Understanding the sensory characteristics and drivers of liking for gochujang (Korean fermented chili pepper paste)

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Abstract The present study investigated the sensory characteristics of 31 types of gochujang, a Korean fermented chili paste, produced in various regions of Korea. Generic descriptive analysis was conducted to analyze the sensory properties of the samples. Among these, four samples were selected for consumer taste test based on their distinct sensory profiles. The drivers of liking for gochujang were identified when the samples were applied to four different food systems. Consumers (age range: 20's–60's) rated the acceptance of the samples. ANOVA and multivariate analyses were conducted on the data. The types of carbohydrate sources or usage of additional seasoning showed stronger influence on the sensory characteristics of gochujang than the production location. Samples with strong fermented soy and fish sauce characteristics were fairly unacceptable to the consumers. The positive drivers of gochujang were appropriate levels of spiciness and sweet odors/flavors, whereas the negative drivers were off-note and fermentation-related flavors.

Keyword: gochujang, descriptive analysis, consumer acceptance test, central location test, home use test

Introduction

Gochujang, a Korean traditional seasoning and condiment, is a fermented red pepper paste made by fermenting a mixture of red chili pepper powder, a carbohydrate source such as glutinous rice, meju powder (fermented soybean), salt, and sometimes koji, depending on the fermentation method (1). The main flavor characteristics of gochujang comprise saltiness, hot and spiciness, sweetness, sourness, umami taste, and distinctive fermented flavors. The fermentation process of glutinous rice and soybean in gochujang produces hydrolysates and metabolites such as organic acids, nucleic acids, and alcohols, which contribute to the rich aromas and flavors of gochujang (2,3).

Because the production of gochujang involves a series of complicated processes, the ingredient source, formulation, fermentation method, length, and condition can all affect the sensory quality of gochujang (4). Owing to the versatile characteristics of gochujang, studies have been conducted in the area of the health functionality (5–9), physicochemical changes (9–10), and quality analysis of gochujang produced by different processing methods. In addition, some studies have investigated the consumer acceptability of newly developed gochujang products (11–13).

In the past, gochujang was primarily produced by traditional methods at home. However, as the society became more

industrialized, the production of gochujang, along with other Korean traditional fermented foods, began to occur on a massive scale in the food industry (4,14). The industrialized production of gochujang has led to quality-controlled products with the trade-off of lesser variation in the flavor characteristics of gochujang compared to homemade gochujang products. It has been reported that 90% of gochujang products available in the market are produced by the top 10 gochujang producers in Korea. Among these companies, two national companies take up approximately 80% of the market. Thus, the majority of consumers who purchase gochujang from the market are exposed to a very limited number of gochujang products.

A significant number of small to mid-sized gochujang producers produce gochujang nationwide, although their market share is low. Analyzing and organizing the sensory characteristics of gochujang products produced by various manufacturers into a sensory database for gochujang can be a valuable approach to conserve the various possible flavor characteristics that can be generated from gochujang products. This database can be utilized as a reliable reference for developing and constructing diverse gochujang products for present and future purposes.

Understanding the factors that positively or negatively influence the liking for a food product of interest is one of the key components that lead to the development of a successful product. Food acceptance is often heavily influenced by the sensory perception of

food because acceptance is considered as an output of brain processing based on the sensory property input from food consumption (15–17). Sensory “quality” and “intensity” perception partly affect the acceptance of food but, in many cases, the subject’s taste and flavor sensitivities are reported to be weak predictors of food liking (18). For example, age is a critical factor that frequently has an effect on the liking of food (19–23). The divergence of food acceptance between different generations is not only due to sensitivity changes from aging but also due to external factors such as flavor familiarity, social interaction, food culture, personal attitudes, and preferences (24–26). The discrepancy in the liking scores for food among young adults (age range: 20’s–30’s) vs. older adults (age range: 40–60’s) whose sensitivities are similar show that external factors become more significant. In the case of gochujang, consumers of different generations are likely to be exposed to different types of gochujang because the gochujang industry has gone through a dramatic change in the last half century.

In the present study, the sensory characteristics of gochujang products produced by mid-sized producers in Korea were analyzed. Then, the sensory drivers of liking for gochujang in different age groups were investigated when it was applied to various types of food systems.

Material and Methods

Descriptive analysis

Subject: Panelists who were experienced in cooking and using gochujang in a variety of dishes were recruited. The panelists were then screened for their sensitivity to the five basic tastants (sweet, salty, umami, sour, and bitterness) and accuracy in evaluating the intensity orders of these basic tastants as well as hot and spicy flavor. Finally, 10 panelists (females, aged 38–58 years) were selected for training and main evaluation of gochujang descriptive analysis.

Sample: Gochujang samples comprised 29 products from local producers who mainly distribute their products locally or nationally via online means and 2 national brand products with the highest market share in Korea. Nearly 100 products were initially screened when selecting the gochujang samples from local producers. The criteria for selecting the gochujang samples for the main investigation were as follows. 1. Gochujang made with specialty ingredients such as mushrooms and deodeok were excluded; 2. The location of the producers was considered an important factor and an attempt was made to include gochujang produced in most of the provinces in Korea to investigate the effect of production location on the sensory characteristics of gochujang. The final sample list (Table 1) of gochujang samples included six products from *Gyeonggi-do*, three from *Kangwon-do*, five from *Chungcheong-do*, three from *Gyeong-sangbuk-do*, six from *Gyeongsangnam-do*, two from *Jeollabuk-do*, four from *Jeollanam-do*, and two from national brands with the highest market share in Korea.

Sample preparation and presentation: Immediately after purchasing, all gochujang products were portioned into 100 g samples, which was the amount required for a single sensory evaluation session, placed in sterilized containers, and stored in a refrigerator (GC-114HCMP, LG Co. Ltd., Chang-won, Korea) at 4°C to prevent contamination and moisture loss during the experiment. For sample preparation, all samples were taken from the refrigerator and kept at room temperature (20–22°C) 1 h prior to performing the experiment. The samples were separately prepared for the appearance and odor/flavor/texture evaluations. Five grams of each sample was measured, placed in disposable containers (diameter: 7 cm, height: 4 cm, Samboopack Corp., Icheon, Korea) and lidded for appearance evaluation. Concerning the odor, flavor, and texture evaluation, 0.5 g of the sample was placed on a disposable spoon and three spoons of each gochujang sample were served to the panelists to minimize the variation caused from the amount of sample placed in the mouth because gochujang has a very intense flavor when consumed in the raw state. Panelists were asked to put the entire 0.5 g sample in their mouth for the flavor and texture evaluation of gochujang.

Procedure: A generic descriptive analysis was conducted. The procedure followed the method described by Lee *et al.* (27). The panelists went through a series of training sessions prior to participating in the main descriptive analysis of the gochujang samples. During the training sessions, the panelists developed lexicons for characterizing the sensory properties of the gochujang samples. The descriptors were clearly defined and the standards that represent each descriptor were established. Whenever possible, the intensities of the standards were determined. The descriptors, their definitions, and the corresponding standards for gochujang descriptive analysis are listed in Table 2. The training continued until the panelists showed sufficient levels of performance concerning discriminating ability and repeatability. The panelists were trained for 2 h per session with three sessions per week. A total of 12 training sessions were conducted.

In the main descriptive analysis, the panelists evaluated the sensory characteristics of 31 gochujang samples using the descriptors developed in the training session. The intensities of attributes elicited from each sample were evaluated on a 15-point intensity scale. “0,” “7,” and “14” were anchored as “not detectable,” “moderate,” and “very strong,” respectively. During the sample evaluation, the standards for the corresponding attributes were provided to assist accurate evaluation of the samples.

The main sample evaluation was performed in individual sensory evaluation booths. The testing was conducted for 3 days per week. Each session did not exceed 2 h. All the samples were coded with 3-digit random numbers. The sample serving order was determined using Williams Latin-Square design (28) and the samples were served in a sequential monadic manner. The numbers of samples tested per session were restricted to 10–11 owing to the intense flavor properties of gochujang. Warm water (35±2°C), a spit cup, and unsalted water cracker (Carr’s Original Table Water, CARR’S OF CARLISLE LTD.,

Carlisle, UK) were provided to cleanse the palate between each sample evaluation. As mentioned earlier, the appearance evaluation and odor/flavor/texture evaluation of the samples were conducted separately. The odor, flavor, and texture evaluation was conducted under a red light to free the panelists from appearance bias. The sample evaluation was repeated four times.

Statistical analysis For data analysis, statistical software SPSS statistics 21 (SPSS Inc., Chicago, IL, USA), XLSTAT (Addinsoft, Paris, France), and EXCEL 2013 (Microsoft Corporation, Redmond, WA, USA) were utilized.

Multivariate analysis of variance (MANOVA) using a general linear model was conducted to evaluate the effect of sample, panel, and session (repetition) on the sensory characteristics of gochujang. The general linear model used was attribute=sample+panel+session+sample×panel+sample×session+panel×session. When the sample effect showed statistical significance ($p<0.05$), Duncan's multiple range test was conducted as a post hoc.

In addition, principal component analysis (PCA) was applied to the mean intensity value of the 31 gochujang samples to visually summarize the data structure. The attributes that showed sample effects were included in the PCA. In the PCA, the 31 samples were categorized and labeled based on the production location, carbohydrate source for gochujang, and additional flavorings added to the gochujang samples.

Consumer acceptance test

Subjects: Consumers varying in age from 20's to 60's were recruited to evaluate the acceptance of gochujang samples applied to various food systems. The subjects who liked hot and spicy food and enjoyed foods flavored with gochujang were recruited online and via flyers. The subjects were divided into a younger group (age range: 20's–30's) and an older group (age range: 40's–60's). Out of the 282 subjects who were recruited, 280 subjects completed the experiments. The subjects evaluated gochujang samples applied to two types of food systems. One group of subjects evaluated gochujang samples in the form of a raw dipping sauce and spicy braised rice cake. The other group of subjects evaluated gochujang samples in the form of a spicy meat sauce for rice and gochujang stew. For the evaluation, the order of the food system was counterbalanced within the group. The number of subjects that completed the evaluation of each food system is as follows: 136 for the raw dipping sauce system (younger group=78, older group=58), 136 for the spicy braised rice cake system (younger group=78, older group=58), 146 for the spicy meat sauce for rice system (younger group=77, older group=69), and 144 for the gochujang stew system (younger group=77, older group=67).

Sample: Based on the results from descriptive analysis, samples to be further investigated in the consumer acceptance test were selected by agglomerative hierarchical clustering. Three main cluster groups were generated as a result. The first cluster comprised samples dominantly characterized by sweetness and used wheat as

Table 1. The sample code and information of 31 gochujang samples used for descriptive analysis

Sample code	Provinces	Carbohydrate source	Usage of additional seasoning
CC_GB1_No	Chungcheong-do	Grain of barley	
CC_GR1_No		Glutinous rice	
CC_GR2_No		Glutinous rice	
CC_R1_No		Rice	
CC_R2_No		Rice	
GG_GR1_No	Gyeonggi-do	Glutinous rice	
GG_GW1_Yes		Whole wheat	O
GG_GW2_Yes		Whole wheat	O
GG_W1_Yes		Wheat	O
GG_W2_Yes		Wheat	O
GG_W3_Yes		Wheat	O
JN_GR1_No	Jeollabuk-do	Glutinous rice	
JN_GW1_No		Whole wheat	
JS_GR1_No	Jeollanam-do	Glutinous rice	
JS_GR2_No		Glutinous rice	
JS_GR3_No		Glutinous rice	
JS_W1_No		Wheat	
GN_GW1_Yes	Gyeongsangbuk-do	Whole wheat	O
GN_GW2_Yes		Whole wheat	O
GN_W1_Yes		Wheat	O
GS_GR1_Yes	Gyeongsangnam-do	Glutinous rice	O
GS_GR2_No		Glutinous rice	
GS_GW1_Yes		Whole wheat	O
GS_GW2_No		Whole wheat	
GS_R1_No		Rice	
GS_W1_Yes		Wheat	O
KW_GR1_No	Kangwon-do	Glutinous rice	
KW_GW1_Yes		Whole wheat	O
KW_GW2_Yes		Whole wheat	O
MJ_R1_No	National brand	Rice	
MJ_R2_No		Rice	

the carbohydrate source, and JN_GW1_No sample was selected as a product of interest. In the second cluster, samples produced from various carbohydrate sources as well as major brand products were included. MJ_R2_No sample, which shows the highest market share in Korea, was selected. Gochujang samples made from glutinous rice and exhibiting strong fermented flavor were dominant in the third cluster. Two samples, CC_GR1_No sample (no usage of additional seasoning) and GS_GR1_Yes sample (usage of additional seasoning), were selected for further investigation. The samples in clusters 1 and 2 were characterized as sweet and umami, whereas the samples in cluster 3 elicited distinctive fermented flavor. Two samples from cluster 3 were selected to counterbalance the number of samples eliciting sweet/umami vs. fermented flavor.

Sample preparation and presentation: Gochujang samples were applied to different food systems in which they are typically consumed or utilized. In previous consumer studies of gochujang

Table 2. Sensory attributes, definitions, reference materials, and reference intensities used for the descriptive attributes of 31 gochujang samples

Modalities	Attributes	Definitions	Reference materials	Reference intensities	F-value ¹⁾	P-value
Appearance	Gloss	Degree of gloss on gochujang	-		16.326	0.000
	Brightness	Brightness of color on gochujang	-		23.408	0.000
	Thickness	Degree of thickness on gochujang	-		30.098	0.000
Odor	Freshly cut grass	Odor associated with green chili	Green chili (Emart Co. Ltd., Seoul, Korea)	7	3.687	0.000
	Hot and spicy	Odor associated with cheongyang chili	Cheongyang chili (Emart Co. Ltd.)	8	1.601	0.022
	Soy sauce	Odor associated with joseon soy sauce	Soy sauce 50 mL:Water 150 mL (Soy sauce F3, Sempio Co. Ltd., Seoul, Korea)	8	1.336	0.107
	Meju	Odor associated with meju powder	Meju powder (Ham-yang agricultural cooperative federation, Seoul, Korea)	7	5.215	0.000
	Grain syrup	Odor associated with grain syrup	Grain syrup (Ottogi Co. Ltd., Anyang, Korea)	6	3.113	0.000
	Refined rice wine	Odor associated with refined rice wine	Rice wine 50 mL:Water 150 mL (Lottecilsing Co. Ltd., Seoul, Korea)	9	1.958	0.002
	Fish sauce	Odor associated with fermented fish sauce	fermented fish sauce 50 mL:Water 150 mL (CJ CheilJedang Co. Ltd., Seoul, Korea)	9	1.059	0.381
	Plum liquid	Odor associated with plum liquid	Plum liquid 50 mL:Water 150 mL (Ham-yang agricultural cooperative federation)	7	1.000	0.467
	Flour	Odor associated with flour	Flour 100 g:Water 200 mL (CJ CheilJedang Co. Ltd., Seoul, Korea)	7	2.115	0.000
	Barely malt	Odor associated with barely malt	Barely malt 75 g:Water 425 mL (Tureban Co. Ltd., Goyang, Korea)	8	0.452	0.995
	Rotten	Odor associated with butyric acid solution	Butyric acid solution 0.03%	8	4.815	0.000
Taste/flavor	Sweet taste	Sucrose solution is typical	Sucrose solution 3%	4	6.018	0.000
	Salty taste	Salt solution is typical	Salt solution 0.7%	7	4.291	0.000
	Sour taste	Lactic acid solution is typical	Lactic acid solution 0.15%	4	3.094	0.000
	Bitter taste	Caffeine solution is typical	Caffeine solution 0.03%	3	2.716	0.000
	MSG taste	MSG solution is typical	MSG solution 0.3%	7	2.016	0.001
	Red pepper powder	Flavor associated with red pepper powder	Red pepper powder (MyeongAmsanchae, agricultural association corporation, Jecheon, Korea)	10	4.218	0.000
	Hot and spicy	Flavor associated with cheongyang chili	Cheongyang chili (Emart Co. Ltd.)	13	3.302	0.000
	Soy sauce	Flavor associated with soy sauce	Soy sauce 50 mL:Water 150 mL (Sempio Co. Ltd.)	8	1.414	0.069
	Meju	Flavor associated with meju powder	Meju powder (Ham-yang agricultural cooperative federation)	6	4.511	0.000
	Grain syrup	Flavor associated with grain syrup	Grain syrup (Ottogi Co. Ltd.)	7	4.548	0.000
	Fish sauce	Flavor associated with fermented fish sauce	fermented fish sauce 50 mL:Water 150 mL (CJ CheilJedang Co. Ltd.)	9	0.964	0.522
	Garlic	Flavor associated with garlic	Garlic flavor (CJ CheilJedang Co. Ltd.)	11	1.973	0.001
	Plum liquid	Flavor associated with plum liquid	Plum liquid 50 mL:Water 150 mL (Ham-yang agricultural cooperative federation)	6	1.661	0.014
	Flour	Flavor associated with flour	Flour 100 g:Water 200 mL (CJ CheilJedang Co. Ltd.)	7	4.413	0.000
	Barely malt	Flavor associated with barely malt	Sikhye (Paldo Co. Ltd., Seoul, Korea)	6	0.627	0.943
	Off flavor	Flavor associated with off flavor	-	-	4.008	0.000
Texture	Astringency	Complex mouth feel associated with dryness, roughness, and lingering residuals after swallowing in mouth	Flour (CJ CheilJedang Co. Ltd.)	6	5.513	0.000
	Viscosity	Degree of thickness of the fluid	-		1.129	0.289
	Burning	Chemical burning sensation upon exposure	-		7.478	0.000
	Sandy texture	Degree of sandy texture on gochujang	-		11.435	0.000

¹⁾F- and p-values indicate the significance of sample effects present for each attribute

products, the samples were generally served with carrier foods: salad dressing applied to lettuce, spicy sauce for stir-fried rice, sauce for barbecued chicken, and sauce for fried chicken (12,13). A similar approach was adopted in the present study. In the present consumer taste test, four food systems were chosen to evaluate the acceptance levels of the gochujang samples since different cooking styles may complement different flavor characteristics of gochujang. The four food systems were raw dipping sauce (no usage of additional seasoning or cooking required), traditional spicy meat sauce for rice (yak gochujang, similar to sautéing or stir-frying methods), spicy braised rice cake (tteokbokki), and gochujang stew (gochujang-jjige) systems.

The samples were tested differently in different age groups because different age groups in Korea are exposed to gochujang in different ways. That is, the younger generations (age range: 20's–30's) rarely cook and mostly taste gochujang when it is added to a cooked dish, whereas the older generations (age range: 40's and above) are often actively involved in cooking and use gochujang as an ingredient to create their own cooked dish (29,30). For the subjects in younger age group, a central location test (CLT) was conducted. All the gochujang samples were prepared as cooked dishes and the subjects evaluated the acceptance of each cooked dish sample. The subjects in the older age group evaluated the gochujang samples in the form of a home use test (HUT) method. Gochujang and fresh ingredients were given to the subjects. The subjects were asked to cook two types of dishes using the given ingredients and evaluate each sample after cooking and tasting. The recipe for each food system was identical between CLT and HUT; however, for CLT, cooked samples were served for evaluation, whereas for HUT, the subjects had to cook for themselves and evaluated the cooked samples. The recipes for each food system are given below.

Raw dipping sauce: Raw gochujang was provided with cucumber sticks. The subjects received 3–4 sticks of cucumbers and 10 g of each gochujang sample.

Traditional spicy meat sauce for rice: To make a single batch of sauce, 500 g ground beef was marinated with seasonings (soy sauce: 25 g, sugar: 15 g, rice wine: 15 g, chopped garlic: 10 g, sesame oil: 5 g, and black pepper: 1 g) for 10 min. The marinated ground beef was cooked in a frying pan for 10 min. Next, 660 g of water and 660 g of the gochujang sample were added and the mixture was cooked for another 40 min. The subjects were instructed to freely add the meat sauce to the rice and mix, taste, and evaluate the sample.

Spicy braised rice cake system: To make a single batch of sauce, 600 g of rice cake was hydrated in 600 g of warm water for 10 min and drained. Gochujang sauce (mixture of gochujang: 220 g, minced garlic: 5 g, oligosaccharide syrup: 70 g, and canola oil: 5 g) and rice cake were added to 800 g of boiling water and boiled for 10 min. The heat was reduced and the rice cake was braised for another 10 min with constant stirring.

Gochujang stew: First, 2 L of water was boiled at high heat. 150 g gochujang, 7 g minced garlic, and 200 g potatoes were added to the

boiling water and boiled for another 10 min. Next, 200 g zucchini pumpkin, 100 g onion, and 50 g green onion were added to the stew and boiled for another 5 min.

Taste test procedure: All samples were coded with 3-digit random numbers. The sample serving order was determined by a factorial design. The palate cleansing method was identical to the one described in the descriptive analysis procedure. It took approximately 5–7 min to evaluate a sample and the subjects were asked to take a 3–5 min break between each sample evaluation.

Each sample was evaluated on overall liking, appearance liking, odor liking, texture liking, flavor familiarity, and willingness to try the sample again with 9-point hedonic/categorical scales. The reasons for liking or disliking each sample were evaluated by a check-all-that-apply method (CATA). The subjects chose the reasons for (dis)liking from a list of sensory attributes (appearance, odor, taste/flavor, and texture) and emotional attributes.

Statistical analysis MANOVA using a general liner model was conducted separately on different age groups to understand the effects of the gochujang sample and food system on the ratings for overall liking, appearance liking, odor liking, texture liking, flavor familiarity, and willingness to try the sample again. The general linear model used was $\text{attribute} = \text{sample} + \text{system} + \text{sample} \times \text{system} + \text{subjects}$. Duncan's multiple range test was conducted as a post hoc when samples showed statistically significant effects ($p < 0.05$).

For CATA data, attributes selected by less than 20% of the subjects were removed prior to further analysis. Frequency analysis and Fisher's exact test in Cochran's Q test were performed to analyze the effect of each sample on the selection of CATA attributes. Chi-square test was applied to the CATA data to analyze the effect of age group on the CATA term usage.

Multiple factor analysis (MFA) was conducted with the descriptive analysis results and the consumer acceptance ratings of four gochujang samples to understand the sensory characteristics that drove the liking and disliking of gochujang samples in the consumer taste test. All statistical analyses were performed using IBM SPSS statistics 21 (SPSS Inc.), XLSTAT (Addinsoft), and EXCEL 2013 (Microsoft Corporation).

Results and Discussion

Descriptive analysis

Sensory characteristics of gochujang samples: PCA was plotted using the attributes that showed significant sample effects (27 out of 35 attributes) to visually summarize the correlations between the samples and the attributes (Fig. 1). The PCA results showed that 56.53% of the total variance was explained by PC 1 (40.03%) and PC 2 (16.50%).

In PC 1, fermentation-related attributes such as meju odor/flavor and fish sauce odor/flavor, flour odor/flavor, freshly cut grass odor,

Fig. 1. Principal component analysis (PCA) map of the significant sensory characteristics (A) and corresponding 31 gochujang samples (B)

¹⁾The detailed information of sample code and attributes is shown in Table 1 and 2, respectively.

²⁾27 attributes that showed significant sample effect were included in the PCA analysis and shown in Fig. 1A.

³⁾Attribute O refers to odor and attribute F refers to flavor.

hot and spicy odor, soy sauce odor, refined rice wine odor, rotten odor, and off flavor/odor were positively loaded. In addition, salty taste, sour taste, and bitter taste were positively loaded. Most of the samples showing high loadings in PC 1 were *Chungcheong-do*, *Jeollanam-do* and *Jeollabuk-do* samples made from glutinous rice with no usage of additional seasonings. In contrast, MSG taste (umami taste), sweet taste, and sweet related flavors such as plum liquid odor/flavor, barely malt odor/flavor, grain syrup odor/flavor were strongly loaded in negative PC 1. National brand product samples MJ_R1_No and MJ_R2_No and samples produced from *Gyeonggi-do*, *Gyeongsangnam-do* and *Gyeongsangbuk-do*, which used wheat as the carbohydrate source and included additional seasoning, were characterized with the attributes in negative PC 1.

Hot and spicy-related attributes, burning, hot and spicy flavor, and overall taste intensity were major attributes defining the positive PC 2, whereas texture-related attributes, thickness, viscosity, and sandy texture defined the negative PC 2. CC_R1_No and CC_GB1_No samples showed relatively strong correlation with positive PC 2, while GS_GR2_No, GS_GW2_No, GS_W1_Yes, and JS_W1_No samples were positioned in the negative PC 2. Other samples showed relatively low correlations with positive or negative PC 2.

In general, the carbohydrate source was one of the most influential factors affecting the sensory characteristics of gochujang. Gochujang samples that used wheat as the carbohydrate source elicited relatively stronger umami taste, sweet taste, and grain syrup odor/flavor, whereas samples made with glutinous rice were characterized by distinctive hot and spicy flavor, fish sauce odor/flavor, and meju odor/flavor. It has been reported that wheat protein and starch can

effectively produce hydrolysates such as glutamate and glucose, which are responsible for the umami and sweet taste, respectively, more than glutinous rice in gochujang. In the gochujang-making process, the saccharified rice syrup is added after gochujang has been saccharified with malted barley powder. This is partly responsible for the sweetness of gochujang (1,14), as confirmed by the results of the present study. Although the data is not shown, the free sugar level was twice as high in wheat-based gochujang samples (261.29 mg/g) than glutinous-rice-based samples (137.43 mg/g) when physico-chemical analysis was conducted on the samples.

One of the interesting findings is that the production proportions of wheat-based gochujang vs. glutinous-rice-based gochujang were different for different provinces. *Gyeonggi-do*, *Gyeongsangnam-do* and *Gyeongsangbuk-do* tend to produce a larger number of wheat-based gochujang but glutinous gochujang was dominant in other provinces. A similar observation was reported by Shin (2). Most provinces showed similar usage patterns for the carbohydrate source applied to gochujang but *Chungcheong-do* tends to use non-waxy rice, whereas *Gyeonggi-do* uses wheat at a higher frequency compared to other provinces. Based on these results, a database listing the sensory information for gochujang that can be utilized as a reliable reference for developing and constructing diverse gochujang products for present and future purposes were created.

Consumer acceptance test

Consumer acceptance rating for four types of gochujang: For each age group, effects of gochujang sample, applied food system on the acceptance, and perception ratings were analyzed separately. As

Fig. 2. Mean overall liking ratings of four gochujang samples applied to different systems among different age groups

¹⁾The detailed information of sample code is shown in Table 1.

²⁾T indicates standard errors of overall liking scores.

³⁾Same alphabets within the same food system and age group indicates that the overall likings do not differ between the samples.

mentioned earlier, different tasting conditions were provided to the two age groups to account for the different involvement in cooking and eating styles in the two groups. Thus, the effect of age was not included in the GLM model since the tasting condition was a confounding factor in comparing the age effect on the liking of gochujang samples. Sample, system, and sample $\times$ system interaction showed significant effects ($p < 0.05$) on the overall liking rating for both age groups. The mean acceptance and perception ratings of the four gochujang samples in different food systems and age groups are shown in Fig. 2.

The MJ_R2_No sample showed the highest acceptance in the raw dipping sauce (6.50), spicy meat sauce for rice (6.36), and spicy braised rice cake (6.44) systems among the younger age group. In the older group, preference for gochujang sample changed depending on the food systems. The JN_GW1_No sample was liked the most overall in the raw dipping sauce (6.26) system, whereas the MJ_R2_No sample (6.14) was liked significantly more than the JN_GW1_No sample (5.58) in the spicy meat sauce for rice system. For the spicy braised rice cake system, the MJ_R2_No sample (5.84) was rated significantly higher than the other samples in overall liking. Overall, the older group preferred both the MJ_R2_No sample and the JN_GW1_No sample over the other two samples in all the food systems. The liking patterns for gochujang stew samples were similar to other food systems in both the younger and older age groups. For the younger group, the JN_GW1_No sample was rated the highest in overall liking (5.73), appearance liking (5.83), odor liking (5.94), texture liking (5.87), experienced degree (5.69), and try again (5.55). In the older group, JN_GW1_No was rated the highest in overall liking (5.25), texture liking (5.54), experienced degree (5.27), and try again (5.21).

In both age groups, the CC_GR1_No and GS_GR1_Yes samples were less preferred compared to the MJ_R2_No or JN_GW1_No sample regardless of the food system to which gochujang was applied. The younger group rated CC_GR1_No and GS_GR1_Yes samples similarly in overall liking when the samples were applied to the raw dipping sauce (4.53 and 4.04, respectively), spicy meat sauce for rice (4.53 and 4.30, respectively), and spicy braised rice cake system (3.87 and 3.81, respectively). In general, younger subjects tended to like the GS_GR1_Yes sample the least, whereas the older subjects tended to like the CC_GR1_No sample the least. In the gochujang stew system, the GS_GR1_Yes sample (younger age group: 3.88, older age group: 4.09) was least liked in all age groups. Combining the results from the descriptive analysis and consumer taste test, these observations indicate that consumers, in general, appreciate sweet, umami tasting gochujang more than unsweetened, fermented gochujang products. It also implies that the consumers are now more used to the gochujang products from national brands regardless of age groups. Similar observations were reported for doenjang (Korean fermented soybean) soup among a young consumer group by Chung and Chung (31). Young consumers preferred modernized doenjang or Japanese-type miso with low fermented flavor and high sweetness intensity over doenjang produced by traditional methods, which is characterized as being salty and high in fermented flavor. Overall, consumers preferred strong sweetness eliciting gochujang when gochujang was tasted as a dipping sauce or in stew, whereas the MJ_R2_No sample (national brand) was preferred when the gochujang was employed for sauteing or braising.

Sensory drivers of liking of gochujang

Reasons for liking and disliking of four types of gochujang: The

Table 3. Percentage (%) of (dis)liking terms of raw dipping sauce system

(dis)liking term ¹⁾		Young group				Older group			
		CC_GR1_No	GS_GR1_Yes	JN_GW1_No	MJ_R2_No	CC_GR1_No	GS_GR1_Yes	JN_GW1_No	MJ_R2_No
Like	Appearance	10.3 ³⁾	26.9	41.0	46.2	12.1	46.6	22.4	32.8
	Like taste* ²⁾	14.1	7.7	38.5	39.7	1.7	8.6	22.4	12.1
	Spiciness	19.2	17.9	55.1	67.9	29.3	10.3	43.1	55.2
	Saltiness	10.3	10.3	23.1	17.9	17.2	17.2	25.9	22.4
	Sweetness*	3.8	10.3	26.9	19.2	12.1	24.1	29.3	46.6
	Umami taste	11.5	6.4	19.2	16.7	10.3	10.3	27.6	6.9
	Meaty flavor	11.5	10.3	1.3	6.4	8.6	10.3	8.6	3.4
	Ripe flavor	16.7	10.3	1.3	10.3	12.1	10.3	12.1	6.9
	Smell/odor*	16.7	7.7	20.5	16.7	1.7	1.7	15.5	12.1
	Rich flavor	21.8	5.1	3.8	10.3	8.6	5.2	8.6	5.2
	Go well with cucumber	16.7	19.2	35.9	46.2	24.1	13.8	43.1	32.8
	Like for no particular reason	3.8	1.3	11.5	11.5	0.0	1.7	10.3	15.5
	Mouth-watering*	9.0	2.6	19.2	29.5	0.0	5.2	10.3	10.3
	Familiar	17.9	16.7	38.5	34.6	10.3	13.8	39.7	34.5
	Satisfying	6.4	6.4	20.5	17.9	5.2	5.2	19.0	20.7
	Easy to eat*	12.8	14.1	33.3	21.8	20.7	27.6	50.0	25.9
	Attractive*	10.3	0.0	20.5	23.1	3.4	3.4	13.8	6.9
	Stimulating	9.0	0.0	10.3	11.5	10.3	1.7	5.2	8.6
	Feel better	3.8	0.0	9.0	5.1	1.7	1.7	5.2	0.0
	Addictive	9.0	1.3	9.0	16.7	5.2	3.4	10.3	15.5
	Ethnic	20.5	10.3	5.1	7.7	12.1	6.9	10.3	6.9
	Want to eat more	3.8	2.6	15.4	11.5	1.7	1.7	5.2	8.6
	None of the above	23.1	26.9	1.3	1.3	27.6	17.2	1.7	5.2
Dis-like	Appearance*	32.1	20.5	11.5	3.8	15.5	1.7	8.6	0.0
	Dislike taste	23.1	15.4	2.6	1.3	22.4	19.0	0.0	3.4
	Too spicy	7.7	1.3	15.4	15.4	6.9	1.7	15.5	17.2
	Not spicy enough	16.7	23.1	10.3	1.3	8.6	22.4	6.9	6.9
	Too salty	32.1	2.6	20.5	15.4	44.8	5.2	13.8	20.7
	Too sweet*	1.3	14.1	6.4	6.4	3.4	17.2	19.0	12.1
	Not sweet enough	12.8	5.1	0.0	7.7	6.9	6.9	0.0	0.0
	Sourness	15.4	2.6	1.3	2.6	12.1	0.0	3.4	0.0
	MSG flavor*	6.4	0.0	14.1	7.7	13.8	13.8	10.3	17.2
	Musty flavor*	12.8	19.2	5.1	1.3	22.4	43.1	3.4	8.6
	Too ripe flavor	11.5	14.1	0.0	1.3	6.9	3.4	1.7	1.7
	Smell/odor	17.9	25.6	1.3	6.4	10.3	17.2	3.4	3.4
	Too rich flavor	11.5	7.7	2.6	0.0	6.9	10.3	3.4	1.7
	Unbalanced flavor	10.3	17.9	7.7	2.6	15.5	22.4	5.2	8.6
	Strange odor/flavor	17.9	28.2	3.8	0.0	17.2	25.9	1.7	6.9
	Residual*	19.2	9.0	9.0	14.1	29.3	31.0	13.8	8.6
	Too monotonous	1.3	17.9	5.1	9.0	3.4	8.6	12.1	22.4
	Dislike for no particular reason	9.0	10.3	1.3	1.3	12.1	6.9	0.0	1.7
	Disgusting	3.8	11.5	0.0	0.0	5.2	5.2	0.0	1.7
	New*	16.7	19.2	7.7	2.6	25.9	20.7	17.2	20.7
	Nauseating	7.7	11.5	1.3	0.0	6.9	6.9	0.0	0.0
	Feel worse	9.0	12.8	1.3	0.0	5.2	6.9	0.0	3.4
	Unique	7.7	3.8	0.0	1.3	3.4	5.2	1.7	1.7
	Like spoilt food	2.6	11.5	0.0	0.0	1.7	6.9	0.0	0.0
	Too stimulating	14.1	6.4	10.3	15.4	22.4	1.7	8.6	10.3
	Too much	11.5	9.0	2.6	5.1	20.7	6.9	5.2	8.6
	Lack distinct character*	7.7	10.3	11.5	14.1	12.1	20.7	22.4	24.1
	Do not know what flavor it is	10.3	29.5	6.4	2.6	10.3	20.7	3.4	6.9
	Do not want to eat again	16.7	26.9	5.1	0.0	19.0	20.7	3.4	3.4
	None of the above	6.4	5.1	26.9	24.4	3.4	5.2	17.2	13.8

¹⁾Descriptive terms selected by more than 20% of the subjects are listed.²⁾Significant age effect using Cochran's Q test.³⁾Bold entries denote the presence of significant product effect ($p < 0.05$) on the checked frequency of each CATA attribute.

Fig. 3. Multiple factor analysis map of sensory characteristics and consumer acceptance rating (A) of four types of gochujang (B)

¹⁾The detailed information of sample code is shown in Table 1.

²⁾Attribute O refers to odor and attribute F refers to flavor.

³⁾DA refers to the descriptive analysis data set; O_and Y_refer to older and younger consumer group data sets, respectively.

frequencies of the reasons for liking and disliking CATA for the four samples in the raw dipping food system and the significant differences in attribute selection frequencies are shown in Table 3. Because the CATA results of the four food systems were rather similar, only the results from the raw dipping sauce system are presented. When the number of attributes that showed significance between the samples were analyzed, more attributes showed significance in the younger group (approx. 40 attributes) than in the older group (30 attributes) for most of the food systems. These observations imply that younger consumers were able to discriminate and describe the distinctive reasons for liking or disliking individual samples more than the older group.

The types of terms favorably selected by the subjects differed between the age groups. The younger group tended to select emotional/non-sensory related terms such as mouth-watering and attractive to describe the reasons for liking and too ripe flavor, musty flavor, strange odor/flavor, disgusting, and feels worse to describe the reasons for disliking. The older group preferred sensory terms like too sweet, MSG flavor, residual, and lack of distinct character to elucidate the reasons for disliking the samples.

For the CC_GR1_No sample with a low acceptance level, the younger age group rarely selected any positive terms, whereas terms such as appearance and too salty were selected as reasons for disliking the sample by more than 20% of the subjects regardless of the food system. For the same sample, older age group subjects chose spiciness and easy to eat as the reasons for liking but too salty and too stimulating as the reasons for disliking the sample. Appearance was the reason for liking but not spicy enough, strange odor/flavor,

do not know flavor what it is, and do not want to eat again were the reasons for disliking the GS_GR1_Yes sample among the younger age group. Similar results were observed among the older age group. The JN_GW1_No sample was one of the most preferred samples among the younger group owing to its spiciness, saltiness, sweetness, mild flavor, familiarity, and ease of eating. A negative driver for liking was not identified. The older age group liked the JN_GW1_No sample because of its spiciness, familiarity, and ease of eating but disliked the sample because it lacked distinct character to them. In the case of the MJ_R2_No sample, the drivers of liking were different between different food systems to which the sample was applied. For raw dipping sauce, spicy meat sauce for rice, and spicy braised rice cake systems, appearance, spiciness, mouth-watering, familiar, easy to eat, attractive, and addictive attributes were selected as the reasons for liking the sample. However, in the gochujang stew system, reasons for disliking terms such as appearance, too spicy, non-ripe flavor, too monotonous, and do not know the flavor were selected with high frequency, indicating that the MJ_R2_No sample did not match well when it was applied to the stew system.

Correlating the results of descriptive analysis and consumer taste

test: The visual MFA summaries of correlation between sensory characteristics, acceptance ratings (raw dipping sauce system) for four types of gochujang evaluated separately by older and younger subjects are plotted in Fig. 3. A total of 90% variance was explained by Factor 1 (75.99%) and Factor 2 (14.06%). Most of the liking attributes, regardless of age groups, are loaded on positive factor 1. The JN_GW1_No and MJ_R2_No samples, which both showed high levels of acceptance, were located on the positive factor 1 as well.

These samples were mainly characterized by barley malt odor, plum liquid odor/flower, grain syrup odor, sweet taste, garlic flavor, soy sauce flavor, hot and spicy flavor, and burning. In contrast, the CC_GR1_No and GS_GR1_Yes samples, which received lower acceptance scores in general, showed high positive correlations with the negative direction of factor 1. Negative factor 1 was dominantly defined by attributes such as fish sauce odor/flower, meju odor/flower, rotten odor, soy sauce odor, flour odor/flower, off flavor/odor, freshly cut grass odor, and hot and spicy odor.

Factor 2 (14.06%) was characterized by attributes from descriptive analysis, which showed relatively low correlation with liking attributes. Viscosity, salty taste, and thickness defined the positive axis of Factor 2, whereas gloss, grain syrup flavor, barley malt flavor, MSG taste, plum liquid flavor, and sweet taste defined the negative axis of Factor 2. Descriptive analysis results of the CC_GR1_No and JN_GW1_No samples were loaded strongly on the positive and negative axes of Factor 2, respectively. In summary, most of the samples and liking attribute loadings (Fig. 3B) from consumer taste test data were positioned on Factor 1, whereas descriptive analysis results of CC_GR1_No and JN_GW1_No, which did not strongly affect the liking ratings of the samples but differed in their sensory characteristics, were positioned on Factor 2. That is, viscosity, thickness, and gloss were important factors in characterizing the samples but contributed little in describing the liking of the samples. Little difference was observed in the sample liking patterns between younger and older consumer groups based on the MFA map (Fig. 3A and 3B).

The present study investigated the sensory properties and consumer's drivers of liking of gochujang. The types of carbohydrate source and usage of additional seasoning were the influential factors explaining the sensory characteristics of gochujang more than the production location. In the case of drivers of liking, strong fermented soy and fish sauce characteristics were the negative drivers of liking, whereas appropriate levels of spiciness and sweet-related odors/flavors were the positive drivers. These results were consistent across both age groups.

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