Modified Food *Kansei* Model to Integrate Differences in Personal Attributes between In-house Expert Sensory Assessors and Consumer Panels

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The food *kansei* model (Ikeda *et al.*, 2004) has been modified to integrate differences in personal attributes between in-house expert sensory assessors and consumer panels for sensory evaluation in the food industry. Three selection tests for expert sensory assessors revealed that the percentage of questions answered correctly on the tests had not significantly changed over the last three decades. Several characteristics of the expert sensory assessors as a surrogate consumer panel have been identified through four sensory tests for comparing the assessors. Applying correspondence analysis to the results of a questionnaire survey on the level of understanding sensory descriptors was found effective to investigate the differences and similarities in personal attributes between the expert sensory assessors and consumer panel. The modified food *kansei* model provides a practical path diagram to further investigate the effects of cognitive factors on sensory scores using structural equation modeling.

Keywords: consumer panel, correspondence analysis, food *kansei* model, modified food *kansei* model, in-house expert sensory assessors, questionnaire survey

Introduction

The key factor to the success of product development is the quality of sensory evaluation as a measurement tool of the usability and palatability of the targeted product. Therefore, sensory assessors must be evaluated from many viewpoints: taste sensitivity, accuracy, reproducibility, stability, quantification of sense perception, and ability to express assessment. After exploring the similarities and differences between the assessments of a trained panel and a group of naïve consumers during a case study on ewe milk cheeses, Barcnas *et al.* (2004) recommended the use of specifically trained, expert sensory assessors in conjunction with consumer panels to avoid inaccurate or biased conclusions. Labbe *et al.* (2004) demonstrated the importance of training for the benchmarking of soluble coffees based on a review of previous studies concerning the impact of training on sensory evaluation, which could be divided into three groups according to their conclusions: 1) training has a significant

impact on panel performance (Wolters and Allchurch, 1994; Roberts and Vickers, 1994; Chollet and Valentin, 2001); 2) training has a low impact on panel performance (Gou *et al.*, 1998); and 3) training has no impact on panel performance (Moskowitz, 1995).

In particular, expert sensory assessors in a food company are expected to serve as a surrogate consumer panel, within the allowable limits of time, labor, and costs, during industrial sensory evaluation for product development. In-house expert sensory assessors are superior to consumer panels in taste sensitivity, experience, cost-effectiveness, time-saving and eligibility for evaluating prototyped items that should not be presented to anyone outside of the company; however, depending on the type of food product, expert sensory assessors are not always useful as surrogate consumer panels. Furthermore, the way in-house expert sensory assessors are selected has rarely been made known outside of the company.

Food *kansei* engineering (Sagara, 1994) gives a theoretical framework for investigating whether or not expert sensory assessors may serve as surrogate consumer panels. In

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particular, the food *kansei* model (Ikeda *et al.*, 2004; Ikeda, 2005) has been proposed to: 1) qualitatively evaluate the process of emerging pleasantness, that is, of affective change in an individual during short-term eating behavior; and 2) use this quantitative information to optimize product design and manufacturing processes. The model consists of two routes—perception and cognition—that reveal the causal relationship between food attributes and pleasantness. The simplified food *kansei* model, consisting of only the route of perception, was successfully applied to design flavors of green tea beverage (Ikeda *et al.*, 2004) and sesame-flavored dressing (Ikeda *et al.*, 2006); however, the route of cognition has yet to be effectively applied, mainly due to the difficulty in quantifying extrinsic food attributes such as information that is cognized by individuals. The model might be extended if these extrinsic attributes can be quantified through investigation of industrial sensory evaluation.

Correspondence analysis, for example, has been widely used to quantify qualitative data gained from questionnaire surveys. An alternative questionnaire is beneficial for reducing costs in product development and for facilitating rapid decision-making in the company. In addition to these practical advantages, the correspondence analysis approach might reveal differences and similarities between expert sensory assessors and consumer panels, given that significant extrinsic attributes of the product are predetermined.

The objectives of this study, then, are: 1) to investigate changes in taste sensitivity of new employees at a food company over three decades through the percentage of questions answered correctly on three selection tests; 2) to examine the abilities of expert sensory assessors through comparative sensory evaluations; 3) to investigate the similarities and differences between assessments of expert sensory assessors and consumer panels; and 4) to integrate differences in personal attributes between expert sensory assessors and consumer panels into a modified food *kansei* model.

Theoretical

Differences and similarities between in-house expert sensory assessors and consumer panels Japanese Industrial Standards (JIS Z8144; 2004) and the International Standardization Organization (ISO 8586-1;1993, 8586-2;1994) define a wide variety of assessment-related terms. An assessor is defined as a “person who participates in sensory analysis”, while a panel is “a group of assessors who participate in sensory analysis.” Expert sensory assessors are defined as “selected assessors with a demonstrated sensory sensitivity and with considerable training and experience in sensory testing, who are able to make consistent and repeatable sensory assessments of various products.” Other assessment-related

terms, such as “selected assessor”, “expert”, and “consumer” are also defined by JIS and ISO.

The number of panelists required in industrial sensory evaluations depends on the purpose of the assessment at each developmental stage. Large-scale sensory evaluations, generally supervised by the business department in charge of the targeted theme within the company, may require the participation of hundreds to thousands of consumer panelists in order to extract a product concept from ideas at the initial stage and to evaluate the finalized prototype at the final stage. These consumer panelists are usually the targeted users of the product under evaluation.

On the other hand, Smaller sensory evaluations are more frequently performed with only five to 40 expert panelists and in-house expert sensory assessors and are typically led by the departments of research and development, and the department of production development. During these sensory evaluations, assessors are often managed by a special division of sensory evaluation. Small-scale sensory evaluations are performed at each developmental stage following creation of the product concept in order to preliminarily evaluate prototypes (at the test production stage) and to control product quality (at the production stage).

Panelists are selected in accordance with the purpose of assessment: persons in charge of developing the targeted food product serve as experts; product development and quality control experts serve as analytical panel members; and family members of company employees are recruited for household use tests. In addition, in-house expert sensory assessors are frequently used for preliminary evaluations prior to the final evaluation by consumers.

In Company A, in-house expert sensory assessors are primarily new employees who are not involved in food product development and have passed selection tests for taste sensitivity. Their duties are to engage in in-house sensory evaluations at least once a week and to participate in an introductory lectures and annual seminars on sensory evaluation methods and consumer attitudes. In these sensory evaluations, expert sensory assessors are mainly treated as an analytical panel. If the similarity between the expert sensory assessors and targeted users of the product is confirmed, the assessors can be used for preference evaluation. Company A has approximately 200 assessors, from which panelists of any specified gender or food preference can be selected in accordance with the purposes of sensory evaluation.

Judging differences and similarities between in-house expert sensory assessors and consumer panels is important to accurately interpret sensory evaluation data during product development. Factors influencing the differences and similarities should be also explored using one of two approaches.

One approach is to use the sensory evaluation results obtained for test samples, and the other is to estimate the differences and similarities without test samples. The former approach is usually called the “Central Location Test” or “Hall Test” in the food industry. In this test, 60 or more consumer candidates, recruited as the targeted users of the food product under evaluation, are gathered in a hall where no indication is given of the company or product name; all candidates then evaluate raw or cooked samples. The results obtained are compared with those from in-house expert sensory assessors.

On the other hand, the latter approach uses a questionnaire survey, and real samples are not needed. The consumer panel-again, the targeted users of the product-can answer the questionnaire via mail, fax or the Internet, and the results obtained are compared with those from in-house expert sensory assessors. The questionnaire approach is simpler, more rapid, and more cost-effective than using test samples, especially when many panelists are required, or when the product under evaluation needs extensive preparation or cooking. In addition, if, through a preliminary survey, the results obtained from in-house expert sensory assessors and consumer panels for the targeted products are found to be similar enough for the expert sensory assessors to act as a surrogate consumer panel, the feasibility of the test product can be judged using only the sensory evaluation results obtained from in-house expert sensory assessors. This will contribute to effective and economical product development for all types of products, especially for products that need high-mix low-volume production or frequent renewals. As a result, all food companies should hold in-house expert sensory assessments, regardless of their scale of production, to respond to diversified consumer needs and short product life.

During product development, detailed knowledge of the sensory characteristics of the product in relation to blend-

ing, design and technical development is essential. To this end, careful treatment of sensory descriptors, through which the relationship between panelists and test samples can be indirectly measured during sensory evaluation, is extremely important.

Food kansei model, variables and path coefficients Fig. 1 shows a conceptual diagram of the food *kansei* model formulating the causal relationships between the characteristics and perceived quality of final products (Ikeda *et al.*, 2004; Ikeda, 2005). As described above, the purposes of the model are to: 1) quantitatively evaluate the process of emerging pleasantness (affective change in an individual during short-term eating behavior); and 2) use this quantitative information to optimize product design and manufacturing processes. The model is not intended to explain the process by which preference for certain foods is formed.

The model assumes that all product attributes can be classified into “intrinsic” and “extrinsic” categories. Intrinsic attributes are perceptual factors caused by the physicochemical properties of food ingredients (e.g., texture, temperature and appearance), while extrinsic attributes are cognitive factors affecting the apparent palatability of the food product. In the model, pleasantness is defined as something that can be felt by an individual: emotions and feelings emerging from perception and mediated by individual preference, cognition or attitude. Preference as an individual criterion for perceived quality, however, is clearly differentiated from palatability, as cognitive factors such as the product name, manufacturer and health-promoting benefits, are transmitted to the user through packages and advertisements rather than by the product itself. Nevertheless, palatability and preference are thought to be correlated to one another, although the causal relationship between the two factors is still unknown.

Variables and path coefficients used in the model are

(Source: Ikeda *et al.*, 2004; Ikeda, 2005)

Fig. 1. Food *kansei* model.

Table 1. Food *kansei* model: variables and path coefficients.

Food <i>kansei</i> variables	Types of variables	
Intrinsic attribute	I	Quantitative; Vector
Extrinsic attribute	E	Qualitative
Perceived quality	P	Quantitative; Vector
Cognized quality	C	Qualitative
Pleasantness	PL	Quantitative; Vector
Path (I to P)	pc_1	Coefficient; Scalar
Path (E to C)	pc_2	Coefficient; Scalar
Path (P to PL)	pc_3	Coefficient; Scalar
Path (C to PL)	pc_4	Coefficient; Scalar

shown in Table 1. The route of perception can usually be described by quantitative vector variables (*I*: Intrinsic attributes; *P*: Perceived quality; *PL*: Pleasantness). In contrast, the route of cognition includes some qualitative variables (*E*: Extrinsic attribute *C*: Cognized quality). The relationships between these variables can be described by *kansei* functions, including path coefficients (pc_1 , pc_2 , pc_3 and pc_4). In other words, the purpose of the present model is to determine the path coefficients for improving the product design and

manufacturing processes of the targeted product.

From the viewpoint of sensory evaluation, one of the most important differences between the route of perception and cognition in the model is intensity evaluation; that is, the route of perception can be measured by successive category scales, while the route of cognition can be evaluated only by binary choice (yes or no).

Since the food *kansei* model focuses on an individual, different individuals should be interpreted by different models. Fig. 2 shows the models for an expert sensory assessor as well as a consumer. Using the models, the similarities and differences in sensory evaluation between expert sensory assessors and consumer panels can be investigated. If the path from extrinsic attributes to cognition for expert sensory assessors (pc_{e3}) is nearly equal to that for consumer panels (pc_{c3}), the paths from intrinsic attributes to perception for consumer panels (pc_{c1}) and from perception to pleasantness for consumer panels (pc_{c2}) might be predictable using the same paths for the expert sensory assessors (pc_{e1} and pc_{e2}). Otherwise, the model should be modified to integrate differences in other influential factors between in-house expert sensory assessors and consumer panels.

Fig. 2. Food *kansei* model for investigating similarities and differences between in-house expert sensory assessors and consumer panels.

Materials and Methods

Selection tests of in-house expert sensory assessors In-house expert sensory assessors are usually 1) excellent in the specified senses that are important for in-house evaluations, 2) not in charge of food product development, and 3) employed for analytical sensory evaluation. In this study, in-house expert sensory assessors were asked to complete the following three selection tests to investigate chronological changes in the percentage of questions on the tests answered correctly: 1) difference test of five basic tastes, 2) discrimination test for concentration difference of four basic tastes, and 3) discrimination test for taste and flavor of three food products.

The number of the panelists for tests 1) and 2) were: $n = 153$ in 1979 - 1989, $n = 200$ in 1987 - 1989, and $n = 163$ in 1994 - 1996 (516 man-days total). Those for test 3) were: $n = 24$ in 1996, $n = 60$ in 1997, and $n = 107$ in 1998 (191 man-days total).

The evaluation methods and adoption criteria for these tests are based on the conventional method (Furukawa, 1977), although the material for bitterness was changed from quinine sulfate (a reagent) to anhydrous caffeine (a food additive) with its concentration controlled at 0.02% since 1994. Because informed consent is required from all study subjects when using a reagent and such a disclosure may unexpectedly bias the results, food additive was selected for bitterness. Each test sample was served at room temperature (20 °C).

Characteristics of the expert sensory assessors To grasp the characteristics of the expert sensory assessors, four case studies of sensory evaluation were performed as follows:

Case 1: This case study was carried out to compare two homogeneous groups in 1977. Two samples of commercial fish sausage were tested. All panelists were either successful expert sensory assessor candidates in Company A ($n = 34$) or unsuccessful applicants who had failed the selection tests ($n = 201$). The intensities of sweet taste, salty taste, umami and elasticity were evaluated by two-point discrimination tests, and preference was evaluated by a pair test. Percentage analysis was performed for all data (Furukawa, 1977) to compare successful and unsuccessful applicants.

Case 2: This case study was carried out to compare three heterogeneous groups in 1993. Eight samples of commercial lactic acid beverages were tested. Panelists were the targeted consumers of the product (teenagers and those in their twenties, $n = 120$), expert sensory assessors from Company A ($n = 40$) and in-house sensory assessors from Company L ($n = 30$). All samples were presented in plain beverage cans and served at random in blind tasting conditions. The overall palatability of the samples was evaluated using an 11-point hedonic scale (10 = extremely like; 0 = extremely dislike). Average sensory scores were compared between different

groups and samples, and correlation coefficients were calculated.

Case 3: This case study was carried out to compare two heterogeneous groups in 1995. Two samples of cooked curry were prepared: one with a prototype of western-style seasoning added, and the other without the seasoning. Panelists were consumer housewives who indicated that they usually add some seasonings to a commercial curry cube when cooking ($n = 60$) and expert sensory assessors from Company A ($n = 62$). Paired comparison tests were carried out to evaluate one item of appearance, one item of smell, five items of flavor and seven items of taste, as well as the overall palatability. Percentage as well as principal component analyses were performed.

Case 4: This case study was carried out to compare three heterogeneous groups in 1994. Three salad samples were prepared using different western-style seasonings (samples L, M and N). Panelists were consumer housewives who indicated that they usually use sample L ($n = 80$), consumer housewives who indicated that they usually use sample M ($n = 80$), and expert sensory assessors from Company A ($n = 60$). Proto monadic tests were performed for 10 quality characteristic items and 10 preference characteristic items on a three-point category scale, (1 point = weak or bad; 3 points = moderate; 5 points = strong or good, where Sample N = 0) by the combination of sample L and N, and by the combination of sample M and N. Average sensory scores were compared between different groups and samples, and principal component analysis was applied to these data.

Correspondence analysis for investigating the similarity between expert sensory assessors and consumer panel Based on the similarity data obtained through the previous sensory evaluations, four test samples were selected to conduct a simplified estimation method for the similarities between the expert sensory assessors and consumer panel. Among them, two samples had low similarity (P: Japanese-style soup, Q: Western-style seasoning) and the other two had high similarity (X: Fermented lactic beverage, Y: Western-style soup). Numbers of tested panelists were 41 to 46 for in-house expert sensory assessors in Company A, and 61 to 62 for consumer panelists. To ensure the reliability of consumer panelists, they were selected using the Nikkei Research monitoring system, which includes residents extracted by a random sampling method based on the Basic Resident Register: housewives as sample P users in their twenties to fifties ($n = 61$), housewives as the Q users in their twenties to fifties ($n = 61$), men and women as the X users aging 20 to 35 years old ($n = 62$), and men and women as the Y users aging 20 to 35 years old ($n = 61$).

In 1997, a questionnaire survey using the Nikkei Re-

search monitoring system was carried out via fax to explore respondents' level of understanding of 34 sensory descriptors for each sample. Division analysis and correspondence analysis were applied to the questionnaire survey results expressed in binary data.

All statistical analyses were carried out using the computer software JMP 6.0.3 (SAS Institute, Inc., Cary, NC, USA).

Results and Discussion

Selection test of in-house expert sensory assessor Table 2 shows a summary of the percentage of questions answered correctly for tests 1), 2), and 3). The percentages of right answers for test 1) were 81 to 83% for sweetness, saltiness and acidity; 78% for umami; and 62% for bitterness. Several panelists drank distilled water after the bitterness test. The difference in the percentages of right answers for test 2) between two trials was about 10% for all four basic tastes. The percentages of right answers for test 3) were around 65% for consommé and orange juice samples and 50 to 55% for soy sauce samples. Selection tests for the expert sensory assessors revealed that the percentage of questions on the tests answered correctly had not significantly changed over the last three decades.

Characteristics of the expert sensory assessors as surrogate consumer panel In Case 1, the expert sensory assessors expressed the quality characteristics of the products more

clearly than unsuccessful candidates (Fig. 3); that is, the expert sensory assessors were found to more effectively explore the characteristics that influence individual preference.

The results of the three groups in Case 2 are shown in Fig. 4. The capital letters from E to L in Fig. 4 show the samples of fermented lactic beverages, and numbers in Fig. 4 show the scores of the overall judgment out of 10 points. The difference probably arises from the fact that the panelists from Company L were used to drinking company products (Sample E and Sample L) and were therefore familiar with their tastes and flavors. Also, the average sensory scores of the Company A expert sensory assessors were lower than those of consumer panelists at one point. The simple correlation coefficient between consumer panelists and Company A expert sensory assessors was 0.784, showing coincidence between two groups. These results indicated that the Company A expert sensory assessors were similar to consumer panelists in preference for these samples. On the other hand, the simple correlation coefficient between consumer panelists and in-house panelists from Company L was 0.482, and that between expert sensory assessors from Company A and in-house panelists from Company L was 0.567. Therefore, it is apparent that while the in-house panelists from Company A were similar to consumer panelists in this case, those from Company L showed a different pattern.

In Case 3, consumer panelists expressed the quality char-

Table 2. Percentage of correct responses on selection tests for expert sensory assessors over three decades.

【Test 1】 Difference test of 5 basic tastes (% correct)						
Kind of taste	Sweetness	Saltiness	Acidity	Bitterness *	Umami	Number of Subjects
Solute	Cane sugar	Salt	Tartaric acid	Anhydrous caffeine*	M S G **	
Concentration (g/dl)	0.4	0.13	0.005	0.02*	0.05	
Aggregate average	83	81	82	62	78	
1977 to 1979 annual average	79	83	79	62	78	
1987 to 1989 annual average	82	78	81	64	80	200
1994 to 1996 annual average	88	83	86	59	77	163
*Bitterness: 0.0004% of quinine sulfate was used before 1987.						
** Mono Sodium glutamate						

【Test 2】 Concentration difference discrimination test of four tastes (% correct)									
Kind of taste	1st				2nd				Number of Subjects
	Sweetness	Saltiness	Acidity	Umami	Sweetness	Saltiness	Acidity	Umami	
Solute	Cane sugar	Salt	Tartaric acid	M S G	Cane sugar	Salt	Tartaric acid	M S G ^	
Concentration (g/dl)	5.00 5.50	1.00 1.06	0.020 0.024	0.200 0.266	5.00 5.25	1.00 1.03	0.020 0.022	0.200 0.24	
Aggregate average	81	73	74	78	69	65	66	71	516
1977 to 1979 annual average	80	75	76	73	71	67	71	72	153
1987 to 1989 annual average	84	75	71	77	70	63	63	68	200
1994 to 1996 annual average	79	70	75	84	66	66	63	73	163
【Test 3】 Discrimination test of taste and flavor of three sort of foods (% correct)									
Kind of food	Consomme		Orange juice		Soy sauce diluted solution				Number of Subjects
Concentration	Granule : 1.54g/ml Granule : 1.85g/ml		Concentrated juice : water = 1 : 5 Concentrated juice : water = 1 : 6.25		Soy sauce: water = 1:10 Soy sauce + a soy sauce raw material (1:1) : water= 1: 10				
Aggregate average	64		63		53				469
1996 to 1997 annual average	62		59		50				84
1998 to 1999 annual average	65		65		55				224
2000 to 2001 annual average	64		67		54				161

*Bitterness:
0.0004% of quinine sulfate was
used before 1987.

** Mono Sodium glutamate

*1) Expert sensory assessors at Company A (n=43)

*2) Unsuccessful applicants for sensory assessor positions at Company A (n=201)

Fig. 3. Percentages of either/or choices in Case 1.

Fig. 4. Case 2: Average hedonic ratings of 8 items.

Table 3. Cases 3 and 4: Factor loadings for comparison of consumer panels and expert sensory assessors.

Case 3		Case 4			
	PC1	Characteristics item		Preference item	
		PC1	PC2	PC1	PC2
Consumer : sample Q	0.907	E.S.A.** : sample L	0.892	0.803	
Consumer : sample R	-0.906	Consumer user L : sample L	0.371		0.662
E.S.A.* : sample Q	0.907	E.S.A.** : sample M		0.975	0.837
E.S.A.* : sample R	-0.907	Consumer user M : sample M	-0.969	0.857	
Eigenvalue	3.3	Eigenvalue	1.9	1.0	1.9
Contribution (%)	82.3	Contribution (%)	47.9	25.2	48.3
Cumulative contribution (%)	82.3	Cumulative contribution (%)	47.9	73.1	48.3
					85.1

* : In-house expert sensory assessor

** : In-house expert sensory assessor

Note: Consumers were housewives who usually add some seasonings to a commercial curry cube when cooking.
Expert sensory assessors were Company A employees.

Fig. 5. Case 3: Percentages of consumers and of expert sensory assessors preferring/identifying a variety of qualities in a western-style seasoning.

Fig. 6. Case 4: Profile patterns showing differences between consumers and expert sensory assessors in preferences and in assessment of quality characteristics in comparisons between samples L and M and sample N.

acteristics of the products more clearly than the expert sensory assessors due to the personal experiences of the consumer panelists as housewives who cook using seasonings (Fig. 5). The factor loadings of each panel for the same sample showed the same value, and the contribution stressing the importance of cooking experience in a surrogate consumer panel.

In Case 4, the evaluation patterns differed in quality characteristics and preference between in-house expert sensory assessors and the targeted consumer users of each sample, showing differences in sensory scores between L and M as well (Fig. 6). The results of principal component analysis showed lower contribution ratios of the first principal component: 54% for quality characteristics and 48% for preference. In other words, few similarities were found between the expert sensory assessors and consumer panel for the targeted samples. The results indicated that in the case a product that

monopolizes the market, both expert sensory assessors and consumer panels should be properly used according to the purposes of product development.

Simplified estimation of the similarity between expert sensory assessors and consumer panels The correlation coefficients and the standardized coefficients of Cronbach's alpha (the coefficients of reliability) were calculated for 34 descriptors of each sample food to investigate the similarities between different groups and to reduce the number of sensory descriptors. Based on the values of Cronbach's alpha coefficient, two descriptors were eliminated for sample P, three for Q, three for X, and two for Y. After elimination, the reliability coefficients were 0.915 for P, 0.909 for Q, 0.934 for X, and 0.926 for Y. Larger Cronbach's alpha coefficients reflect stronger one-dimensionality; X is the largest, followed by Y, P, and Q (Table 4).

Based on the contingency table of binary data obtained

Table 4. Reliability of evaluation factor items (Cronbach α coefficient).

P			Q			X			Y		
Whole standardization α coefficient 0.905			Whole standardization α coefficient 0.910			Whole standardization α coefficient 0.931			Whole standardization α coefficient 0.924		
Evaluation factor item	Correlation coefficient	Exclusion item Std. α coefficient	Evaluation factor item	Correlation coefficient	Exclusion item Std. α coefficient	Evaluation factor item	Correlation coefficient	Exclusion item Std. α coefficient	Evaluation factor item	Correlation coefficient	Exclusion item Std. α coefficient
PQ1	0.515	0.902	QQ1	0.536	0.907	XQ1	0.574	0.929	YQ1	0.5162	0.922
PQ2	0.653	0.900	QQ2	0.464	0.908	XQ2	0.590	0.928	YQ2	0.6423	0.921
PQ3	0.515	0.902	QQ3	0.614	0.906	XQ3	0.637	0.928	YQ3	0.6695	0.921
PQ4	0.508	0.902	QQ4	0.345	0.910	XQ4	0.563	0.929	YQ4	0.5004	0.923
PQ5	0.733	0.898	QQ5	0.567	0.906	XQ5	0.646	0.928	YQ5	0.7811	0.919
PQ6	0.471	0.903	QQ6	0.506	0.907	XQ6	0.711	0.927	YQ6	0.5857	0.922
PQ7	0.419	0.903	QQ7	0.581	0.906	XQ7	0.152	0.933	YQ7	0.1924	0.926
PQ8	0.402	0.904	QQ8	0.706	0.904	XQ8	0.288	0.932	YQ8	0.4715	0.923
PQ9	0.314	0.905	QQ9	0.368	0.909	XQ9	0.641	0.928	YQ9	0.6434	0.921
PQ10	-0.128	0.912	QQ10	0.436	0.908	XQ10	0.444	0.930	YQ10	0.3805	0.924
PQ11	0.635	0.900	QQ11	0.625	0.906	XQ11	0.141	0.933	YQ11	0.5365	0.922
PQ12	0.537	0.902	QQ12	0.588	0.906	XQ12	0.702	0.927	YQ12	0.1482	0.927
PQ13	0.587	0.901	QQ13	0.418	0.909	XQ13	0.672	0.927	YQ13	0.3384	0.925
PQ14	0.572	0.901	QQ14	0.595	0.906	XQ14	0.531	0.929	YQ14	0.4629	0.923
PQ15	0.614	0.901	QQ15	0.426	0.909	XQ15	0.566	0.929	YQ15	0.5978	0.921
PQ16	0.442	0.903	QQ16	0.179	0.912	XQ16	0.536	0.929	YQ16	0.3773	0.924
PQ17	0.437	0.903	QQ17	0.570	0.906	XQ17	0.524	0.929	YQ17	0.3677	0.924
PQ18	0.142	0.908	QQ18	0.518	0.907	XQ18	0.645	0.928	YQ18	0.3311	0.925
PQ19	0.301	0.905	QQ19	0.573	0.906	XQ19	0.688	0.927	YQ19	0.4475	0.923
PQ20	0.438	0.903	QQ20	0.634	0.905	XQ20	0.726	0.927	YQ20	0.5942	0.921
PQ21	0.702	0.899	QQ21	0.651	0.905	XQ21	0.677	0.927	YQ21	0.7662	0.919
PQ22	0.626	0.900	QQ22	0.436	0.909	XQ22	0.459	0.930	YQ22	0.5038	0.923
PQ23	0.688	0.899	QQ23	0.515	0.907	XQ23	0.608	0.928	YQ23	0.7313	0.920
PQ24	0.604	0.901	QQ24	0.648	0.905	XQ24	0.502	0.930	YQ24	0.7452	0.920
PQ25	0.676	0.899	QQ25	0.523	0.907	XQ25	0.097	0.934	YQ25	0.7254	0.920
PQ26	0.480	0.903	QQ26	0.672	0.905	XQ26	0.644	0.928	YQ26	0.4648	0.923
PQ27	0.246	0.906	QQ27	0.629	0.905	XQ27	0.607	0.928	YQ27	0.3643	0.924
PQ28	0.403	0.904	QQ28	0.320	0.910	XQ28	0.725	0.927	YQ28	0.5022	0.923
PQ29	0.464	0.903	QQ29	0.317	0.910	XQ29	0.515	0.929	YQ29	0.5524	0.922
PQ30	0.710	0.899	QQ30	0.575	0.906	XQ30	0.635	0.928	YQ30	0.7224	0.920
PQ31	0.543	0.902	QQ31	0.454	0.908	XQ31	0.704	0.927	YQ31	0.6288	0.921
PQ32	0.527	0.902	QQ32	0.600	0.906	XQ32	0.664	0.928	YQ32	0.6879	0.920
PQ33	0.411	0.904	QQ33	0.233	0.911	XQ33	0.465	0.930	YQ33	0.5666	0.922
PQ34	0.530	0.902	QQ34	0.226	0.911	XQ34	0.471	0.930	YQ34	0.6173	0.921
After-removal whole std. α coefficient 0.915			After-removal whole std. α coefficient 0.909			After-removal whole std. α coefficient 0.934			After-removal whole std. α coefficient 0.926		

These terms were removed in terms of Cronbach α coefficient.

after the elimination of the descriptors, the chi-square test (Pearson's chi-square test) was performed, resulting in almost the same numbers of significant descriptors among the samples. Singular values in correspondence analysis were then calculated for each sample to compare the ratios of the first singular values to the second singular values, which correspond to eigenvalues in principal component analysis. The singular values and the ratios of the first singular values to the second were 0.300 and 3.4 for P, 0.283 and 4.2 for Q, 0.349 and 4.8 for X, 0.324 and 4.6 for Y, respectively. The ratios of the first singular values to the second for X and Y were relatively larger than those for P and Q. The degree of dimensionality aggregation was the largest in X, followed by Y, Q, and P.

The ranking of similarities were obtained through the results of one-dimensionality evaluation by the Cronbach's alpha coefficients and correspondence analysis, which coincided with the tendency found in the existing results of sensory evaluation for each sample. The results of the chi-square test imply inequality between the sum of the degree of understanding of the descriptors and the degree of coincidence among different groups, supporting the results of similarities obtained by applying correspondence analysis to the data.

Additional correspondence analysis was performed, using only the data for consumer panels, to investigate the degree of cooking or processing perceived by assessors. Although the results are theoretically the same for all the samples because of the uniformity of consumer panels, the singular value of Q, a seasoning, was lower than the singular values of other three samples. Since seasonings have wider ranges of uses with various cooking processes, each individual's recollection may differ. Other than eating frequency, experiences as users and ranges of uses for a certain seasoning should also be considered as important factors.

Personal attributes of each panelist, such as age and gender, affect the frequency of eating and experience using certain products. Such personal attributes were almost equally distributed in the panels for X and Y, while P and Q panels consisted mainly of housewives. In addition, Q and Y tended to correspond to cases of captive products (Case 2) if eating experience and frequency are considered.

These results indicated that, from the viewpoint of commercial product development, applying correspondence analysis to the results of a questionnaire survey enabled simple, rapid, and cost-effective investigation of the differences and similarities in personal attributes between expert sensory assessors and consumer panels. Further challenges are to investigate the effects of personal attributes of each panel on sensory descriptors in more detail and to explore how these sensory descriptors are properly and effectively selected and

reduced.

Conventional and modified food kansei models as well as kansei functions As shown in Fig. 2, if the questionnaire survey results indicate similarities between two groups (that is, if the path from extrinsic attributes to cognition for expert sensory assessors (pc_{e3}) is nearly equal to that for consumer panels (pc_{c3})), the paths from intrinsic attributes to perception for consumer panels (pc_{c1}) and from perception to pleasantness for consumer panels (pc_{c2}) might be predictable using the same paths for the expert sensory assessors (pc_{e1} and pc_{e2}), making sensory evaluations become more efficient for the company.

On the other hand, if the questionnaire survey results indicate differences between two groups (that is, if pc_{e3} is not equal to pc_{c3}), the model should be modified to integrate differences in other influential factors between different groups of panelists. In this study, the food *kansei* model has been modified to integrate differences in personal attributes between in-house expert sensory assessors and consumer panels for sensory evaluation in the food industry (Fig. 7). In the modified model, the path from personal attributes to cognition (pc_3) was added at the bottom of the figure. The personal attributes contain age, gender, and experiences of cooking and eating, all of which are considered as factors influencing the similarities between different groups. Other factors influencing the results of sensory evaluation, such as types of food products and share of market, can be regarded as extrinsic attributes that affect the route of cognition (pc_3). Consequently, hedonic rating, or pleasantness (PL), is affected by seven paths: perception to pleasantness, cognition to pleasantness, personal attributes to cognition, and the two directional pathways between perception and cognition.

Therefore, when in-house expert sensory assessors are employed for sensory evaluation of new food products, similarities between the expert sensory assessors and consumer panels can be roughly predicted by using the modified model if types of food products, market share, and personal attributes of targeted users are segmented. Adding correspondence analysis for the questionnaire survey results raises the probability of predicting the similarities. Other effective approaches are to check the reality of daily diet and to accumulate such data for the assessors.

The usefulness of the food *kansei* model depends on whether or not *kansei* functions and variables were properly selected; for instance, the artificial neural network (ANN) was adapted as a *kansei* function in previous studies on green beverages (Ikeda *et al.*, 2004) and beef bouillon (Krishnamuthy *et al.*, 2007) to predict consumer preference due to its high accuracy. However, the ANN is not always the only function that works, especially in the case of numer-

Fig. 7. Food *kansei* model modified to integrate individual differences in personal attributes of tasters.

ous *kansei* variables in the input layer of the ANN model. In addition, no comparative studies can be found investigating methodological superiority of the ANN among other nonlinear analyses such as response surface methodology by spline (Kaseda, 2004).

A path diagram based on the modified food *kansei* model would be useful to conduct further studies in food *kansei* engineering. Concretely, a seven-axis path diagram given by the modified food *kansei* model might be applied to structural equation modeling to clarify the interaction between the routes of perception and cognition in the model. Although Toyoda *et al.* (2004) investigated paired comparison analysis in a framework of structural equation modeling, the study lacked a model showing the causal relationships between factors influencing pleasantness. The modified food *kansei* model proposed in this study would therefore further improve previous investigations.

Data related to the route of cognition in the food *kansei* model often corresponds to the qualitative data collected through questionnaire surveys during the development of real products. These data might be quantified by applying correspondence analysis to create *kansei* variables as indicators that clarify the interactions between the routes of perception and cognition in the modified model.

Conclusions

1. The selection tests for in-house expert sensory assessors revealed that their taste sensitivity had not significantly changed over the last three decades.
2. In-house expert sensory assessors were found to effective-

ly explore quality characteristics that influence individual preference because they expressed the quality characteristics of the products more clearly than consumer panels while having the same preference as consumers.

3. Several factors influencing the results of sensory evaluation were identified: type of food products, frequency of eating, cooking experience, and market share.
4. From the viewpoint of commercial product development, applying correspondence analysis to the results of a questionnaire survey was found to enable simple, rapid and cost-effective investigation of the differences and similarities in personal attributes between in-house expert sensory assessors and consumer panelists.
5. The modified food *kansei* model proposed in this study was found to more effectively integrate the differences in personal attributes between in-house expert sensory assessors and consumer panelists than the conventional food *kansei* model.
6. A seven-axis path diagram given by the modified food *kansei* model might be applied to structural equation modeling in order to clarify the interaction between the routes of perception and cognition in the model.

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