Spicy Taste Rating of *Gochujang* and its Ripple Effects

Seongweon Jeong, Ku Kyung Hyun, and Jongchan Kim

***Abstract*—** In order to introduce spicy taste ratings of *Gochujang* (red chili pepper paste) registered in 2009 according to CODEX international standards, five specimens were selected and the correlation of the sensory taste results and capsaicinoids analyzer results for the five specimens was analyzed. When compared the spicy taste levels(capsaicinoids) of five specimens with their sensory test results, they were found that capsaicinoids content(capsaicin and dihydrocapsaicin) and sensory test results had a high correlation (R^2) at more than 0.9 in both analyzing methods(GC and HPLC). Categorizing the pungency of the *Gochujang* into five levels best reflected the status of *Gochujang* products on the market(mild hot, slight hot, medium hot, very hot, extream hot). Furthermore, the spicy taste levels were more simplified by applying conversion factor(0.769) to enhance consumer awareness and a simple design was developed for indicating the levels easily. As a result, 42.1% of initial consumers easily recognized the spicy taste levels of *Gochujang* in the market, while 85.0% showed positive reactions to the ratings.

***Keywords*—**spicy taste, capsaicinoids, five levels, *Gochujang*(red chili pepper paste)

I. Introduction

GOCHUJANG is a well-known traditional food of Korea characterized by its spicy taste, and sales continuously increase around the world. *Gochujang* registered in 2009 as CODEX international standards[1].

In light of the growing consumption trends, development of products that can harmonize with the food culture of different parts of the world has been in demand. Accordingly, in order to reflect the preference for spicy taste for various nations around the world, research was conducted on the implementing rating for spicy taste.

As a result, it was confirmed that the most feasible method was to rate the spicy taste into five groups(mild hot, slight hot, medium hot, very hot, extreme hot).

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II. Material And Methods

A. Sensory Test

Consumer panel: 120 general consumers made evaluations (9 point category scale) and carried out the analysis of variance and ANOVA tests using SPSS.

Expert Panel: Of the 31 person panel, 25 experts who passed training carried out tests using the ASTM E1871-06 method(15 line scale). The results conducted correlation with results analyzed using SPSS and sensory test results, and the analysis of variance and ANOVA tests were carried out.

B. Awareness Investigation

Valid consumer samples were carried out for 1,000 people and the collected data were statistically processed using SPSS.

C. Gas Chromatography

GC system.—Agilent Technologies (Wilmington, DE) 6890 GC system with flame ionization detector (FID).

GC capillary column. —(5% Phenyl)-methylpolysiloxane column, length 30 m, internal diameter (id) 250 µm, film thickness 0.25 µm (Agilent Technologies, Palo Alto, CA).

GC operating conditions.—Injector temperature 320℃, helium carrier gas 2.0 mL/min, column inlet pressure 18.6 psi, 1 µL injection with split ratio of 50:1, average carrier gas velocity 40 cm/s; GC oven temperature program: initially 220℃ for 1 min, ramp at 5℃/min to 270℃, and hold for 10 min.

D. High Performance Liquid Chromatography

HPLC system.—HPLC apparatus including the following: an eluent reservoir;Model 980 pump (JASCO Co. Ltd, Tokyo, Japan).

HPLC analytical column.—Mightysil RP18GP (particle size 5 µm, 4.6 mm id, length 150 mm; Kanto Chemical Co. Chuoku, Japan).

HPLC detector.—Fluorescence detector, Model FP 920 (JASCO Co. Ltd), excitation wavelength 280 nm, emission wavelength 325 nm.

HPLC mobile phase.—Acetonitrile–1% acetic acid in water (6 + 4, v/v).

E. Reagents and Sample Preparation

Capsaicin(>99%, C18H27NO3, FW 305.42, CAS No.404-86 - 4) stock solution, squalene(CAS No. 111-02-4, Sigma) internal standard solution, hexane, methanol,

methanol– water(80 + 20, v/v), 95% ethanol, DCM, saturated sodium, chloride, and anhydrous sodium sulfate.

GC.—From a thoroughly mixed 10 g portion of *Gochujang*, capsaicin was extracted with 50mLmethanol in a shaker for 2 h and filtered through Whatman No. 2 filter paper into a 250 mL flask. Thirty mL methanol was added to the residue and shaken for 1 h. The extract was then evaporated to 5 mL and dissolved in 20 mL methanol–water (80 + 20, v/v) and 20 mL hexane. Nonpolar components were removed by extracting the methanol layer twice with 20 mL hexane, and the combined hexane layers were counter-extracted with a second addition of methanol solution (20 mL). Twenty mL saturated NaCl and 20mL DCM were added to the pooled methanol layer to remove more polar components, and the capsaicin was extracted 3 times with 20 mL DCM. After dehydration with anhydrous sodium sulfate (Na2SO4), the solvent was removed using a vacuum rotary evaporator, 2 mL internal standard solution was added, and 1.0 µL of the sample solution was injected into the gas chromate- graph for quantitative analysis. For GC analysis using a capillary column, squalene was used as an IS to minimize the injection error possibly caused by the split injection. Calibration graphs for GC were based on peak area and were prepared by injecting 1 µL of the 25, 125, and 250 µg/mL solutions prepared by the dilution of capsaicin stock solution with squalene IS solution.

HPLC.—Weigh approximately 10 g *Gochujang* into a 250 mL boiling flask. Add 100 mL ethanol and several glass beads, and attach the flask to a reflux condenser. Gently reflux the solution for 5 h and allow to cool. Filter 1–4 mL solution through a 0.45µm syringe filter into a small glass vial and use it for HPLC analysis. Calibration graphs for HPLC were based on peak area and were prepared by injecting 20 µL of the 5, 25, 50, and 100 µg/mL solutions prepared by dilution of capsaicin stock solutions with 95% ethanol.

III. Results And Discussion

Based on the most representative *Gochujang* products most widely circulated and distributed in Korea, 5 specimens of manufactured *Gochujang* samples were selected and analyzed their capsaicinoids(capsaicin and dihydrocapsaicin) according to the AOAC method[2-3]. Analysis was conducted separately using GC and HPLC methods(Table Ⅰ)[6-21, 27-29].

When compared the spicy taste levels(capsaicinoids) with their sensory test results[4, 22-25], they were found that capsaicinoids content(capsaicin and dihydrocapsaicin) and sensory test results had a high correlation (R^2) at more than 0.9 in both analyzing methods(GC and HPLC)(Fig. 1).

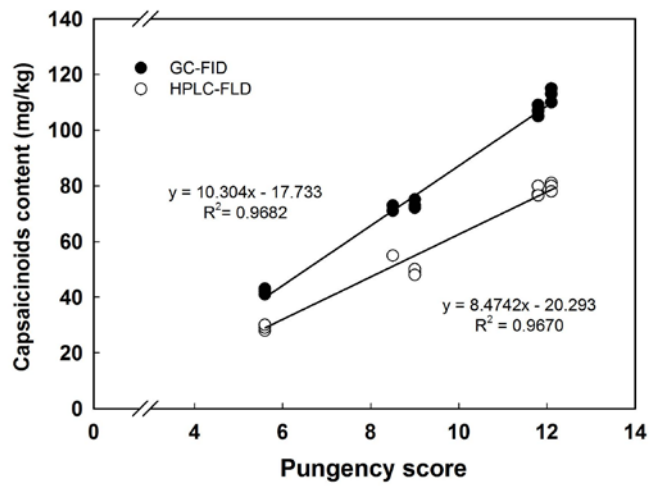

Fig. 1 Capsaic inoids content and sensory test results by GC-FID and HPLC-FLD

TABLE I
SPICY TASTE COMPONENT ANALYSIS OF *GUCHUJANG* BY GC AND HPLC

Product Name	Capsa-icina GC -FID	HPLC -FLD	Dihydro-capsaicina GC-FID	HPLC-FLD	Capsai-cinoidsa GC -FID	HPLC-FLD
H-Spicy	72.30±3.40	51.29 ±0.82	34.60 ±1.15	30.72 ±0.38	106.91 ±4.56	82.01 ±1.20
H-Gold	44.01±3.09	27.91 ±0.52	23.18 ±0.90	20.11 ±0.34	67.18 ±3.28	48.02 ±0.86
S-Chal	43.58±3.49	29.37 ±0.09	26.96 ±1.16	24.19 ±0.13	70.53 ±4.55	53.56 ±0.19
S-Spicy	64.73±1.42	45.79 ±1.12	36.35 ±1.18	32.12 ±0.82	101.08 ±2.32	77.91 ±2.02
S-Mild	26.59 ±0.73	15.36 ±0.21	15.17 ±0.33	13.27 ±0.18	41.76 ±0.67	28.63 ±0.32

[a]units : mg/kg

Therefore, it is judged that spicy taste analysis of *Gochujang* can use both GC and HPLC methods. Also, it was confirmed that the GC/HPLC ratio of the analysis value on the total content of capsaicinoids was between 1.3 and 1.4. Meanwhile, the capsaicin/dihydrocapsaicin ratio of spicy taste analysis results for *Gochujang* products was in the range of 1.62-2.09 for GC and 1.16-1.67 for HPLC(Table Ⅱ).

TABLE II
CAPSAICIN/DIHYDROCAPSAICIN RATIO OF *GOCHUJANG* PRODUCTS CURRENTLY BEING DISTRIBUTED

Product Name	GC-FID Capsaicin/ Dihydrocapsaicin ratio	HPLC-FLD Capsaicin/ Dihydrocapsaicin ratio
H-Spicy	2.09	1.67
H- Gold	1.90	1.39
S-Chal	1.62	1.21
S-Spicy	1.78	1.43
S-Mild	1.75	1.16

In this study, HPLC method was applied to rate the spicy taste level of *Gochujang*. When comparing the *Gochujang* product analysis results and sensory test results according to the HPLC method, it is found that they are separated into three main levels. In other words, the pungency score of the sensory test results can be divided into the 5-6 area, 8-9 area, and 11-12 area(Fig. 2, Fig. 3, Fig. 4) The capsaicinoids contents corresponding to the pungency score areas are 30 mg/kg, 50-60mg/kg and 80mg/kg areas.

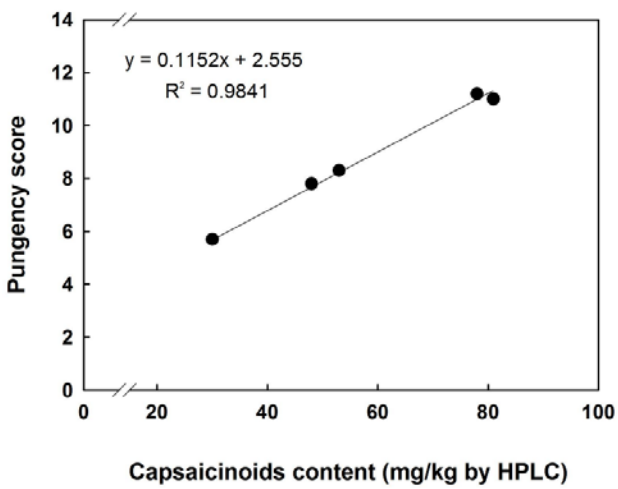

Fig. 2 Capsaicinoids content and sensory test results by HPLC

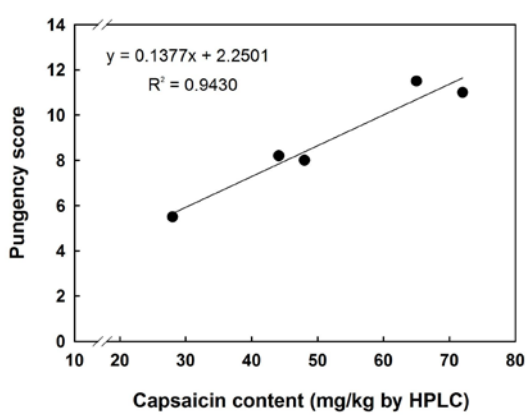

Fig. 3 Capsaicin content and sensory test results by HPLC

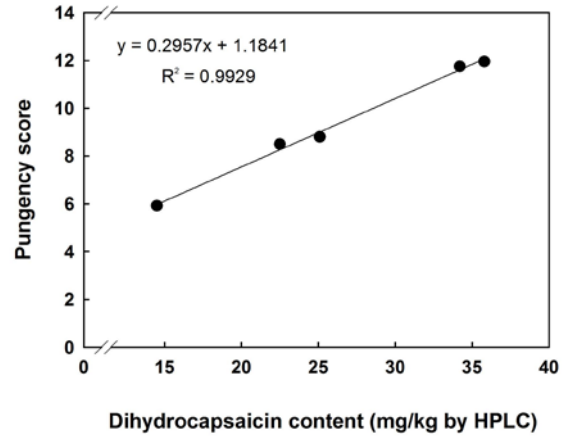

Fig. 4 Dihydrocapsaicinoids content and sensory test results by HPLC

The above results were set as the basic ratings (level 1, level 2, level 3) of *Gochujang* spicy taste. And, various consumer preferences were reflected on the basic ratings by setting additional levels that are spicier than level 3 such as level 4 and level 5.

The results showed that the most widely and commonly consumed range of spicy tastes were set, and through the sensory test, the range was divided into the five fields that the sensory test panel could identify(Table Ⅲ). The result showed that the five fields were categorized as level 1 (10-40mg/kg), level 2 (40-60mg/kg), level 3 (60-100mg/kg), level 4 (100-130mg/kg) and level 5 (130mg/kg or higher). However, depending on the need to enhance consumer awareness (comprehension), a conversion factor (0.769) was applied to introduce the % concept (GHU: *Gochujang* Hot taste Unit) based on 100% for spicy taste levels(Table Ⅲ). The results showed that the five spicy taste fields for *Gochujang* were finally categorized as level 1 (under 30GHU), level 2 (30-45 GHU), level 3 (45-75 GHU), level 4 (75-100 GHU) and level 5 (100 GHU or higher). (Table Ⅲ)[26, 28-29]

TABLE III
COMPARISON BETWEEN SPICY UNITS FOR THE FIVE SPICY LEVELS OF *GOCHUJANG*

Name of Level	Unit		
	ppma (mg/kg)	SHUb	GHUc
Mild Hot (level 1)	Less than 40	Less than 600	Less than 30
Slight Hot (level 2)	40~60	600~900	30~45
Medium Hot (level 3)	60~100	900~1,500	45~75
Very Hot (level 4)	100~130	1,500~2,000	75~100
Extreme Hot (level 5)	More than 130	More than 2,000	More than 100

[a]ppm : mg/kg
[b]SHU : Scoville Heat Unit(ppm x 15)
[c]GHU : Gochujang Heat Unit(ppm x 0.769)

Also, by developing and applying a design that could be easily understood by consumers, the marking illustration as seen in Fig. 5 was confirmed and applied in products[5, 28-29]. The result showed that upon investigating the effects for a total of 1,000 consumers in the initial introduction stage, 42.1% of general consumers easily comprehended the content, while 85.0% showed positive reactions to the markings.

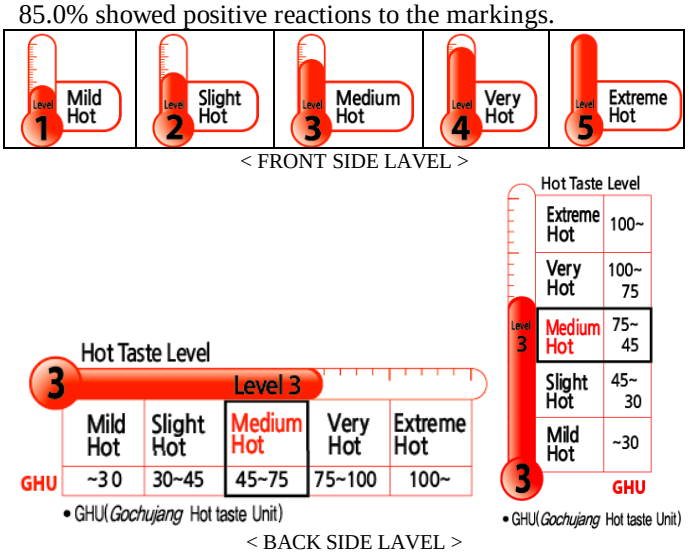

Fig. 5 Various graphic designs for the labelling of *Gochujang*

Currently in Korea, spicy taste levels are applied not only on various *Gochujang* products being distributed in Korea(Table Ⅳ), but also for export products. Furthermore, spicy taste levels are being expanded to other spicy products (*Kimchi*, powdered chili pepper, etc) for the convenience of consumers with different tastes. Korea, which is a country with high consumption of spicy chili peppers, naturally recognizes the importance of attempts to rate the spicy taste levels of food.

TABLE IV
THE PERCENTAGE OF FIVE SPICY LEVELS OF *GOCHUJANG* IN KOREA(2013)

	Level 1	Level 2	Level 3	Level 4	Level 5	Total
Numbers of products	7	23	52	17	19	118
Market share (%)	5.9	19.5	44.1	14.4	16.1	100

REFERENCES

[1] CODEX STAN 294R-2009, REGIONAL STANDARD FOR *GOCHUJANG*

[2] JAEHO HA, KYU-JAI HAN, KI-JIN KIM, and SEONG-WEON JEONG, Gas Chromatographic Analysis of Capsaicin in *Gochujang*, JOURNAL OF AOAC INTERNATIONAL VOL. 91, NO. 2, 2008

[3] AOAC INTERNATIONAL (2005) Official Methods of Analysis, Ch. 43, p.14, AOAC 995.03, 18th Ed., Gaithersburg, MD.

[4] Ku Kyung Hyun' Pungency grade index for quality improvement of *Gochujang*, 2009, 4, Korea Food Research Institute

[5] Heesang Lee, Seongweon Jeong et al., Standards as vehicle for industry development and Innovation: Case study in Korea, Korean Agency for Technology and Standards, ISBN 978-89-458-3794-1, 2011.

[6] Bennett, D.J., & Kirby, G.W. (1968) *J. Chem. Soc. C* **4**,442–446 http://dx.doi.org/10.1039/j39680000442

[7] Todd, P.H., Bensinger, M.G., & Riftu, T. (1977) *J. Food Sci.***42**, 660–665 http://dx.doi.org/10.1111/j.1365-2621.1977.tb12573.x

[8] Reilly, C.A., Crouch, D.J., & Yost, G.S. (2001) *J. ForensicSci*. **46**, 502–509

[9] Altinkurt, T. (1980) *Eczacilik Bull*. **22**, 22–28

[10] Rhyu, H.Y. (1978) *J. Food Sci*. **43**, 1632–1643 http://dx.doi.org/10.1111/j.1365-2621.1978.tb02563.x

[11] Iwai, K., Suzuki, T., & Fujiwake, H. (1979) *J. Chromatogr.***172**, 303–311 http://dx.doi.org/10.1016/S0021-9673(00)90966-X

[12] Chiang, G.H. (1986) *J. Food Sci*. **51**, 499–503 http://dx.doi.org/10.1111/j.1365-2621.1986.tb11165.x

[13] Jung, J., & Kang, S. (2000) *Korean J. Food Sci. Technol*. **32**,42–49

[14] Hoffman, P.G., Lego, M.C., & Galetto, W.G. (1983) *J. Agric.Food Chem.* **31**, 1326–1330 http://dx.doi.org/10.1021/jf00120a044

[15] Saria, A., Lembeck, F., & Skofitsch, G. (1981) *J.Chromatogr*. **208**, 41–46 http://dx.doi.org/10.1016/S0021-9673(00)87957-1

[16] Hawer, W., Ha, J., Hwang, J., & Nam, Y. (1994) *Food Chem*.**49**, 99–103 http://dx.doi.org/10.1016/0308-8146(94)90239-9

[17] Jurenitsch, J., Kubelka, W., & Jentzsch, K. (1978) *Sci.Pharmaceut.* **46**, 307–318

[18] Kawada, T., Watanabe, T., Katsura, K., Takami, H., & Iwai ,K. (1985) *J. Chromatogr*. **329**, 99–105 http://dx.doi.org/10.1016/S0021-9673(01)81899-9

[19] Lee, K.R., Suzuki, T., Kobashi, M., Hasegawa, K., & Iwai, K. (1976) *J. Chromatogr*. **123**, 119–128 http://dx.doi.org/10.1016/S0021-9673(00)81108-5

[20] Masada, Y., Hashimoto, K., Inoue, T., & Suzuki, M. (1971) *J. Food Sci*. **36**, 858–860 http://dx.doi.org/10.1111/j.1365-2621.1971.tb15544.x

[21] ASTA analytical method 21.3. Pungency of capsicum and their oleoresins(HPLE method)

[22] ASTA E1083-00. Reapproved 2006. Standard test method for sensory evaluation of red pepper heat

[23] ASTA E1395-90. Standard test method sensory evaluation of low heat chilles.

[24] Anna M. Krajewska, John J. Powers. 1988, Sensory properties of naturally occurring capsaicinoids, J. of Food Science, 53(3): 902-905. http://dx.doi.org/10.1111/j.1365-2621.1988.tb08981.x

[25] C.A. Reilly et al.: Quantitative analysis of capsaicinoids in fresh peppers, olesin capsicum and pepper spray products., 2001, J. of Forensic science, Vol. 43, No. 3. Pp. 502-509

[26] James D. Batchelor and Bradley T. Jones, 2000, Determination of scoville heat values for hot sauce and chilles: HPLC. J. Chemical Education, 77(2): 266-267 http://dx.doi.org/10.1021/ed077p266

[27] Thomas A. Betts, Pungency quantitation of hot pepper sauces using HPLC, 1999, J. Chemical Education. 76(2): 240-244 http://dx.doi.org/10.1021/ed076p240

[28] Korean Industrial Standards , KS H 2120 *Guchujang*

[29] National Standard of Korean Traditional Food, T013 *Guchujang*