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Original article

Cross-cultural comparisons between Korean and U.S. adults with respect to texture perception and acceptance of cooked milled rice

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Summary This study aimed to determine whether texture perception and acceptance of cooked rice could differ with cultural background, especially between Korean and American participants. Participants evaluated eight cooked rice samples with respect to intensities of textural attributes such as visual stickiness, hardness, stickiness and chewiness. Participants also rated the acceptability of and familiarity with those samples. Results showed that Americans gave higher ratings to cooked rice samples with respect to visual stickiness, stickiness and chewiness, while Koreans gave higher ratings to hardness than their counterpart. For Americans, chewiness was considered as a negative driver; whereas for Koreans, visual stickiness and stickiness were identified as positive drivers of overall liking for cooked rice samples. Moreover, a familiarity level of cooked rice samples was a pronounced positive driver of liking for both American and Korean participants. In conclusion, our findings provide empirical evidence that cultural background influences texture perception and liking of cooked rice.

Keywords Chewiness, cultural background, familiarity, liking, rice, stickiness, texture perception.

Introduction

There has been an increasing interest in cross-cultural studies regarding sensory perception and preference of food and beverages in the fields of sensory science, foodservice business and culinary science. Numerous cross-cultural sensory studies have focused on culture-induced differences with respect to sensory attribute intensities and consumer acceptances of either ethnic or nonethnic food/beverage items. For ethnic food or beverage items, previous studies not only have compared consumers from different countries or cultural backgrounds in terms of attribute intensities and/or consumer acceptances (Yusop *et al*., 2009; Hong *et al*., 2011, 2014; Chung *et al*., 2012), but have also identified sensory and nonsensory factors to modulate consumer acceptance of those ethnic items (Chung *et al*., 2012; Hong *et al*., 2014). Moreover, using descriptive sensory analysis, sensory lexicons, generated from multiple countries, of specific ethnic food or beverage items have been compared (Chung & Chung, 2007).

Such cross-cultural differences with respect to attribute intensity, consumer preference and sensory lexicon have also been observed in food and beverages widely consumed around the world: for example, cheese (Drake *et al*., 2005), jellies (Blancher *et al*., 2007), green tea (Kim *et al*., 2013) and soy sauce (Cherdchu *et al*., 2013). Most previous cross-cultural sensory studies have emphasised culture-induced differences in chemosensory-related perception, such as odour, flavour, taste and chemesthesis (Moskowitz *et al*., 1975; Prescott & Bell, 1995; Sorokowska *et al*., 2017). Studies have found that cultural differences in consumer preference for chemosensory cues result from not only genetic variations, but also dietary patterns and experience/familiarity (Moskowitz *et al*., 1975; Prescott & Bell, 1995; Sorokowska *et al*., 2017); in general, the latter appeared to have a greater impact on culture-induced preference for chemosensory cues.

There is a knowledge gap among cross-cultural sensory studies on food and beverages. First, even though a variety of food and beverage categories have been used as test samples in previous investigations, cooked cereals, which have been popularly consumed around the world, have not received much attention. However, it is worth noting that cooked cereals, such as cooked rice, are a staple food for people in many Asian, South American and African countries (Mohanty, 2013). Second, earlier cross-cultural research, as described above, has highlighted variations in flavour perception more than those in texture perception (Drake *et al*., 2005).

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Most food and beverage samples that have been used in cross-cultural studies are generally appreciated by consumers due to their abundant flavour. Several studies have focused on cross-cultural differences in texture perception of food and beverages (Blancher *et al.*, 2007; Hong *et al.*, 2014; Kim & Lee, 2016). For example, using free sorting tasks and flash profile techniques, Blancher *et al.* (2007) compared how similarly and differently French and Vietnamese participants described textural attributes of jellies. The results showed that Vietnamese participants used more similar strategies, that is, less variations and fewer words describing textural attributes in characterising jelly samples than did French participants. Such differences might result from differences in (i) language, in particular the amount of vocabulary that describes a specific sensation (Kim & Lee, 2016) and/or (ii) the extent of familiarity with the foods (Blancher *et al.*, 2007).

Cooked rice serves as a particularly apt example for illustrating cross-cultural variations with respect to texture perception and acceptance. First, even though rice (*Oryza sativa* L.) is a staple crop for almost half of the world's population, more than 90% of the world's rice is consumed in Asian countries (Mohanty, 2013), resulting in cross-cultural variations in dietary patterns, cooking patterns and familiarity. Dietary habits and cooking patterns of rice have been found to vary with regional and cultural backgrounds, even within Asian countries (Son *et al.*, 2013). Second, there are regional differences in the rice varieties that are mainly cultivated and consumed in the world. For instance, while short grain rice is popular in Korea and Japan, about 75% of the rice produced in the United States is long grain (Street & Bollich, 2003), indicating regional diversities with respect to variety of rice grains mainly consumed between cultural backgrounds. Finally, as textural attributes, such as hardness and stickiness, have been considered crucial determinants of consumer preference for cooked rice (Suwansri & Meullenet, 2004; Suwannaporn & Linnemann, 2008), textural attributes preferred may vary with cultural backgrounds.

Building on previous cross-cultural sensory studies and their knowledge gap, the primary objectives of this study were twofolds: (i) to compare perceived intensity and acceptance with respect to cooked rice samples varying in textural attributes between Korean and American consumers and (ii) to compare impacts of textural attributes on overall acceptance of cooked rice samples between the two cultural backgrounds.

Materials and methods

This study was conducted according to the Declaration of Helsinki for studies on human subjects. The protocol used in this study was approved by the Institutional Review Board of the University of Arkansas (Fayetteville, AR, USA). A written informed consent was obtained from each participant prior to participation.

Participants

A total of 87 volunteers (50 American and 37 Korean adults) ranging in age from 19 to 62 years were recruited through the consumer profile database of the University of Arkansas Sensory Service Center and from the University of Arkansas community (Northwest Arkansas, AR, USA). All participants reported eating cooked rice at least once a month. All Korean participants were born in South Korea, and they had completed undergraduate and/or high school education in that country. On average, Korean participants had lived in the USA for 46 months (SD = 65 months). The American (35 females and 15 males) and Korean (23 females and 14 males) groups were not significantly different in terms of gender ratio ($\chi^2 = 0.59$, $P = 0.44$), but the mean age of the American group [mean age ± SD = 38 ± 12 years] was greater than that of the Korean group (31 ± 10 years) ($t = 2.86$, $P = 0.005$). Table 1 shows more details on demographic profiles of American and Korean participants.

Rice grain products

To provide a wide spectrum of textural attributes in cooked rice, eight milled rice grain products, that is two short grain, two medium grain, two long grain and two waxy grain, were purchased from local supermarkets and Asian grocery stores (Northwest Arkansas, AR, USA) in May 2016. As shown in Table 2, the eight products were selected based on variations with respect to types of grain, market price and amylose content. The cultivar and crop-year of the commercial rice grain products were unknown.

To measure the amylose content of the rice grain products, a head rice sub-sample (60 g) of each rice grain product was ground into flour with a UDY cyclone sample mill (3010-30, Fort Collins, CO, USA) fitted with a 0.5-mm sieve. The apparent amylose content of the rice flour was determined by the simplified iodine assay method (Juliano *et al.*, 1981). Table 2 shows the amylose content (%) of rice grain products used in this study. As expected, two waxy rice samples (WGA and WGB) had the smallest amount of apparent amylose content.

Preparation of cooked rice

Each milled rice grain product (300 g) was cooked in an electronic rice cooker (RC3314W, Black &

Table 1 Demographic profiles of American and Korean participants

	Americans (N = 50)	Koreans (N = 37)
Gender (female:male)	35: 15	23: 14
Mean age (±SD)	38 ± 12 years	31 ± 10 years
Frequency of rice consumption (%)		
≤1 times per month	0 (0.0)	0 (0.0)
2–3 times per month	7 (14.0)	2 (5.4)
1–2 times per week	14 (28.0)	4 (10.8)
3–4 times per week	21 (42.0)	10 (27.0)
5–6 times per week	7 (14.0)	8 (21.6)
Everyday	1 (2.0)	13 (35.1)
Rice cultivars purchased for past 3 months (%)*		
Did not purchase	0 (0.0)	3 (8.1)
Short grain (milled)	5 (10.0)	17 (45.9)
Medium grain (milled)	6 (12.0)	8 (21.6)
Long grain (milled)	20 (40.0)	1 (2.7)
Waxy rice (milled)	5 (10.0)	3 (8.1)
Brown rice	21 (42.0)	10 (27.0)
Jasmine rice (milled)	15 (30.0)	2 (5.4)
Basmati rice (milled)	6 (12.0)	0 (0.0)
Parboiled rice	2 (4.0)	0 (0.0)
Instance rice	13 (26.0)	3 (8.1)
Others	2 (4.0)	1 (2.7)
Other ingredients added (%)*		
No addition	6 (12.0)	35 (94.6)
Salt	31 (62.0)	0 (0.0)
Sugar	10 (20.0)	0 (0.0)
Oil	7 (14.0)	0 (0.0)
Seasoning	23 (46.0)	0 (0.0)
Milk	5 (10.0)	0 (0.0)
Butter	12 (24.0)	0 (0.0)
Others	3 (6.0)	2 (5.4)

*Multiple choices were allowed.

Decker, Beachwood, OH, USA). Optimum water-to-rice ratios for individual rice grain products were established based on a preliminary test (Table 2). Optimum cooking duration (Table 2) was determined by the Ranghino test (Ranghino, 1966), that is, by testing 10 rice kernels every 5 min after cooking for 30 min until at least nine kernels showed no starchy cores when compressed between two glass plates. Cooked milled rice was held in the rice cooker for additional 5 min and then gently fluffed and mixed. Subsequently, 45 g of the cooked rice was placed in a 120-mL Styrofoam cup (Dart Container Corporation, Mason, MI, USA) identified with a three-digit code.

The moisture content of cooked milled rice (Table 2) was measured by the moisture measurement protocol (44-15.02) proposed by the American Association of Cereal Chemists International (AACC International, 1999). Two waxy rice samples (WGA and WGB) showed significantly lower moisture content than nonwaxy rice samples.

Procedure

This study was conducted in individual sensory booths at the University of Arkansas Sensory Service Center. Prior to a sample presentation, an introduction describing both the experimental protocol and the scaling was given to each participant. Instructions and scales were presented using the sensory analysis software, Compusense® five (Release 5.6; Compusense Inc., Guelph, ON, Canada).

Following the orientation session, each participant was presented with eight cooked rice samples and a white plastic spoon, in a sequential monadic fashion consistent with the Williams Latin Square design (Williams, 1949). Each cooked rice sample was presented at 70 ± 2 °C. All participants were asked to evaluate the cooked rice samples with respect to visual stickiness, hardness, stickiness and chewiness, on 9-point category scales ranging from 1 ('extremely low') to 9 ('extremely high'), respectively. The four attributes were also evaluated on 7-point 'Just-About-Right' (JAR) scales (1 = 'much too little', 4 = 'JAR' and 7 = 'much too much'), respectively. In addition, a degree of familiarity to each cooked rice sample was evaluated on a 9-point category scale ranging from 1 ('extremely unfamiliar') to 9 ('extremely familiar'). Finally, overall liking for each cooked rice sample was rated on a 9-point hedonic scale ranging from 1 ('dislike extremely') to 9 ('like extremely').

A 90-s break was allowed between sample presentations. During the break, spring water (Clear Mountain Spring Water, Taylor Distributing, Heber Springs, AR, USA) was presented for palate cleansing.

Statistical analysis

Data analysis was performed using JMP® Pro (version 13.0, SAS Institute Inc., Cary, NC, USA) and XLSTAT software (Addinsoft, New York, NY, USA). To determine whether ratings of texture attribute intensity, familiarity and overall liking could differ with cultural background and cooked rice sample, a three-way analysis of variance (ANOVA), treating 'cultural background' and 'cooked rice sample' as main effects and 'panellist' as a random effect (Lundahl & McDaniel, 1988), was performed. If a significant difference of means was determined, *post hoc* comparisons between variables were conducted using Tukey's honestly significant difference (HSD) tests. A statistically significant difference was defined as $P < 0.05$.

To determine whether cultural background could influence the pattern of clustering cooked rice samples based on texture attribute intensities, both agglomerative hierarchical clustering (AHC) and principal component analysis (PCA) were used. AHC was conducted using Euclidian distance and Ward's

Table 2 Sample codes and characteristics of both uncooked and cooked milled rice samples used in this study

	Uncooked milled rice				Cooked milled rice			
Codes	Type of rice grain	Cultivation area	Price (US $/kg)	Amylose content (%)*	Duration of soaking (min)	Rice-to-water ratio (w/w)	Duration of cooking (min)	Moisture content (%)†
WGA	Glutinous/short grain	USA	2.50	0.4 ± 0.1e	30	1:0.55	30	34.1 ± 1.1b
WGB	Glutinous/short grain	USA	2.79	0.0 ± 0.3e	30	1:0.55	30	33.3 ± 0.9b
SGA	Nonglutinous/short grain	USA	6.76	17.9 ± 0.3bc	0	1:1.65	30	37.8 ± 0.7a
SGB	Nonglutinous/short grain	USA	3.38	14.9 ± 2.0cd	0	1:1.65	30	38.4 ± 0.5a
MGA	Nonglutinous/medium grain	USA	2.38	12.1 ± 1.7d	0	1:1.65	25	36.1 ± 1.3ab
MGB	Nonglutinous/medium grain	USA	2.18	22.4 ± 2.5a	0	1:1.65	25	38.7 ± 1.1a
LGA	Nonglutinous/long grain	USA	1.63	19.7 ± 0.1ab	0	1:1.8	25	37.6 ± 0.2a
LGB	Nonglutinous/long grain	USA	1.96	18.6 ± 0.8bc	0	1:1.8	25	38.9 ± 1.7a

*Mean values with different letter within a column represent a significant difference determined by one-way analysis of variance (ANOVA) ($F = 123.41$, $P < 0.001$) followed by *post hoc* comparisons using Tukey's honest significant difference (HSD) test ($P < 0.05$).
†Mean values with different letter within a column represent a significant difference determined by one-way ANOVA ($F = 12.92$, $P = <0.001$) followed by *post hoc* comparisons using Tukey's HSD test ($P < 0.05$).

method, and a dendrogram of AHC was used to visualise the pattern of clustering based on dissimilarity between cooked rice samples. Moreover, a bi-plot of PCA was used to demonstrate the distribution of cooked rice samples based on the first two factor scores of four texture attributes of eight cooked rice samples. The degree of similarity between the PCA configurations of the cooked rice samples evaluated by either American or Korean participants was measured using both the regression vector (RV) coefficient and the normalised RV (NRV) (Schlich, 1996; Findlay *et al.*, 2006; Jarma Arroyo & Seo, 2017). As the RV coefficient, considered a correlation coefficient in a multidimensional configuration, was closer to 1.0, the two multidimensional configurations were considered more similar (Schlich, 1996; Findlay *et al.*, 2006; Jarma Arroyo & Seo, 2017). In addition, if the NRV coefficient, characterised as a normalised deviation between the observed RV and the calculated RV, was greater than 2.0, a similarity between the two multivariate configurations was considered greater than a randomly obtained similarity (Schlich, 1996; Findlay *et al.*, 2006; Jarma Arroyo & Seo, 2017).

For the JAR scale data, a penalty analysis was used to identify how much each texture attribute affected the overall liking of cooked rice samples. JAR was determined when the percentage of the JAR score was greater than 70%, and no more than 20% of responses were on either minus (−) or plus (+) side of the scale (Cho *et al.*, 2016).

A partial least squares regression (PLSR) was conducted to determine the impacts of individual texture attributes and familiarity on overall liking of cooked rice samples as a function of cultural background. Centred and scaled values of the independent (four textural attribute intensities and familiarity level) and dependent (overall liking) variables were used with Leave-One-Out cross-validation method to determine the lowest number of factors required to both minimise root meat PRESS (RM-PRESS) value and maximise percentages of variations explained for independent X-variable and dependent Y-variable (Cox & Gaudard, 2013; Samant *et al.*, 2016). The variable influence on projection (VIP) values and standard coefficients was used to determine important contributors to overall liking of cooked rice samples. VIP is an established parameter used for measuring the cumulative influence of individual X-variables on the PLSR model (Galindo-Prieto *et al.*, 2014). While independent variables with VIP values above 0.8 were considered to be important (Rossini *et al.*, 2012; Samant *et al.*, 2016), those with below 0.5 are considered to be irrelevant variables (Galindo-Prieto *et al.*, 2014). In addition, positive and negative standardised coefficients of independent variables represented positive and negative correlations of those variables with overall liking of cooked rice samples (Gomes *et al.*, 2014).

Results

Cross-cultural comparison in the intensity ratings of textural attributes in cooked rice samples

Visual stickiness

There was a significant interaction between 'cultural background' and 'cooked rice sample' with respect to intensity ratings of visual stickiness ($F = 2.38$, $P = 0.02$). As shown in Fig. 1a, while American participants rated SGA ($P < 0.01$), MGA ($P < 0.001$), and LGB ($P < 0.05$) samples visually stickier than did Korean participants, such significant differences were not observed in other samples. When considering all eight samples, Americans (mean ± SD = 5.71 ± 2.06) rated

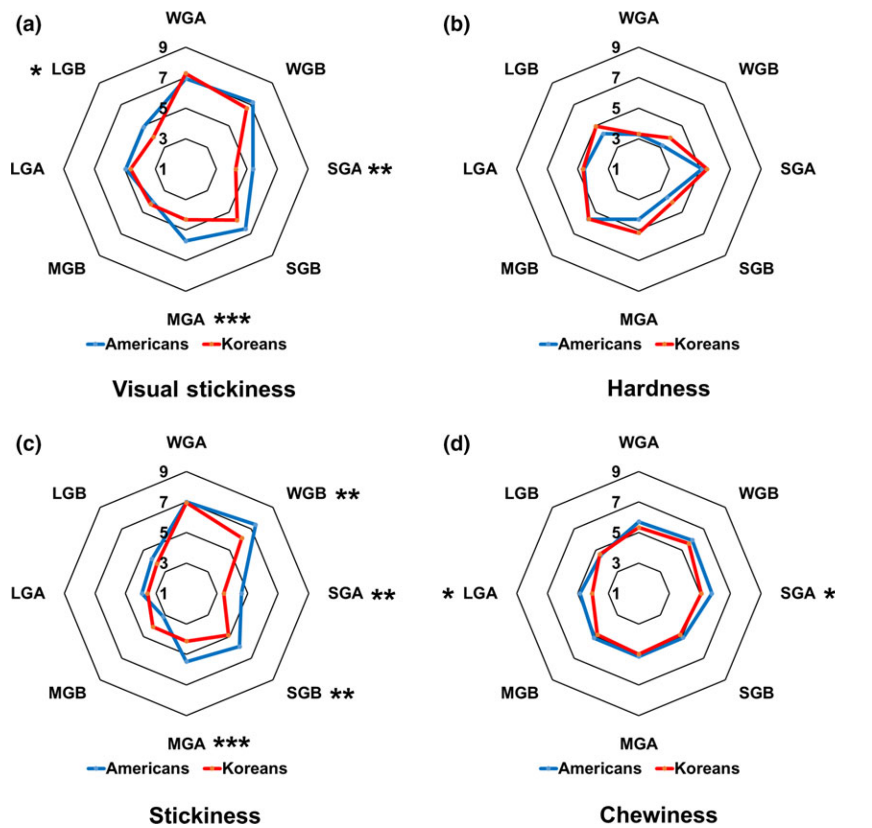

Figure 1 Comparisons between American and Korean participants with respect to mean intensity ratings of visual stickiness (a), hardness (b), stickiness (c) and chewiness (d) in the eight cooked rice samples. Sample codes are represented in Table 2. *, **, and *** represent a significance at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively. [Colour figure can be viewed at wileyonlinelibrary.com]

cooked rice samples visually stickier than did Koreans (5.14 ± 2.37) ($F = 19.32$, $P < 0.001$).

A significant main effect of the 'cooked rice sample' on visual stickiness was also observed ($F = 32.91$, $P < 0.001$). More specifically, when considering all participants (i.e. when collapsing both American and Korean data), WGA, WGB and SGB samples were rated visually stickier than MGA, SGA, LGA, LGB and MGB samples. In addition, the MGA sample was rated visually stickier than the MGB sample, which is in accordance with the result that the MGA sample had a smaller percentage of amylose content than the MGB sample (Table 2). When analysing data for each cultural background, participants tended to be more sensitive when rating visual stickiness among cooked rice samples that they had more exposure to in everyday life (Table 3). More specifically, while sticky cooked rice samples (WGA, WGB and SGB) produced no significant differences in visual stickiness among Americans, the WGA sample was rated visually stickier than the SGB sample among Koreans. In addition, less sticky cooked rice samples (MGA, MGB, LGA and LGB) generated no significant differences in visual stickiness among Koreans; however, the MGA sample was rated visually stickier than the MGB sample among Americans.

Hardness

Figure 1b shows no significant interaction between 'cultural background' and 'cooked rice sample' with respect to intensity ratings of hardness ($F = 0.85$, $P = 0.55$). In contrast, there was a significant main effect of 'cultural background' on intensity ratings of hardness ($F = 18.64$, $P < 0.001$). Overall, Korean participants (mean ± SD = 4.66 ± 2.02) rated cooked rice samples significantly harder than did American participants (4.25 ± 2.07).

When combining both American and Korean participants' data, there was a significant main effect of 'cooked rice sample' on intensity ratings of hardness ($F = 10.24$, $P = 0.001$). As shown in Table 3, SGA, MGA and MGB samples were rated harder than WGA, WGA and SGB samples. LGA and LGB samples were rated softer than MGA sample, but those samples were rated harder than WGB and WGA samples.

Stickiness

A significant interaction between 'cultural background' and 'cooked rice sample' was exhibited with respect to intensity ratings of stickiness ($F = 4.41$, $P < 0.001$). As shown in Fig. 1c, while American participants rated WGB ($P < 0.01$), SGA ($P < 0.01$), SGB ($P < 0.01$)

Table 3 Mean intensity ratings (±SD) of textural attributes as a function of cooked rice sample and cultural background

	WGA*	WGB	SGA	SGB	MGA	MGB	LGA	LGB	*P*-value
All participants									
Visual stickiness	7.07a (±1.69)	6.95ab (±1.77)	4.92 cd (±2.04)	6.20b (±1.84)	5.13c (±1.99)	4.15d (±2.18)	4.81 cd (±2.11)	4.53 cd (±2.02)	<0.001
Hardness	3.28d (±2.14)	3.48d (±1.99)	5.31ab (±1.80)	3.82 cd (±1.63)	4.70b (±1.98)	5.64a (±2.05)	4.61bc (±1.82)	4.56bc (±1.83)	<0.001
Stickiness	6.98a (±1.76)	6.85a (±1.78)	4.10 cd (±1.77)	5.47b (±1.70)	4.91bc (±1.91)	3.56d (±2.17)	3.76d (±1.71)	4.01d (±1.77)	<0.001
Chewiness	5.53a (±2.13)	5.81a (±1.98)	5.47a (±1.66)	4.98ab (±1.60)	5.07ab (±1.73)	5.01ab (±2.13)	4.53b (±1.62)	4.55b (±1.80)	<0.001
American participants									
Visual stickiness	6.94a (±1.79)	7.20a (±1.50)	5.40c (±1.93)	6.54ab (±1.70)	5.72bc (±1.59)	4.06d (±1.90)	4.94 cd (±2.09)	4.90 cd (±1.82)	<0.001
Hardness	3.26d (±2.35)	3.18d (±2.03)	5.14ab (±1.88)	3.62 cd (±1.64)	4.30bc (±2.04)	5.66a (±1.87)	4.58bc (±1.63)	4.28bc (±1.75)	<0.001
Stickiness	7.00a (±1.65)	7.38a (±1.31)	4.60 cd (±1.90)	5.92b (±1.47)	5.48bc (±1.59)	3.16e (±1.81)	3.92de (±1.72)	4.86d (±1.51)	<0.001
Chewiness	5.70ab (±2.11)	5.94a (±2.04)	5.78ab (±1.43)	5.10abc (±1.61)	5.14abc (±1.67)	5.14abc (±1.97)	4.86bc (±1.51)	4.54c (±1.69)	<0.001
Korean participants									
Visual stickiness	7.24a (±1.55)	6.62ab (±2.06)	4.27d (±2.04)	5.73bc (±1.94)	4.32d (±2.21)	4.27d (±2.52)	4.62 cd (±2.14)	4.03d (±2.19)	<0.001
Hardness	3.30d (±1.85)	3.89 cd (±1.88)	5.54a (±1.68)	4.08bcd (±1.59)	5.24ab (±1.77)	5.62a (±2.29)	4.65abc (±2.07)	4.95abc (±1.88)	<0.001
Stickiness	6.95a (±1.91)	6.14a (±2.08)	3.43c (±1.32)	4.86b (±1.81)	4.14bc (±2.04)	4.11bc (±2.49)	3.54c (±1.69)	3.76bc (±1.69)	<0.001
Chewiness	5.30ab (±2.17)	5.62a (±1.89)	5.05ab (±1.87)	4.81ab (±1.60)	4.97ab (±1.83)	4.84ab (±2.34)	4.08b (±1.67)	4.57ab (±1.95)	0.03

*For sample codes, see Table 2.

and MGA ($P < 0.001$) samples stickier than did Korean participants, no other significant cultural differences were observed in other cooked rice samples.

When considering all eight samples, Americans (mean ± SD = 5.21 ± 2.17) rated cooked rice samples stickier than did Koreans (4.61 ± 2.24) ($F = 18.64$, $P < 0.001$), revealing an opposite trend in culture-induced hardness ratings, that is greater ratings of hardness for Korean participants who were familiar with soft cooked rice.

The 'cooked rice sample' had a significant effect on intensity ratings of stickiness ($F = 52.06$, $P < 0.001$). WGA, WGB, SGB and MGA samples were rated stickier than MGB, LGA and LGB samples (Table 3). Similarly, Americans rated WGA, WGB, SGB and MGA samples as significantly stickier than MGB, LGA and LGB samples. However, Koreans could not differentiate the MGA sample from the SGA, MGB, LGA and LGB samples with respect to stickiness.

Chewiness

There was no significant interaction between 'cultural background' and 'cooked rice sample' with respect to intensity ratings of chewiness ($F = 0.47$, $P = 0.86$). However, intensity ratings of chewiness among eight cooked rice samples differed with 'cultural background' ($F = 6.64$, $P = 0.01$). In particular, Americans (mean ± SD = 5.28 ± 1.81) rated eight cooked rice samples significantly chewier than did Koreans (4.91 ± 1.95). Furthermore, when combining both American and Korean participants' data, there was a main effect of 'cooked rice sample' on the intensity ratings of chewiness. As shown in Table 3, WGA, WGB and SGA samples were rated chewier than two long-grain samples (LGA and LGB).

Cross-cultural comparisons in the pattern of clustering eight cooked rice samples

Using an AHC analysis, it was determined whether the pattern of clustering the eight cooked rice samples, based on dissimilarities with respect to intensity ratings of four textural attributes among the samples, could differ by cultural background. As shown in Fig. 2a, American participants categorised eight samples into three clusters: Cluster 1 (SGA, MGB, LGA, and LGB), Cluster 2 (WGA and WGB) and Cluster 3 (SGB and MGA). Similarly, Korean participants differentiated those samples into three clusters: Cluster 1 (SGA, MGA, MGB, LGA, and LGB), Cluster 2 (SGB) and Cluster 3 (WGA and WGB) as shown in Fig. 2b. However, unlike clusters drawn by American participants, the MGA sample was not classified with SGB sample, but with SGA, MGB, LGA and LGB samples among Korean participants. Bi-plots of PCA supported such patterns of clustering cooked rice

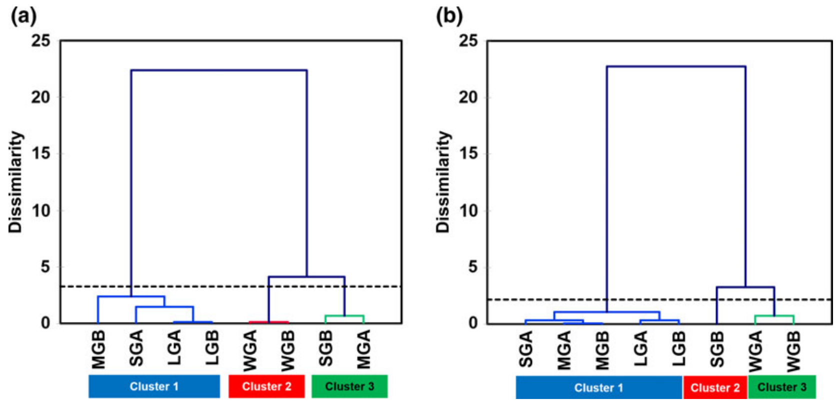

Figure 2 Dendrograms of agglomerative hierarchical clustering (AHC), based on dissimilarities with respect to intensity ratings of four textural attributes among the eight cooked rice samples, as a function of cultural background: American (a) vs. Korean (b) participants. Sample codes are represented in Table 2. [Colour figure can be viewed at wileyonlinelibrary.com]

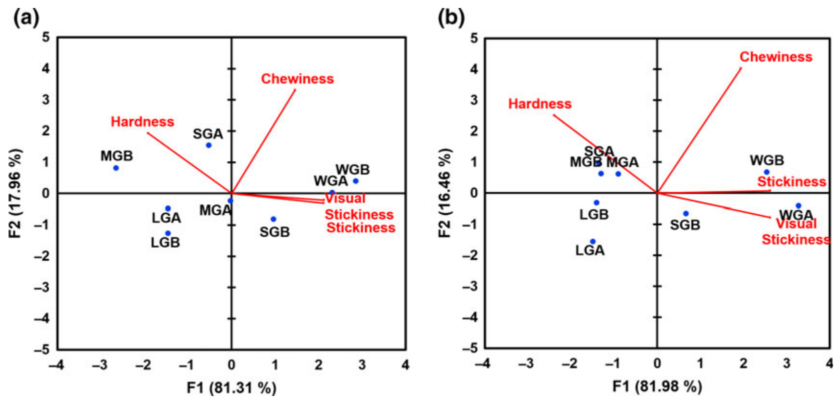

Figure 3 Bi-plots of principal component analysis (PCA), based on intensity ratings of four textural attributes among the eight cooked rice samples, as a function of cultural background: American (a) vs. Korean (b) participants. Sample codes are represented in Table 2. [Colour figure can be viewed at wileyonlinelibrary.com]

samples. SGB and MGA samples were more closely placed with respect to both F1 and F2 axes of the bi-plot among American participants (Fig. 3a) than among Korean participants (Fig. 3b).

Generally, a similar pattern of clustering was observed on the bi-plots of the PCA for the eight cooked rice samples based on four textural attributes evaluated by either Americans or Koreans. A measure of the similarity between the PCA factor scores for the eight samples evaluated by either Americans or Koreans was represented by both RV and NRV coefficients. The RV coefficient value of 0.83 was closer to 1.0, demonstrating the similarities between that the two multidimensional spaces drawn by the American and the Korean participants (Schlich, 1996; Findlay *et al.*, 2006). In addition, the NRV coefficient value of 3.98 was greater than 2.0, indicating that the two multidimensional configurations are very similar (Schlich, 1996; Findlay *et al.*, 2006; Jarma Arroyo & Seo, 2017).

Cross-cultural comparison in the familiarity and overall liking of cooked rice samples

Familiarity

There was a significant interaction between 'cultural background' and 'cooked rice sample' with respect to familiarity ($F = 12.12$, $P < 0.001$). While Americans rated MGB ($P < 0.05$), LGA ($P < 0.001$) and LGB ($P < 0.001$) samples more familiar, Koreans rated WGA ($P < 0.001$) and WGB ($P < 0.001$) samples more familiar than their counterpart (Fig. 4a). Familiarity ratings of eight cooked rice samples differed significantly ($F = 5.36$, $P < 0.001$). The SGB sample was rated more familiar than SGA, MGB and WGA samples (Table 4). However, when considering overall familiarity ratings of all eight samples, there was no significant cultural difference ($F = 0.08$, $P = 0.78$).

Overall liking

There was a significant interaction between 'cultural background' and 'cooked rice sample' with respect to overall liking ($F = 8.73$, $P < 0.001$). As shown in Fig. 4b, while Americans liked MGB ($P < 0.01$), LGA ($P < 0.001$) and LGB ($P < 0.001$) samples, Koreans liked two waxy rice samples, WGA ($P < 0.01$) and WGB ($P < 0.05$) samples, more than did their counterpart. Overall liking ratings of eight samples differed significantly ($F = 7.76$, $P < 0.001$). Like the trend shown in the above result of familiarity ratings, when combining both American and Korean participants' data, the SGB sample received higher liking ratings

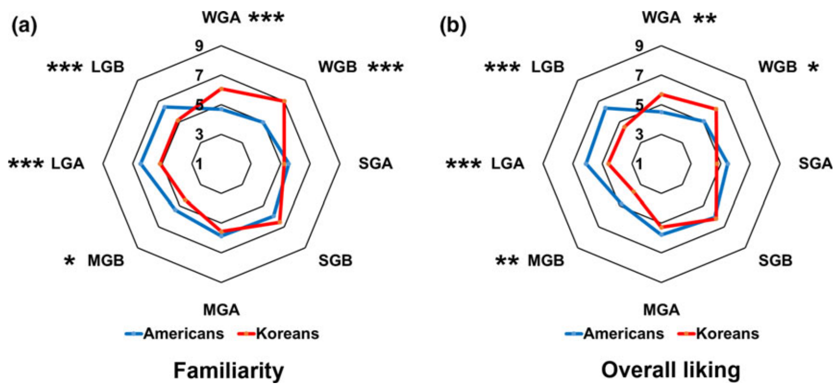

Figure 4 Comparisons between American and Korean participants with respect to mean ratings of familiarity (a) and overall liking (b) in the eight cooked rice samples. Sample codes are represented in Table 2. *, ** and *** represent a significance at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively. [Colour figure can be viewed at wileyonlinelibrary.com]

than did SGA, MGB and WGA samples (Table 4). Interestingly, American participants (mean ± SD = 5.53 ± 2.01) liked the eight cooked rice samples significantly more than did Korean participants (5.12 ± 2.09) ($F = 8.69$, $P = 0.003$).

Cross-cultural comparisons in the just-about-right (JAR) ratings and their impacts on overall liking of cooked rice samples

Visual stickiness

American participants labelled WGA, SGA, MGB and LGB samples as having 'too much' in terms of visual stickiness, while Korean participants considered MGA, MGB and LGB samples visually 'too little' regarding stickiness (Table 5). When considering all eight samples, more than half (50.50%) of American participants considered the visual stickiness of cooked rice samples to be 'too much', thereby decreasing overall liking (1.57 points of 7 points) of cooked rice samples. In contrast, 39.86% of Korean participants classified the visual stickiness of the cooked rice sample as 'too little', resulting in a mean drop (2.15 points) (Table 5).

Hardness

While Americans considered two waxy rice samples 'too little' in terms of hardness, such a trend was not observed in Koreans (Table 5). In contrast, while Korean participants rated MGA and MGB samples' hardness 'too little', such an observation was not present among American participants. When considering all eight samples, 30.50% of American participants rated cooked rice samples 'too little' with respect to hardness, and 28% of American participants rated those samples 'too much' (Table 5). Both cases decreased overall liking of cooked rice samples. Similarly, 38.18% and 33.45% of Korean participants rated cooked rice samples 'too little' and 'too much', respectively, thereby dropping overall liking of samples (Table 5).

Stickiness

While Americans evaluated the WGB, SGB, MGA samples as 'too much' considering stickiness, Koreans rated those samples 'too little' sticky (Table 5). When considering all eight samples, 21.00% of American participants rated cooked rice samples 'too little' with respect to stickiness, whereas 41% of American participants rated those samples 'too much' (Table 5). Both cases decreased overall liking of cooked rice samples. Similarly, 50.34% and 27.70% of Korean participants rated cooked rice samples 'too little' and 'too much', respectively, thereby decreasing overall liking of samples (Table 5).

Chewiness

As shown in Table 5, 24% to 62% of American participants rated seven of the eight samples 'too much' chewy, while 20% and 30% of American participants rated only WGA and MGB samples 'too little' chewy. When considering all eight samples, almost half (45.50%) of American participants rated cooked rice samples 'too much' with respect to chewiness, thereby decreasing overall liking (2.10-point) of cooked rice samples. For Korean participants, 45.95% and 35.14% rated WGB and LGB samples 'too much' chewy, while 27.03% to 35.14% considered four of eight samples 'too little' sticky. In this way, when considering all eight samples, 39.19% and 35.47% considered rice samples 'too little' and 'too much', respectively, thereby decreasing overall liking of samples (Table 5).

Impacts of textural attributes and familiarity on overall liking of cooked rice samples

For American participants, the PLSR model (three factors) with the lowest RM-PRESS value (0.81) explained 57.68% and 35.51% of variations with respect to independent (four textural attribute intensities and familiarity level) and dependent (overall liking) variables, respectively. As shown in Fig. 5a, a

Table 4 Mean intensity ratings (±SD) of familiarity and overall liking as a function of cooked rice sample and cultural background

	WGA*	WGB	SGA	SGB	MGA	MGB	LGA	LGB	*P*-value
All participants									
Familiarity	5.29bc (±2.03)	5.83ab (±2.09)	5.39bc (±1.71)	6.22a (±1.68)	5.75ab (±1.84)	5.00c (±1.95)	5.90ab (±1.81)	5.89ab (±1.67)	<0.001
Overall liking	5.03b (±2.04)	5.55ab (±2.10)	5.15bc (±1.99)	6.15a (±1.71)	5.56ab (±2.02)	4.34c (±2.16)	5.46ab (±2.00)	5.57ab (±1.98)	<0.001
American participants									
Familiarity	4.70c (±2.02)	4.96c (±2.25)	5.54bc (±1.72)	5.98ab (±1.56)	5.88ab (±1.57)	5.40bc (±1.85)	6.46a (±1.40)	6.42a (±1.51)	<0.001
Overall liking	4.50c (±1.81)	5.06bc (±2.26)	5.48ab (±2.06)	6.10b (±1.75)	5.78ab (±1.76)	4.84bc (±2.14)	6.10a (±1.83)	6.34a (±1.72)	<0.001
Korean participants									
Familiarity	6.08abc (±1.79)	7.00a (±1.03)	5.19cd (±1.70)	6.54ab (±1.80)	5.57bcd (±2.17)	4.46d (±1.97)	5.14cd (±2.03)	5.16cd (±1.61)	<0.001
Overall liking	5.76ab (±2.14)	6.22a (±1.67)	4.70bc (±1.82)	6.22a (±1.67)	5.27ab (±2.32)	3.68c (±2.03)	4.59bc (±1.92)	4.54bc (±1.85)	<0.001

*For sample codes, see Table 2.

familiarity level showed the highest VIP value (1.84), followed by chewiness (0.82), stickiness (0.66), visual stickiness (0.53) and hardness (0.49) intensities. This result indicates that both ratings of familiarity level and chewiness intensity are important in modulating overall liking of cooked rice. In addition, the impact of hardness intensity on overall liking of cooked rice was found to be smaller compared to those of other textural attributes. Standard coefficients of the important variables, familiarity level (+0.54) and chewiness intensity (−0.09) indicated that the familiarity level of cooked rice samples was identified as a positive driver, while chewiness intensity was considered a negative driver of liking.

For Korean participants, the PLSR model (three factors) with the lowest RM-PRESS value (0.64) explained 85.32% and 60.15% of variations with respect to independent and dependent variables, respectively. As shown in Fig. 5b, for Korean participants, three variables, that is, familiarity level (1.74), visual stickiness (0.89) and stickiness (0.89) intensities, showed higher VIP values above 0.8, followed by hardness (0.53) and chewiness (0.32) intensities. In other words, Koreans were found to consider the familiarity level, as well as visual stickiness and oral stickiness intensities to be important for their overall liking of cooked rice. However, the impact of chewiness intensity on overall liking of cooked rice was found to be smaller compared to those of other textural attributes. Based on standard coefficients of the important variables, the familiarity level (+0.73), visual stickiness (+0.08) and stickiness (+0.03) intensities were considered positive drivers of overall liking for cooked rice.

Discussion

Rice is a good example of a product that elicits cultural and regional differences with respect to average-rice-consumption per capita (OECD/Food and Agriculture Organization of the United Nations, 2014), rice varieties primarily consumed (Mohanty, 2013), cooking patterns (Son *et al*., 2013) and dietary habits (Hatae *et al*., 1997; Suwannaporn & Linnemann, 2008). Thus far, research using either questionnaire-based surveys or focus group interviews has found evidence supporting the influences of cultural backgrounds on sensory perception and acceptance of cooked rice (Hatae *et al*., 1997; Suwannaporn & Linnemann, 2008); however, little research using sensory evaluation techniques has been done on this aspect.

As textural attributes have been found to play an important role in modulating consumer acceptance of cooked rice (Okabe, 1979; Suwannaporn & Linnemann, 2008; Son *et al*., 2014), the present study using sensory evaluation techniques has highlighted how

Table 5 Summary of penalty analysis for the 7-point Just-About-Right (JAR*) scale† attributes in the eight cooked rice samples as a function of cultural background

	WGA‡	WGB	SGA	SGB	MGA	MGB	LGA	LGB	Total
American participants									
Visual stickiness§							−26.00% (1.56)		
	+82.00% (2.64)		+42.00% (1.57)			+20.00% (1.61)	+34.00% (1.75)	+30.00% (1.92)	+50.50% (1.57)
Hardness	−56.00% (1.12)	−50.00% (2.72)							−30.50% (1.48)
			+50.00% (1.98)		+26.00% (1.86)	+56.00% (2.50)	+28.00% (2.23)		+28.00% (2.21)
Stickiness			−34.00% (2.34)			−54.00% (2.04)	−28.00% (1.79)	−28.00% (1.25)	−21.00% (1.94)
	+76.00% (2.22)	+84.00% (2.02)		+54.00% (1.24)	+42.00% (1.83)				+41.00% (1.91)
Chewiness	−20.00% (1.90)					−30.00% (1.89)			
	+62.00% (1.81)	+62.00% (2.61)	+62.00% (2.13)		+34.00% (1.44)	+48.00% (2.94)	+30.00% (2.01)	+24.00% (1.58)	+45.50% (2.10)
Korean participants									
Visual stickiness					−43.24% (3.15)	−56.76% (3.10)		−64.86% (1.54)	−39.86% (2.15)
Hardness					−21.62% (2.83)	−21.62% (3.66)			−38.18% (1.32)
						+59.46% (3.06)	+40.54% (2.11)	+43.24% (2.15)	+33.45% (2.29)
Stickiness		−24.32% (2.33)		−29.73% (2.15)	−48.65% (3.19)		−72.97% (1.85)		−50.34% (2.35)
									+27.70% (2.38)
Chewiness	−35.14% (2.18)	−27.03% (2.70)		−29.73% (1.79)	−32.43% (2.94)				−39.19% (2.11)
		+45.95% (2.08)						+35.14% (2.17)	+35.47% (1.69)

*JAR indicates that the percentage of JAR scores is greater than 70% and no more than 20% of responses are on either minus (−) or plus (+) side of the scale.
†Four textural attributes of each sample were evaluated on 7-point 'Just-About-Right' (JAR) scales ranging from 1 ('much too little'), 4 ('JAR'), and 7 ('much too much').
‡For sample codes, see Table 2.
§Percentage (%) of participants (mean drop of overall liking); minus (−) and plus (+) symbols indicate 'too little' and 'too much', respectively.

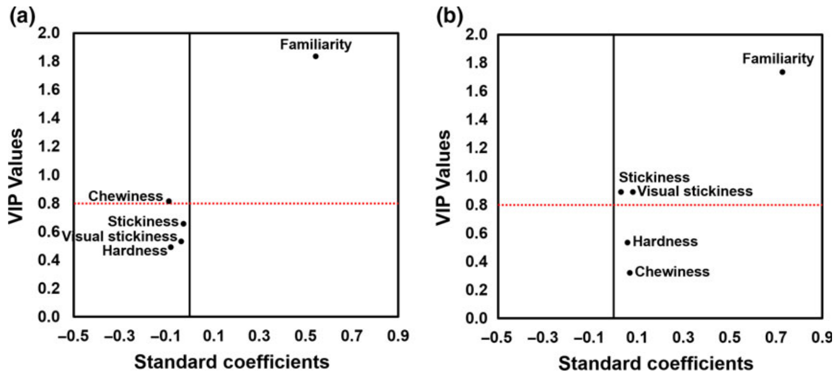

Figure 5 Variable influence on projection (VIP) and standard coefficient values of partial least squares regression (PLSR) with respect to visual stickiness, hardness, stickiness, chewiness and familiarities for overall liking of the eight cooked rice samples as a function of cultural background: American (a) vs. Korean (b) participants. Centred and scaled data of independent and dependent variables were used for the PLSR analysis. The horizontal dot line represents the cut-off VIP value of 0.8. Independent variables, having VIP values above cut-off value of 0.8 were considered to be important. In addition, the positive (or negative) standard coefficient value of each attribute is considered to be positively (or negatively) correlated with the overall liking rating of the cooked rice samples. [Colour figure can be viewed at wileyonlinelibrary.com]

cultural backgrounds affected intensities of 'textural attributes' of cooked milled rice. Even though cooked milled rice can be characterised using a variety of textural attributes (Meullenet *et al.*, 2000; Park *et al.*, 2001), four textural attributes, representing perceived attributes at each stage of consumption: before biting (visual stickiness), first bite (hardness) and chew-down (oral stickiness and chewiness), were chosen. In addition, as the temperatures of hot cooked rice quickly change over time and textural attributes of cooked rice are influenced by temperatures (Pramudya & Seo, 2018), the number of textural attributes was limited. Finally, as untrained panellists participated in this study, four attribute terms which are consumer-friendly and commonly used in both languages (i.e. English and Korean languages) were employed in this investigation.

This study showed cultural differences in the intensities of the four textural attributes among eight cooked rice samples. While American participants rated those cooked rice samples stickier and chewier, Korean participants rated those samples harder than did their counterpart. In addition, significant interactions between cultural background and cooked rice samples were observed in both visual and oral stickiness intensities. These results might be due to differences in dietary habits, in particular rice varieties primarily consumed. As Korean participants were accustomed to eating soft cooked rice, cooked rice samples tested in this study, especially cooked medium- or long-grain rice samples, were likely perceived as being harder than their expectations. In a similar vein, as American participants were used to eating less sticky rice in a regular basis, cooked rice samples tested in this study, especially cooked short and waxy rice grains could have been perceived as being stickier than their expectations, resulting in higher ratings of the stickiness attribute. Textural attributes, such as hardness, of cooked rice have been found to be influenced by many factors, including the degree of milling (Park *et al.*, 2001), water-to-rice ratio (Juliano & Perez, 1983), moisture content (Meullenet *et al.*, 2000; Park *et al.*, 2001), mineral (Juliano, 1985), lipid (Park *et al.*, 2001) and protein (Park *et al.*, 2001) contents. Herein, our findings add 'cultural background' to the list of determinants of textural attribute intensities.

Although cultural background was found to affect textural attribute intensities of cooked rice, the pattern of clustering the eight cooked rice samples was similar between the American and Korean groups (Figs 2 and 3). As described above, both RV (0.83) and NRV (3.98) coefficients also supported similar patterns of clustering between the two cultural groups. These results indicate that both American and Korean participants were able to differentiate the eight cooked rice samples in a similar pattern, in terms of the four textural attributes. Based on Figs 2 and 3, visual and oral stickiness attributes were found to play a crucial role in clustering the cooked rice samples by both American and Korean participants. Notably, Fig. 3 shows that impacts of the chewiness attribute on the clustering of cooked rice samples were more pronounced in American participants than in Korean participants. This result is in accordance with a higher VIP value of American participants (0.82) than that of Korean participants (0.32) with respect to chewiness (Fig. 5). Interestingly, the chewiness attribute was considered a negative driver of liking among Americans, while the attribute was not considered a driver of liking among Koreans (Fig. 5). Similarly, cooked rice samples considered 'too much' sticky or chewy decreased their acceptance among Americans, but such trends were generally opposite among Koreans (Table 5). These findings demonstrate that a negative hedonic valence was an important factor underlying the clustering pattern of cooked rice samples among Americans.

There was no significant difference between American and Korean participants in terms of familiarity ratings of all cooked rice samples. This is not in accordance with our expectation that Koreans are more familiar with cooked rice samples than Americans based on not only their higher frequency of rice consumption (Table 1), but also greater average rice consumption per capita [i.e. 11.6 kg (US) vs. 68.7 kg (Korea) during a period of 2011 to 2013 estimated] (OECD/Food and Agriculture Organization of the United Nations, 2014). A plausible explanation for no cultural difference in the familiarity ratings of the cooked rice samples is that only regular rice consumers (Table 1) had participated in this study. Another unexpected outcome was that Americans liked the cooked rice samples tested in this study significantly more than did Koreans. This result might be due to the fact that Koreans, in comparison with Americans, might be more conservative in evaluating the eating quality of cooked rice as it is a staple in their everyday meals (Mohanty, 2013). In addition, compared to the Americans, the Koreans might have a more pronounced preference for specific rice varieties such as short grain rice and waxy rice because they are used to consuming a narrow range of rice varieties in their daily diet (Table 1). These assumptions are supported by Table 4. More specifically, Korean participants showed broader ranges between the highest and lowest mean ratings of either familiarity or overall liking for the eight cooked rice samples than did American participants [familiarity rating: Koreans (2.54) vs. Americans (1.76) and overall liking rating: Koreans (2.54) vs. Americans (1.60)].

Textural attributes were found to influence overall liking of cooked rice samples (Table 5; Fig. 5). While more than half of the American participants classified the visual stickiness of the eight samples as 'too much', almost 40% of Korean participants considered the visual stickiness of those samples to be 'too little', thereby decreasing overall liking of cooked rice samples. This finding suggests that both American and Korean consumers' acceptances for cooked rice can be determined, prior to first biting, by observing its visual stickiness. Previous research has found that appearance- and texture-related attributes were often used when describing 'good rice' among Korean, Japanese and French people (Son *et al.*, 2014). Moreover, the present study showed that the influential direction of visual stickiness towards acceptability of cooked rice was either positive (for Koreans) or negative (for Americans). However, the influence of the hardness attribute to acceptability of cooked rice appeared to be similar between American and Korean participants. As shown in Table 5, both 'too little' and 'too much' intensities with respect to hardness attribute could have decreased overall liking of cooked rice samples in either the American or Korean group. In addition, the mean drop values resulted from the JAR ratings of the hardness attribute were greater when cooked rice samples were considered 'too much' rather than 'too little' in both the American and Korean groups, indicating that softer cooked rice is appreciated by both cultures. However, the results of PLSR analysis showed that neither American nor Korean participants considered the hardness attribute to be important for their overall liking of cooked rice samples. Our results are to some extent in line with the findings of a questionnaire-based survey wherein the respondents who preferred short grain rice (Japanese and Korean) were not different from those who had no specific grain preference (American, Canadian, European, Australian and New Zealander) with respect to mean hardness preference for cooked rice (Suwannaporn & Linnemann, 2008). It is also worth noting that all four textural attributes produced negative standard coefficients of the PLSR among American participants. As cooked rice is not a main meal item for the majority of American people, they might have no positive preference for specific textural attributes. In contrast, because cooked rice is considered an everyday meal item for a large portion of Korean people (Table 1), they have an obvious preference for specific textural attributes, thereby resulting in positive drivers of liking, such as visual stickiness and stickiness. In addition, all four textural attributes showed positive standard coefficients of the PLSR among Korean participants.

Our findings support and extend the notion that a familiarity level is a main determinant of consumer preference for specific foods and beverages (Prescott & Bell, 1995; Sorokowska *et al.*, 2017). As shown in Fig. 5, a PLSR analysis revealed that the familiarity level serves as a pronounced contributor to overall liking of cooked rice; that impact was found to be greater than the impacts of textural attributes. In other words, participants preferred the type of cooked rice that they are used to eating in everyday life.

The results from the present study can provide a better understanding about how cultural backgrounds modulate texture perception and acceptance of cooked milled rice although further study with a large number of participants may be needed to confirm the present findings. The findings would be beneficial for breeders, sensory professionals, processors, marketers and traders in the rice industry to improve the eating quality of rice both in rice-eating and rice-importing countries.

In addition, our findings can also help foodservice business owners and culinary professionals develop and optimise their rice-based menus in the foodservice industry.

Conclusion

To summarise, this study provides empirical evidence that both texture perception and acceptance of cooked rice samples vary with cultural background, that is, between American and Korean consumers. More specifically, while American participants rated eight cooked rice samples (two short-, two medium-, two long-, and two waxy-grains) stickier and chewier, Korean participants rated those samples harder than did their counterpart. Significant interactions between cultural background and cooked rice samples were also observed in both visual and oral stickiness intensity ratings. However, American and Korean participants showed similar patterns of clustering the eight cooked rice samples. Cultural background was found to affect drivers of overall liking for cooked rice. For American participants, a chewiness attribute was identified as a negative driver. For Korean participants, visual and oral stickiness attributes were identified as positive drivers of overall liking for cooked rice. Interestingly, a familiarity level of the cooked rice sample was found to be a pronounced positive driver of overall liking for both American and Korean participants. In conclusion, this study provides a better understanding of how cultural backgrounds affect texture perception and overall liking of cooked rice. While impacts of textural attributes on overall liking of cooked rice are different between American and Korean consumers, both prefer cooked rice products that are familiar to them.

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Conflict of interest

The authors have declared that no conflict of interest exists.

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