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-Q 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, Daiiichi Yakuhin Sangyo Co., Ltd., Tokyo, Japan): β-phenylethyl alcohol at 10⁻³.₃ (w/w), methyl cyclopentenolone at 10⁻⁶.₅ (w/w), isovaleric acid at 10⁻⁴.₀ (w/w), γ-undecalactone at 10⁻³.₅ (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 0.002% (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

<table>
<thead>
<tr>
<th>Sample</th>
<th>Type</th>
<th>Package</th>
<th>Origin</th>
<th>Brix (%)</th>
<th>pH</th>
</tr>
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<tbody>
<tr>
<td>UC</td>
<td>Reconstituted</td>
<td>Paper</td>
<td>Japan</td>
<td>12.0</td>
<td>3.72</td>
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<tr>
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<td>Can</td>
<td>Japan</td>
<td>11.3</td>
<td>3.67</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>13.5</td>
<td>3.78</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>12.3</td>
<td>3.32</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Glass bottle</td>
<td>US</td>
<td>14.3</td>
<td>3.83</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Reconstituted</td>
<td>Can</td>
<td>Japan</td>
<td>11.8</td>
<td>3.81</td>
</tr>
<tr>
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<td>Reconstituted</td>
<td>Paper</td>
<td>Japan</td>
<td>11.4</td>
<td>3.68</td>
</tr>
<tr>
<td>C</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>11.3</td>
<td>3.49</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Paper</td>
<td>Australia</td>
<td>11.9</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Reconstituted</td>
<td>Can</td>
<td>Japan</td>
<td>11.0</td>
<td>3.67</td>
</tr>
<tr>
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<td>Reconstituted</td>
<td>Can</td>
<td>Japan</td>
<td>12.3</td>
<td>3.62</td>
</tr>
<tr>
<td>UC</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>12.1</td>
<td>3.82</td>
<td></td>
</tr>
<tr>
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<td>Paper</td>
<td>Japan</td>
<td>11.7</td>
<td>3.65</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>12.2</td>
<td>3.83</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Glass bottle</td>
<td>Japan</td>
<td>11.1</td>
<td>3.77</td>
<td></td>
</tr>
<tr>
<td>UC</td>
<td>Paper</td>
<td>Japan</td>
<td>13.8</td>
<td>3.63</td>
<td></td>
</tr>
</tbody>
</table>

aC=Clarified, UC=Unclarified, C_UC=Mixed.
bMeans from triplicate analyses using a digital refractometer (PR-100, Atago Co., Ltd., Tokyo, Japan).
cMean from triplicate analyses using a pH meter (Toa Electronics Ltd., Tokyo, 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 \((p < 0.05)\), metallic taste \((p < 0.05)\), 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-
ности. Один из возможных вариантов — использовать рассчитанный критический уровень значимости при более низком значении, чем предполагаемое значение (Sheskin 2000). Это означает, что при использовании значения .01 и выше. Сравнение различий при значении .01 и выше в двух вариантах ANOVA с дупликацией. Интеракции между панелированием и выбором были незначительными (p > .05) для 12 аналитических характеристик и значительными (p < .01) для 20. Значимость аналитических характеристик варьировалась от 5.0 до 12.8, за исключением ароматического, который оставался на уровне 14.4, схожим с ароматическим предпочтением (14.8) и общей предпочтительностью (14.3) (Таблица 3). Lawless (1988) отмечал, что результаты панелирования показывают стандартное отклонение от 5.0 до 12.8, за исключением аспрессивности, где стандартное отклонение было 14.4, схожим с ароматическим предпочтением (14.8) и общей предпочтительностью (14.3) (Таблица 3). Lawless (1988) сообщил о том, что результаты панелирования показывают стандартное отклонение от 5.0 до 12.8, за исключением аспрессивности, где стандартное отклонение было 14.4, схожим с ароматическим предпочтением (14.8) и общей предпочтительностью (14.3) (Таблица 3).

**Relationship Between Attributes**

**Consumer panel attributes.** Четыре признака потребителя имели высокую корреляцию (r = 0.81 to 0.95, p < 0.01), в то время как вкус и аромат имели наименьшую корреляцию (r = 0.95, p < 0.01) (Таблица 4).

**Trained panel attributes.** Корреляции (Таблица 4) были высокими для карамельного, медового, и черного сиропа. Эти ароматы, которые имели высокие значения для исходных ароматов, показали сильную положительную корреляцию (r = 0.88 to 0.95, p < 0.01) с ароматическим предпочтением. Ароматность имела значительную корреляцию (r = 0.83, p < 0.01), с медовым ароматом. Аромат-подобный аромат коррелировал с (r = 0.81, p < 0.01), с карамельным ароматом.

**Consumer and trained panel preferences.** Аромат и предпочтения были использованы для сравнения с помощью F-критерия, чтобы найти значимые различия в выборе анализируемых ароматов на уровне 95% и выше (p < 0.01). Тестирование значимости было проведено с помощью множественного регрессионного анализа, чтобы предсказать выбор потребителей на основе регрессионной модели. Модель для корреляции между общей потребительской и общей предпочтительностью была только получена следующим образом:

\[ y = 1.99 + 0.01x_1 + 0.02x_2 \]  

где y — общий выбор потребителей, x_1 — вкус для предварительного выбора, и x_2 — аромат-подобный выбор для предварительного выбора. Корреляция выбора сверху (с оценками выбора было удалено 16 выборов) между фактическими и предсказанными значениями была 0.58, что указывало на тот факт, что модель была неэффективной в практической ситуации. Для других признаков, ни одна из множественных регрессионных моделей не оказалась простой регрессионной моделью, что делало ее трудной для предсказания предпочтений потребителей на основе регрессионных моделей с анализом аромата-исходной признака на выборе регрессионного анализа. Для других признаков, множество регрессионных моделей вышло из простых регрессионных моделей, что делало их трудными для предсказания предпочтений потребителей на основе регрессионных моделей с анализом аромата-исходной признака на выборе регрессионного анализа. Эффекты, которые могут предсказать предпочтение, не были успешными, и работы продолжались.
Sensory Evaluation 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 (R² of the ANOVA model) of each attribute, 2 attributes—freshness or green-...
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 (McBurney 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.

References


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