterilization treatment can be prevented. It is possible to sterilize even in refrigerated and frozen state by minimizing the destruction of ingredients because there is no temperature rise of the product [1]. However, there is a negative impact on food due to irradiation, the examples are as follows. First, the exposed protein in the aqueous solution is converted into a complex structure by peptide chain folding, disulfide bond, hydrogen bond, ionic bond, etc., and is divided into smaller units [2]. Second, the degradation of triglycerides by radiation occurs through autoxidation promoted by oxygen molecules, or through direct or indirect effects of high-energy radiation [3]. Nevertheless, the food irradiation technology has been developed in the past half-century by multifaceted researches centered on developed countries. Currently, it is more effective than any sanitary treatment method, and it is evaluated as a useful technology that has secured microbiological, toxicological, genetic, and nutritional safety [1, 4]. Furthermore, International organizations, such as the United Nations Food and Agriculture Organization (FAD), the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO), report that all foods irradiated to below 10 kGy have no toxicological disorder and do not cause nutritional and biological problems [5]. However, concerns about the safety of irradiated food have increased as the negative perception of radiation is spreading due to the accident in Chernobyl nuclear power plant in 1986 and the accident in Fukushima nuclear power plant in Japan in 2011. For this reason, consumers' acceptance attitudes toward irradiation foods are not expected to be high, and only 50% of consumers in the United States, who are more commonly used for irradiated food, purchase the irradiated food [6]. Consumers were also concerned that they might affect safety, taste, and nutrients even when there is an intent to purchase [7]. Furthermore, it is also reported that only 11% of the Turks responded that the irradiated food was safe [8]. In addition, a decent number of consumers still confuse the irradiation foods with the radio nuclides-contaminated foods. Thus, despite the high availability of the food irradiation, it has not been activated with negative perception. One of the ways to solve this problem is education. This is because consumers who are unfamiliar with or unfavorable to irradiation have a more favorable attitude toward irradiated food after receiving information on the treatment techniques and advantages of radiation irradiation. This shows the importance of education in the acceptance of irradiation foods [9]. In addition, a study conducted by the Food Marketing Institute in the United States in 1997 also showed that after receiving training on the irradiation treatment process, about 60% of people responded

that they would purchase the irradiated food [10]. Education and promotion of food irradiation are important factors for the activation of irradiation foods. In order for education and publicity to be effective, it is necessary to know the type of consumer's perception. In order for education and publicity to be effective, it is necessary to know the type of consumer's perception. In other words, it is necessary to investigate to collect basic data on the perceptions, interest, and purchasing attitude on the irradiated food. Therefore we try to to investigate the type of consumers' perception of irradiated foods, using a Q methodology that studies people's attitudes through subjective perceptions. The Q methodology is a new approach to human behavior research devised by Stephenson and developed by his student Brown [11, 12]. It is a method of using psychometric measurement manipulation theory to study human subjectivity in a systematic and rigorous quantitative way by utilizing the statistical methods such as correlation coefficient and factor analysis. The results of this study are expected to provide basic data to support the development of educational, public relations programs and curriculums for the irradiation foods suitable for each type. Furthermore, it will be able to provide information on the direction of quantitative research for hypothesis testing related to irradiated food.

II. WHAT IS Q-METHOD?

II.I Definition and terminology

The Q method, which is widely used as the main method of objectifying the subjective reaction in social science research today, is a new approach to human behavior research devised by Stephenson and developed by his student Brown. It is a method of using psychometric measurement manipulation theory to study human subjectivity in a systematic and rigorous quantitative way by utilizing the statistical methods such as correlation coefficient and factor analysis. And Q-method is a robust technique for revealing individual points of view and highlighting shared understanding, or narratives without losing the individual perspective in a confidential manner. Researcher bias is minimized as data used in Q method is generated by and structured by interested participants rather than researchers [13, 14]. The main terms used in Q method study are summarized in <Table 1> below.

Table 1. Main terms and definitions related to Q method

Terms	Definition
Q item	Q item is the thing that is classified by a response sheet, also referred to as a stimulus item. Statements printed on cards are most commonly used as Q items, but in addition to statements, any stimulus, such as photographs, pictures, person names, advertisements, etc., may be Q items.
Q population	Q population means the concourse of items collected for the Q study.
Q sample	Q sample means the items extracted from Q population
Q sorting	Q sorting refers to the process by which one respondent classifies a Q sample, that is, a score for each item
P population	P population refers to the concourse that can be thought of as respondents to Q sorting
P sample	P sample refers to the respondent or subject who is extracted from the P population and actually participates in the Q sorting, and is also called a Q sorter

II.II Characteristics and procedures

The general features of the Q method are summarized as follows. First, it is used to identify subjective opinions or perceptions of the study subjects about specific topics and stimuli. Second, the study subject of Q method has a subjective nature, in other word, a subjective opinion such as good and bad, good and evil. Third, it is also used for in-depth studies on a small number of subjects, and sometimes one person. Therefore, the Q method is a method that can be understood and explained for each type according to different subjectivity structure for each individual person, starting from the viewpoint of the actor rather than the assumption of the researcher. The procedure of the Q method is generally divided into five steps, and the details are as follows.

Step 1: Q sample (composition of Q population, selection of Q sample, and creation of Q distribution chart)

Q Population refers to the concourse of statements related to the research topic The Q-sample extracted from the constructed Q population (statement) should not be biased by a particular point of view or opinion, and The items constituting the Q sample should be selected so as to cover the research topic as a whole and contribute individually to the whole as a unique meaning [15]. There is no clear standard for how many Q samples should be taken, but in the case of Huggins et al. [16], about 10% (60) of the 653 statements constituting the Q population were selected as Q samples. Then, read the Q statement in the selected Q-sample and create a Q-distribution chart that can sort the responses according to the degree of positive or negative that you think.

Step 2: Extracting the P Sample

P samples of the Q method are in principle based on small samples. This is because the Q methodology deals with differences in significance or semantics within an individual rather than between individuals. In the case of a sample that is too large, the person becomes a variable, contrary to the overall small sample theory in Q methodology. Therefore, if the P sample is large, it causes a statistical problem in which a plurality of people are concentrated on one factor (Q-factor) and their characteristics are not clearly revealed [17].

Step 3: Q sorting (classification from strongest agreement to strongest disagreement and in-depth interview) Selected individuals (P samples) are asked to evaluated and order statements on a pre-prepared scale, which is pyramid shaped, with placement or scores for each statement from the Q sample ranging from “Agree with most strongly” to “Disagree with most strongly”. Q studies commonly use 7 or 9-point scales [18]. Afterwards, in-depth interviews are conducted on the selected statements with the strongest agreement and the statements selected with the strongest disagreement, and the results are recorded.

Step 4: Data processing (using exclusive program PC QUANL)

Enter the data collected from the subjects into the computer. In this study, for example, data were scored like the "the strongest disagreement (-3)” starts with 1 point, and give 2 points (-2), 3 points (-1), 4 points (0), 5 points (+1) 6 points (+2), and ”the strongest agreement (+3)” with 7 points, etc. Analysis of the scored data is carried out using the dedicated program PC QUANL. In Q factor analysis, the principle component analysis is used for specific options for analysis. Recently, Q type search method using R program has been developing and introducing [19, 20].

Step 5: Interpretation (type sorting and characterization by type)

Using the factors derived from the Q factor analysis, the characteristics of the subjective perception type are identified, and interpreted through linkage with the information obtained from the in-depth interview.

III. RESEARCH DESIGN

III.I Demographics

The demographics in 8 items such as gender, marital status, educational background, age, religion, occupation, the degree of recognition and route of obtaining information for the irradiated food, etc. were investigated as a information required to identify the subjective type of the irradiation foods.

III.II Q statements

In order to make a Q statement, which is the first step of the Q method, we first derive 250 statements through discussion and brainstorming of a group of experts consisting of two professors of radiology, two radiological technologists, and one professor of psychology. These statements were defined as concours. After that, we conducted pre-processing such as integrating statements that five experts read repeatedly and thought to have a common meaning. Furthermore, 23 statements were selected as final Q samples by referring to "Attitudes and Knowledge regarding the irradiated foods [21]" and "Safety Knowledge on Radiation [22].

III.III P sample

In Q method, usually a smaller number of respondents is adequate; more important than size of the sample is the structure [18]. Considering these various circumstances, 37 adults were selected as P samples in this study. For the extraction of detailed samples, the convenience quota sampling was used to those who agreed consent to participate, taking into account the ethical aspects of the study.

III.IV Q sample sorting

In order to sort the Q samples, a Q card of 10 cm by 6 cm size, in which 23 statements were recorded, and the Q sample distribution map as shown in [Figure 1] were prepared. Q sorting is classified by 7 points scale from -3 (the strongest disagreement) to +3 (the strongest agreement) in the distribution chart of [Figure 1] according to the degree you think after read the Q statements, so that it can be forced to a normal distribution.

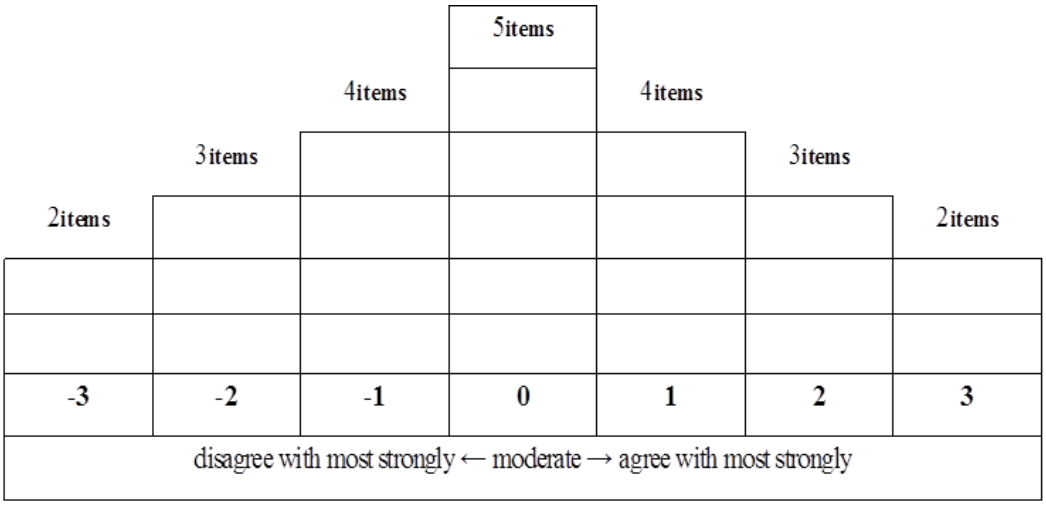

Figure 1. Q standard normal distribution

III.V In-depth interview

After Q sorting using Q statements, the reason for Q statements with the strongest agreement and the strongest disagreement was investigated in depth interviews. In this process, the respondents were given the most comfortable environment to be interviewed and the interview time was not exceeded over 30 minutes. Respondents who completed an in-depth interview were given coffee coupons as a reward.

III.VI Data analysis

After collecting data from 37 of P samples, we entered the contents of the response into a txt file in order to utilize the PC QUANL program, which is dedicated to the Q method. While confirming the statement item number recorded in the Q sample distribution chart, coding was given 4 points for "moderate (0)" and 7 points for "the strongest agreement (+3)", with 1 point for "the strongest disagreement (-3)". As a specific option for analysis, Q factor analysis and principal component analysis were used, and the varimax method was used for factor rotation.

IV. RESULTS AND DISCUSSION

IV.I Optimal number of Q type

In order to determine the optimal number of factors for the Q factor analysis of the subjectivity of 37 subjects for the irradiated food by varimax rotation using the QUANL PC program, the initial factor was set to 4 and analyzed.

After that, the analysis was repeatedly carried out by changing the number of factors and the most optimal model was selected as the final model. As a result, it was deemed most appropriate to search the perception type with three factors. The eigenvalue of the first factor is 12.74, which is much higher than 4.46 of the second factor or 2.03 of the third factor. These three factors explain 51.97% of the total variate, which means that the diversity of respondents' opinions is large. As shown in <Table 2>, the correlation between types showed that the correlation between Type 1 and Type 3 were slightly higher by 0.305, and that the correlation among the other types was not high. From this, it can be seen from the condition that 'the lower the correlation between factors is the more desirable' required in the general statistical method is satisfied.

Table 2. Correlation coefficients between three types

	Type 1	Type 2	Type 3
Type 1	1	0.263	0.305
Type 2	0.263	1	0.227
Type 3	0.305	0.227	1

IV.II The common consensus items in all types

The consensus items represent items that have achieved similar scores in all types, which are the items that the difference of the Z-score is all within 1.00. Consensus items are commonly used to explain the type of subjectivity of irradiated foods, as they are used to understand the characteristics between factors by finding commonality of factors, rather than to interpret the characteristics of each factor. As shown in <Table 3>, consensus items in this study are all 5 items and correspond to 18.5% of all items.

Table 3. Consensus items and Z-score mean

item number	Q statement	Z-score mean
18	There should be a limit to the tolerance range of irradiated food.	1.49
4	Strengthening publicity about the safety of irradiated food will stimulate more consumption than is currently possible.	0.92
10	The irradiated foods do not mean that contaminated with radioactivity.	0.47
14	When purchasing food, I buy it regardless of the size of the irradiated dose.	-1.12
7	I think that the research on the safety of irradiated food has been done sufficiently.	-1.23

As shown in <Table 3>, it can be seen that there are many items that all respondents commonly evaluate positively than negative items (item 18).

IV.III Ideal respondents for each type

A total of 37 subjects consisted of 24 subjects in type 1, 10 subjects in type 2, and 3 subjects in type 3. The person with the highest factor weight within each type represents the type with the person who is the prototype or ideal of the type to which the person belongs. <Table 4> summarizes the demographic characteristics of respondents representing each type.

Table 4. Demographics of Ideal Respondents by Type

Type	Respondent Number	factor weight	gender	marital status	age	educational background	religion	occupation	degree of perception	route of obtaining information
Type 1 (n=24)	34	6.2035	2	1	20	3	4	College students	1	5
Type 2 (n=10)	36	2.0316	2	2	52	3	2	Career counselor	1	5
Type 3 (n=3)	14	1.3186	2	2	46	3	4	teacher	3	1

* gender: 1(male), 2(female)

Marital status: 1 (single), 2 (married)

Education: 1 (middle school or lower), 2 (High school or lower), 3(University graduates or lower), 4 (Graduate school or higher)

Religion: 1 (Buddhist), 2 (Christian), 3 (Catholic), 4 (No religion)

Awareness degree of the Irradiated Food: 1 (no knowledge), 2 (do not know), 3 (average), 4 (relatively familiar)

5 (know very well)

The route of acquiring information on irradiated food: 1 (press media such as Internet, broadcasting, newspapers, etc.), 2 (conversation with people around), 3 (education)

4 (books, magazines, etc.), 5 (never heard of it)

IV.IV Interpretation by type

First of all, in analyzing and describing the subjectivity of irradiated food by type, the characteristics of each type will be firstly described by focusing on the statement that each subject shows an affirmative / negative consensus. In addition, we will primarily analyze and explain the items that have significant difference between the standard score of a particular type and the average standard score of the remaining types. When analyzing the characteristics of each type, we will also refer to the demographic contents and the in-depth interviews in the Q sample sorting process. The types of subjectivity of the irradiated food derived from the above method are summarized as the following.

Type 1 - Safety suspicion type (negative type)

Items with strong agreement in Type 1 are the items that have skeptical aspects about the safety of irradiated food, such as, ‘For safety reasons, it is necessary to check whether foods are irradiated when purchasing food (Z = 1.64)’, and ‘The allowable range of the irradiated foods should be limited (Z = 1.57)’. On the other hand, items showing disagreement in the type 1 are the items that have non-favorable aspects for irradiated food, such as, 'Purchase food regardless of the size of the irradiated dose (Z = -1.64)', 'Have intent to recommend the irradiate food to family members (Z = -1.33).'or the like.(<table 5>) Respondent No. 34, who showed the highest factor weight of 6.2035 in type 1, is a single female college student who has never heard about the irradiated food and does not know about specific details. The items with the strongest agreement of No. 34 respondent were that 'the allowable range for irradiated food should be limited' and 'for the safety, the dose (size) of radiation should be checked '. She said the reason for choosing these items is that *'Because the degree of influence on the human body varies according to the amount of radiation, I think it is right to know the size of the radiation dose and to set the limit.*' Next, the item with the strongest disagreement were, 'I bought foods regardless of the size of the irradiated amount', and, 'I think that the research on the safety of the irradiated food was done sufficiently'. She said the reason for choosing these items is that ‘*We do not know how it will affect the human body because the radiation experiments for humans have not been done sufficiently.’* When these results were integrated, the subjects belonging to type 1 are suspicious of the safety of irradiated food, and as a result, they are considered to be a type of person who has no intention to purchase. Therefore, type 1 was named 'safety suspicion type'.

Table 5. Items with a Z-score greater than +1 or less than -1 in the type 1

Item number	11	18	2	20	4	22	14	6	7	9	8
Z-score	1.64	1.57	1.46	1.20	1.08	1.07	-1.64	-1.33	-1.24	-1.14	-1.06

Type 2 - Necessity Recognition Type (affirmative type)

In type 2, items with strong agreement have the affirmative aspects for irradiation need and safety. Those items were, 'In order to prevent food corruption and to preserve it for a long time, I think it is necessary to treat it with radiation (Z = 1.84) ', and, ' I think that irradiated food is safer than chemically treated food '(Z = 1.30), and so on. On the other hand, items showing disagreement in type 2 are, 'I think that the research on the safety of irradiated food has been done sufficiently (Z = -1.66)', 'Food irradiation should be prohibited unconditionally (Z = -1.56)', and, 'Currently, it is very erroneous (Z = -1.49)' that allows radiation on potatoes, onions and herbal medicines. Although there is some concern about safety, those items have a positive aspect for the food irradiation treatment (Table 6). Respondent No. 36, who showed the highest factor weighting of 2.0316 in type 2, is a married female vocational counselor who is not familiar with the irradiated food and has never heard of it. The items with the strongest agreement for respondent No. 36 is that, 'the allowable range for irradiated food should be limited' , and, 'education and publicity about the safety of irradiated food need to be strengthened'. The reasons for choosing these items are the following: she said that '*Although there is insufficient studies at present, if the sufficient researches will be done and the safety will be confirmed later, we should improve quality of life by eliminating vague fears and negative perceptions about radiation through the extensive education and publicity.*' Next, the items with the strongest disagreement were, 'I think that the research on the safety of irradiated food has been done sufficiently', and, 'It is very wrong to allow the irradiation on potatoes, onions, herbal medicine, etc.'. The reasons for choosing these items are the following: '*Currently, the public is not familiar with irradiated foods, but I think that the positive change of perception can be derived by opening these information after the sufficient studies on the safety will be completed.'* Based on these results, it is considered that the subjects in type 2 are those who agree with the necessity of irradiation treatment for food if the safety of the irradiated food is ensured. In addition, this type of person has the need to educate and publicize the safety of irradiated food. Accordingly, type 2 was named 'necessity recognition type'.

Table 6. Items with a Z-score greater than +1 or less than -1 in the type 2

item Number	2	3	18	4	13	7	16	23	17	19	14
Z-score	1.84	1.30	1.23	1.10	1.07	-1.66	-1.56	-1.49	-1.42	-1.14	-1.00

Type 3 - Dubious type (intermediate type)

Items with strong agreement in type 3 are items that agree with the need for irradiation but can't accept it in reality. 'The allowable range for irradiated food should be limited.(Z = 1.68) ','The irradiated foods may be further expanded because it is possible to prevent the deterioration of foods(Z = 1.68) '. On the other hand, in type 3, items showing disagreement are items that do not negate the irradiation treatment on food even though they are concerned about safety (Table 7). These are: 'There is an intention to buy irradiated foods. (Z = -1.85) ', 'If the amount of radiation irradiated during food purchase is in an adequate range, it is acceptable to purchase. (Z = -1.35)', 'When purchasing food such as potatoes, it is right to buy something that has not been irradiated even though it may sprout in the distribution process. (Z = -1.26)', and so on. In type 3, respondent 14, who showed the highest factor weight of 1.3186, is a married female teacher has some familiarity with the irradiated foods through the internet, broadcasts, newspapers, etc. The items with the strongest agreement of 'dubious type'. respondent 14 was, 'Limit the allowable range for irradiated food', and, 'Irradiation is necessary for food safety in distribution process'. The reason for choosing these items is that '*it is necessary to set a proper tolerance range for radiation, in order to ensure safety, and irradiation is preferably necessary to prevent deterioration during the distribution process.*' Next, items with the strongest disagreement were, 'I intend to purchase food irradiated with radiation', and, 'If the amount of radiation irradiated during food purchase is within the appropriate range, it is acceptable to purchase.' She said the reasons for choosing these items are that "*Until now, safety is not clear and there is a strong negative image about radiation.*" These results suggest that the subjects of type 3 partially sympathize with the necessity of food irradiation treatment, but because of the negative image about radiation, they are the type of person who does not show any positiveness towards subjects, such as the purchase of irradiated foods, immediately. Type 3 was named as

Table 7. Items with a Z-score greater than +1 or less than -1 in the type 3

item number	18	15	19	12	1	13	22	21
Z-score	1.68	1.68	1.65	1.20	-1.85	-1.35	-1.26	-1.02

V. CONCLUSION

The irradiation for food is a processing method in which food is kept close to the original state by irradiating the radiation energy to the food for a suitable time and a proper amount. By doing so, it is possible to improve hygiene, such as sterilization and insecticidal action, control of growth and improvement of physical properties. At this time, the transmitted radiation energy is converted into heat energy and then disappears, which is harmless to the human body. The technology for irradiating food has less energy consumption than other food preservation technologies are currently using and has fewer nutrient destruction and changes since there is little temperature rise during treatment. Despite these advantages, preference for irradiated food is not high due to the tendency of consumers to perceive irradiated food the same as radioactive contaminated food. In addition, as noted in many previous studies, the consumers' perception of irradiated foods themselves is low. Such environment (circumstance) is a big obstacle to consumption of irradiated food, and it is necessary to eliminate misperceptions about irradiated food. There are many ways to do this, but it is necessary to educate and publicize the safety of irradiated food. However, in order to maximize the effects of education and public relations, educational programs and contents should be provided in accordance with the types of consumers. To do this, it is required to investigate how consumer perception types of irradiated foods are, so this study, using Q method, has been performed. As a result, it was found that consumers' perception types were classified into three categories. The first type is the 'safety suspicion type', which is 64.9% of all respondents. Consumers of this type are suspicious of the safety of the irradiated food itself and reluctant to purchase the irradiated food. This type consist mainly young female consumers, due to the vague anxiety caused by the lack of understanding of irradiation. Therefore, it is desirable to systematically carry out scientific facts from very basic items in education and publicity to be conducted on these subjects. The second type was the 'necessity recognition type', corresponding to 27.0% of all respondents. Consumers belonging to this category are older females who acknowledge the need for irradiation treatment of food as a precondition for ensuring safety. For these types of consumers, publicity using TV or radios, which is relatively easy to communicate, is considered to be more effective than active education. Finally, the 'dubious type' accounted for 8.1% of all respondents. Consumers belonging to this category agree with the basic necessity of radiation treatment for foods, but because of the negative image about radiation, it is elderly females who do not show any positiveness, such as the purchase of irradiated food. Respondents belonging to this type not only have a small number of respondents but also a behavior that is close to the type 1 as a whole. In all of the three types derived from this study, females were selected as representative respondents. This is because the purchase of food is often done by women rather than men.

The results obtained through the Q method above have significance in that they help discover something deeper and more useful hidden behind the quantitative information. In other words, the Q method, that is newly illuminated in recent years, is a research method of human behavior actively used in marketing, medical sociology, political science, nursing, medical science, communicology, journalism, and the like. In addition, among the qualitative research methodologies, it is an abductive approach for empirical research. It is meaningful that this study shows the possibility of using the Q method in radiation studies.

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