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Using education on irradiated foods to change behavior of Korean elementary, middle, and high school students

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BACKGROUND/OBJECTIVES: Educational interventions targeted food selection perception, knowledge, attitude, and behavior. Education regarding irradiated food was intended to change food selection behavior specific to it.
SUBJECTS AND METHODS: There were 43 elementary students (35.0%), 45 middle school students (36.6%), and 35 high school students (28.5%). The first step was research design. Educational targets were selected and informed consent was obtained in step two. An initial survey was conducted as step three. Step four was a 45 minute-long theoretical educational intervention. Step five concluded with a survey and experiment on food selection behavior.
RESULTS: As a result of conducting a 45 minute-long education on the principles, actual state of usage, and pros and cons of irradiated food for elementary, middle, and high-school students in Korea, perception, knowledge, attitude, and behavior regarding the irradiated food was significantly higher after the education than before the education ($P < 0.000$).
CONCLUSIONS: The behavior of irradiated food selection shows high correlation with all variables of perception, knowledge, and attitude, and it is necessary to provide information of each level of change in perception, knowledge, and attitude in order to derive proper behavior change, which is the ultimate goal of the education.

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INTRODUCTION

As the food industry advances and becomes global, technologies for safe raw material supply, hygienic production, effective manufacturing processes, and distribution in order to produce high value products are required [1,2]. Increasingly, the chemical fumigation method used in quarantine processing of agricultural products has been prohibited around the world for environmental pollution and toxicity to humans. However, irradiation technologies have been strongly encouraged as the most effective means to replace chemical preservatives, fumigation agents, and other tools. They have been proven to be safe by international agencies and international societies including the World Health Organization (WHO), Food and Agricultural Organization (FAO), and World Trade Organization (WTO) [3]. Food irradiation refers to the process of applying a predetermined radiation dosage based on the food's characteristics and purpose, with the goals of inhibiting germination, killing insects, sterilizing, and controlling maturity [4,5]. International agencies, including the WHO, FAO, International Atomic Energy Agency (IAEA), and International Organization of Consumer's Union (CI), reported that they could not find any significant chemical change in the irradiation process below 10 kilo gray (kGy). Compounds generated by the irradiation process are uniquely generated only in irradiated foods and the DCB (2-dodecylcyclobutanone) is not harmful in terms of public health. Irradiation technology was studied as a sanitization technology in America and Europe before and after World War I and was commercialized in the1980s [6-9]. Currently in Korea, irradiation is allowed on 26 items, and it is regulated to indicate that the product was irradiated [4,5]. Internationally, more than 50 countries allow food irradiation, and annually about 500,000 metric tons are irradiated. International irradiated food market trends indicate that the economic value was 2.4 billion dollars. About 45% (183,000 tons) of irradiated food, amounting to 470 million dollars, are produced in the Asia and Oceania regions [10-14]. It is expected that all countries globally will increasingly use irradiation technology as the core technology in the food industry. This expectation is based on hygienic improvements as well as the economic advantages and benefits of the chief items of export within the countries [1,10-16].

However, one of the reasons why irradiation technology is not widely used in Korea despite its advantages is because consumer acceptance cannot be assured, and efforts to remind consumers about irradiated foods are quite passive [17,18]. Most domestic consumers indicated that they were unaware of irradiated foods [2,17,19,20]. However, consumers are concerned over the safety of irradiated foods which reduces the acceptance rate of irradiated foods [20-23]. Although anxiety about nuclear technology has risen since the Chernobyl and Fuku-

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shima accidents, food poisoning due to a radioactive substance and food irradiation have fundamentally different principles [16]. Nonetheless, consumers are concerned about irradiated food safety and are uncertain about food selection decisions due to the lack of accurate information on irradiated foods [23,24].

This is consistent with research that states that individual risk perception of scientific technology is based on emotional judgment, and not rational judgment [25-28]. Some studies indicated currently, when various opinions regarding scientific technology exist, students are required to show social and moral sensitivity, but do not display such capabilities [29-32]. Hodson (2003) and Roth (2009) argued that social and moral sensitivity education should be included in the curriculum so that students, as future citizens, could discuss and actively participate in problem resolution using their values [33,34]. As scientific technology develops, science education researchers globally are highlighting the capability to make value judgments on socio scientific issues regarding science, and the importance of understanding scientific technologies [35-40].

The irradiation standard of the Codex Alimentarius Commission (Codex), which regulates irradiation on every food in international trade, is forcibly conducted in Organization for Economic Cooperation and Development (OECD) countries. Consumer education on the use of food irradiation technology should be actively conducted in Korea as well [1,17]. The present research was designed to be part of an education strategy to develop and enhance public understanding and approval for the use of irradiated food. In order to provide basic evidence required to plan an educational intervention strategy, we analyzed changes in perception, knowledge, attitude, and behavior regarding irradiated food, targeting elementary, middle, and high school students who are expected to provide a ripple effect of education among general population.

SUBJECTS AND METHODS

Research procedure

Educational interventions targeted food selection perception, knowledge, attitude, and behavior Education regarding irradiated food was intended to change food selection behavior specific to it. The first step was research design. Educational targets were selected and informed consent was obtained in step two. An initial survey was conducted as step three. Step four was a 45 minute-long theoretical educational intervention. Step five concluded with a survey and experiment on food selection behavior. In the research design, we determined the target of education, method of education, content of education, time of education, and so on (Fig. 1).

Research subjects

Elementary, middle, and high school students, the leading group regarding public opinion on the irradiation on the food, were selected as research subjects. We analyzed the samples of 123 students enrolled in three schools located in the capital area after receiving the written consent from their parents. There were 82 male students (66.7%) and 41 female students (33.3%).There were 43 elementary students (35.0%), 45 middle school students (36.6%), and 35 high school students (28.5%).

Research tool and method

The research tools were the surveys including the questionnaires regarding the perception, knowledge, attitude, and behavior regarding the irradiated food, education video materials and types of food (samples of regular food and irradiated food, five of each). The irradiated food samples were highly preferred by the students (inferred through a preliminary survey) and similar to the group classified as actual irradiated food (food 1: potato snack; food 2: Choco pie; food 3: PpushuPpushu; food 4: dried filefish fillet; food 5: soda).

The education method included a 10-minute video and a 25-minute lecture covering principles, and actual and current uses of irradiation. In order to minimize error, the education a method was prepared by one radiation expert per class. The education was conducted from December 11 to 20, 2013.

The contents of the survey covered knowledge, attitude, and behavior according to the traditional learning model. Perception was analyzed by necessity, safety (dangerousness), information acquisition (familiarity), and subjective knowledge of the irradiated food, similar to previous research (Fig. 2). Each item was rated on a 5-point scale (1 point: strongly disagree to 5 points: strongly agree). Five questionnaires were distributed

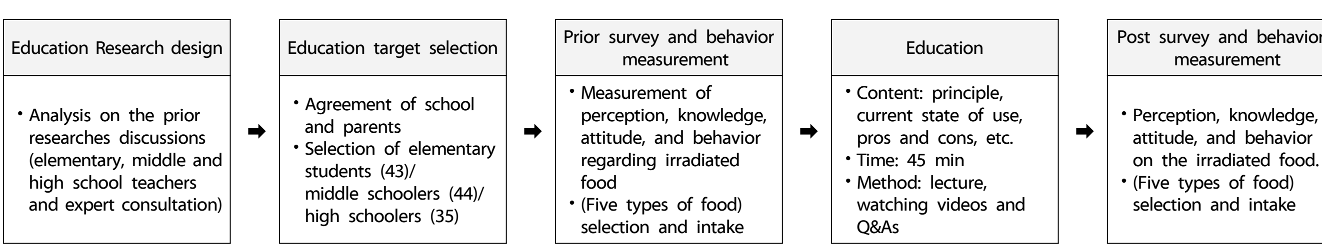

Fig. 1. Research procedure

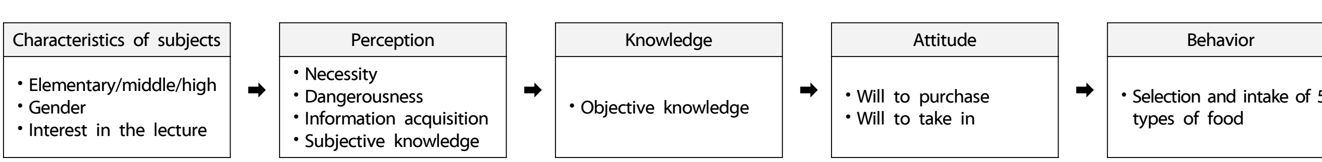

Fig. 2. Survey constitution

regarding the classification of irradiated and radioactively polluted foods, and the principles, features, and actual state of irradiated food. Objective knowledge level was considered higher as the number of correct answers increased. We defined behavioral change as higher selection of irradiated food. The research subjects had to select at least one of the regular or irradiated foods from the types of food. Before the education, Cronbach´s α value for perception, which includes the necessity, safety, information acquisition, and subjective knowledge of the irradiated food, was 0.777, objective knowledge was 0.712, and attitude of 0.833. Cronbach´s α value after the education for perception was 0.856, objective knowledge of 0.743, and attitude of 0.926, respectively.

Analysis method

We used SPSS/WIN 15.0 for checking the frequency, percentage average and standard deviation, simple correlation analysis (Pearson's Correlation Analysis), t-test, one-way ANOVA, and multi regression analysis. We used the Scheffe method for testing a posteriori. We used Cronbach´s α to check the credibility of the scales.

RESULTS

Characteristics of subjects before and after education

The students who showed high interest in the education before and after the education were 83.7% (103students) and 82.9% (102 students), respectively. The frequency of selecting the irradiated food was higher after the education than before the education (Table 1).

Change in perception, knowledge, attitude, and behavior before and after education by class

The level of perception including the necessity, safety, information acquisition, and subjective knowledge regarding irradiated food was significantly higher after the education than before the education in all students. Objective knowledge,

Table 1. General characteristics of the subjects

Item	Section	Before education n (%)	After education n (%)
Interest in education	Low	4 (3.3)	5 (4.1)
	Moderate	16 (13.0)	16 (13.0)
	High	103 (83.7)	102 (82.9)
	Total	123 (100.0)	123 (100.0)
Selection behavior			
Food 1 (Potato snack)	Regular food	59 (49.6)	28 (22.8)
	Irradiated food	60 (50.4)	95 (77.2)
	Total	119 (100.0)	123 (100.0)
Food 2 (Choco pie)	Regular food	62 (52.5)	24 (19.5)
	Irradiated food	56 (47.5)	99 (80.5)
	Total	118 (100.0)	123 (100.0)
Food 3 (Ppushuppushu)	Regular food	55 (45.8)	21 (17.1)
	Irradiated food	65 (54.2)	102 (82.9)
	Total	120 (100.0)	123 (100.0)
Food 4 (Dried filefish fillet)	Regular food	51 (43.6)	20 (16.3)
	Irradiated food	66 (56.4)	103 (83.7)
	Total	117 (100.0)	123 (100.0)
Food 5 (Soda)	Regular food	69 (57.0)	31 (25.2)
	Irradiated food	52 (43.0)	92 (74.8)
	Total	121 (100.0)	123 (100.0)

Table 2. Change in perception, knowledge, attitude, and behavior before and after the education per class

Item	Education	Elementary school		Middle school		High school		Total	
		Mean ± SD	*t* (*P*)	Mean ± SD	*t* (*P*)	Mean ± SD	*t* (*P*)	Mean ± SD	*t* (*P*)
Interest in education	Before	4.19 ± 0.76	-0.829 (.412)	4.36 ± 0.65	-2.558 (.014)	3.84 ± 1.03	-0.502 (.619)	4.15 ± 0.83	-2.199 (.030)
	After	4.26 ± 0.85		4.64 ± 0.61		3.96 ± 1.05		4.31 ± 0.88	
Perception									
Necessity	Before	4.00 ± 0.85	-2.942 (.005)	3.80 ± .944	-4.719 (.000)	3.77 ± 0.88	-4.149 (.000)	3.86 ± 0.89	-6.759 (.000)
	After	4.30 ± 0.67		4.58 ± 0.66		4.34 ± 0.68		4.41 ± 0.68	
Safety	Before	3.91 ± 0.81	-2.048 (.047)	3.69 ± 0.99	-6.502 (.000)	3.09 ± 0.98	-5.543 (.000)	3.59 ± 0.98	-7.941 (.000)
	After	4.16 ± 0.65		4.62 ± 0.61		4.11 ± 0.76		4.32 ± 0.71	
Information acquisition	Before	2.93 ± 0.99	-5.737 (.000)	3.16 ± 1.33	-6.936 (.000)	1.91 ± 1.20	-10.164 (.000)	2.72 ± 1.28	-12.336 (.000)
	After	4.00 ± 0.72		4.64 ± .61		4.17 ± 0.66		4.28 ± 0.72	
Subjective knowledge	Before	2.86 ± 0.64	-6.511 (.000)	2.87 ± 1.25	-9.426 (.000)	2.09 ± 1.09	-9.623 (.000)	2.64 ± 1.08	-13.837 (.000)
	After	3.70 ± 0.74		4.58 ± 0.58		3.91 ± 0.74		4.08 ± 0.79	
Objective knowledge	Before	3.88 ± 0.96	-2.920 (.006)	3.64 ± 1.19	-4.929 (.000)	2.77 ± 0.88	-7.880 (.000)	1.52 ± 1.51	-15.154 (.000)
	After	4.23 ± 0.81		4.56 ± 0.79		3.97 ± 0.86		3.80 ± 1.46	
Attitude									
Purchase	Before	1.47 ± 1.67	-6.117 (.000)	1.69 ± 1.43	-13.552 (.000)	1.37 ± 1.44	-8.593 (.000)	3.34 ± 0.97	-10.149 (.000)
	After	3.07 ± 1.76		4.40 ± 0.86		3.94 ± 1.30		4.23 ± 0.84	
Intake	Before	3.37 ± 0.95	-6.437 (.000)	3.62 ± 1.03	-5.340 (.000)	2.94 ± 0.80	-6.298 (.000)	3.48 ± 1.12	-8.372 (.000)
	After	4.14 ± 0.80		4.53 ± 0.73		3.94 ± 0.91		4.28 ± 0.83	
Behavior	Before	3.00 ± 1.62	-4.971 (.000)	2.87 ± 2.18	-5.070 (.000)	1.49 ± 1.69	-5.832 (.000)	2.50 ± 1.97	-8.843 (.000)
	After	4.05 ± 1.43		4.51 ± 1.31		3.31 ± 1.88		4.01 ± 1.60	

* Standard: perfect 5; the higher the points, the more the behaviors of selecting the irradiated food, i.e., higher behavior level.

attitude, and behavior level was statistically higher after the education than before the education. In particular, the level of perception, objective knowledge, attitude, and behavior toward irradiated food after the education was highest for middle school students (4.51 ± 1.31; $P < .000$) (Table 2).

Behavior change before and after the education by subject characteristics

If the number of irradiated foods selected was higher, the behavior level was considered higher. One point was awarded for each irradiated food selected (range was 0 to 5). Both before and after the education, Elementary and middle school students ($P < 0.001$, $P < 0.003$, respectively), the students with high interest in education ($P < 0.04$, $P < 0.000$, respectively), the students with a high purchase attitude toward irradiated food ($P < 0.000$, $P < 0.007$, respectively), and the students with high intake attitude ($P < 0.000$, $P < 0.000$) showed higher behavioral change (Table 3).

Correlation between prime variables before and after the education

There was a statistically significant difference in the interest in education, perception (necessity, safety, information acquisition, and subjective knowledge) of the irradiated food, objective knowledge, purchase and intake attitude, and behavior, showing positive correlations. The correlation between the purchase attitude and intake attitude was highest both before and after the education. Behavior after the education showed positive correlations with every variable (perception, knowledge, and attitude). The variable which showed the highest correlation with the intake behavior is the purchase attitude (Table 4).

Factors affecting the irradiated food selection behavior before and after the education

We conducted a multiple linear regression analysis, setting the behavior of the experimental group regarding the irradiated food as the dependent variable and setting the interest in education, perception (necessity, safety, information acquisition, and subjective knowledge), objective knowledge, and attitude (purchase and intake) as the independent variables. Purchase attitude exercised the largest influence, followed by intake attitude and objective knowledge.

After the education, perception regarding the safety of the irradiated food exercised the largest influence, followed by intake attitude and purchase attitude. The explanatory power is 48.5%. This confirms Choi *et al*. (2010)'s findings that consumers are most interested in food safety when purchasing food [2]. However, the risk perception of individuals is not highly relevant to the actual severity of the risk [42,43] (Table 5).

Table 3. Behavior change before and after the education according to the characteristics of the subjects

Item		Section		Before the education			After the education	
				Mean ± SD	t or F (P)		Mean ± SD	t or F (P)
Gender		Male		2.56 ± 2.03	.483 (.630)		4.11 ± 1.50	1.167 (.245)
		Female		2.37 ± 1.87			3.76 ± 1.73	
Class		Elementary	b	3.00 ± 1.62	7.312 (.001)	b	4.05 ± 1.43	6.070 (.003)
		Middle	b	2.87 ± 2.18		b	4.51 ± 1.31	
		High	a	1.49 ± 1.69		a	3.31 ± 1.88	
Interest in education		Low	a	0.75 ± 1.50	3.311 (.040)	a	1.00 ± 1.41	15.400 (.000)
		Moderate	a b	1.75 ± 1.91		b	3.19 ± 1.87	
		High	b	2.69 ± 1.95		b	4.26 ± 1.35	
Perception	Necessity	Low		2.00 ± 2.74	1.666 (.847)		-	-1.551 (.123)
		Moderate		2.54 ± 1.96			3.30 ± 1.42	
		High		2.51 ± 1.95			4.09 ± 1.55	
	Safety	Low		1.87 ± 1.96	1.594 (.208)	a	0.50 ± 0.71	22.988 (.000)
		Moderate		2.30 ± 1.95		a	1.82 ± 1.72	
		High		2.77 ± 1.97		b	4.27 ± 1.33	
	Information acquisition	Low		2.36 ± 1.90	1.058 (.351)		-	-1.815 (.072)
		Moderate		2.30 ± 2.02			3.38 ± 1.67	
		High		2.94 ± 2.05			4.12 ± 1.52	
	Subjective knowledge	Low		2.13 ± 1.85	1.930 (.150)		-	22.988 (.007)
		Moderate		2.67 ± 1.92			3.36 ± 1.73	
		High		3.05 ± 2.27			4.22 ± 1.48	
Attitude	Purchase	Low	a	0.94 ± 1.60	20.031 (.000)	a	0.330 ± .58	23.135 (.007)
		Moderate	b	2.05 ± 1.74		b	2.59 ± 1.87	
		High	c	3.74 ± 1.71		c	4.33 ± 1.27	
	Intake	Low	a	0.95 ± 1.62	13.455 (.000)	a	0.00 ± 0.00	24.481 (.000)
		Moderate	b	2.33 ± 1.90		b	2.47 ± 1.78	
		High	c	3.29 ± 1.76		c	4.35 ± 1.26	

* a, b, c refer to the same group in the post analysis.

Table 4. Correlation of interest in education, perception, knowledge, attitude, and behavior before and after the education

Section	Item	Interest in education	Necessity	Safety	Information acquisition	Subjective knowledge	Objective knowledge	Purchase attitude	Intake attitude	Behavior
Before education	Interest in education	1								
	Necessity	.395**	1							
	Safety	.309**	.554**	1						
	Information acquisition	.248**	.304**	.418**	1					
	Subjective knowledge	.190*	.332**	.480**	.727**	1				
	Objective knowledge	.210*	.145	.199*	.379**	.361**	1			
	Purchase attitude	.431**	.310**	.421**	.319**	.335**	.229*	1		
	Intake attitude	.361**	.298**	.455**	.316**	.326**	.200*	.721**	1	
	Behavior	.214*	.005	.139	.121	.169	.212*	.485**	.461**	1
After education	Interest in education	1								
	Necessity	.513**	1							
	Safety	.515**	.719**	1						
	Information acquisition	.431**	.548**	.581**	1					
	Subjective knowledge	.450**	.492**	.590**	.670**	1				
	Objective knowledge	.219*	.322**	.378**	.373**	.328**	1			
	Purchase attitude	.638**	.483**	.585**	.490**	.545**	.291**	1		
	Intake attitude	.647**	.502**	.569**	.424**	.511**	.184*	.862**	1	
	Behavior	.519**	.278**	.486**	.361**	.356**	.183*	.624**	.621**	1

* It means that if the irradiated food purchase attitude level is high, the behavior level of selecting the irradiated food would be high.

Table 5. Factors affecting the irradiated selection behavior before and after the education

Section	Item	Unstandardized coefficient		Standardized coefficient	*t*	*P*-value
		B	Standard error	Beta		
Before education	(Constant)	-.064	.934		-.069	.945
	Interest in education	.112	.227	.048	.491	.624
	Necessity	-.360	.226	-.161	-1.596	.113
	Safety	-.105	.219	-.053	-.481	.632
	Information acquisition	-.152	.184	-.100	-.823	.413
	Subjective knowledge	.125	.228	.070	.551	.583
	Objective knowledge	.161	.116	.125	1.391	.167
	Purchase attitude	.620	.264	.304	2.344	.021
	Intake attitude	.476	.220	.270	2.167	.032
	P	5.777 (.000)				
	R^2	0.300				
After education	(Constant)	-1.613	.792		-2.038	.044
	Interest in education	.329	.170	.183	1.942	.055
	Necessity	-.701	.240	-.299	-2.923	.004
	Safety	.702	.250	.312	2.805	.006
	Information acquisition	.221	.219	.100	1.009	.315
	Subjective knowledge	-.205	.200	-.101	-1.022	.309
	Objective knowledge	-.002	.082	-.002	-.024	.981
	Purchase attitude	.429	.272	.226	1.577	.118
	Intake attitude	.546	.267	.290	2.041	.044
	P	13.395 (.000)				
	R^2	0.485				

DISCUSSION

As a result of conducting a 45 minute-long education on the principles, actual state of usage, and pros and cons of irradiated food for elementary, middle, and high-school students in Korea, perception, knowledge, attitude, and behavior regarding the irradiated food was significantly higher after the education than before the education ($P < 0.000$). This is consistent with research (Bruhn *et al*., 1986) that even consumers who are not well aware of or have a negative opinion of irradiation start to have more hospitable attitudes toward irradiated food after encountering promotions on the processing techniques or advantages of the irradiation [44]. The students who have high interest in education before or after the education and the students who have high purchase and intake attitude toward the irradiated food showed a high behavior rate of selecting the irradiated food. The behavior of choosing the irradiated food showed positive correlation with all variables of perception, knowledge, and attitude. The variable which affected the behavior the most before the education was the purchase attitude, but safety of the irradiated food showed the largest influence after the education. The importance of knowledge of danger has been highlighted, but other factors play more significant roles [45,46]. Since individuals generally do not have sufficient knowledge on scientific technologies and thus base their emotional judgment on their experiences, not rational judgment [47], emotional recognition of danger may be effective. However, in Korea, there is no chance to provide positive knowledge on the irradiated food to the public while the media reports negative information on radioactively polluted food. Negative recognition is formed nationwide, even though polluted food is created by completely different means from that of irradiated food.

The government, companies, and food experts need to make efforts to actively provide proper information regarding new food production and processing technologies for the public so that vague, groundless uncertainties cannot spread. Further, citizens should view food safety issues with a scientific and rational perspective, rather than an emotional approach [16]. It is reported that 90% of the consumers are not well aware of irradiation. Thus, as systems of labeling irradiated food are reinforced, consumers must be educated in order to enhance recognition and acceptance of the irradiated food [2].

It is necessary to develop logical intervention strategies in order to transform public recognition through educational intervention in a short period. In the present research, the perception, knowledge, attitude, and behavior level of the middle school students were higher than those of the elementary and high school students. Thus, if information is provided as part of school curricula, it appears that the educational effect would be highest among middle school. The behavior of irradiated food selection shows high correlation with all variables of perception, knowledge, and attitude, and it is necessary to provide information of each level of change in perception, knowledge, and attitude in order to derive proper behavior change, which is the ultimate goal of the education. In particular, it seems necessary to provide sufficient content explanation on irradiated food safety, which has the largest influence on behavior change. In order to induce the behavior change, which is the ultimate purpose of the education, it would be necessary to apply both strategies.

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