Sensory Characteristics of Apple Juice Evaluated by Consumer and Trained Panels

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ABSTRACT: To identify sensory characteristics of unclarified apple juice and to compare unclarified and clarified types, 140 consumers and 10 trained panelists evaluated 16 commercial apple juice samples (4 clarified and 12 unclarified). Unclarified and clarified juices were clearly separated by the first principal component (PC1), whose main factor was fresh, green, and sweet aroma. It was difficult to predict consumer preference by regression models using trained panel preference and analytical attributes. Mapping consumers' overall preferences on a sensory profile made by PC1 and PC2, the consumer panel preferred apple juice with moderately increased fresh and green aroma and thoroughly decreased sour and astringent.

Keywords: apple, juice, sensory evaluation, consumer preference, descriptive analysis

Introduction

APPLE JUICE IS A POPULAR BEVERAGE WORLDWIDE. GLOBALLY clarified apple juice has a fair share of the apple juice market, but unclarified has a considerable share in Japan. Unclarified juice is produced from fresh apples without enzymatic treatment; its browning is constrained by adding L-ascorbic acid (Kakiuchi and others 1987). In Japan apple juice is the second most consumed fruit juice (Japan Fruit Juice Association 1999); consumption of clarified apple juice there has recently increased as apple juice concentrate and apple juice imports have increased. Numerous researchers have studied the sensory characteristics of clarified apple juice (Moskowitz 1983; Sugahara and others 1983; Drake and Nelson 1986; Petró-Turza and others 1986; Padilla and McLellan 1989; McDaniel and others 1990; Cliff and others 1997), but few studies on sensory characteristics of unclarified apple juice have been done.

Comparing clarified and unclarified apple juice, we studied (1) consumer preference, (2) sensory characteristics judged by a trained panel, and (3) relationships between consumer preference and trained panel attributes.

Materials and Methods

Sample

Sixteen commercial brands of apple juice (Table 1), purchased from local stores in April 1998, were chosen from over 30 samples based on sensory characteristics, soluble solids (Brix), pH, and package material. The sensory characteristics of appearance, aroma, and flavor were first evaluated by the researchers and then by 8 to 10 selected panelists in preliminary sensory tests.

Consumer Preference Test

The consumer panel consisted of 140 people—72 women and 68 men—from their teens to the 60s. Panelists liking apple juice were recruited from over 1,500 visitors to the National Food Research Institute on April 15, 1998, to balance age and gender. Each group of 5 panelists was conducted to panel booths (room temperature 23 to 24 °C, relative humidity 67% to 75%). Each panelist evaluated 4 types of apple juice after being instructed in the procedure. Each juice was presented as a 30-ml sample in a 70-ml clear plastic cup without a sample number at room temperature (23 to 24 °C). Cups of 16 samples were put on each section divided with an alphabetical order on a large table in a preparation room. Four samples of them were picked up from each section according to the balanced incomplete block design (Hirosaki 1989; Gacula 1993). Samples were orderly evaluated from left to right according to indication by a test conductor. Two test conductors checked the procedure of each group of 5 panelists. Four attributes—aroma, overall, sweet, and sour preferences—were rated on a 5-point category scale: dislike very much (left), dislike, neither like nor dislike, like, and like very much (right). Purified water was obtained by passing deionized water through a Milli-RQ system (Millipore Corp., Bedford, Mass., U.S.A.) and used for mouth-rinsing between samples.

Descriptive Analysis By Trained Panel

Panel candidates were first screened from the National Food Research Institute staff and assistants for their ability to recognize basic aromas (T&T Olfactometer, Daiichi Yakuhin Sangyo Co., Ltd., Tokyo, Japan): β-phenylethyl alcohol at $10^{-5.5}$ (w/w), methyl cyclopentenolone at $10^{-6.0}$ (w/w), isovaleric acid at $10^{-6.0}$ (w/w), γ-undecalactone at $10^{-5.5}$ (w/w), Skatole at $10^{-7.5}$ (w/w); and basic tastes (Jellinek 1985): sweet (sucrose) at 0.15% and 0.30% (w/v), salty (sodium chloride) at 0.02% and 0.04% (w/v), sour (citric acid) at 0.0012% and 0.0020% (w/v), bitter (caffeine) at 0.01% and 0.02% (w/v), and umami (sodium L-glutamate, mono) at 0.012% and 0.020% (w/v). The basic aromas are officially recognized for olfactory diagnosis in Japan (Kawasaki 1994). The panel candidates discriminating between sweet/sour intensities of 4 model apple juices were then selected. A commercial unclarified apple juice with low Brix (11.1) and high pH (3.8) was used for the model juice base. Fructose (Kanto Chemical Co., Inc., Tokyo, Japan: 1, 2, and 3 g) was added to 100 ml of the juice base as a sweetener. DL-malic acid (Kishida Chemical Co., Ltd., Osaka, Japan, food grade: 0.1, 0.2, and 0.3 g) was added to 100 ml of the juice base to increase sourness. A sweet/sour test was duplicated. Panelists were asked to rank

Table 1—Apple juice samples

Sample	Type[a]		Package	Origin	Brix (%)[b]	pH[c]
1	C	Reconstituted	Paper	Japan	12.0	3.72
2	UC		Can	Japan	11.3	3.67
3	UC		Glass bottle	Japan	13.5	3.78
4	UC		Glass bottle	Japan	12.3	3.32
5	C		Glass bottle	US	14.3	3.83
6	UC	Reconstituted	Can	Japan	11.8	3.81
7	UC	Reconstituted	Paper	Japan	11.4	3.68
8	UC		Glass bottle	Japan	11.3	3.49
9	C		Paper	Australia	11.9	3.84
10	UC	Reconstituted	Can	Japan	11.0	3.67
11	UC		Glass bottle	Japan	13.2	3.68
12	UC		Glass bottle	Japan	12.1	3.82
13	C	Reconstituted	Paper	Japan	11.7	3.65
14	UC		Can	Japan	13.2	3.83
15	C+UC	Reconstituted	Paper	Japan	11.1	3.77
16	UC		Paper	Japan	13.8	3.63

[a]C=Clarified, UC=Unclarified, C+UC=Mixed.
[b]Means from triplicate analyses using a digital refractometer (PR-100, Atago Co., Ltd., Tokyo, Japan).
[c]Meand from triplicate analyses using a pH meter (Toa Electronics Ltd., Tokyo, Japan).

Table 2—Vocabulary and references for apple juices

Attributes (anchor words)	References (scale value: preparation)
Appearance	
Color (light-dark)	20: 25 ml unclarified apple juice ("Starking" Aoren, Aomori, Japan) was diluted with purified water to make a 100 ml solution. 50: 25 ml unclarified apple juice. 80: 75 ml clarified apple juice (Takanashi Milk Products Co. Ltd., Yokohama, Japan) was diluted with purified water to make a 100 ml solution.
Aroma	
Fresh (none-strong)	100: 25 ml unclarified juice with L-ascorbic acid (0.75 g/l) produced from a fresh apple (Fuji cultivar) using a juicer.
Green (none-strong)	80: 20 g green vegetable juice (Sunstar Inc., Osaka, Japan) was diluted with purified water to make a 200 g solution. A 25 ml solution was used as a reference.
Apple-like (none-strong)	80: 25 ml solution of 7 ml/l Hexyl acetate (Kanto Chemical Co., Inc., Tokyo, Japan) diluted with purified water.
Estery (none-strong)	80: 25 ml solution of 7 ml/l Ethyl n-Hexanoate (Kanto Chemical Co., Inc., Tokyo, Japan) diluted with purified water.
Caramel (none-strong)	100: 10 g caramel source (Watashinodaidokoro Ltd., Miyazaki, Japan).
Honey (none-strong)	100: 10 g honey ("Pure Honey" Meiji-ya Co, Ltd., Tokyo, Japan) was diluted with hot purified water (40-50 °C) to make a 40 g solution. A diluted 10 g sample at room temperature was used as a reference.
Black sugar syrup (none-strong)	100: 10 g black sugar syrup ("Kuromitsu" Kitao Corp., Kyoto, Japan).
Flavor	
Sweet (weak-strong)	20: 25 ml base juice adjusted to Brix 10.5 and pH 3.80. 80: 25 ml juice with Brix 14.0, whose Brix was adjusted by adding fructose to the base juice.
Sour (weak-strong)	20: 25 ml base juice adjusted to Brix 10.5 and pH 3.80. 80: 25 ml juice with pH 3.45, whose pH was adjusted by adding DL-malic acid to the base juice.
Metallic (none-strong)	80: 25 ml solution of 2 mg/l metal sulfate (Kanto Chemical Co., Inc., Tokyo, Japan).
Astringent (none-strong)	80: 25 ml solution of 0.3 g/l tannic acid (Kanto Chemical Co., Inc., Tokyo, Japan).

sweet/sour intensity of 4 samples, and 14 panelists making correct rankings were selected. The panelists were trained for 2 mo. When 10 panelists—4 women and 6 men—finished the training, they attended quantitative descriptive analysis (Stone and others 1974; ASTM 1992; Gacula 1997) from May to June 1998.

Sixteen juices were divided into 4 groups, and an evaluation of each group was duplicated. The 4 groups were defined to maximize the expected sample differences within each session and to balance clarified to unclarified juices and can packaging compared with other package materials. Each juice was presented at room temperature (22 to 24 °C) as a 30-ml sample in a 70-ml clear plastic cup with a 3-digit random number and arranged in random order. Forty attributes were collected from the panel, and 12 attributes and their references (Table 2) were determined through preliminary tests following the normative ISO 11035 (ISO 1994), which introduces the 2-step reduction of the number of descriptors. The first step eliminates descriptors with the low geometric mean calculated from the frequency and the intensity score of each descriptor. The second step uses multidimensional analysis and analysis of variance (ANOVA) to reduce the number of descriptors. Trained panel preferences in aroma and overall were also queried to compare consumers and trained panel. A 10-cm unstructured scale with anchor points at each end (Table 2) was used for each attribute. Ten panelists in panel booths (room temperature 22 to 24 °C, relative humidity 52% to 62%, illumination 600 to 660 lx) were instructed in the procedure, and they clarified each reference intensity before evaluation. Each session lasted took 20 to 40 min. In evaluating flavor attributes, purified water and unsalted crackers were available for cleaning the palate between samples.

Data Analysis

Microsoft® Excel 97 was used for ANOVA. Correlation analysis (CORR), regression analysis (REG), and principal component analysis (PRINCOMP) were done using SAS® Release 6.12 (SAS Institute Inc., Cary, N.C., U.S.A.) on an HP9000/889 (Hewlett Packard Co., Palo Alto, Calif., U.S.A.) at the Computer Center of the Agriculture, Forestry, and Fisheries Research Council Secretariat (Tsukuba, Japan).

Results and Discussion

Validity of Sensory Data

Consumer panel. Each attribute had homogeneity of variance confirmed by the Hartley test (Hartley 1950). Significant sample differences ($p < 0.01$) were detected for 4 attributes by intrablock ANOVA for a balanced incomplete block design (Hirosaki 1989; Gacula 1993). Treatment means adjusted for block effects were used as sample means for analysis. Standard deviations of the 4 attributes ranged from 0.82 to 0.99 (Table 3).

Trained panel. Homogeneity of variance was confirmed by the Hartley test (Hartley 1950). Seven attributes—color ($p < 0.01$), fresh ($p < 0.01$), green ($p < 0.01$), apple-like ($p < 0.05$), caramel ($p < 0.05$), black sugar syrup ($p < 0.01$), and metallic taste ($p < 0.05$)—showed significant heterogeneity of variance. The heterogeneity of each attribute was not eliminated by data transformation and affects a test statistic of ANOVA (Sokal and Rohlf 1995). A variety of strategies have been suggested regarding how to deal with heteroge-

Table 3—Statistics on apple juice attributes

	Sample Numbers																	
Attribute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Mean	Standard deviation[b]
Consumer panel																		
Aroma preference	3.9	3.2	3.1	2.4	2.9	3.4	3.0	3.1	3.0	3.3	3.0	2.8	2.2	3.0	3.6	3.4	3.1	0.82
Overall preference	3.5	3.1	3.1	2.2	2.9	3.5	3.0	3.0	2.8	3.3	3.4	3.2	2.5	3.2	3.3	3.5	3.1	0.97
Sweet preference	3.4	3.2	2.9	2.5	2.8	3.6	3.0	3.2	3.1	3.4	3.2	3.2	2.6	3.0	3.4	3.3	3.1	0.99
Sour preference	3.5	3.2	3.1	2.5	3.0	3.5	3.1	3.0	2.7	3.2	3.2	3.3	2.5	3.3	3.3	3.5	3.1	0.93
Trained panel																		
Color	40.5	30.2	38.5	65.6	51.6	37.9	25.8	32.2	32.0	36.6	39.8	23.9	86.7	33.1	26.5	42.1	40.2	5.0
Aroma preference	63.2	46.3	44.5	37.1	43.7	53.3	61.1	34.2	55.3	51.0	40.1	35.3	40.6	54.1	57.0	44.8	47.6	14.8
Fresh	12.4	45.8	42.6	43.4	7.3	47.4	43.4	35.3	10.2	33.1	48.5	42.5	5.3	41.6	35.8	50.7	34.1	12.8
Green	5.7	28.9	41.8	38.6	3.4	26.9	18.3	43.8	4.5	15.3	40.5	44.0	3.0	28.7	14.3	46.6	25.2	10.7
Apple-like	32.0	36.7	33.1	22.8	17.1	39.0	50.3	26.1	18.9	53.3	30.0	26.9	9.7	37.8	48.8	29.8	32	12.3
Estery	17.4	24.6	22.0	15.9	13.4	20.4	23.3	16.2	14.1	52.5	18.2	18.3	8.3	18.6	30.9	20.6	20.9	11.1
Caramel	15.5	6.7	5.5	7.8	20.7	4.4	4.0	7.2	13.6	4.3	6.1	4.7	22.6	4.8	5.2	4.3	8.6	7.3
Honey	42.1	19.2	17.1	16.2	46.4	19.2	14.3	16.7	42.4	23.2	18.1	16.9	51.4	23.5	19.9	18.1	25.3	10.8
Black sugar syrup	11.7	5.8	5.2	8.2	16.1	3.9	3.7	6.9	12.2	5.0	5.6	5.8	21.0	6.4	2.6	4.6	7.8	6.4
Overall preference55.3	44.4	61.1	23.5	50.0	52.6	54.7	32.2	54.6	44.9	48.0	58.9	36.4	57.0	56.1	47.4	48.6	14.3	
Sweet	41.0	34.7	65.3	21.3	63.6	46.9	30.6	23.2	43.1	34.1	42.8	52.5	29.5	54.5	39.0	51.1	42.1	10.7
Sour	32.3	46.8	31.5	82.3	22.0	37.2	37.9	70.3	22.3	38.8	46.4	29.7	34.3	34.2	29.3	53.7	40.5	11.8
Metallic	6.2	28.4	13.0	20.0	7.9	18.2	15.5	14.0	5.4	16.2	15.5	10.6	10.8	8.1	6.1	19.5	13.4	11.3
Astringent	15.1	28.6	22.1	43.0	14.9	26.3	19.1	32.7	14.3	34.3	26.9	25.6	36.5	23.6	15.6	29.2	25.5	14.4

[a]Sample numbers are shown in Table 1.
[b]Standard deviation was the square root of the error variance of ANOVA.

neity. One option available is to employ an adjusted critical F value associated with a lower significant level than the prespecified significant level (Sheskin 2000). The significant level 0.01 was thus employed to estimate a critical 0.05 F value. Sample differences of each attribute were significant ($p < 0.01$) through 2-way ANOVA with duplication. Interactions between panelists and samples were not significant ($p > 0.05$) for 12 analytical attributes and were significant ($p < 0.01$) for 2 preference attributes. Standard deviations of analytical attributes ranged from 5.0 to 12.8, except for astringency, whose standard deviation was 14.4, similar to aroma preference (14.8) and overall preference (14.3) (Table 3). Lawless (1988) reported that trained panels show standard deviations at about 10% of scale range. Most attributes met this condition. Arithmetic means were used for data analysis.

Relationship Between Attributes

Consumer panel attributes. Four preference attributes had high correlations (r = 0.81 to 0.95, $p < 0.01$), with overall and sour showing the highest correlation (r = 0.95, $p < 0.01$) (Table 4).

Trained panel attributes. Correlations (Table 4) were high between caramel, honey, and black sugar syrup aromas (r = 0.92 to 0.97; $p < 0.01$). These aromas, which had high scores for clarified apple juices, showed a strong negative correlation (r = –0.88 to –0.95, $p < 0.01$) with freshness. Freshness had a significant correlation (r = 0.83, $p < 0.01$) with green aroma. An apple-like aroma correlated (r = 0.81, $p < 0.01$) with an estery aroma.

Consumer and trained panel preferences. Aroma and overall preferences were compared using F values of sample variation in ANOVA. F values of aroma preference were almost the same (consumer panel: 7.45, trained panel: 7.56), while the F-value of overall preference of the trained panel (10.52) was much higher than that of the consumer panel (3.96). This was similar to the result of Roberts and Vickers (1994), who reported that trained judges tended to find larger differences in liking among cheeses than an untrained panel.

Consumer and trained panel analytical attributes. Correlation coefficients between 4 consumer panel attributes and 14 trained panel attributes ranged from –0.67 to 0.63 with no high correlation (Table 4). Aroma preference correlation between consumer and trained panels was 0.62 ($p < 0.01$), and that of overall preference was 0.63 ($p < 0.01$). These low correlations agreed with earlier reports (Lawless and Claassen 1993; Cliff and others 1997) that trained/experienced panels could not be used as preliminary indicators of consumer preference.

Multiple regression analysis was conducted to predict consumer preferences by analytical attributes of the trained panel because correlation analysis did not show a strong relationship between consumer preferences and trained panel attributes. Seven aroma attributes of the trained panel were used for the consumer aroma preference; 12 analytical attributes were used for the consumer overall preference; and 4 flavor attributes were used for consumer sweet and sour preferences. A stepwise method was used for variable selection, and a regression model without collinearity was searched. Partial F statistics (F_{out} and F_{in}) of backward elimination and forward selection were set from 0.15 to 0.25 to search regression models. The model for the consumer overall preference was only obtained as follows:

$$y = 1.99 + 0.01x_1 + 0.02x_2 \ (R^2 = 0.54,\ F_{out} = F_{in} = 0.2)$$

where y is the consumer overall preference, x_1 is sweet for the trained panel, and x_2 is apple-like for the trained panel. The correlation of cross-validation (a sample for prediction was removed from 16 samples) between actual and predicted values was 0.58, meaning this model was not valid in practical use. For other attributes, no multiple regression models outperformed simple regression models, making it difficult to predict consumer preferences of samples by regression models using analytical attributes of the trained panel as explanatory variables. Efforts to compute a prediction model were unsuccessful, and research efforts are continuing.

Table 4—Correlations between sensory attributes

Attribute	AR-PR[a]	OV-PR[a]	SW-PR[a]	SO-PR[a]	CO[b]	AR-PR[b]	FR[b]	GR[b]	AP[b]	ES[b]	CA[b]	HO[b]	BL[b]	OV-PR[b]	SW[b]	SO[b]	ME[b]	As[b]
AR-PR[a]	1	0.85**	0.86**	0.81**	-0.63**	0.62*	0.17	-0.06	0.62**	0.47	-0.35	-0.18	-0.51*	0.50	0.20	-0.23	-0.06	-0.51*
OV-PR[a]	0.85**	1	0.88**	0.95**	-0.63**	0.43	0.35	0.14	0.59*	0.42	-0.46	-0.28	-0.55*	0.63**	0.41	-0.34	-0.01	-0.43
SW-PR[a]	0.86**	0.88**	1	0.83**	-0.67**	0.41	0.30	0.08	0.59*	0.50	-0.47	-0.28	-0.57*	0.45	0.12	-0.23	0.04	-0.32
SO-PR[a]	0.81**	0.95**	0.83**	1	-0.64**	0.36	0.44	0.24	0.58*	0.36	-0.51*	-0.37	-0.60*	0.61*	0.45	-0.26	0.03	-0.39
CO[b]	-0.63**	-0.63**	-0.67**	-0.64**	1	-0.35	-0.45	-0.26	-0.64**	-0.41	0.67**	0.54*	0.74**	-0.60*	-0.22	0.22	0.02	0.51*
AR-PR[b]	0.62*	0.43	0.41	0.36	-0.35	1	-0.17	-0.58*	0.55*	0.29	-0.05	0.17	-0.15	0.55*	0.08	-0.50*	-0.31	-0.64**
FR[b]	0.17	0.35	0.30	0.44	-0.45	-0.17	1	0.83**	0.53*	0.31	-0.92**	-0.95**	-0.88**	0.03	-0.01	0.46	0.63**	0.31
GR[b]	-0.06	0.14	0.08	0.24	-0.26	-0.58*	0.83**	1	0.08	-0.01	-0.69**	-0.81**	-0.61*	-0.14	0.06	0.59*	0.51*	0.44
AP[b]	0.62**	0.59*	0.59*	0.59*	-0.64**	0.55*	0.53*	0.08	1	0.81**	-0.73**	-0.59*	-0.79**	0.36	-0.07	-0.07	0.20	-0.16
ES[b]	0.47	0.42	0.50	0.36	-0.41	0.29	0.31	-0.01	0.81**	1	-0.53*	-0.38	-0.56*	0.14	-0.10	-0.05	0.22	0.08
CA[b]	-0.35	-0.46	-0.47	-0.51*	0.67**	-0.05	-0.92**	-0.69**	-0.73**	-0.53*	1	0.94**	0.97**	-0.20	0.01	-0.30	-0.43	-0.14
HO[b]	-0.18	-0.28	-0.28	-0.37	0.54*	0.17	-0.95**	-0.81**	-0.59*	-0.38	0.94**	1	0.92**	0.00	0.11	-0.50	-0.55*	-0.28
BL[b]	-0.51*	-0.55*	-0.57*	-0.60*	0.74**	-0.15	-0.88**	-0.61*	-0.79**	-0.56*	0.97**	0.92**	1	-0.27	-0.03	-0.23	-0.38	0.01
OV-PR[b]	0.50	0.63**	0.45	0.61*	-0.60*	0.55*	0.03	-0.14	0.36	0.14	-0.20	0.00	-0.27	1	0.73**	-0.82**	-0.44	-0.81**
SW[b]	0.20	0.41	0.12	0.45	-0.22	0.08	-0.01	0.06	-0.07	-0.10	0.01	0.11	-0.03	0.73**	1	-0.63**	-0.32	-0.55*
SO[b]	-0.23	-0.34	-0.23	-0.26	0.22	-0.50*	0.46	0.59*	-0.07	-0.05	-0.30	-0.50	-0.23	-0.82**	-0.63**	1	0.60*	0.76**
ME[b]	-0.06	-0.01	0.04	0.03	0.02	-0.31	0.63**	0.51*	0.20	0.22	-0.43	-0.55*	-0.38	-0.44	-0.32	0.60*	1	0.61*
AS[b]	-0.51*	-0.43	-0.32	-0.39	0.51*	-0.64**	0.31	0.44	-0.16	0.08	-0.14	-0.28	0.01	-0.81**	-0.55*	0.76**	0.61*	1

AR-PR=Aroma preference, AR-PR=Aroma preference, SW-PR=Sweet preference, SO-PR=Sour preference, CO=Color, FR=Fresh, GR=green, AP=Apple-like, ES=Estery, CA=Caramel, HO=Honey, BL=Black sugar syrup, SW=Sweet, SO=Sour, ME=Metallic, AS=Astringent
[a]Consumer panel attribute
[b]Trained panel attribute
*significant at 5% level
**significant at 1% level

Sensory Profile of Apple Juice

Principal component analysis (PCA) was run on the correlation matrix using 12 analytical attribute means of the trained panel. The first 3 principal components (PC1 to PC3) had eigenvalues exceeding 1.0. The variance explained by the 3 PCs was 87.5% (PC1: 49.9%, PC2: 25.6%, PC3: 12.0%). The meaning of the first 2 PCs was explained using PCA loadings exceeding 0.7 (Figure 1): PC1 is related to fresh, green, honey, caramel and black sugar syrup aromas, PC2 is done to sourness and astringency. Clarified and unclarified juices were clearly separated by PC1, and juices with strong sourness/astringency were separated by PC2 (Figure 2). Judging from PCA loading and evaluation precision (R^2 of the ANOVA model) of each attribute, 2 attributes—freshness or green-

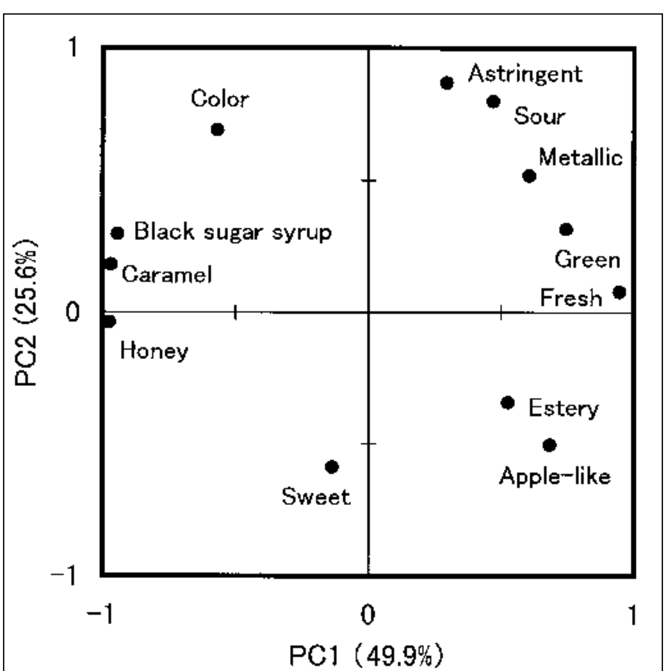

Figure 1—PCA loading plot of analytical attributes of trained panel

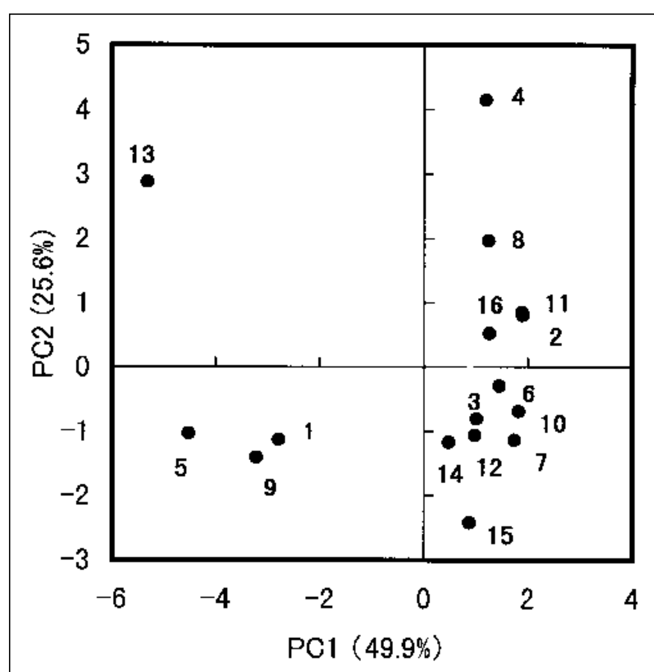

Figure 2—Apple juice profile using PC1 and PC2. Sample numbers are shown in Table 1. Clarified juice Nr: 1, 5, 9, 13.

ness, and sourness—are useful for getting a rough profile of clarified and unclarified apple juices.

Mapping consumer preference on sensory profiles

Mapping consumer's overall preference on a sensory apple juice profile by PC1 and PC2 showed that juices with low scores for PC1 and PC2 were preferred. Samples with strong sweet aromas (caramel, honey, and black sugar syrup), and strong sourness or astringency, such as samples Nr 4 and Nr 13, were not preferred. The samples were served at room temperature, instead of the more actual 4 °C, to allow better discrimination. Perception of smell and taste depends on sample temperature (Resurreccion 1998). Some studies (McBurny and others 1973; Paulus and Reisch 1980; Green and Frankmann 1987, 1988) reported relationships between taste thresholds (or intensities) and temperatures. It seems that room temperature enhanced sweetness more than sourness. The serving temperature probably affected the preference of samples with high Brix values, such as samples Nr 5 and Nr 16, most. However, the results suggest that the consumer panel preferred apple juices with moderately increased fresh and green and fully decreased sour and astringent.

Conclusions

THE CONSUMER PANEL PREFERRED APPLE JUICES WITH MODerately increased fresh and green and fully decreased sour and astringent. Unclarified and clarified apple juices were clearly separated by PC1, to which freshness, greenness, and sweet aroma contributed highly. Consumer preferences were not, however, simply determined by differences between unclarified and clarified juice. It was difficult to predict consumer preference by regression models using the trained panel preference and analytical attributes because correlations were lower than 0.7 and because a practical multiple regression model was not found.

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