Quality Assurance and Safety of Crops & Foods, 2017; 9 (4): 413-423

Wageningen Academic Publishers

Water to rice ratio and cooked rice texture's liking – internal preference mapping approach

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Received: 10 November 2016 / Accepted: 20 June 2017

RESEARCH ARTICLE

Abstract

This study was undertaken to determine the optimal cooking water-to-rice ratio for rice consumers and to evaluate the existence of consumer preference segmentation. One long and one medium grain rice cultivars was used in this study. Rice was cooked to either: 1.4:1.0, 1.6:1.0, 1.8:1.0, 2.0:1.0 or 2.2:1.0 water to rice ratio and 69 rice consumers were recruited to evaluate cooked rice sensory attributes. Multivariate internal preference mapping method was used to assess consumer's degree of liking and the presence of consumer's segmentation. Results indicated that 80.3 and 49.3% of consumers respectively, prefer long grain rice hardness and stickiness cooked using 2.0:1.0 water to rice ratio. Consumers of brown and parboiled rice presented 20% of the population studied; representing similar consumer percentages preferred harder cooked rice (i.e. water to rice ratio of 1.4:1.0 and 1.6:1.0 combined).

Keywords: preference mapping, water to rice ratio, consumer's liking, cooked rice

1. Introduction

Cooked rice texture is considered the primary quality indicator of consumer acceptance and preference (Sitakalin and Meullenet, 2000). Consumers from different countries are usually preferring variety of texture indicators or qualities when consuming cooked rice (Champagne *et al.*, 2010; Crowhurst and Creed, 2001). Therefore, factors that affect cooked rice texture are of vital interest and could be affected by the cooking methodology (Bergman *et al.*, 2004).

Rice cooking methodologies vary greatly and can mostly be divided into of two basic cooking techniques: the excess or American, and the exact or pilaf method. In the American cooking water method, rice is usually cooked in excess amount of water that is drained before serving while in the pilaf method, rice is often cooked in a measured amount of water (Juliano, 1982). However, for both cooking techniques texture is related to the ability of water to hydrate rice kernel's core and is correlated to rice surface area per unit weight to rice cooking duration (Bergman *et al.*, 2004; Saleh and Meullenet, 2013a). Kasai *et al.* (2005) and Juliano and Perez (1983) specifically reported that rice is usually cooked to uptake the maximum amount of water or until the core of the grain is completely gelatinised. That is probably why consumers tend to cook their rice to an end point that is usually determined by the fully hydrated rice kernel's core.

Due to its chemical composition and dimensional variations; different rice cultivars were reported to cook differently (Bett-Garber *et al.*, 2007; Del Mundo *et al.*, 1989; Khan and Ali, 1985; Saleh and Meullenet, 2007). Saleh and Meullenet (2007) for instance, indicated that disproportionate losses of lipids, protein and minor components as well as the increase in starch content significantly impacted cooked rice texture. Khan and Ali (1985) specifically reported that cooking long grain rice cultivars requires greater amount of water than medium and short grain cultivars. Therefore, the use of excess amount of water during rice cooking may result in soft, more adhesive cooked rice. Saleh and Meullenet (2013a,b) supported this hypothesis and correlated the cooked rice stickiness with the removal of

amylose leached-out during the draining step of cooked rice. Additionally, other authors have reported that, irrespective of the different cooking water used, the ability of the rice to gel and also its fibre and protein content is not affected (Chukwuemeka *et al.*, 2016).

Consumers' choice of cooked rice is usually based on their preference of various aspects of rice including grain size and cooked rice texture and flavour. For this reason, many authors have studied the effect of water to rice ratio on cooked rice texture and flavour as an indication of consumers' acceptability. Bett-Garber *et al.* (2007) indicated a significant effect of water to rice ratio on texture but not on cooked rice flavour attributes. Srisawas and Jindal (2007) also found that water to rice ratio had an impact on texture and appearance, but not the flavour of cooked rice. A decrease in sensory hardness and an increase in stickiness were reported with the increase in water to rice ratio used during cooking. However, these studies exclusively evaluated the effect of water to rice ratio on cooked rice texture and flavour by descriptive sensory analysis method, which is an objective analysis technique that can find distinct, small differences in texture attributes of rice. These small differences may not be a determination factor affecting consumer preference of the ideal water to rice ratio used during rice cooking. Consumer wider variation, on the other hand, expects to provide detailed quantification and interpretation for the overall consumer preference of the ideal cooking procedure of rice to yield an ideal cooked rice texture. Furthermore, consumer segmentation can be examined. Therefore, the objectives of this study are to map consumers' preference of rice cooked using various water to rice ratios and to investigate consumer segmentation of cooked rice quality indicators.

2. Materials and methods

Rice sampling

One medium (Bengal) and one long (Wells) grain rice cultivars were harvested at moisture contents ranging from 16.8 to 26.0% (wet bases). Rice samples were cleaned using Carter-Day Dockage Tester (Carter-Day Co., Minneapolis, MN, USA) and air dried at ambient temperature to a moisture content of ~12.5% (wet bases). Dried rough rice samples were then stored in air-tight plastic storage containers at 22±3 °C for two months before milling. Rice was milled according to the method described by Saleh and Meullenet (2013a,b).

Rice cooking

Electronic rice cookers (model #SR-W10F-5 quart capacity; Panasonic, Lake Forest, CA, USA) were used to cook all the rice samples. Water to rice ratio of 1.4:1.0, 1.6:1.0, 1.8:1.0, 2.0:1.0 and 2.2:1.0 were used as separate treatments. Approximately 400 grams of rice were combined with the required amount of water, emptied into the cooker holding chamber, covered with the vented lid, and the rice cooker was switched on 30 min prior to the scheduled presentation time to consumers. Samples remained covered throughout the cooking duration. When cooking was completed, the removable holding chamber was immediately lifted out of the heating chamber to prevent over cooking. Cooked samples were kept in a preheated (70 °C) 6 oz glass (~177 ml) bowls until presentations.

Consumer testing

Consumer testing was conducted in the consumer centre at the University of Arkansas, Fayetteville; AR. Sixty nine consumers (i.e. 87% Caucasian, 7% Asian and 3% African American and Hispanic) were recruited among the Fayetteville, AR community. Participant's rice-type consumption preference, age and cooking method of rice were also recorded. For the consumer testing, each consumer was assigned a log number, given a brief explanation of the test objectives and seated at a separate testing booth. Randomised samples (~25 grams) across treatment (hence, water to rice ratio) were served at 70 °C in Styrofoam food cups with watch glasses and identified by a three digit code and consumers were instructed to complete their evaluations before the sample reached 60 °C. Samples were presented one at a time to each of the consumers. Unsalted crackers and water were provided for panellists to rinse their palates between samples. Consumers evaluated each sample in duplicate on separate testing days and averages of both testing days were used in this study.

A ballot consisting of five questions was designed to evaluate consumers' acceptance of various aspects of the sample to be tested. A 9-point hedonic scale according to Resurreccion (1998) was used. Consumers were asked to express their overall acceptance of the product and their acceptance and texture. Consumers were also asked to intensify the overall product firmness, stickiness, glossiness and colour of each sample using Just About Right (JAR) scale.

Data analyses

Internal preference mapping as described by Meullenet *et al.* (2008) was performed to present overall impression of consumers of rice cooked using various water to rice ratio. Principal Component Analysis (PCA) of a data matrix, with water to rice ratio as rows and consumers as variables was performed using a SensGear program developed by Meullenet *et al.* (2008). Consumers and product hedonic scale data for texture and overall liking were used in the analyses. The principal components (PCs) evaluated are referred to preference dimensions as indicated by Greenhoff and MacFie (1999). Data pre-treatment included centring

for each consumer and scaling of individuals to unit variance, as suggested by Greenhoff and MacFie (1999). Consumer's preference space for preference dimensions; 1 and 2 for a PCA performed on centred overall liking data were presented with the direction of each vector representing the direction of increasing liking for each individual consumer. The amount of variance explained for each consumer is assessed by fitting a regression model using consumer scores as a response variable and the products scores on the first two dimensions. Vector Model representing un-standardised and standardised regression coefficients, respectively were estimated. Only consumers for which the regression model was significant ($\alpha<0.05$) were fitted. The length of the vector was directly proportiona1 to the amount of variance explained by the first two preference dimensions for each consumer whereas the direction of each vector represented the direction of increasing liking for each individual consumer.

3. Results and discussion

Figure 1 presents the demographics (i.e. rice type mostly consumed and consumer age group) used in this study. Almost 50% of the consumers selected were of long grain rice consumers (29% long grain rice consumers and 19% flavoured rice that is usually a long grain rice type). 16% of the population used was brown rice consumers; brown rice is the de-hulled rice where bran layers left on the grain for its nutritional value (Sudha *et al.*, 2013). Brown rice is known to require almost twice as much time and larger amounts of moisture to cook to similar texture to long grain white rice types (Daomukda *et al.*, 2011). Only 3% of consumers consumed short grain rice. Figure 1 also presents consumers age where almost 50% of the study population was between the age of 26-35 and only 5% were between the age of 18-25 and >65 years.

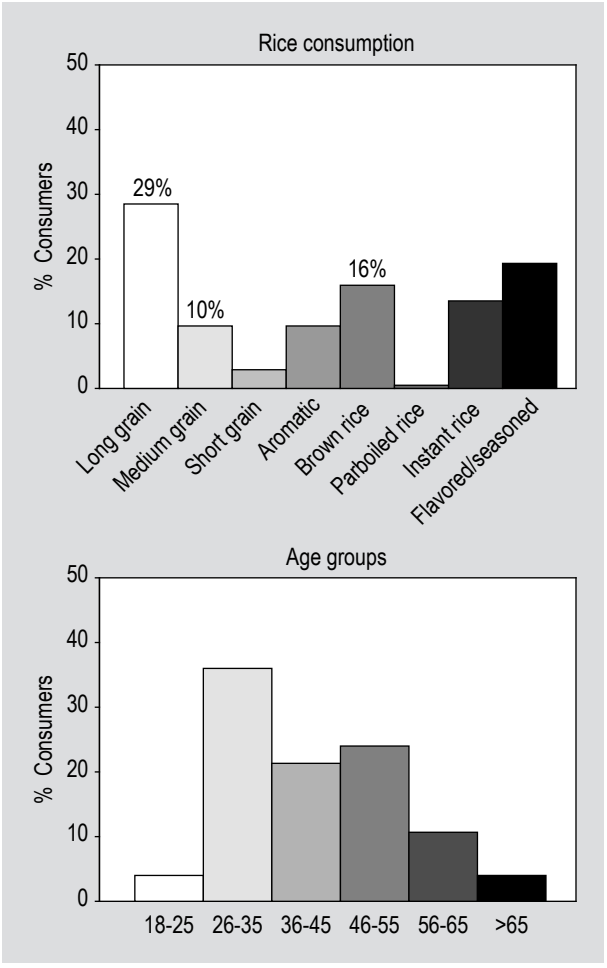

Figure 1. Demographics (type of rice consumed and age group) of consumers used in this study.

Table 1 presents the degree of overall impression liking of long and medium grain rice cooked using various water to rice ratio. Results indicated that 62.0% of the consumers scored like moderately or more of long grain rice cooked using water to rice ratio of 2.0:1.0. 58.2% and 53.5% of consumers scored like moderately or more when long grain rice was cooked using water to rice ratio of 1.8:1.0 and 2.2:1.0, respectively. Similarly 58.7% of the consumers scored like moderately of medium grain rice cooked using 2.0:1.0 water to rice ratio compared to 54.7 and 36.0% when cooking medium grain rice using water to rice ratio of 1.8:1.0 and 2.2:1.0, respectively.

Hardness and stickiness consumer's preference (JAR scale) of long and medium grain rice cooked using various water to rice ratio are presented in Figure 2. JAR scores indicated that 78.9 and 52.1% of consumers prefer long grain rice hardness and stickiness, respectively when cooked using 1.8:1.0 water to rice ratio. In the same manner, cooking medium grain using 2.0:1.0 water to rice ratio resulted in cooked rice hardness and stickiness consumer's preference of 80.3 and 49.3%, respectively. Hardness and stickiness are the two most important attributes of cooked rice that determine its palatability with hardness being the most important parameter (Meullenet *et al.*, 1998). Rice hydration during cooking is considered as a key indicator of rice textural properties with cooked rice texture depending on the cooking condition (i.e. mostly water to rice ratio) where kernels compete for water during cooking. Results are in line with Saleh and Meullenet (2013a) findings that rice kernel's surface area play a major role in determining the kinetics of rice kernels moisture absorption, thus its texture.

Cooking rice using various water to rice ratio probably resulted in changing the rate of water uptake kinetics by kernels with the greater (i.e. excess) amount of water available for kernels to absorb the less competition of kernels for water. As for cooked rice stickiness, it was long related to the amount of starch leach out during cooking as well as to the interactions of leached outs with proteins and lipids (Saleh and Meullenet, 2007). The increase in

Table 1. Values represent percentages of consumer based on their overall liking impression of medium and long grain rice cooked using various water to rice ratio.

	Water to rice ratio				
Medium grain/liking degree	1.4:1	1.6:1	1.8:1	2:1	2.2:1
Dislike extremely	0.0	1.3	0.0	1.3	0.0
Dislike very much	5.3	1.3	0.0	0.0	2.7
Dislike moderately	20.0	9.3	10.7	6.7	9.3
Dislike slightly	18.7	17.3	9.3	13.3	26.7
Neither dislike nor like	12.0	13.3	12.0	6.7	6.7
Like slightly	14.7	20.0	13.3	13.3	18.7
Like moderately	22.7	21.3	36.0	41.3	22.7
Like very much	6.7	16.0	16.0	16.0	13.3
Like extremely	0.0	0.0	2.7	1.3	0.0
Long grain/liking degree	1.4:1	1.6:1	1.8:1	2:1	2.2:1
Dislike extremely	0.0	0.0	0.0	0.0	1.4
Dislike very much	5.6	4.2	0.0	1.4	2.8
Dislike moderately	9.9	1.4	2.8	5.6	1.4
Dislike slightly	18.3	18.3	5.6	5.6	5.6
Neither dislike nor like	12.7	15.5	11.3	7.0	8.5
Like slightly	18.3	12.7	21.1	18.3	26.8
Like moderately	15.5	31.0	23.9	26.8	19.7
Like very much	14.1	15.5	29.6	29.6	29.6
Like extremely	5.6	1.4	5.6	5.6	4.2

the amount of leached out probably contributed to the increased cooked rice stickiness when cooking rice using more than 1.8:1.0 water to rice ratio. On the other hand, cooking rice in low water to rice ratio probably resulted in less amount of starch leach out combined with the enough duration for leached starch to dry out during cooking. Colour and glassy attributes followed similar trends where 1.8:1.0 and 2.0:1.0 water to rice ratios resulted in the majority of consumer's preference according to JAR scores (Figure 3).

Internal preference mapping was adapted in this study to locate the products on the maps based on consumer acceptance ratings (Meilgaard *et al.*, 2006; Meullenet *et al.*, 2008). Eigenvalues and PC scores of overall impression and consumer texture-liking of rice cooked at various water to rice ratio were calculated (data not shown). Principal component 1 and 2 were able to explain 49.76% and 21.47% of overall liking and 47.09% and 23.00% of texture liking variability, respectively. The accumulative percents of the first two principal components was able to explain more than 70% of the variability of both overall impression and texture degree of consumer liking; it is feasible to analyse texture quality of cooked rice to use the first two principal components.

Table 2 and 3 present the significance of consumer preference (Overall Liking: OL) and (Texture Liking: TX), respectively. Of the 69 consumers, 54 consumers were significantly fitted (data not shown) for overall liking and 52 for texture liking, which represents approximately 78% and 75% of the original respondents, respectively. Internal preference mapping of consumer preference space for dimensions (i.e. 1 and 2) and products overall and texture preference of cooked long grain rice are presented in Figure 4. Similar trend was reported for the medium grain rice cultivar used in this study. It is clear from the map that the vast majority of significantly fitted consumers expressed an overall impression and texture liking for rice cooked using water to rice ratio of 2.0:1.0. This was presented by the significantly fitted consumers whose preference vector to ward 2.0:1.0 water to rice ratio.

Segmentation of consumers further according to the location of their preference vectors in the map shows that particular consumers expressed liking to 1.4:1.0 and 1.6:1.0, water to rice ratio that warranted deeper investigation (Figure 4). Consumers ID 14, 27, 31, 32, 43, 49, 50, 55 and 69 showed an overall impression preference for rice cooked using 1.4:1 water to rice ratio while consumers ID 33, 42, 54, 63, 73, 67 and 78 showed an overall impression preference for rice cooked using 1.6:1.0 water to rice ratio (Figure 4). Similar trend were represented for cooked rice texture preference. More specifically, 73% of the same consumer group who preferred overall impression of rice cooked using 1.4:1.0 and 1.6:1.0 also preferred cooked rice texture

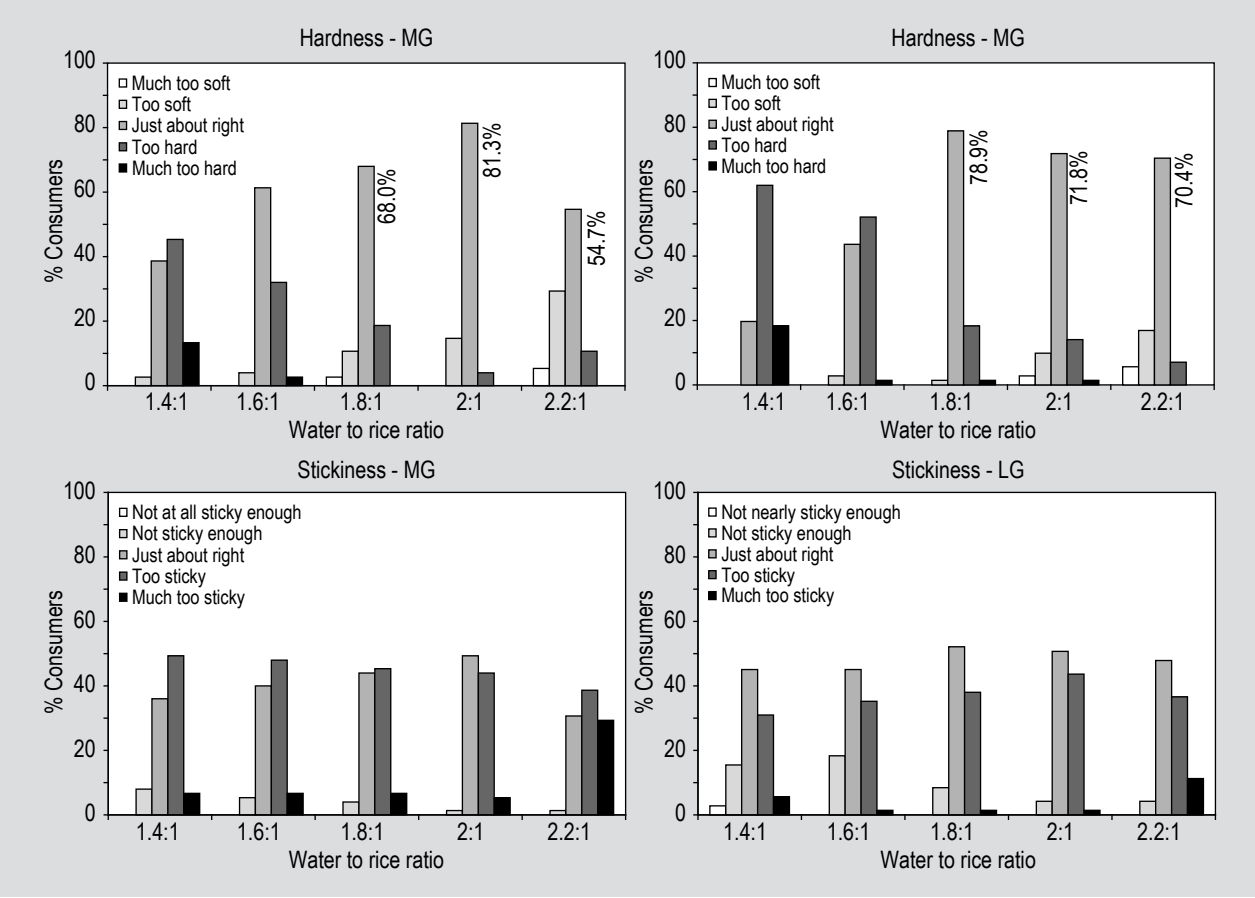

Figure 2. Just about right of consumer's hardness and stickiness preference for cooked long (LG) and medium (MG) rice using various water-to-rice ratios.

(i.e. cooked rice hardness). This indicated that cooked rice hardness play a significant role in the overall preference of consumers yielding to the selection of particular water to rice ratio during cooking.

Results also indicated that 20% of consumers participated in the study preferred overall impression and 23% of consumers preferred texture of rice cooked using water to rice ratio of 1.4:1.0 and 1.6:1.0. Further investigation of those consumers showed that those consumers are in fact brown and medium rice consumers. Of the 69 consumer participated in the study, 16% were of brown rice and 10% were of medium grain rice consumers; also presented in Figure 1. Brown rice was reported to having significantly longer cooking requirement duration than that of milled rice for any given water-to-rice ratio (Billiris *et al.*, 2012; Roy *et al.*, 2008; Sudha *et al.*, 2013). Bran layer of brown rice was reported to provide a physical barrier to water absorption resulting in greater cooking duration requirements (Champagne *et al.*, 2004). Billiris *et al.* (2012) also reported that cooked brown rice moisture content was always less than that of milled rice at a given water to rice ratio. This was related to the greater amount of steam lost with the increase in cooking duration of brown rice. Ondier *et al.* (2012) in the same manner, showed lesser equilibrium moisture content of brown rice than milled rice. Billiris *et al.* (2012) and Park *et al.* (2001) also reported a decrease in moisture content of cooked rice and an increase in water evaporation with the decrease in degree of milling. For instance, Billiris *et al.* (2012) reported a linearly increase in cooking duration of non-parboiled rice with the increase in water to rice ratio from 1.50 to 2.50. The slower water absorption rate of brown rice than milled rice agrees with our finding that cooking rice using less than 1.6:1 water to rice ratio resulted in cooked rice texture resembling those of brown and medium grain rice.

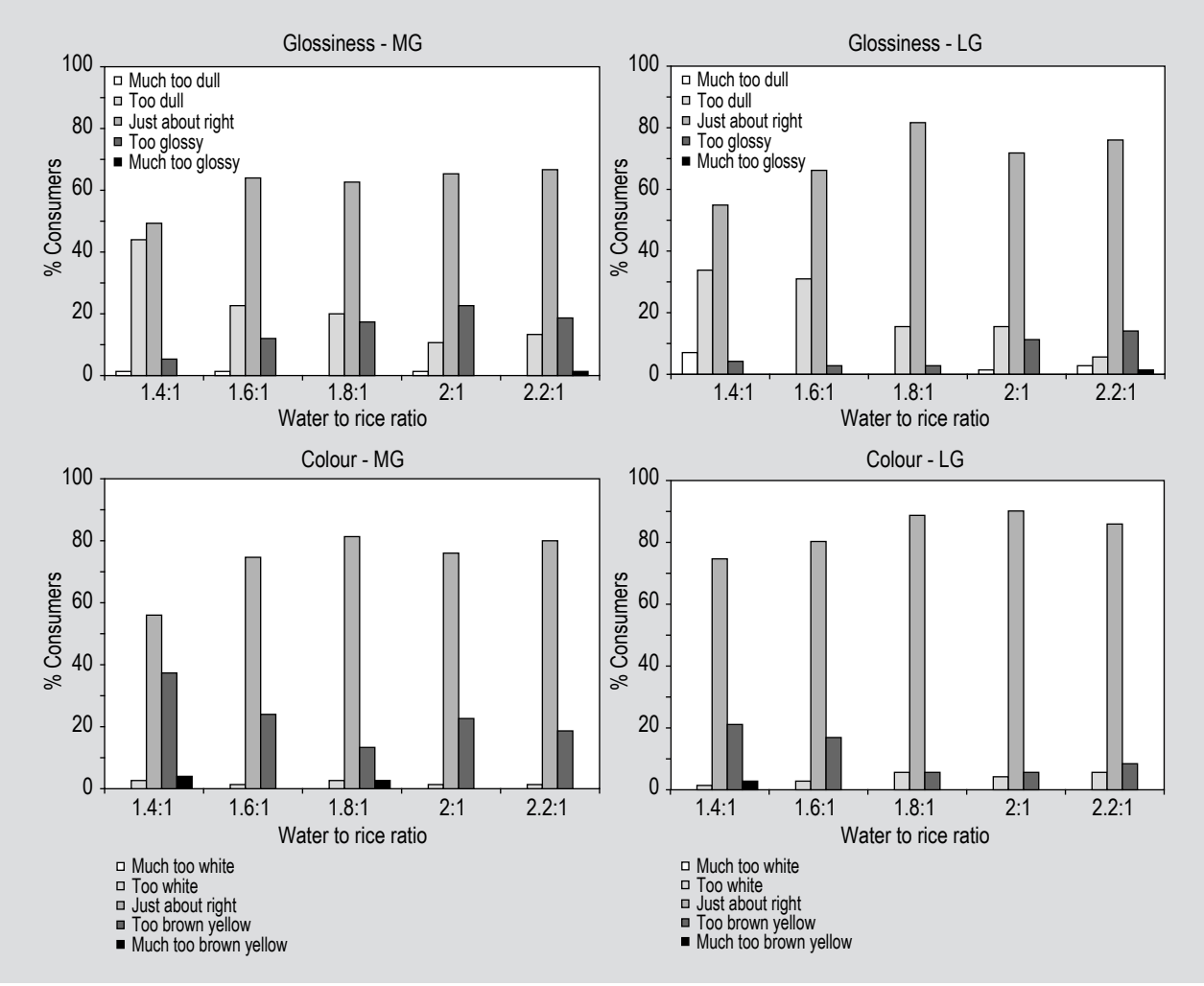

Figure 3. Just about right of consumer glossiness and colour preference for cooked long (LG) and medium (MG) rice using various water-to-rice ratios.

Table 2. Summary of individual consumer fit in preference dimensions for Overall Liking of cooked long grain rice.

Consumer ID	N	R-square	β1[1]	β2	Std. β1	Std. β2	Preference dimension 1	Preference dimension 2	Significance *P*=0.05[2]
11	5	0.7906	-0.0185	0.0408	-0.1739	0.2514	-1.7008	2.4589	*
12	5	0.9816	-0.2050	-0.0487	-0.9624	-0.1501	-10.4887	-1.6359	*
13	5	0.9654	-0.1246	0.0824	-0.7397	0.3213	-7.9945	3.4722	*
14	5	0.9864	0.0133	-0.1857	0.0856	-0.7858	0.9353	-8.5850	*
15	5	0.8727	-0.1817	0.0606	-0.8809	0.1930	-9.0516	1.9837	*
16	5	0.2453	-0.0222	-0.0217	-0.4163	-0.2676	-2.2684	-1.4578	NS
17	5	0.9654	-0.1246	0.0824	-0.7397	0.3213	-7.9945	3.4722	*
18	5	0.7955	-0.0624	-0.0872	-0.6263	-0.5750	-6.1442	-5.6413	*
19	5	0.9029	-0.2515	-0.0603	-0.9172	-0.1446	-9.5873	-1.5110	*
20	5	0.9376	-0.0621	-0.0011	-0.9513	-0.0112	-10.1327	-0.1196	*
21	5	0.9791	-0.1636	0.1044	-0.9061	0.3799	-9.8618	4.1349	*
22	5	0.9990	-0.0724	0.0749	-0.7265	0.4938	-7.9877	5.4287	*
23	5	0.8329	-0.0583	-0.1094	-0.4894	-0.6032	-4.9127	-6.0553	*
24	5	0.9487	-0.1123	0.0955	-0.7697	0.4300	-8.2469	4.6068	*
25	5	0.8208	-0.0868	0.1730	-0.5156	0.6749	-5.1385	6.7259	*
26	5	0.9554	-0.1267	0.1936	-0.6476	0.6499	-6.9627	6.9881	*
27	5	0.9888	0.1028	-0.0180	0.7876	-0.0904	8.6150	-0.9891	*
28	5	0.9102	-0.2009	-0.0708	-0.9287	-0.2150	-9.7460	-2.2566	*
29	5	0.4714	-0.0579	-0.0233	-0.5439	-0.1434	-4.1077	-1.0830	NS
30	5	0.6797	-0.0262	-0.0791	-0.1933	-0.3825	-1.7526	-3.4691	NS
31	5	0.7712	0.1977	-0.0762	0.5870	-0.1487	5.6706	-1.4362	NS
32	5	0.9240	0.0740	-0.0719	0.3931	-0.2508	4.1564	-2.6516	*
33	5	0.7893	0.1873	0.0909	0.8177	0.2608	7.9915	2.5488	*
34	5	0.8536	-0.2110	0.1708	-0.7768	0.4132	-7.8945	4.1991	*
35	5	0.6804	0.0230	0.0232	0.1762	0.1168	1.5988	1.0598	NS
36	5	0.9520	-0.1034	0.3029	-0.3702	0.7125	-3.9731	7.6467	*
37	5	0.9437	-0.0189	-0.0453	-0.2241	-0.3536	-2.3942	-3.7790	*
38	5	0.9949	-0.2019	-0.3291	-0.6756	-0.7233	-7.4124	-7.9355	*
39	5	0.8584	-0.0030	0.1097	-0.0297	0.7235	-0.3027	7.3737	*
40	5	0.6804	0.0115	0.0116	0.1762	0.1168	1.5988	1.0598	NS
42	5	0.9604	0.0295	0.0554	0.5548	0.6837	5.9806	7.3699	*
43	5	0.6834	0.0399	-0.0206	0.7488	-0.2538	6.8092	-2.3080	NS
44	5	0.9967	-0.0916	-0.0565	-0.9193	-0.3728	-10.0961	-4.0939	*
45	5	0.9835	-0.1019	0.0195	-0.9570	0.1200	-10.4397	1.3094	*
46	5	0.9562	-0.1387	-0.2404	-0.5684	-0.6470	-6.1141	-6.9596	*
47	5	0.8337	-0.0660	-0.2292	-0.3505	-0.7996	-3.5203	-8.0305	*
48	5	0.9134	-0.0609	0.0865	-0.4485	0.4184	-4.7147	4.3990	*
49	5	0.7021	-0.0333	0.0528	-0.3344	0.3482	-3.0823	3.2090	NS
50	5	0.9212	0.1142	-0.0064	0.6325	-0.0231	6.6782	-0.2442	*
51	5	0.9403	-0.0506	0.0105	-0.6004	0.0818	-6.4042	0.8723	*
52	5	0.9414	-0.2116	-0.0809	-0.9237	-0.2320	-9.8582	-2.4764	*
53	5	0.2453	-0.0222	-0.0217	-0.4163	-0.2676	-2.2684	-1.4578	NS
54	5	0.8562	0.0313	0.4859	0.0890	0.9087	0.9062	9.2496	*
55	5	0.8593	0.0757	-0.0985	0.4494	-0.3843	4.5827	-3.9188	*
56	5	0.8262	-0.0543	0.1187	-0.5101	0.7322	-5.1003	7.3206	*
57	5	0.8849	-0.0839	0.0633	-0.8419	0.4173	-8.7111	4.3178	*
58	5	0.5494	-0.0049	0.0206	-0.0273	0.0750	-0.2228	0.6119	NS
59	5	0.8708	0.0397	-0.2774	0.1606	-0.7378	1.6485	-7.5738	*
60	5	0.7152	-0.0735	-0.0127	-0.7381	-0.0838	-6.8666	-0.7797	NS
62	5	0.9036	-0.2187	0.051	-0.8959	0.1372	-9.3682	1.4344	*
63	5	0.9386	0.1208	0.0259	0.8897	0.1252	9.4810	1.3338	*

Table 2. Continued.

Consumer ID	N	R-square	β1[1]	β2	Std. β1	Std. β2	Preference dimension 1	Preference dimension 2	Significance *P*=0.05[2]
64	5	0.9915	-0.1829	-0.027	-0.9711	-0.0941	-10.6366	-1.0312	*
65	5	0.9604	-0.0295	-0.0554	-0.5548	-0.6837	-5.9806	-7.3699	*
66	5	0.4608	-0.0547	0.0326	-0.5488	0.2151	-4.0979	1.6060	NS
67	5	0.9689	0.0107	0.0101	0.2005	0.1245	2.1711	1.3480	*
68	5	0.8684	-0.0946	0.0532	-0.7940	0.2934	-8.1395	3.0081	*
69	5	0.9464	0.0913	-0.0296	0.9159	-0.1949	9.8011	-2.0853	*
70	5	0.9883	-0.2848	-0.0075	-0.9930	-0.0172	-10.8585	-0.1884	*
71	5	0.8919	-0.0218	0.0644	-0.4098	0.7944	-4.2577	8.2529	*
72	5	0.8886	0.0077	0.1198	0.0917	0.9348	0.9505	9.6934	*
73	5	0.9146	0.2305	0.1262	0.8926	0.3212	9.3903	3.3792	*
74	5	0.9073	-0.2272	-0.0704	-0.9200	-0.1872	-9.6400	-1.9614	*
75	5	0.7290	-0.0954	0.0517	-0.7024	0.2501	-6.5970	2.3489	NS
76	5	0.9017	-0.1459	0.0622	-0.9134	0.2556	-9.5403	2.6702	*
77	5	0.6834	-0.0399	0.0206	-0.7488	0.2538	-6.8092	2.3080	NS
78	5	0.6804	0.0115	0.0116	0.1762	0.1168	1.5988	1.0598	NS
79	5	0.8584	-0.0030	0.1097	-0.0297	0.7235	-0.3027	7.3737	*
80	5	0.9312	-0.1353	0.0723	-0.8711	0.3058	-9.2465	3.2456	*
81	5	0.9962	-0.1747	0.0083	-0.8926	0.0277	-9.8000	0.3042	*

[1] Estimates of Vector Model (β's and Std. β's represent un-standardised and standardised regression coefficients respectively).
[2] NS represents the non-significance consumer overall liking preference.

Table 3. Summary of individual consumer fit in preference dimensions for Texture (i.e. Hardness) preference of cooked long grain rice.

Consumer ID	N	R-square	β1[1]	β2	Std. β1	Std. β2	Preference dimension 1	Preference dimension 2	Significance *P*=0.05[2]
11	5	0.7439	-0.0169	0.1153	-0.1467	0.6993	-1.7710	8.4439	NS
12	5	0.9888	-0.1572	0.0280	-0.9837	0.1226	-13.6943	1.7062	*
13	5	0.9499	-0.2082	0.2280	-0.7282	0.5574	-9.9361	7.6057	*
14	5	0.7234	-0.0498	0.2540	-0.2102	0.7489	-2.5026	8.9177	NS
15	5	0.9052	-0.1589	-0.0694	-0.9080	-0.2769	-12.0944	-3.6879	*
16	5	0.9952	0.0039	0.0583	0.0867	0.9017	1.21060	12.5936	*
17	5	0.8322	-0.1563	0.0295	-0.8512	0.1121	-10.8707	1.4321	*
18	5	0.7890	-0.1360	-0.0709	-0.5903	-0.2150	-7.3408	-2.6734	*
19	5	0.9656	-0.1503	0.1432	-0.7948	0.5294	-10.9341	7.2827	*
20	5	0.9346	-0.0218	-0.0647	-0.3943	-0.8164	-5.3364	-11.0501	*
21	5	0.9346	-0.0655	-0.1940	-0.3943	-0.8164	-5.3364	-11.0501	*
22	5	0.1827	-0.0247	-0.0013	-0.3461	-0.0130	-2.0713	-0.0778	NS
23	5	0.7424	-0.0786	0.0741	-0.6817	0.4495	-8.2230	5.4225	NS
24	5	0.9952	-0.0039	-0.0583	-0.0867	-0.9017	-1.2106	-12.5936	*
25	5	0.9756	-0.1252	-0.1121	-0.7835	-0.4902	-10.8344	-6.7791	*
26	5	0.9966	-0.1650	-0.0886	-0.8989	-0.3373	-12.5632	-4.7144	*
27	5	0.6816	0.0602	-0.2183	0.2806	-0.7117	3.2428	-8.2260	NS
28	5	0.9854	-0.1724	0.2407	-0.7081	0.6911	-9.8407	9.6048	*
29	5	0.7251	-0.1102	-0.0424	-0.8128	-0.2186	-9.6893	-2.6057	NS
30	5	0.8933	-0.0707	0.1908	-0.4425	0.8343	-5.8557	11.0388	*
31	5	0.9454	0.2358	-0.2900	0.6941	-0.5966	9.4487	-8.1210	*
32	5	0.9141	0.0549	-0.1417	0.3662	-0.6604	4.9010	-8.8400	*

Table 3. Continued.

Consumer ID	N	R-square	β1[1]	β2	Std. β1	Std. β2	Preference dimension 1	Preference dimension 2	Significance *P*=0.05[2]
33	5	0.1542	0.0482	-0.1109	0.2073	-0.3332	1.1399	-1.8318	NS
34	5	0.9522	-0.1958	-0.2037	-0.7597	-0.5525	-10.3792	-7.5480	*
35	5	1.0000	-0.0925	-0.0618	-0.5569	-0.2600	-7.7962	-3.6397	*
36	5	0.9989	-0.1429	-0.2806	-0.5771	-0.7921	-8.0751	-11.0837	*
37	5	0.7604	-0.0696	0.0300	-0.7694	0.2323	-9.3930	2.8358	NS
38	5	0.9996	-0.1771	-0.0069	-0.6196	-0.0169	-8.6729	-0.2367	*
39	5	0.4751	-0.0568	0.0186	-0.6719	0.1535	-6.4835	1.4810	NS
40	5	0.5963	0.0439	-0.0328	0.3546	-0.1853	3.8339	-2.0028	NS
42	5	0.8648	-0.0448	0.0314	-0.8096	0.3961	-10.5403	5.1571	*
43	5	0.6885	0.0466	0.0660	0.5151	0.5102	5.9836	5.9270	NS
44	5	0.9033	-0.0487	-0.0269	-0.8804	-0.3401	-11.7144	-4.5260	*
45	5	0.9066	-0.1550	-0.0110	-0.9335	-0.0464	-12.444	-0.6189	*
46	5	0.9482	-0.1789	-0.1043	-0.6257	-0.2550	-8.5305	-3.476	*
47	5	0.9954	-0.0538	0.0755	-0.5953	0.5833	-8.3157	8.1478	*
48	5	0.9660	-0.1847	-0.1923	-0.7938	-0.5777	-10.9223	-7.9494	*
49	5	0.8261	0.0806	-0.0187	0.6119	-0.0990	7.7863	-1.2604	*
50	5	0.8254	-0.0236	-0.1620	-0.1738	-0.8352	-2.2112	-10.6228	*
51	5	0.6018	-0.0693	-0.1321	-0.4624	-0.6159	-5.0215	-6.6887	NS
52	5	0.9806	-0.2346	-0.0586	-0.9722	-0.1696	-13.4781	-2.3516	*
53	5	0.7664	0.0098	0.0519	0.1775	0.6547	2.1758	8.0245	NS
54	5	0.8639	-0.0573	-0.0259	-0.1657	-0.0524	-2.1562	-0.6821	*
55	5	0.9844	0.0317	0.1165	0.3132	0.8058	4.3505	11.1930	*
56	5	0.9844	-0.0317	-0.1165	-0.3132	-0.8058	-4.3505	-11.1930	*
57	5	0.8335	-0.0666	-0.0333	-0.7881	-0.2752	-10.0731	-3.5168	*
58	5	0.9690	-0.0476	-0.1877	-0.3328	-0.9175	-4.5867	-12.6451	*
59	5	0.9622	0.2577	-0.2254	0.7686	-0.4698	10.5551	-6.4519	*
60	5	0.8618	-0.0936	0.0044	-0.9256	0.0307	-12.0305	0.3985	*
62	5	0.9425	-0.1513	0.0216	-0.8946	0.0891	-12.1588	1.2114	*
63	5	0.9949	0.0855	0.0411	0.9455	0.3176	13.2029	4.4346	*
64	5	0.6901	-0.1192	0.0017	-0.7777	0.0076	-9.0449	0.0885	NS
65	5	0.9989	-0.0577	0.0171	-0.6387	0.1325	-8.9368	1.8534	*
66	5	0.5760	-0.0338	-0.0775	-0.4000	-0.6403	-4.2501	-6.8034	NS
67	5	0.8180	-0.0059	0.0065	-0.1068	0.0815	-1.3518	1.0321	*
68	5	0.8335	-0.0666	-0.0333	-0.7881	-0.2752	-10.0731	-3.5168	*
69	5	0.9984	0.0816	-0.0172	0.9645	-0.1425	13.4918	-1.9933	*
70	5	0.9725	-0.2289	0.0971	-0.9405	0.2789	-12.985	3.8502	*
71	5	0.8648	-0.0448	0.0314	-0.8096	0.3961	-10.5403	5.1571	*
72	5	0.7957	0.0239	-0.0946	0.2075	-0.5738	2.5912	-7.1653	*
73	5	0.9762	0.2328	-0.0388	0.9650	-0.1124	13.348	-1.5548	*
74	5	0.9033	-0.1949	-0.1078	-0.8804	-0.3401	-11.7144	-4.5260	*
75	5	0.5963	-0.0439	0.0328	-0.3546	0.1853	-3.8339	2.0028	NS
76	5	0.9204	-0.1360	-0.2856	-0.5200	-0.7630	-6.9843	-10.2480	*
77	5	0.9209	-0.0676	-0.0347	-0.7990	-0.2870	-10.7345	-3.8561	*
78	5	0.9346	-0.0218	-0.0647	-0.3943	-0.8164	-5.3364	-11.0501	*
79	5	0.7082	-0.0564	-0.1179	-0.3945	-0.5763	-4.6482	-6.7894	NS
80	5	0.9163	-0.1731	-0.0431	-0.9156	-0.1593	-12.2699	-2.1350	*
81	5	0.9800	-0.2099	-0.0572	-0.9577	-0.1826	-13.2736	-2.5302	*

[1] Estimates of Vector Model (β's and Std. β's represent un-standardised and standardised regression coefficients respectively).

[2] NS represents the non-significance consumer Texture preference.

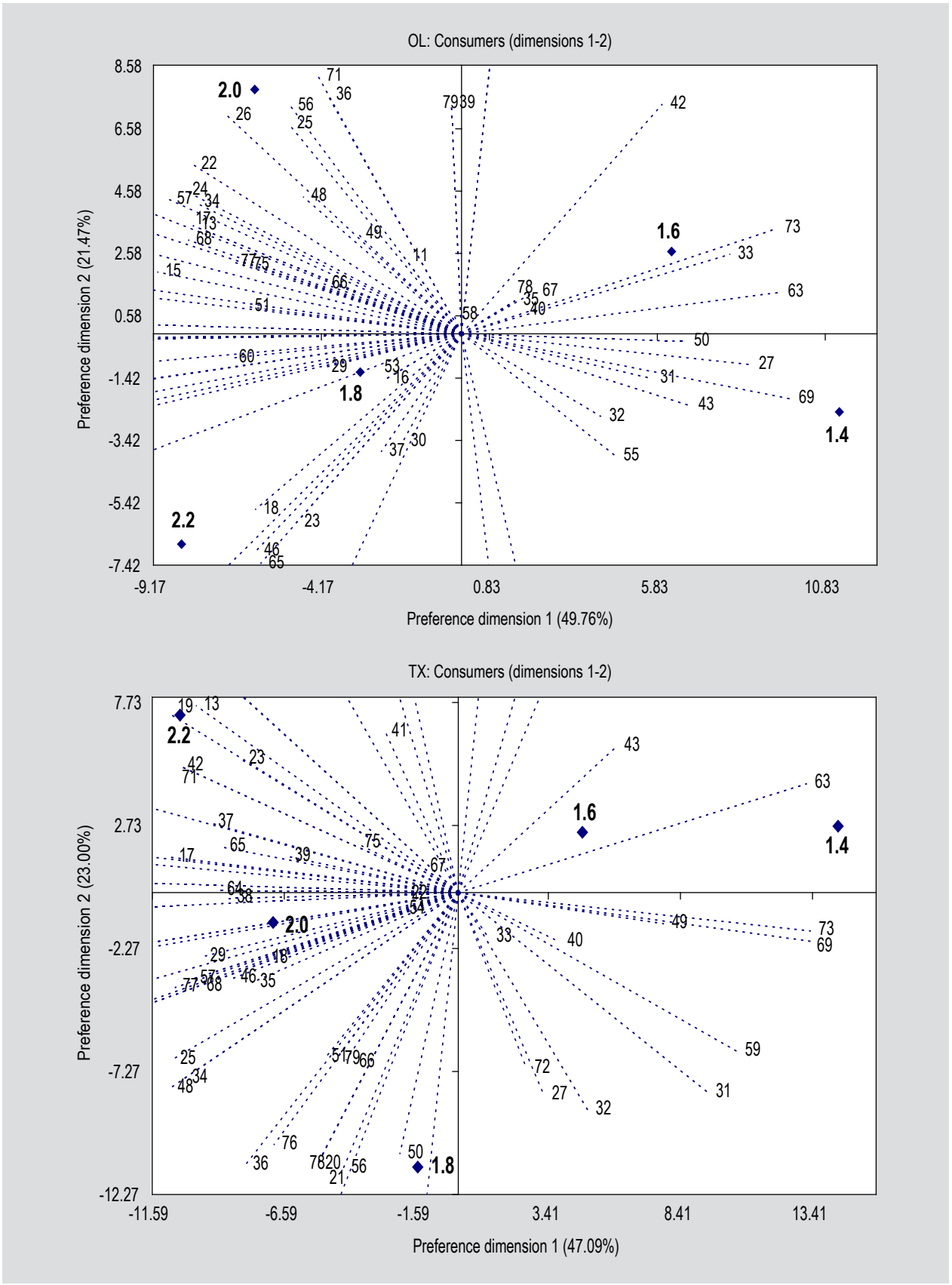

Figure 4. Internal preference mapping of significant (α=0.05) consumer's Overall Liking (OL) and Texture Liking (TX) of cooked long grain rice using various water-to-rice ratios. The direction of each vector represents the direction of increased liking for consumer and the length of each vector is directly proportional to the amount of variance explained by the first two preference dimensions.

Conclusions

Cooked rice hardness and stickiness are the two most influential textural properties that determine cooked rice preference. The ability of water to hydrate the core of rice kernels during cooking seems to derive consumer liking. Multivariate internal preference mapping method was used as a powerful tool to assess consumer's degree of liking and to determine if there is consumer segmentation. Consumers were segmented into several sectors depending on their liking preference. Cooking rice in water to rice ratio of 1.8:1.0 and 2.0:1.0 were the most appropriate levels for a majority of consumers (i.e. 70%). Long and medium grain rice consumers preferred higher water to rice ratio compared to brown and parboiled rice consumers. Consumers of brown and parboiled rice presented 20% of the population studied. Participants of this study were randomly selected and were mostly of Caucasian descent; consumers of specific target groups may present an interest group to study.

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