

# Perception and practice regarding allergen labeling: focus on food-related employees

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**BACKGROUND/OBJECTIVES:** Most consumers are able to recognize allergenic foods. However, the frequency of checking such foods is reportedly low, resulting in higher prevalence of food-related allergic reactions in Korea compared to other countries. Thus, this study was performed to investigate the overall perception of allergenic food labeling and its practice level in food manufacturing company employees.

**SUBJECTS/METHODS:** The survey was administered to food safety employees and food development teams at food companies located in metropolitan areas. A total of 399 (93.8%) valid samples were used in the final analysis. Statistical analyses, including Frequency Analysis, t-test, Anova, PCA (Principal Component Analysis), and Pearson Correlation Analysis using SPSS ver. 21.0, were performed.

**RESULTS:** The correct answer rate in the analysis of allergy-related knowledge level ranged from 15.0% to 89.7%. Analysis of differences in allergy-related perception by knowledge level showed significant differences in introduction of a food recall system, strengthening of relevant laws and regulations, content labeling, description of substitutional food, and differentiated package by age.

**CONCLUSIONS:** It can be concluded that labeling of allergenic foods should be made easier and more convenient for checking by employees, developers, and consumers, and it is necessary to provide contents through the development of publicity, guidelines, or APP along with labeling.

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## INTRODUCTION

Prevalence of allergies has increased recently due to changes in dietary habits, the environment, and lifestyles [1-3]. Particularly, food allergies have greatly increased worldwide as intake of processed foods and animal foods has increased due to the development of food processing technologies [4].

Food allergies are an adverse response in individuals mediated by the immune system, resulting in hypersensitive reactions to certain kinds of foods [5]. Food allergies are distinct from food intolerance, which occurs regardless of immune function. Symptoms usually include hives, abdominal pain, diarrhea, vomiting, and discomfort. However, fatal anaphylaxis can sometimes occur [6]. There is no such treatment to completely cure allergies, which means the only way to prevent food allergies is to avoid the relevant foods [7]. Food allergy prevalence in Korea was surveyed in 1995 and 2000 by the ISAAC (International Study of Asthma and Allergies in Childhood)

in elementary and middle school students, and rates of pediatric asthma and allergic disorders were 4.6% in 1995 and 5.2% in 2000 [8-10]. In an epidemiological study conducted in 2005, the prevalence of allergies in elementary students in Seoul was 6.2% and constantly increased [11]. According to MFDA data on allergenic Korean foods, the "Allergenic Food Labeling System" in 2003 forced food companies and services to label ingredients such as eggs, milk, buckwheat, peanut, soybean, wheat, mackerel, crab, pork, peach, and tomato regardless of amount. Shrimp was added in 2007 and sulfites added in 2011, resulting in a total of 13 items for allergenic food labeling [12-15]. Milk, eggs, peanut, soybean, and wheat constitute 90% of allergenic foods in children under 10 years of age, whereas peanuts and nuts, fish, and shellfish constitute about 85% of allergenic foods in adolescents and adults [16]. In particular, the need for group management in addition to individual management should be emphasized since children and adolescents have demonstrated insufficient perception and management of food allergies [17].

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As concerns over food allergies have increased, a revised School Meals Act was proposed in 2011, and the allergenic food labeling system has been enforced in all schools nationwide since September 2012 [18]. As anaphylaxis can be fatal, the school meals system, which is used by about 14% of Korean population, must be safe. Recognition of allergenic foods and safety is required in restaurants and food service companies. Legal regulations for solving food allergy problems have already been prepared in advanced countries such as the UK and USA by establishing a database [19,20].

For food allergy-related problems, 618 cases in 2010 and 736 cases in 2011 were filed to the Korea Consumer agency [21]. The only treatment for food allergies is to restrict intake of allergy-inducing foods. Thus, consumers with food allergies should be careful when purchasing foods and cooking meals. However, although most consumers are able to recognize allergenic foods, frequency of checking for those foods is low, resulting in higher prevalence in Korea compared to other countries [22].

Several allergy-related studies in Korea have been carried out. Yang *et al.* [23] studied dietary habits and eating patterns with or without allergies, Lee *et al.* [22] studied consumer use and satisfaction of the allergenic food labeling system, and Lee *et al.* [17] studied the prevalence of food allergies in students and the perception on food allergen labeling in school meals. Kim *et al.* [24] conducted a study on the perception and performance on food allergy-related works in nutritionists at elementary and middle schools in the Jeonnam area, and Han *et al.* [25] conducted a study on the frequency of food allergies and allergenic foods in Koreans. In addition, Park *et al.* [26] studied food allergy occurrence and the relationship with other allergic diseases in elementary students in the Bucheon area while Kim [6] investigated the diagnosis and treatment of food allergies in children. Recently, Kwak *et al.* [21] studied IPA (importance-performance analysis) according to the level of allergenic food labeling recognition in food company employees. Previous studies have mainly been performed in children and adolescents or general consumers. Therefore, there have not been many Korean studies conducted in food industry employees, who are the main subjects of food manufacturing and development, as shown in studies by Choi & Rajagopal [27] and Kwak *et al.* [21].

Thus, this study was investigated the overall perception of allergenic food labeling and the practice level in food manufacturing company employees. These results will help prepare a basic foundation for allergy-related research in academic circles and requirements for the development of allergy-related food labeling and manual development in industry.

## SUBJECTS AND METHODS

### *Subjects and survey period*

The survey was performed on food safety employees and food development teams at food companies located in metropolitan areas in Korea. The survey questionnaire was prepared by modifying and supplementing questions after conducting a preliminary survey, and the main survey was conducted from October 1 to November 15, 2013. Among 425 questionnaires collected from nine food companies, 399 (93.8%)

valid samples were used in the final analysis, except those with less reliable and insincere responses.

### *Survey contents and methods*

The questionnaire used in this survey was developed by modifying and supplementing related questions from previous studies [5,17,21,22,28-40].

The survey questionnaire consisted of a total of three categories, including allergy-related knowledge level [31-35], perception and practice of allergenic food labeling [21,36-40], general characteristics and others [5,17,22,28-30]. The questions for measuring allergy-related knowledge level were made of 10 O/X questions. The questions for measuring allergenic food labeling-related perception and practice levels were made of 13 questions such as introduction of the food recall system, strengthening of related laws and regulations, relevant ingredient control by food manufacturers, promotion, consumer education, professional training, simple allergen labeling, differentiated related item labeling, adverse effect information, content labeling, substitutional foods information, and package differentiation notice, which were scored using a 5-point Likert scale. This survey was approved by the institutional review board of Yonsei University (1040917-201311-SB-125-02) and performed on the basis of a questionnaire with an informed consent waiver.

### *Statistical analysis*

Collected questionnaires were coded into numbered data using a spreadsheet program, and all statistical analyses were performed using SPSS ver. 21.0 as follows. The analysis for general characteristics and education levels of subjects was performed by frequency analysis to obtain frequency (n) and percentage (%), and the significance was tested by  $\chi^2$ -test. The differences in perception and practice by gender, work experience, age, and knowledge level were subjected to descriptive analysis to obtain mean and standard deviation. Significance of the results was tested by t-test and one-way ANOVA (Analysis of Variance). When a significant difference was observed in more than three groups, Scheffe's multiple range comparison post-hoc test was performed, and the difference among the groups was analyzed at  $\alpha=0.05$ . Differences in general characteristics, knowledge level, perception, and practice were visually summarized and described by PCA (principal component analysis), and correlation analysis between perception and practice of allergy labeling was carried out by Pearson's correlation analysis.

## RESULTS

### *Characteristics of study subjects*

The general characteristics of the subjects are shown in Table 1. Among 399 total subjects, the ratio of males was higher (56.9%) compared to females. For age distribution, 30s was the largest age group (55.9%), with 61.7% males and 55.9% females. For education level, the highest ratio among all subjects was 50.9% for graduate college. The largest group for males was graduate college (53.7%) and the largest group for females was college (50.6%). For work experience, the largest group was 6-10 years (27.9%) for males and 3-5 years (37.3%) for females.

**Table 1.** General characteristics of subjects by gender

	Male		Female		Total		P-value <sup>1)</sup>
	n	%	n	%	n	%	
Age (yrs)							
20-29	29	12.8	81	47.1	110	27.6	
30-39	140	61.7	83	48.3	223	55.9	<.001
≥40	58	25.6	8	4.7	66	16.5	
Average age	35.63 ± 6.13 <sup>3)</sup>		30.47 ± 4.51		33.40 ± 6.05		<.001 <sup>2)</sup>
Education level							
High school	5	2.2	4	2.3	9	2.3	
College	100	44.1	87	50.6	187	46.9	.417
Graduate school	122	53.7	81	47.1	203	50.9	
Work experience							
≤2 yrs	54	23.9	58	34.3	112	28.4	
3y-5 yrs	53	23.5	63	37.3	116	29.4	
6y-10 yrs	63	27.9	32	18.9	95	24.1	<.001
≥11 yrs	56	24.8	16	9.5	72	18.2	

<sup>1)</sup> P-value by Chi-square

<sup>2)</sup> P-value by t-test

<sup>3)</sup> Mean ± SD

#### Correct answer rate on allergy-related knowledge

Allergy-related knowledge was analyzed to measure the level of relevant knowledge of food company employees, as shown in Table 2. The correct answer rate for ten true/false questions ranged from 15.0% to 89.7%, with an average rate of 60.5%. Questions with a correct answer rate higher than 70% were 'Food allergy reactions can be fatal (89.7%)', 'Food allergies can be prevented by heating food at high temperature (79.2%)' and 'Food poisoning is a type of food allergy (77.4%)' in decreasing order. On the other hand, 'Individuals with allergies to a certain foods can show allergic reactions just by touching that food' had the lowest correct answer rate at below 15%. Knowledge levels were divided into high, middle, and low based on the scores obtained from allergy-related questions (Table 3). A score of 0-50 points (32.4%) was low knowledge level, 60 points (23.3%) was middle, and 70-100 points (44.3%) was high. No significant differences were observed by cross tabulation analysis of allergy-related knowledge level and general characteristics such as gender, age, and work experience.

#### Analysis of differences in allergy-related perception by general characteristics and knowledge level

Differences in the 13 allergy-related perception items by

**Table 2.** Correct answer rate for allergy-related knowledge

No.	Item	Answer	%
1	Hives, itching, and diarrhea after eating a certain food are symptoms of food allergies.	×	68.4
2	Food allergy reactions can be fatal.	○	89.7
3	Food allergies can be treated by modern medical technology.	×	51.9
4	Individuals with allergies to a certain food can show allergic reactions by just touching that food.	○	15.0
5	Individuals with milk allergies should not eat yogurt or cheese.	○	55.6
6	All allergenic foods are labeled in processed food packages in Korea.	×	39.8
7	Food allergies can be prevented by heating the food at high temperature.	×	79.2
8	Individuals with childhood allergies to a certain food show allergic reactions all his/her life.	×	61.9
9	Food poisoning is a type of food allergy.	×	77.4
10	Food additives are the most representative food allergens.	×	65.7

**Table 3.** Knowledge level by total scores from allergy questions

	Score <sup>1)</sup>	N	%	Mean Score
Low	≤30	31	7.9	40.31 ± 11.38 <sup>2)</sup>
	40	42	10.5	
	50	56	14.0	
	Sub total	129	32.4	
Middle	60	93	23.3	60.00 ± 0.00
	Sub total	93	23.3	
High	70	98	24.6	75.59 ± 7.14
	80	62	15.5	
	90	14	3.5	
	100	3	0.7	
	Sub total	177	44.3	
Total		399	100.0	60.55 ± 17.25

<sup>1)</sup> Total 100 points (per question, correct answer-10 points, incorrect answer-0 point)

<sup>2)</sup> Mean ± SD

general characteristics and knowledge level are shown in Table 4. For perception items by gender, no significant differences were observed in any item except for relevant laws, regulations, and content labeling ( $P < 0.001$ ). For perception items by age, significant differences were observed in food recall system introduction, strengthening of relevant laws and regulations, content labeling, description of substitutional foods, and differentiated package ( $P < 0.001$ ). For perception items by work experience, significant differences were observed in food recall system introduction, strengthening of relevant laws and regulations, content labeling, warning labeling, relevant ingredient control by food manufacturers, and warning labels ( $P < 0.05$ ). For perception items by knowledge level, significant differences were observed in strengthening of relevant laws and regulations, differentiated labeling of relevant items, and description of substitutional foods ( $P < 0.05$ ).

#### PCA by general characteristics, knowledge level, and perception

PCA was performed to visually summarize the relationship between perception level and general characteristics of food company employees. The first principal and second principal components accounted for 89.1% of the total variance (Fig. 1 and Table 5). Among total variance, the first principal component constituting 68.45% of the explained variance was positively correlated with professional training, warning labels, simple labeling of food allergens, differentiated labeling of relevant items, relevant ingredient control by food manufacturers,

**Table 4.** Analysis of differences in allergy-related perception by gender, age, work experience, and knowledge level

Perception	1		2		3		4		5		6		7		8		9		10		11		12		13		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
<b>Gender</b>																											
male	3.20	.96	3.12	.88	3.49	.86	3.73	.80	3.74	.85	3.32	.93	3.68	.86	3.43	.90	3.02	1.00	2.65	1.05	2.69	.96	2.57	.97	3.53	.89	
female	3.34	.90	3.38	.84	3.62	.80	3.67	.81	3.66	.85	3.39	.93	3.70	.84	3.45	.89	3.13	1.08	2.94	1.07	2.84	.98	2.70	1.04	3.60	.90	
<i>P</i> -value <sup>1)</sup>	.142		<.001		.153		.521		.334		.443		.867		.865		.291		.001		.121		.223		.478		
<b>Age (yrs)</b>																											
20-29	3.34 <sup>b</sup>	.86	3.37 <sup>b</sup>	.80	3.64	.76	3.70	.74	3.67	.73	3.40	.90	3.68	.87	3.48	.88	3.25 <sup>b</sup>	1.06	3.11 <sup>c</sup>	1.02	2.95 <sup>b</sup>	.99	2.79 <sup>b</sup>	1.04	3.61	.85	
30-39	3.35 <sup>b</sup>	.97	3.29 <sup>b</sup>	.90	3.54	.87	3.71	.85	3.71	.90	3.34	.96	3.73	.84	3.46	.94	3.06 <sup>ab</sup>	1.01	2.74 <sup>b</sup>	1.05	2.79 <sup>b</sup>	.94	2.65 <sup>b</sup>	.99	3.57	.91	
≥40	2.86 <sup>a</sup>	.86	2.82 <sup>a</sup>	.80	3.41	.80	3.70	.76	3.74	.85	3.29	.91	3.56	.84	3.29	.78	2.82 <sup>a</sup>	1.04	2.35 <sup>a</sup>	1.06	2.30 <sup>a</sup>	.93	2.26 <sup>a</sup>	.90	3.45	.93	
<i>P</i> -value <sup>2)</sup>	<.001		<.001		.225		.992		.863		.734		.362		.322		.032		<.001		<.001		<.001		.534		
<b>Work experience</b>																											
≤2 yrs	3.38 <sup>a</sup>	.84	3.48 <sup>a</sup>	.76	3.73 <sup>a</sup>	.72	3.82	.67	3.85 <sup>a</sup>	.77	3.45	.81	3.85	.80	3.61	.82	3.27	1.03	3.06 <sup>a</sup>	.96	3.04 <sup>b</sup>	.95	2.94 <sup>a</sup>	.99	3.79 <sup>a</sup>	.80	
3y-5 yrs	3.40 <sup>b</sup>	.96	3.24 <sup>ab</sup>	.93	3.57 <sup>ab</sup>	.90	3.69	.91	3.60 <sup>b</sup>	.95	3.28	1.06	3.67	.91	3.44	.95	3.03	1.08	2.77 <sup>ab</sup>	1.17	2.69 <sup>ab</sup>	1.06	2.53 <sup>ab</sup>	1.05	3.46 <sup>b</sup>	1.02	
6y-10 yrs	3.26 <sup>ab</sup>	.95	3.22 <sup>ab</sup>	.85	3.45 <sup>ab</sup>	.82	3.59	.75	3.55 <sup>b</sup>	.75	3.28	.90	3.62	.85	3.39	.88	3.00	.96	2.75 <sup>ab</sup>	1.02	2.82 <sup>b</sup>	.86	2.65 <sup>ab</sup>	.92	3.4b <sup>b</sup>	.80	
≥11 yrs	2.90 <sup>a</sup>	.97	2.89 <sup>b</sup>	.86	3.35 <sup>b</sup>	.87	3.69	.88	3.83 <sup>a</sup>	.87	3.35	.94	3.56	.82	3.28	.91	2.88	1.03	2.36 <sup>b</sup>	1.03	2.35 <sup>a</sup>	.87	2.29 <sup>b</sup>	.91	3.49 <sup>b</sup>	.90	
<i>P</i> -value <sup>2)</sup>	<.001		<.001		.015		.231		.024		.532		.103		.093		.057		<.001		<.001		<.001		.021		
<b>Knowledge level</b>																											
Low	3.31	.85	3.38 <sup>a</sup>	.86	3.57	.78	3.61	.71	3.62	.78	3.36	.83	3.75	.83	3.58 <sup>a</sup>	.89	3.10	1.01	2.94	1.07	2.95 <sup>a</sup>	.98	2.79	1.01	3.62	.79	
Middle	3.22	.87	3.09 <sup>b</sup>	.80	3.59	.76	3.68	.84	3.60	.89	3.20	.94	3.55	.87	3.26 <sup>b</sup>	.86	3.12	1.04	2.74	.98	2.65 <sup>b</sup>	.88	2.58	.89	3.45	.90	
High	3.25	1.03	3.21 <sup>ab</sup>	.91	3.50	.91	3.79	.85	3.82	.86	3.42	1.00	3.72	.85	3.43 <sup>ab</sup>	.91	3.02	1.06	2.67	1.11	2.67 <sup>ab</sup>	1.00	2.53	1.04	3.58	.96	
<i>P</i> -value <sup>2)</sup>	.753		.045		.643		.172		.053		.201		.182		.032		.712		.091		.023		.072		.371		

Scores (1 point: not very perceive, 3 points: normal, 5 points: very perceive)

<sup>1)</sup> *P*-value by t-test, <sup>2)</sup> *P*-value by Anova

<sup>abc</sup> Different superscript letters mean significantly different between groups at  $\alpha = 0.05$  level by Scheffe's multiple comparison.

Perception items (1, Introduction of food recall system for violating allergenic food labeling, 2, Strengthening of food allergen-related laws and regulations, 3, Food allergen control for food manufacturers, 4, Publicity for allergenic food labeling, 5, Consumer education for food allergies, 6, Professional training specialized in food allergies, 7, Simple ingredient labeling for allergenic foods, 8, Differentiated ingredient labeling between allergenic and non-allergenic foods, 9, Description of adverse reactions of food allergies, 10, Food allergen content labeling, 11, Description of substitutional foods for allergenic foods, 12, Differentiated package for allergenic foods, 13, Food allergy warning labels).

**Table 5.** Factor loadings by gender, age, work experience, knowledge level, and perception

	PC 1 (axis X)	PC 2 (axis Y)
perception 1	0.85	-0.35
perception 2	0.97	-0.17
perception 3	0.89	-0.12
perception 4	0.28	0.81
perception 5	0.01	0.99
perception 6	0.63	0.65
perception 7	0.90	0.30
perception 8	0.91	0.11
perception 9	0.91	-0.14
perception 10	0.94	-0.28
perception 11	0.95	-0.25
perception 12	0.96	-0.19
perception 13	0.87	0.44
Eigenvalue	8.86	2.70
Variability (%)	68.16	20.80
Cumulative %	68.16	88.96

description of adverse reactions, strengthening of relevant laws and regulations, differentiated package, description of substitutional foods, content labeling, and introduction of food recall system (Factor loading > |0.5|). General characteristics showing strong correlation included work experience under 2 years, female gender, 20-29 years of age, and low knowledge level.

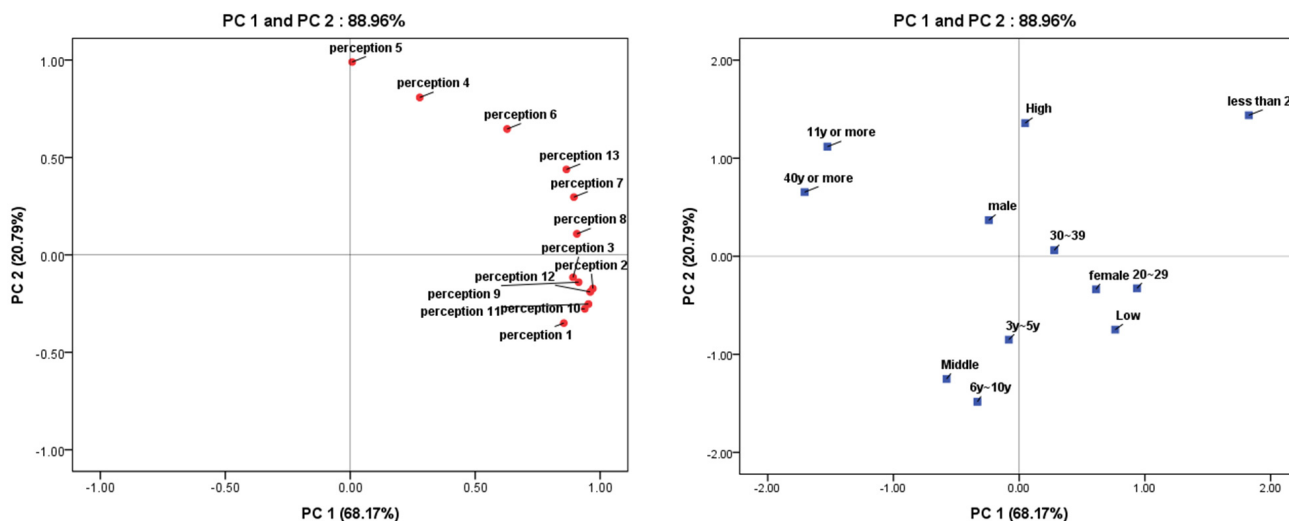
The second principal component constituting 20.60% of the explained variance was positively correlated with publicity and consumer education (Factor loading > |0.75|). General characteristics showing strong correlation included work experience over 11 years, age over 40 years of age, and high knowledge level. Those showing weak correlation included middle knowledge level and work experience of 3-10 years.

#### Analysis of differences in allergy-related practice level by gender, age, work experience, and knowledge level

Differences in the 13 allergy-related practice items by general characteristics and knowledge level are shown in Table 6. For practice items by gender, a significant difference was observed only in relevant ingredient control by food manufacturers ( $P < 0.05$ ). Age and work experience were not significantly different. For practice items by knowledge level, significant differences were observed in professional training, content labeling, description of substitutional foods, and differentiated package ( $P < 0.05$ ).

#### PCA by gender, age, work experience, knowledge level, and practice

PCA was performed to visually summarize the relationship between practice level and general characteristics of food company employees. The first principal and second principal components accounted for 70.3% of the total variance (Fig. 2 and Table 7). Among total variance, the first principal component constituting 41.54% of the explained variance was positively



**Fig. 1.** PCA by gender, age, work experience, knowledge level, and perception. Perception items (1, Introduction of food recall system for violating allergenic food labeling, 2, Strengthening of food allergen-related laws and regulations, 3, Food allergen control for food manufacturers, 4, Publicity for allergenic food labeling, 5, Consumer education for food allergies, 6, Professional training specialized in food allergies, 7, Simple ingredient labeling for allergenic foods, 8, Differentiated ingredient labeling between allergenic and non-allergenic foods, 9, Description of adverse reactions of food allergies, 10, Food allergen content labeling, 11, Description of substitutional foods for allergenic foods, 12, Differentiated package for allergenic foods, 13, Food allergy warning labels).

**Table 6.** Analysis of differences in allergy-related practice by gender, age, work experience, and knowledge level

Practice	1		2		3		4		5		6		7		8		9		10		11		12		13	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Gender</b>																										
Male	2.93	.85	3.11	.76	3.38	.80	2.87	.80	2.70	.87	2.54	.88	3.25	.81	2.92	.78	2.42	.77	2.39	.82	2.28	.79	2.38	.80	3.30	.88
Female	2.77	.75	3.01	.65	3.20	.79	2.84	.83	2.55	.84	2.48	.84	3.16	.74	2.88	.85	2.43	.76	2.45	.87	2.38	.83	2.38	.80	3.29	.83
<i>P</i> -value <sup>1)</sup>	.055		.142		.030		.723		.087		.497		.233		.640		.879		.480		.211		.991		.959	
<b>Age (yrs)</b>																										
20-29	2.74	.79	2.95	.70	3.26	.86	2.81	.83	2.54	.80	2.51	.78	3.07	.77	2.86	.75	2.43	.76	2.50	.79	2.39	.73	2.43	.77	3.25	.81
30-39	2.90	.80	3.12	.72	3.33	.78	2.88	.82	2.71	.86	2.55	.87	3.25	.81	2.88	.86	2.43	.77	2.38	.88	2.32	.86	2.38	.83	3.28	.84
≥40	2.91	.89	3.09	.72	3.29	.76	2.86	.76	2.55	.91	2.42	.96	3.32	.66	3.02	.73	2.41	.76	2.38	.80	2.24	.75	2.30	.72	3.42	.98
<i>P</i> -value <sup>2)</sup>	.187		.116		.781		.736		.134		.594		.075		.441		.986		.448		.486		.607		.378	
<b>Work experience</b>																										
≤2 yrs	2.79	.82	3.01	.70	3.37	.78	2.92	.84	2.63	.84	2.56	.83	3.14	.72	2.88	.78	2.46	.79	2.53	.84	2.44	.83	2.48	.83	3.28	.74
3y-5 yrs	3.00	.82	3.09	.72	3.31	.86	2.85	.87	2.65	.87	2.54	.87	3.28	.87	2.89	.85	2.39	.69	2.34	.84	2.25	.79	2.31	.83	3.29	.89
6y-10 yrs	2.76	.77	3.09	.76	3.27	.79	2.77	.78	2.67	.86	2.48	.81	3.16	.79	2.89	.82	2.41	.86	2.37	.88	2.35	.82	2.40	.76	3.22	.88
≥11 yrs	2.88	.84	3.07	.70	3.24	.76	2.90	.73	2.58	.90	2.47	.98	3.32	.69	2.99	.80	2.44	.71	2.42	.82	2.25	.78	2.32	.77	3.40	.94
<i>P</i> -value <sup>2)</sup>	.129		.792		.724		.572		.926		.865		.326		.836		.886		.383		.277		.369		.598	
<b>Knowledge level</b>																										
Low	2.90	.81	3.09	.74	3.26	.70	2.98	.73	2.76	.80	2.67 <sup>a</sup>	.83	3.21	.75	2.98	.74	2.59 <sup>a</sup>	.76	2.61 <sup>a</sup>	.80	2.52 <sup>a</sup>	.78	2.57 <sup>a</sup>	.79	3.23	.88
Middle	2.81	.86	3.01	.77	3.28	.94	2.84	.80	2.56	.81	2.39 <sup>b</sup>	.82	3.23	.85	2.87	.92	2.39 <sup>ab</sup>	.74	2.43 <sup>ab</sup>	.80	2.28 <sup>ab</sup>	.79	2.40 <sup>ab</sup>	.78	3.44	.85
High	2.85	.79	3.07	.67	3.35	.79	2.79	.87	2.59	.91	2.47 <sup>ab</sup>	.89	3.20	.77	2.86	.80	2.32 <sup>b</sup>	.76	2.26 <sup>b</sup>	.86	2.21 <sup>b</sup>	.81	2.23 <sup>b</sup>	.79	3.26	.84
<i>P</i> -value <sup>2)</sup>	.701		.687		.564		.122		.135		.040		.975		.422		.009		.001		.003		.001		.160	

Scores (1 point: not very practice, 3 points: normal, 5 points: very practice)

<sup>1)</sup> *P*-value by t-test, <sup>2)</sup> *P*-value by Anova

<sup>abc</sup> Different superscript letters mean significantly different between groups at α=0.05 level by Scheffe's multiple range comparison

Perception items (1, Introduction of food recall system for violating allergenic food labeling, 2, Strengthening of food allergen-related laws and regulations, 3, Food allergen control for food manufacturers, 4, Publicity for allergenic food labeling, 5, Consumer education for food allergies, 6, Professional training specialized in food allergies, 7, Simple ingredient labeling for allergenic foods, 8, Differentiated ingredient labeling between allergenic and non-allergenic foods, 9, Description of adverse reactions of food allergies, 10, Food allergen content labeling, 11, Description of substitutional foods for allergenic foods, 12, Differentiated package for allergenic foods, 13, Food allergy warning labels).

correlated with consumer education, publicity, professional training, description of adverse reactions, differentiated package, content labeling, and description of substitutional foods. General characteristics showing strong correlation included

work experience under 2 years, 20-29 years of age, and low knowledge level. The second principal component constituting 28.74% of the explained variance was positively correlated with strengthening of relevant laws and regulations and introduction

**Table 7.** Factor loadings by gender, age, work experience, knowledge level, and practice

	PC 1 (axis X)	PC 2 (axis Y)
perception 1	-.131	.911
perception 2	-.101	.868
perception 3	-.122	.320
perception 4	.689	.534
perception 5	.573	.566
perception 6	.830	.303
perception 7	-.395	.855
perception 8	.128	.657
perception 9	.930	.219
perception 10	.893	-.164
perception 11	.953	-.267
perception 12	.943	-.141
perception 13	-.500	.227
Eigenvalue	5.417	3.763
Variability (%)	41.666	28.950
Cumulative %	41.666	70.616

of food recall system. General characteristics showing strong correlation included work experience of 3-5 years, work experience over 11 years, age over 30, age over 40, and males.

#### Correlation analysis between perception and practice

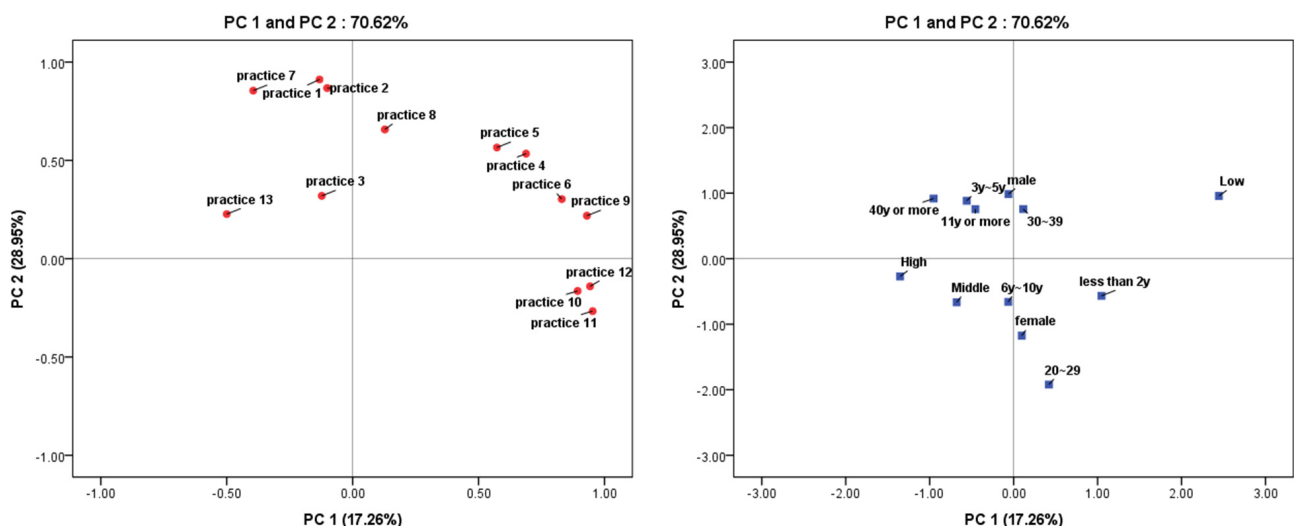
The correlation between perception and practice was analyzed by using the 13 question items to determine the effect of allergenic food labeling-related perception on the degree of practice (Table 8). The analytical results confirmed correlation coefficients of less than 0.4 for all items, and significant items with correlation coefficients of over 0.3 in the positive direction are as follows ( $P < 0.05$ ). The correlation coefficients between perception and practice were 0.303 for content labeling and 0.316 for description of substitutional foods. Perception of

differentiated package showed a correlation coefficient of 0.3-0.356 with three practice items (content labeling, description for substitutional foods, and differentiated package). A negative correlation as low as -0.106 was observed for perception of differentiated package and recognition of warning labels ( $P < 0.05$ ).

## DISCUSSION

Food allergies are a hypersensitive reaction to certain food allergens and are caused by disorder in the immune response after food intake [5,17]. Various symptoms are developed in several organs in the body, including digestive, pulmonary, circulatory systems, and the skin, and food allergies can be fatal in severe cases [4,5,41]. Therefore, the most effective method for preventing food allergies is to restrict intake of allergy-inducing foods and provide proper education for substitutional foods to prevent adverse reactions via professional consultation [42-44]. Since intake of allergy-inducing foods can be harmful and often fatal to consumers with allergies, the development and cooking of foods containing food allergens should be carried out. Thus, it is necessary to establish criteria for labeling of foods. In this study, the overall perception and practice of allergenic food labeling were investigated in employees of food manufacturing companies based on previous research outcomes.

The allergy-related knowledge level of food company employees in this study showed an average correct answer rate of 60%. Of the question items, the highest correct answer rate was 'Food allergy reactions can be fatal (89.7%)' while the lowest correct answer rate was 'Individuals with allergies to a certain food can show allergic reactions by just touching that food' as 15%. This result was similar to those from a study on foodservice employees in the Midwest USA, which showed a knowledge level ranging from 17.7% to 78.4% [27]. Labeling of major allergenic foods has been legally mandated in several countries, including Korea,



**Fig. 2.** PCA by gender, age, work experience, knowledge level, and practice. Perception and Practice items (1. Introduction of food recall system for violating allergenic food labeling, 2. Strengthening of food allergen-related laws and regulations, 3. Food allergen control for food manufacturers, 4. Publicity for allergenic food labeling, 5. Consumer education for food allergies, 6. Professional training specialized in food allergies, 7. Simple ingredient labeling for allergenic foods, 8. Differentiated ingredient labeling between allergenic and non-allergenic foods, 9. Description of adverse reactions of food allergies, 10. Food allergen content labeling, 11. Description of substitutional foods for allergenic foods, 12. Differentiated package for allergenic foods, 13. Food allergy warning labels).

**Table 8.** Correlation analysis between perception and practice

	Perception												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Practice 1	.267 <sup>1)</sup> **	.157**	.178**	.139**	.147**	.205**	.114*	.124*	-.006	.000	.045	.039	.118*
2	.150**	.140**	.134**	.082	.094	.116*	.145**	.100*	-.030	-.036	.001	-.033	.053
3	.078	.085	.184**	.105*	.122*	.097	.135**	.038	.044	-.020	.063	.035	.078
4	.062	.117*	.028	.032	.031	.107*	.071	.074	.137**	.088	.118*	.105*	.081
5	.041	.111*	-.017	.022	.039	.149**	.052	.067	.170**	.138**	.159**	.161**	.054
6	.093	.168**	.078	.065	.048	.188**	.076	.100*	.193**	.222**	.216**	.218**	.089
7	.051	.074	.143**	.059	.015	.103*	.042	.040	-.059	-.033	-.068	-.053	.017
8	-.021	.023	.096	-.003	-.040	.116*	-.056	.002	.002	.052	.042	.056	-.033
9	.069	.076	-.049	-.037	-.043	.106*	-.045	.033	.213**	.231**	.264**	.270**	.015
10	.047	.059	-.008	-.045	-.050	.088	-.041	.039	.177**	.303***	.261**	.300***	.035
11	.119*	.112*	.030	-.018	-.068	.173**	-.006	.101*	.183**	.284**	.316***	.332***	.066
12	.088	.110*	.028	.010	-.031	.129**	-.011	.059	.201**	.277**	.296**	.356***	.096
13	.001	-.056	.060	.046	.030	.042	-.006	-.040	-.049	-.089	-.089	-.106*	.106*

<sup>1)</sup>  $r$  = correlation coefficient \*\*\*  $P < 0.001$ , \*\*  $P < 0.01$ , \*  $P < 0.05$

Perception and Practice items (1, Introduction of food recall system for violating allergenic food labeling, 2, Strengthening of food allergen-related laws and regulations, 3, Food allergen control for food manufacturers, 4, Publicity for allergenic food labeling, 5, Consumer education for food allergies, 6, Professional training specialized in food allergies, 7, Simple ingredient labeling for allergenic foods, 8, Differentiated ingredient labeling between allergenic and non-allergenic foods, 9, Description of adverse reactions of food allergies, 10, Food allergen content labeling, 11, Description of substitutional foods for allergenic foods, 12, Differentiated package for allergenic foods, 13, Food allergy warning

USA, Japan, and Canada, so consumers can easily distinguish allergenic foods. Particularly in Korea, the Allergenic Food Labeling System has been enforced for 13 kinds of foods [22]. However, Kim *et al.* [24] reported that the level of understanding of allergy-related perception was 40-60% in 236 employees (dietitian and nutrition teachers) at school food services in the *Jeollanam-do* area. In another study on the allergy-related perception level of adults at seven university hospitals in Seoul and Gyeonggi-do, 643 (65.7%) out of 962 subjects answered that they do not regularly check allergy labels, whereas 87 (9.0%) of subjects were not even aware of the labeling requirements [22]. Based on these results, the knowledge level of food allergies was not high in general consumers or even food industry employees. Thus, guidelines and public promotion are needed to improve the overall perception of allergenic foods.

Analysis of differences in allergy-related perception by general characteristics and knowledge level showed significant differences in food recall system introduction, strengthening of relevant laws and regulations, content labeling, warning labeling, relevant ingredient control by food manufacturers, and warning labels depending on work experience ( $P < 0.05$ ). This study reported that the knowledge level of employees regarding allergenic foods differed greatly depending on work experience. Thus, it is necessary to develop an in-house education or training program for employees.

Overall, the knowledge level of employees regarding allergenic foods, which was the most important item, differed depending on work experience, gender, and age. However, employees should have full knowledge of allergies when developing foods, and thus in-depth and detailed research is needed for overall improvements as reported in other studies on nutrition labeling [45,46]. Studies on allergy labeling are rare in Korea except for a study on adolescents by Choi *et al.* [47]. Therefore, labeling of allergenic foods should be made easier and more convenient

for employees, developers, and consumers. Difficult and complicated labels can be misunderstood by both developers and consumers. Further, it is necessary to develop publicity, guidelines, or APP along with food labels since the developed contents should be distributed to consumers and relevant employees.

The limitation of this study might be the size of the selected areas, since the study was conducted in food company employees in the Seoul and Gyeonggi-do regions. Further studies on food company and foodservice employees nationwide are needed in the future to obtain in-depth and more distinct outcomes.

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