RICE EXTERNAL PREFERENCE MAPPING FOR ASIAN CONSUMERS LIVING IN THE UNITED STATES

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Received for Publication October 24, 1999

ABSTRACT

Twenty-one rice samples covering examples of aromatic, long and medium grain, instant, and parboiled products were evaluated by a group of 120 Asian consumers, currently living in the United States and by a professionally trained sensory panel. Results showed that imported Thai Jasmine rice was preferred by this group of Asian consumers over every other rice tested including domestically grown Jasmine rice. The most important acceptance factors for Asian consumers were cooked rice appearance and aroma. Predictive models of rice overall acceptance were evaluated using descriptive sensory evaluation data (i.e. including appearance, flavor and texture attributes). These models allowed the identification of sensory characteristics most important to rice acceptance by this consumer group. This information could be useful to rice breeders to select for specific sensory characteristics expected by Asian consumers.

INTRODUCTION

Per capita rice consumption in the US has risen from 10.25 lb in 1980 to 21.33 lb in 1997 (USA Rice Council 1998). Convenience and nutritional value continue to be contributing factors to the increasing rice consumption throughout the US and consumers are now beginning to appreciate the versatility of this American grown grain (Meyers 1998). An emerging trend in US rice consumption is the growing market share attributed to imported specialty varieties such as Thai Jasmine and Basmati rice and the US Asian population is the primary consumer of these specialty rices (USA Rice Council 1998). The US Asian

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population is the fourth largest ethnic group in the US and the fastest-growing group in all regions (Campbell 1996). Additionally, rice consumption by Asian ethnic groups is usually about ten times more than the average for the US population (i.e. 150-200 lb per capita consumption) (Goodwin 1992). It is projected that the US Asian population will increase by more than 11 million by 2015.

Rice imports to the US have grown by 85% since 1990 while the overall rice consumption has increased only 20%. The rice imports to the US come primarily from Thailand (73%), India (13%), Vietnam (7%), and Pakistan (3%) demonstrating that Thai Jasmine and Basmati varieties represent most of the import market (USA Rice Council 1998). The total retail value of aromatic rice imported for 1998 was projected to be $240 million for a total of 285,000 metric tons.

Specialty rice varieties such as Thai Jasmine, grown in Thailand, and Basmati, grown in southern Asia are generally not adapted to growing conditions found in the US. However, breeding programs in the US have devoted some efforts to adapting specialty rice varieties to climatic conditions found in North America. US Rice growers have not been able to capitalize on this growing market for aromatic rice varieties. Goodwin (1992) reported that the source of the obvious shortcomings of domestically grown aromatic rice varieties was unclear. As a result, rice breeders in the US need useful information on the sensory characteristics of rice (e.g. appearance, aroma, flavor and texture) that Asian consumers expect.

Aromatic rice is one that has a distinctive fragrant odor due to naturally occurring aroma and flavor compounds. Paule and Powers (1989) used US and Asian panelists to describe the flavor of aromatic varieties. US judges used the term 'popcorn-like' while Asian judges termed the flavor as 'pandan-like' (i.e., Pandan tree leaves are used for seasonings in Asian countries). It has been suggested that the main compound responsible for the popcorn-like note was 2-Acetyl Pyrroline (Buttery *et al.* 1982; Widjaja *et al.* 1996). It is also well known that Asian consumers are very specific with their expectations of rice quality and it very unlikely that the presence of aromatic compounds such as 2-Acetyl Pyrroline is the only determinant of rice acceptance by Asian consumers.

The work reported here was designed as a preliminary study to determine preferences by Asian consumers for rice and to quantify specific sensory characteristics present in both imported and domestically produced rice. More specifically, the objectives of this preliminary study were (1) to determine the drivers of rice acceptance among Asian consumers (2) and to evaluate predictive models of Asian consumers' acceptance of rice from descriptive sensory data.

MATERIALS AND METHODS

Samples

Twenty-one rice samples (Table 1), obtained from either major rice processors or purchased from local supermarkets, were collected and prepared for testing. Samples used in this study included: domestic and imported Jasmine, domestic and imported Basmati, domestic long and medium grain, and parboiled and instant rice. Each sample was premeasured to yield six 4-ounce servings, placed into a plastic bag (Glad Sandwich Bags), coded with a 3-digit number and sealed. The coded and sealed samples were then placed in plastic, airtight storage buckets. The buckets were then stored in a commercial walk-in refrigerator (4C) until ready for testing. A list of samples and their respective cooking procedures are presented in Table 1.

Sample Preparation

Rice samples were retrieved from cold storage and allowed to temper for approximately 12 h before cooking. Rice cookers (Rice-O-Mat, National Brand: model #SR-w10F-5 quart capacity) were used to prepare imported and domestic aromatic rices, long grain and medium grain rice varieties. Samples were prepared using a 2:1 water to rice ratio (200 g of rice in 400 mL of water). The rice sample and water were emptied into the cooker holding chamber, covered with a vented lid, and the rice cooker switched to "on" twenty-one minutes prior to the scheduled presentation time to either the consumer panel or the trained descriptive panel. The 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 overcooking or scorching.

The instant and parboiled samples were prepared in six quart, stainless steel saucepans with lids according to the manufacturer's instructions (Table 1). An electric portable buffet range (Munsey Brand, model #702-1650 watt) was used to cook these products. Cooking duration ranged from 10-30 min depending on the sample (Table 1). After cooking, the samples were immediately removed from heat to prevent scorching. Samples were then fluffed using a plastic fork.

For the descriptive panel, the sample was dipped into preheated (165F) 6 oz glass bowls. The heated glass bowls were then placed inside styrofoam cups and covered with coded watch glasses. For the consumer test, the rice was spooned into a coded Styrofoam food cup (WinCup Brand 8FC) and covered with an air-tight lid (WinCup Brand-FL13108).

TABLE 1.
RICE SAMPLES AND COOKING PROCEDURES

Product Name	Water to Rice Ratio (vol/vol)	Cooking Instructions
Aromatic Rice		
Della (dB_1)	2:1	Cook for 21 Min.
Rice Tec Kasmati (dB_2)	2:1	Cook for 21 Min.
Rice Tec Jasmati (dJ)	2:1	Cook for 21 Min.
Rice Tec Texmati (dA)	2:1	Cook for 21 Min.
Thai Kitchen Jasmine (iJ_1)	2:1	Cook for 21 Min.
Dragon 88 Jasmine (iJ_2)	2:1	Cook for 21 Min.
Double Horse Jasmine (iJ_3)	2:1	Cook for 21 Min.
Basmati Sharda (iB_1)	2:1	Cook for 21 Min.
Basmati Royal (iB_2)	2:1	Cook for 21 Min.
Instant Rice		
Boil in Bag (Kraft Minute Rice) (I_1)	1 2/3 : 2	Boil water. Submerge bag & cook for 5 min.
Riceland Quickcook (I_2)	1 2/3:2	Bring water & rice to boil. Let simmer for 20 min. Let stand for 5 min.
Minute Rice (Kraft) (I_3)	1 1/3:2	Boil water. Stir in rice and let stand for 5 min.
Minute Rice Premium (Kraft) (I_4)	1 2/3:2	Boil water. Stir in rice. Let stand for 5 min.
Long Grain Rice		
Riceland (L_1)	2:1	Cook for 21 Min.
Producers Rice Mill (L_2)	2:1	Cook for 21 Min.
Mahatma (Riviana) (L_3)	2:1	Cook for 21 Min.
Medium Grain Rice		
Gulf Coast (M_1)	2:1	Cook for 21 Min.
Riceland (M_2)	2:1	Cook for 21 Min.
Parboiled Rice		
Riceland Instant Parboiled (P_1)	2:2	Cook for 20 min. Let stand for 5 min.
Riceland Parboiled (P_2)	2 1/4:1	Cook for 20 min. Let stand for 5 min.
Uncle Bens (P_3)	3 1/3: 1 2/3 cups	Cook for 20 min. Let stand for 5 min.

Descriptive Analysis

An 11 member panel, professionally trained in descriptive analysis of rice (Spectrum Method, Meilgaard *et al.* 1991) and employed by the University of Arkansas Institute of Food Science & Engineering, evaluated 5 visual, 16 flavor and 11 texture attributes for all 21 rice samples. Visual, flavor and texture attributes of cooked rice were developed by the trained panelists in three orientation sessions (Meullenet *et al.* 1998). During orientation, a frame of reference, which represented as many as possible of the attribute differences likely to encountered in rice, was presented to the panel. These reference samples assisted the panel in developing descriptors and appropriate techniques. The visual, flavor and texture lexicons used to describe the attributes evaluated, their definitions, and references used are described in Tables 2, 3 and 4, respectively. Samples were unimodally (i.e., one at a time) presented to panelists in individual booths featuring controlled lighting and positive air pressure. Panelists quantified all attributes on a 0 to 15 continuous scale. Scores for each attribute were given by panelists using paper ballots. Rice samples were presented at a temperature of 160F and the panelists were instructed to complete their evaluation before the sample reached 140F (i.e. digital thermometers were provided to each panelist). Crackers and water were provided for panelists to clean and rinse their palate between samples. Sample serving order was randomized across treatments and all panelists evaluated each of the 21 samples in duplicate on separate testing days.

TABLE 2.
DESCRIPTIVE VISUAL LEXICON

TERM	DEFINITION	REFERENCE
DEGREE OF WHITENESS V_1	The degree to which the sample is visually pure white	Uncle Ben's parboiled (5.0) Thai Kitchen Jasmine (11.0)
STICKINESS V_2	The degree to which grains stick together. Fluff sample with fork to evaluate degree to which kernels stick together.	Thai Kitchen Jasmine (1.5) Uncle Ben's parboiled (3.0)
GRAIN INTEGRITY V_3	The degree to which grains are cracked. Observe the sample and determine to which kernels are split.	Uncle Ben's parboiled (0.0) Thai Kitchen Jasmine (2.5)
SURFACE ROUGHNESS V_4	The degree to which kernels are rough. Observe and determine the degree of roughness.	Uncle Ben's parboiled (1.5) Thai Kitchen Jasmine (4.0)
GLOSS V_5	The degree to which kernels shine. Observe and determine the degree of shine.	Thai Kitchen Jasmine (10.0) Uncle Ben's parboiled (13.0)

TABLE 3.
DESCRIPTIVE AROMATICS AND BASIC TASTES LEXICON

TERM	DEFINITION	REFERENCE
STARCHY F_1	The aromatic associated with the starch of a particular grain source.	Rice flour paste; Rice flour in water.
COOKED GRAIN F_2	A general term used to describe the aromatics of raw or cooked grains, which cannot be tied to a specific grain	Cereal Grains: 2methyl pyrazene
FEEDY F_3	The aromatic associated with a mixture of grains reminiscent of animal feed.	Chicken Feed Bran Buds
WET CARDBOARD/ PAPERY F_4	The aromatic associated with early stages of oxidation.	Place wet cardboard in a reference jar and sniff.
NUTTY F_5	The aromatic associated with nuts or nut meats which cannot be tied to a specific origin.	Toasted Wheat Germ
SULFUR F_6	The aromatic associated with Hydrogen sulfide, boiled or rotten eggs	Boiled Eggs, Struck Match, Sewer Gas, Cooked Cabbage
HEATED OIL F_7	The aromatic associated with fresh oil that has been heated: not indicative of any oxidized or "off" notes.	Heated Vegetable Oil Heated Cottonseed Oil
METALLIC F_8	1) The aromatic associated with metals, tinny or irony. 2) A flat chemical feeling factor stimulated on the tongue and teeth by metal (coins, tin foil).	Pineapple Can, Tin Foil
DAIRY NOTE F_9	The aromatic associated with an off or negative note reminiscent of soured or old dairy products.	Soured milk
BURLAP F_{10}	The aromatic associated with burlap.	Burlap Rice Bags
FLORAL/MINTY F_{11}	The aromatic associated with a nonspecific floral note and sometimes described as minty.	Jasmine Scent
WOODY F_{12}	The aromatic associated with a nonspecific wood note	Heptanol
ASTRINGENCY F_{13}	The chemical feeling factor associated with the shrinking and puckering of the tongue caused by substances such as tannins or alum.	Grape juice (Welch's) Tea bags/1 h soak
SWEET B_1	The basic taste on the tongue stimulated by sugars and high potency sweeteners.	Solutions of sucrose and spring water
SALT B_2	The basic taste on the tongue stimulated by sodium chloride	Solutions of sodium chloride and spring water
SOUR B_3	The basic taste on the tongue stimulated by acids.	Solutions of citric acid in spring water
BITTER B_4	The basic taste on the tongue stimulated by solutions by substances such as quinine and certain other alkaloids.	Solutions of caffeine and spring water

TABLE 4.
DESCRIPTIVE TEXTURE LEXICON

TERM	DEFINITION	TECHNIQUE
INITIAL		
SAMPLE COHESIVENESS T_1	The degree to which the unchewed sample holds or sticks together.	Place ¼ teaspoon of sample in mouth and immediately evaluate how tightly the mass is sticking or holding together.
MASS SIZE T_2	The amount of space the particle takes up in the mouth.	Place sample in center of mouth and evaluate.
PARTIAL COMPRESSION		
ADHESION TO LIPS T_3	The degree to which the sample adheres to the lips.	Compress sample between lips, release and evaluate the degree to which the product remains on the lips.
FIRST BITE / CHEW		
HARDNESS T_4	The force required to compress the sample.	Compress or bite through sample one time with molars or incisors.
COHESIVENESS T_5	The amount the sample deforms rather than splits apart, cracks or breaks.	Place sample between the molar teeth and compress fully. May also be done with incisors.
CHEWDOWN		
COHESIVENESS OF MASS T_6	The amount that the chewed sample holds together.	Chew sample with molar teeth up to 15 times and evaluate.
MACRO ROUGHNESS OF MASS T_7	The amount of roughness perceived on the surface of the chewed sample.	Chew the sample with molars and evaluate the irregularities on the surface of the sample mass.
TOOTHPULL T_8	The force required to separate the jaws during mastication.	Chew sample 2 - 3 times and evaluate.
RESIDUAL		
RESIDUAL FILM T_9	The amount and degree of residue felt by the tongue when moved over the surface of the mouth.	Swallow the sample and feel the surface of the mouth with the tongue to evaluate.
TOOTHPACK T_{10}	The amount of product packed into the crowns of your teeth after mastication.	Chew sample 10-15 times, expectorate and feel the surface of the crowns of the teeth to evaluate.
LOOSE PARTICLES T_{11}	The amount of particles remaining in and on the surface of the mouth after swallowing.	Chew sample with molars, swallow and evaluate.

Consumer Testing

The consumer test was conducted in the food court of a national retail store and in the consumer testing facilities of the Center for Poultry Excellence at the University of Arkansas. Asian consumers (120) were recruited among the

Fayetteville, AR community and the foreign student population at the University of Arkansas. Participants belonged to one of ten nationalities including southern and southeastern Asian countries. Among this consumer group, 51% originated from Southeastern Asia (Indonesia, Malaysia, Thailand, etc.), 36% from China, and 13% from Southern Asia (India, Sri Lanka, and Bangladesh). Of these consumers, 50% indicated white rice as their favorite rice while 38% and 12% preferred Jasmine and Basmati, respectively. In addition, 75% of the consumers had consumed aromatic rice within 30 days of the test. To encourage participation, a $10 gift certificate was offered upon completion of the test. Each consumer was assigned a log number, given a brief explanation of the test objectives and seated at a test booth with foam board partitions. Once seated and briefed, each person received an 8-page questionnaire about his or her rice consumption habits to complete before testing began. Each consumer was provided with a Styrofoam tray (Formpac), a ballot, individually wrapped spoons (Clear Shield National INC., Shreveport, LA), napkins and a cup of water. Samples were presented in styrofoam food cups with lids and identified by a three digit code. From the 21 rice samples, each consumer monadically evaluated a subset of seven samples selected according to a Balanced Incomplete Block design (Cochran and Cox 1957). Consumers were asked to record the three-digit code for the rice sample about to be tasted on the ballot provided. The ballot consisted of five questions designed to evaluate the consumers' acceptance of various aspects of the sample to be tested. A 9-point verbal hedonic scale, a scale that records the likes, dislikes, preferences and acceptance of a product (Resurreccion 1998) was used. Consumers were asked to express their overall acceptance of the product and their acceptance of the appearance, aroma, flavor, and texture. Consumers were also asked to intensify the overall product aroma, flavor, firmness and stickiness of each sample using a 9-point category scale, labeled from none to much (Lawless and Heymann 1998).

Data Analyses

Descriptive analysis data was analyzed according to a two-way analysis of variance (Proc glm, SAS 1996) with samples and panelists as main effects. The interaction between panelist and sample was also evaluated (i.e., to ensure that it was not significant) to ensure mean attribute intensity values could be used in further analysis. Consumer scores were averaged (Proc means, SAS 1996) for each of the 21 samples (n=40). Consumer data and descriptive analysis intensities were then combined and consumer overall acceptance scores predicted using descriptive attribute intensities as predictive variables in a Partial Least Squares Regression model (The Unscrambler, version 6.1b, Camo, Norway). Overall consumer acceptance was also predicted with similar modeling methods using consumer acceptance of appearance, aroma, flavor, and texture as predictors. Finally, consumer acceptance of appearance, flavor, and texture was predicted using the corresponding descriptive analysis attributes. The regression coefficients expressed numerically the link between variation in the predictors (i.e. descriptive attributes) and variation in the responses (i.e. consumer response). The consumer responses were most highly influenced by the instrumental parameters with the highest weighted regression coefficients (r). Weighted regression coefficients (i.e. coefficients weighted by the variable mean value) were used to express their relative influence independently of differences in descriptive attributes intensities.

RESULTS AND DISCUSSION

Descriptive Analysis Results

Descriptive intensity means are presented in Tables 5, 6 and 7 for visual, flavor and texture attributes, respectively. These means will not be discussed directly in this paper but will be used as a support for later discussion of preference mapping regression models. In addition, Fisher's Least Square Differences for each attribute are presented to indicate significant differences reported between samples.

Prediction of Overall Acceptance from Descriptive Profiles. Figure 1 is a graphical representation of observed consumer overall acceptance of the rice samples studied versus predicted scores calculated using descriptive attributes as predictors in a partial least squares regression model. In this analysis, appearance, flavor, and texture attributes were used. Aroma descriptors (i.e. same attributes as for aromatic descriptors) were omitted from the prediction to limit data collinearity and to avoid introducing noise in the partial least squares model. Two principal components were retained in the model to maximize the Root Mean Square Error of Prediction (RMSEP=0.24). The model R^2 was close to 1 (R^2=0.95) indicating that consumer overall acceptance of rice was well predicted by descriptive analysis data.

Results reported for Asian consumers (Fig. 1) show that the three imported jasmine rices (iJ) were most preferred by this consumer group. This is not surprising since a majority of Asians participating in the test (51%) originated from Southeastern Asia. Domestically grown jasmine rice (dJ) and one of the domestically grown "Basmati type" (dB) were less accepted than the imported Thai jasmine rice but were overall liked by Asian consumers. Asian consumers

TABLE 5.
MEANS OF VISUAL DESCRIPTIVE ATTRIBUTES

	Visual Attributes [1]				
Sample Code [2]	**V1**	**V2**	**V3**	**V4**	**V5**
dB1	9.29	5.55	3.11	5.12	2.79
dB2	7.90	4.07	2.69	5.06	1.52
dJ	9.81	5.43	2.43	5.16	3.00
dA	8.20	3.18	2.32	4.76	0.45
iJ1	10.99	7.11	2.72	5.37	1.85
iJ2	11.02	7.85	2.48	4.75	6.27
iJ3	10.78	6.97	2.76	5.33	4.64
iB1	9.10	3.02	2.14	5.62	0.11
iB2	9.30	3.63	1.95	5.19	1.76
I1	7.23	3.55	3.25	5.14	1.41
I2	5.80	2.50	1.61	2.95	0.08
I3	9.78	2.56	3.97	4.76	1.31
I4	6.85	2.33	3.32	5.17	0.39
L1	8.92	5.97	3.18	5.65	1.30
L2	9.08	5.54	3.29	5.40	2.16
L3	9.31	5.62	3.10	5.73	2.03
M1	8.32	9.33	3.38	5.08	7.63
M2	8.14	6.05	3.45	5.65	3.12
P1	4.05	3.19	2.94	4.22	0.80
P2	5.07	2.90	1.99	3.14	2.37
P3	6.10	2.13	1.49	2.54	9.42
LSD [3]	0.79	0.55	0.51	0.71	0.83

[1] See definitions on Table 2
[2] See definitions on Table 1
[3] Least Squares Differences (α=0.05)

TABLE 6.
MEANS OF FLAVOR DESCRIPTIVE ATTRIBUTES

	Flavor Attributes [1]															
Sample Code [2]	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	B_1	B_2	B_3	B_4
dB1	4.59	3.05	0	2.20	0.37	0.24	0.30	3.86	0	0	0.20	0.18	0.53	0.42	0.32	0.08
dB2	4.66	3.68	0.36	2.24	0.58	0.12	0.41	3.68	0.66	0.27	0.20	0	0.56	0.32	0.29	0.04
dJ	4.45	3.15	0.45	2.41	0.59	0.33	0.32	3.35	0.70	0.36	0.18	0	0.57	0.25	0.27	0.02
dA	3.85	3.31	0.39	2.31	0.42	0.41	0.34	3.56	0.73	0.66	0.23	0.14	0.59	0.41	0.40	0
iJ1	4.55	2.94	0	2.60	0.09	0.51	0.38	3.09	0.27	3.36	0.84	0	0.35	0.39	0.45	0.16
iJ2	4.79	3.51	0	2.22	0	0.32	0.39	4.19	0.59	1.99	0.25	0	0.47	0.38	0.48	0.25
iJ3	4.80	2.80	0.36	2.04	0	0.32	0.20	4.04	0	1.86	0.20	0.14	0.32	0.37	0.35	0.20
iB1	3.05	1.65	0.52	1.48	0.20	0.29	0.18	3.16	0.88	5.03	0.11	0	0.43	0.32	0.47	0.34
iB2	3.72	1.11	0.45	1.22	0	0.61	0.18	3.73	0.13	6.33	0.11	0.18	0.45	0.30	0.54	0.28
I1	3.88	0.72	3.45	1.77	0.96	0.14	0.14	4.71	0.23	0.18	0.23	0	0.39	0.18	0.54	0.31
I2	3.45	1.71	1.50	3.06	0.95	0.26	0	2.73	0.41	0.16	0.35	0	0.71	0.25	0.20	0
I3	3.96	1.64	2.41	2.10	0	0.11	0.11	4.25	0	0.45	0	0	0.41	0.32	0.55	0.24
I4	3.22	1.69	4.10	2.10	0.96	0.36	0.18	4.10	0.32	0.14	0.30	0	0.60	0.21	0.43	0.23
L1	4.87	3.00	0.18	2.21	0.24	0.27	0.50	4.07	0.14	0.48	0.13	0	0.50	0.35	0.26	0.09
L2	5.06	3.27	0.16	2.66	0.26	0.39	0.27	3.71	0.39	0.32	0.20	0	0.52	0.43	0.32	0.10
L3	4.76	2.90	0.16	2.01	0.30	0.32	0.38	3.60	0.67	0.14	0.39	0	.038	0.35	0.43	0.09
M1	5.51	2.17	0.55	2.22	0.31	0.78	0.14	3.97	0.25	0.23	0	0	0.43	0.40	0.35	0.13
M2	5.16	3.05	0.23	2.23	0.32	0.26	0.14	3.86	0.40	0.27	0.23	0	0.62	0.37	0.35	0.17
P1	3.34	1.42	4.43	2.05	0.47	0	0.77	4.14	1.15	0.43	0.25	1.20	0.76	0.51	0.51	0.26
P2	3.28	1.90	2.96	2.40	1.05	0.18	0.45	2.68	2.66	0.53	0	0.35	0.45	0.28	0.44	0.26
P3	3.98	1.91	2.75	2.45	0.77	0.18	0.65	3.80	1.50	0.41	0.47	1.60	0.50	0.41	0.63	0.16
LSD [3]	0.66	0.32	0.48	0.63	0.55	0.27	0.77	0.76	0.81	0.32	0.22	0.45	0.19	0.57	0.12	0.39

[1] See definitions on Table 3
[2] See definitions on Table 1
[3] Least Squares Difference (α=0.05)

TABLE 7.
MEANS OF TEXTURE DESCRIPTIVE ATTRIBUTES

	Texture Attributes +										
Sample Code *	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
dB1	4.75	1.06	8.73	5.10	4.86	4.11	5.83	2.41	0.94	2.08	4.85
dB2	3.88	0.98	8.04	4.97	5.20	3.70	5.77	2.23	1.18	2.22	5.09
dJ	4.26	0.90	9.45	4.86	5.02	4.22	5.57	2.27	1.00	2.09	4.78
dA	2.34	1.03	7.28	5.36	5.13	2.94	5.91	1.96	1.11	1.85	5.49
iJ1	5.10	1.08	9.14	4.54	5.20	4.06	5.80	2.33	1.26	2.10	5.00
iJ2	6.09	1.01	10.32	3.36	5.41	5.13	5.49	2.58	1.35	2.36	4.46
iJ3	5.73	1.06	10.67	4.18	5.30	4.69	5.50	2.46	1.20	2.26	4.60
iB1	2.17	1.14	8.56	4.75	4.80	2.87	5.91	1.80	1.13	2.00	5.67
iB2	2.74	1.68	8.13	4.54	5.08	3.25	5.88	1.93	1.23	1.79	5.27
I1	4.89	1.03	7.33	4.38	5.49	4.37	5.46	2.31	1.31	2.01	4.95
I2	2.21	1.13	8.56	5.51	6.01	2.87	6.34	2.33	1.00	2.21	5.82
I3	2.05	1.01	7.60	4.42	5.46	3.26	5.87	2.09	1.10	1.99	5.52
I4	1.87	0.98	8.14	4.16	5.01	3.47	5.73	2.23	1.08	2.00	5.08
L1	4.98	1.26	8.74	4.93	5.01	4.18	6.04	2.56	1.26	2.26	4.84
L2	4.83	1.09	8.66	5.66	4.88	4.17	6.17	2.38	1.20	2.24	5.56
L3	4.68	0.99	9.12	5.06	5.29	4.10	5.91	2.41	1.09	2.05	5.11
M1	6.49	1.63	11.37	4.67	5.89	5.72	5.51	3.24	1.89	2.79	4.41
M2	5.30	1.09	9.64	4.56	5.30	5.10	5.46	2.69	1.55	2.47	4.66
P1	2.77	1.30	8.53	3.90	5.48	3.93	5.53	2.31	1.27	1.96	4.46
P2	1.90	1.29	6.72	5.33	5.28	2.73	6.25	2.24	1.25	1.65	4.84
P3	2.37	1.41	7.68	5.05	4.87	3.51	6.21	2.32	1.43	1.86	4.64
LSD [3]	0.74	0.74	1.50	0.75	0.77	0.64	0.58	0.48	0.29	0.63	1.05

[1] See definitions on Table 4
[2] See definitions on Table 1
[3] Least Squares Difference (α=0.05)

were fairly indifferent to long grain (L), domestic and imported Basmati rice samples (dB, iB). Overall, parboiled, instant and medium grain rice samples were disliked by the consumer group studied.

Differences were observed between samples but it would be difficult to rationally explain the reasons for the preferences expressed by consumers by just discussing the differences in descriptive profiles. For this reason, weighted regression coefficients (i.e., each regression coefficient was weighted by the mean value to eliminate the influence of units or range differences) were used to relate consumer data to descriptive analysis results obtained for each of the 21 rice samples. The use of weighted regression coefficients allows the

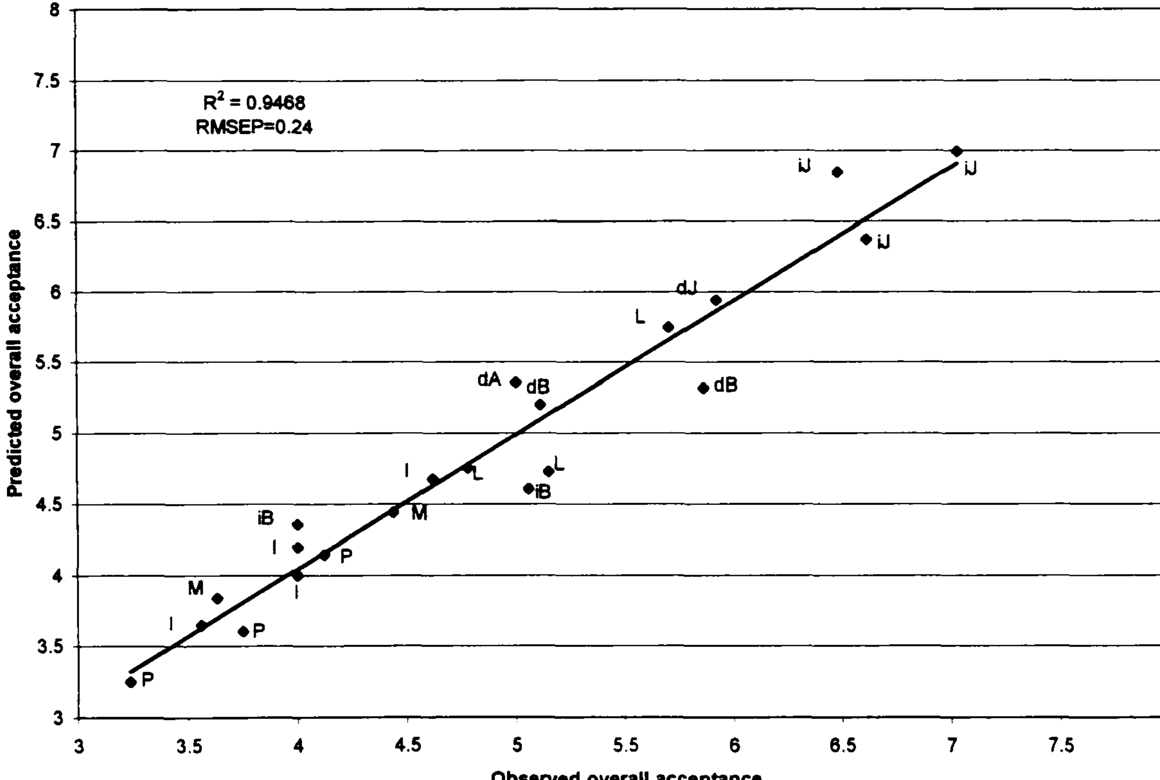

FIG. 1. PREDICTED VERSUS OBSERVED OVERALL ACCEPTANCE BY ASIAN CONSUMERS
Predicted scores obtained from sensory descriptive attributes using a partial least squares regression model. Sample name abbreviations can be found in Table 1.

assessment of the relative importance of each predictive variable (i.e., descriptive attribute) to the prediction of the response variable; in this case overall acceptance. Figure 2 is a graphical representation of the weighted regression coefficients for each of the descriptive sensory attributes present in the model. To simplify the following discussion, the most influential sensory attributes will be defined as those with weighted regression coefficients greater than 0.2 (i.e., absolute value). Other important sensory attributes will be defined as those with regression parameters greater than 0.1 (i.e., absolute value). Degree of whiteness, grain integrity, cooked grain, particle size, and residual film were the most influential descriptors defining the overall consumer acceptance of rice by the Asian consumer group tested. Greater degree of whiteness and cooked grain intensity resulted in higher acceptance scores while greater grain integrity, residual film and particle size lowered acceptance scores. Goodwin (1992) studied the potential marketing of a domestically grown variety (i.e., Jasmine 85) exhibiting some of the Jasmine rice traits and reported a lower acceptance for Jasmine 85 than for imported Jasmine varieties. They hypothesized that the lack of whiteness in Jasmine 85 could have been the cause of poor acceptance by Asian consumers. The results reported here would tend to confirm the hypothesis formulated by Goodwin (1992). Cooked grain notes were found to be highest in aromatic varieties except in the imported Basmati varieties. Bitter, feedy, nutty, hardness, cohesiveness, macro-roughness, toothpull and toothpack were also involved in predicting overall acceptance of rice by consumers of Asian origin. Greater floral aroma and cohesiveness were associated with greater overall acceptance while greater hardness, bitter, feedy, nutty, macro-roughness, toothpull and toothpack intensities contributed to lowering acceptance scores. Floral was found in samples at very low intensities. The highest floral note was found in sample iJ1 (Table 6) but was not really detected in other imported jasmine rice. However, it seemed to be an important determinant of acceptability. This result will need to be further investigated to assess its potential involvement in rice acceptance by Asian consumers. Consumers expressed a definite preference for rice samples with a texture that was cohesive, soft (i.e. low hardness), and not sticky (i.e. low intensities from particle size, toothpull and toothpack).

Prediction of Overall Acceptance from Attribute Acceptance. Figure 3 is a graphical representation of weighted regression coefficients for a model predicting overall consumer acceptance from acceptance scores for appearance, aroma, flavor and texture. Consumers indicated that the most important factor in determining their overall acceptance of a rice product was first its appearance, and second, its aroma (Fig. 3). Flavor and texture seemed to play a smaller role in determining overall acceptance by Asians. In order to determine acceptable

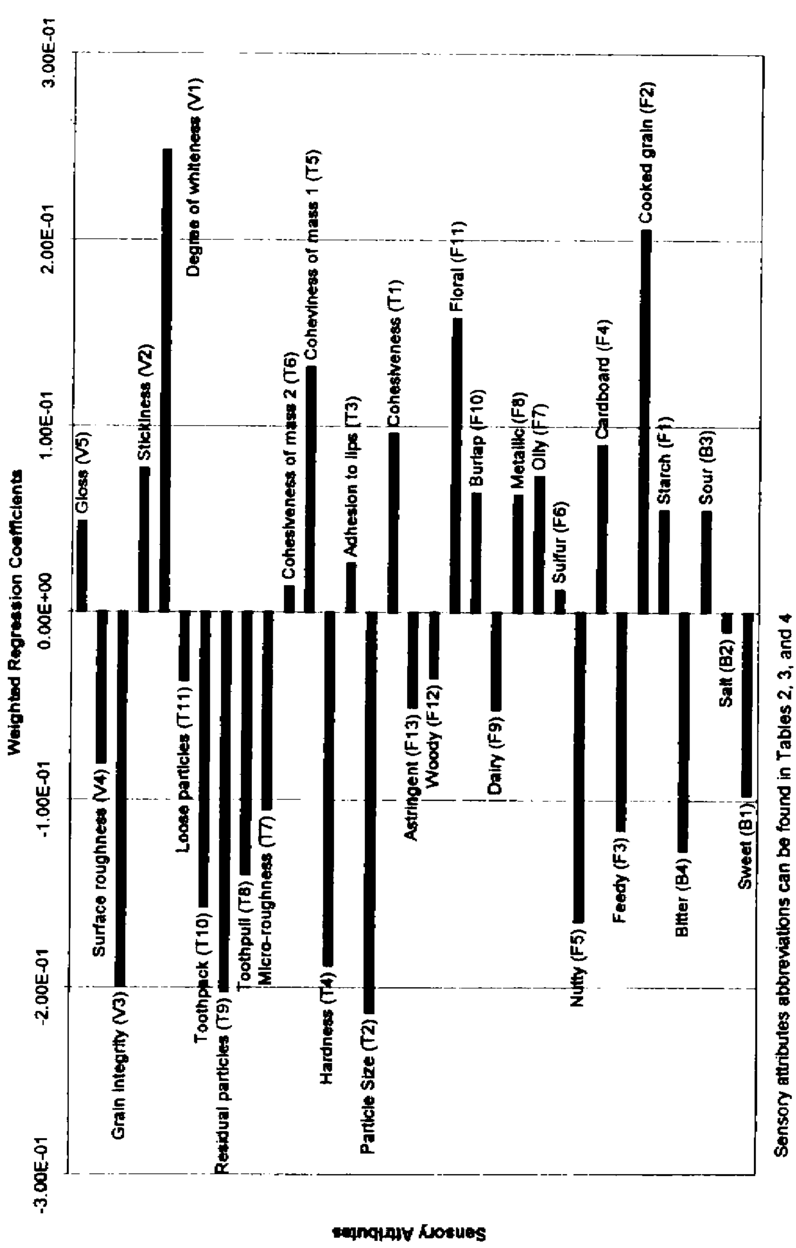

FIG. 2. WEIGHTED REGRESSION COEFFICIENTS FOR THE PARTIAL LEAST SQUARES REGRESSION MODEL PREDICTING OVERALL ACCEPTANCE FROM VISUAL, FLAVOR, AND TEXTURE DESCRIPTORS

Descriptors name abbreviations are defined in Tables 2, 3, and 4, respectively.

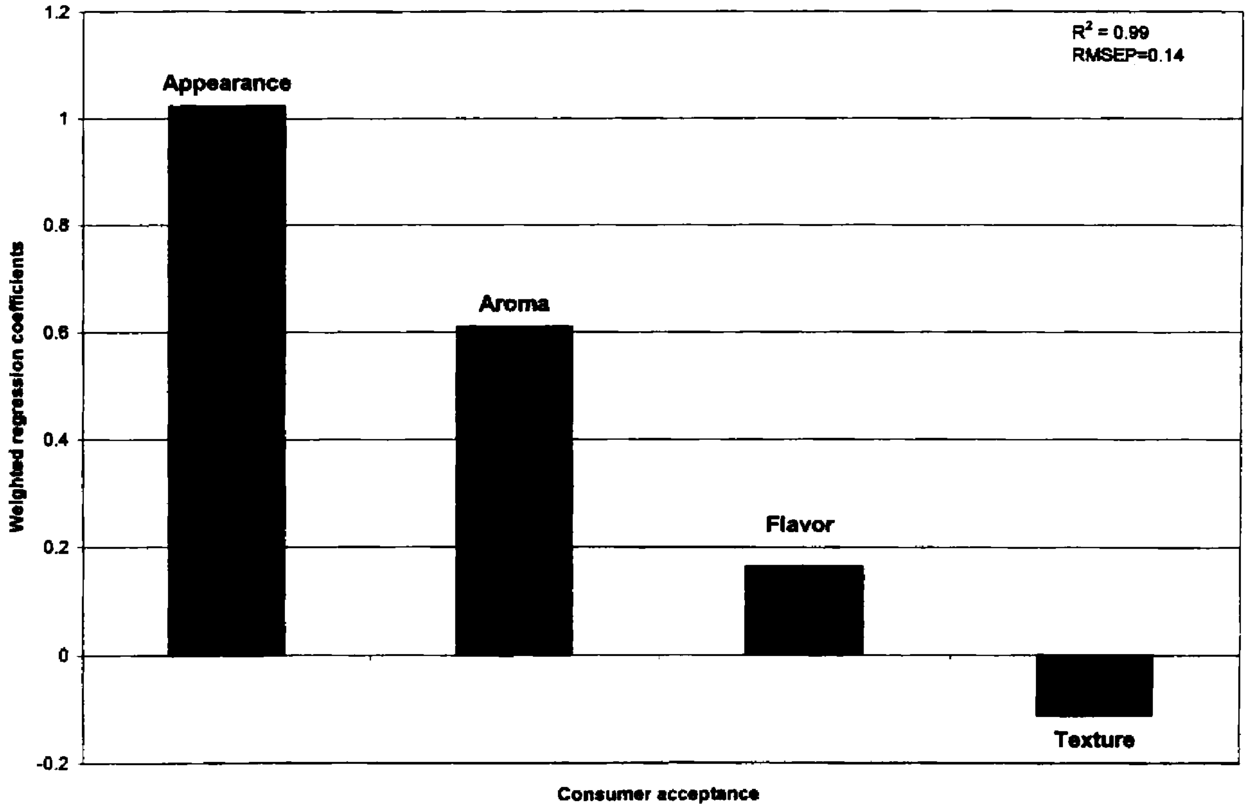

FIG. 3. WEIGHTED REGRESSION COEFFICIENTS FOR THE PARTIAL LEAST SQUARES REGRESSION MODEL PREDICTING OVERALL ACCEPTANCE FROM THE ACCEPTANCE SCORES FOR APPEARANCE, AROMA, FLAVOR AND TEXTURE

appearance, flavor and texture characteristics, regression models were evaluated using descriptive attributes as predictors of acceptance scores for appearance, flavor and texture.

Prediction of Rice Appearance from Visual Descriptors. Degree of whiteness was determined to be the most important parameter in defining acceptance of rice appearance by consumers from Asian origin (Fig. 4). This result is not surprising since it was offered as a possible explanation for the poor performance of Jasmine 85 (Goodwin 1992). Visual stickiness between kernels and surface roughness were also important contributors to the acceptance of appearance (i.e. the higher the intensity, the higher the acceptance) while grain integrity and gloss were not important contributors.

Prediction of Rice Flavor Acceptance from Flavor Descriptors. Starchy, cooked grain, nutty, sulfur, heated oil, and metallic attributes were most important in influencing the acceptance of rice flavor by Asian consumers (Fig. 5). Starch, cooked grain, heated oil and metallic attributes contributed to increased acceptance of rice flavor while nutty and sulfur notes decreased it. This result is in general agreement with the results observed for overall acceptance to the exception of the floral note which did not seem to be critical in determining flavor acceptance. Jasmine rice samples (i.e. high overall acceptance) exhibited high starch, cooked grain and metallic notes and low nutty and sulfur notes.

Prediction of Texture Acceptance from Texture Descriptors. Sample cohesiveness, particle size, hardness and macro-roughness of mass were the most influential attributes in predicting texture acceptance (Fig. 6). Higher sample cohesiveness contributed to increased consumer acceptance of texture while higher particle size, firmness and macro-roughness decreased acceptance. This result could at first seem to contradict the discussion provided for overall acceptance of rice. However, samples exhibiting low sample cohesiveness, such as parboiled rice, were not accepted by consumers for reasons probably other than their lack of stickiness (e.g. color or firmness).

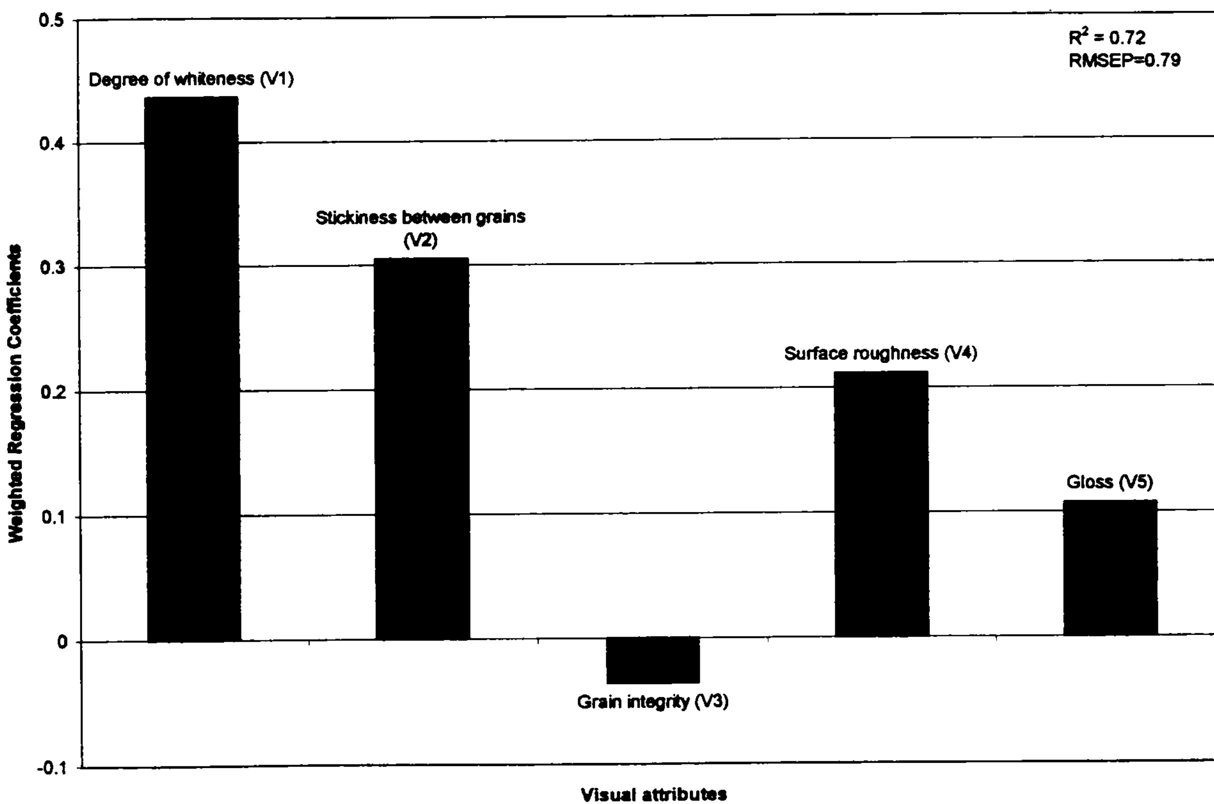

FIG. 4. WEIGHTED REGRESSION COEFFICIENTS FOR THE PARTIAL LEAST SQUARES REGRESSION MODEL PREDICTING THE ACCEPTANCE OF RICE APPEARANCE FROM VISUAL ATTRIBUTES EVALUATED BY A DESCRIPTIVE PANEL

Descriptors name abbreviations are defined in Table 2.

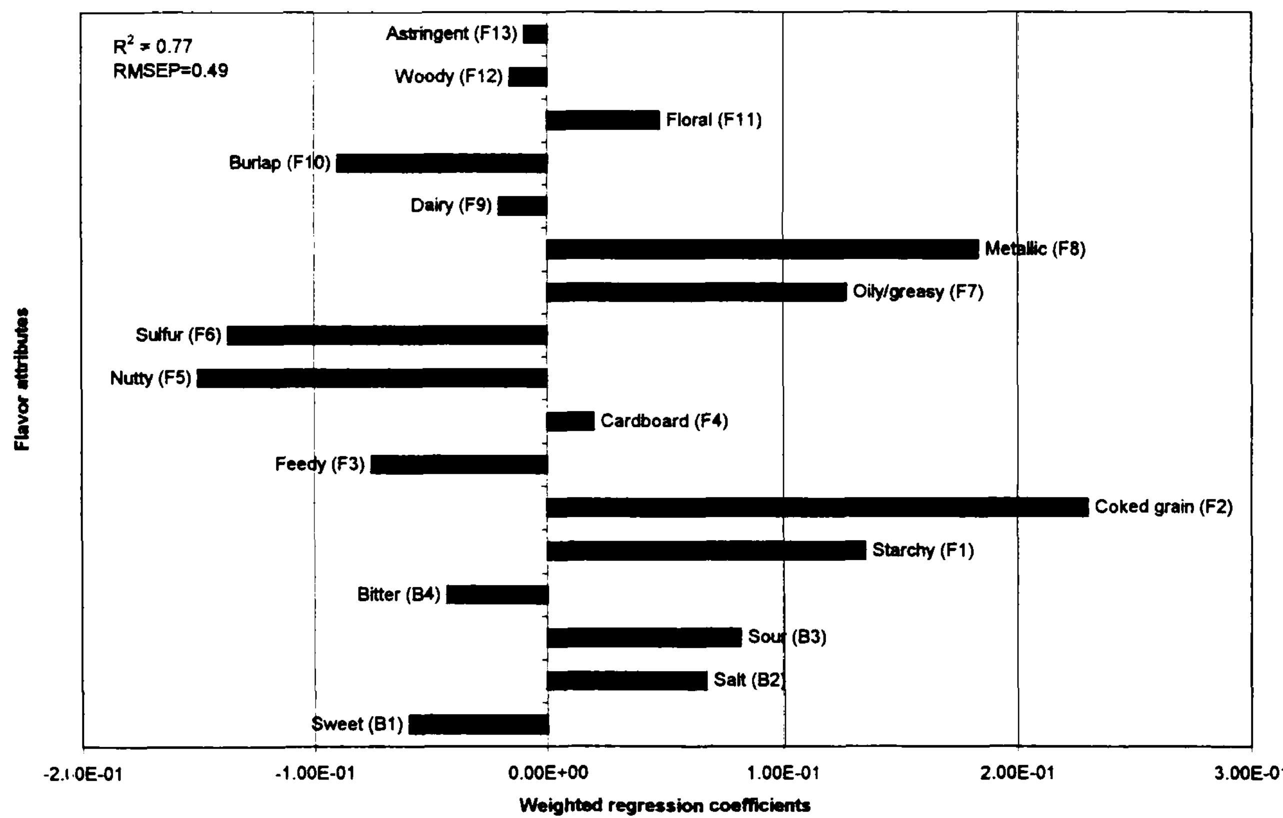

FIG. 5. WEIGHTED REGRESSION COEFFICIENTS FOR THE PARTIAL LEAST SQUARES REGRESSION MODEL PREDICTING THE ACCEPTANCE OF RICE FLAVOR FROM FLAVOR ATTRIBUTES EVALUATED BY A DESCRIPTIVE PANEL

Descriptors name abbreviations are defined in Table 3.

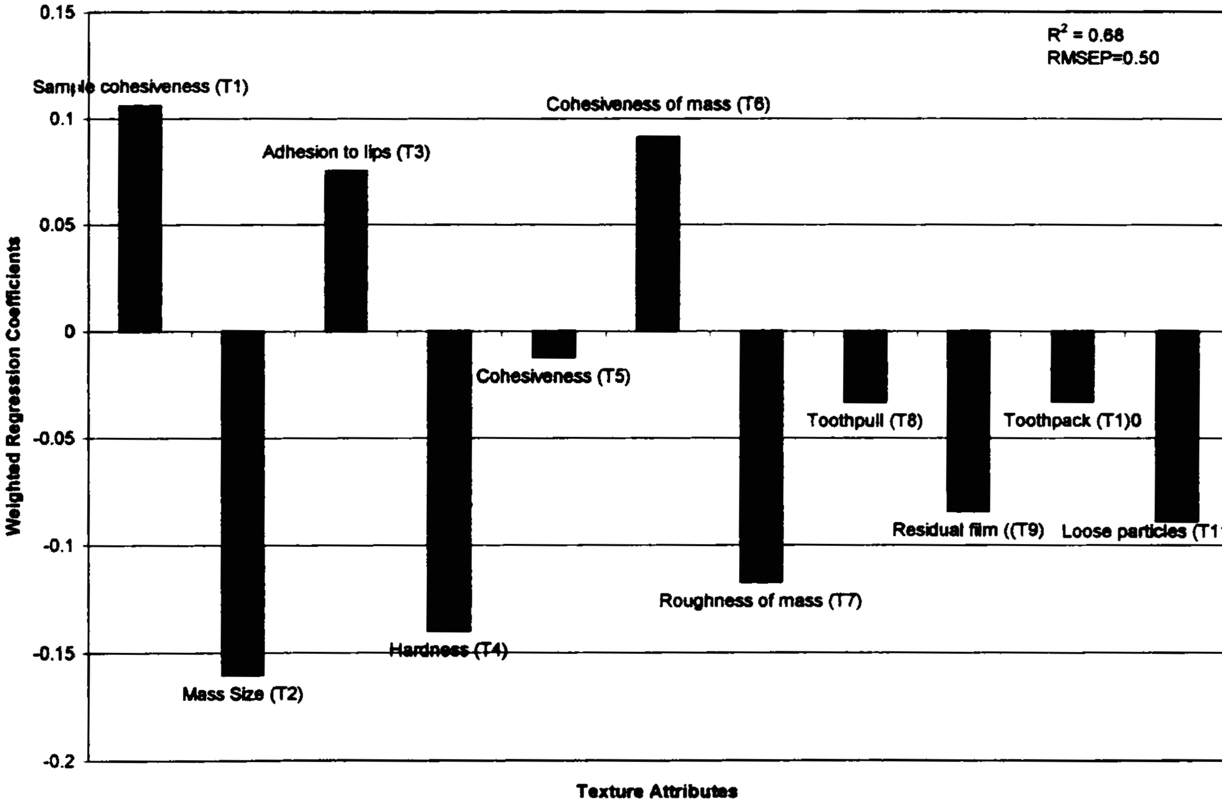

FIG. 6. WEIGHTED REGRESSION COEFFICIENTS FOR THE PARTIAL LEAST SQUARES REGRESSION MODEL PREDICTING THE ACCEPTANCE OF RICE TEXTURE FROM TEXTURE ATTRIBUTES EVALUATED BY A DESCRIPTIVE PANEL
Descriptors name abbreviations are defined in Table 4.

CONCLUSIONS

Imported Jasmine type rice was preferred over any of the other rice tested including domestically grown Jasmine rice. Future work should focus on identified sensory characteristics maximizing Asian consumer acceptance of rice so that "gold standards" can be identified. Current breeding efforts directed toward the development of specialty rice are emphasizing yield, pest resistance and production characteristics without accurately quantifying the sensory quality of the new crosses. The US Asian population is very discriminative of the quality of the rice they eat. In order to take full advantage of this and other potential markets, information is needed to ensure that varieties to be released in the future will fulfill consumer needs. The research reported here provides preliminary data toward the identification of a "gold standard". However, future experiments should sample a larger consumer group and concentrate on aromatic varieties. In addition, specific imported cultivars should be identified and the number of imported products should be increased to be more representative of aromatic rices consumed in Southern Asia. Finally, a more exhaustive list of domestically grown aromatic cultivars should be compiled and these products tested against imported rices.

ACKNOWLEDGMENTS

The authors thank the UofA Rice Processing Program and the food companies who provided the rice samples for this study.

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