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Culture-Specific Variation in the Flavor Profile of Soymilks

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Short Version of Title; Flavor of Soymilks....

Journal Section; Sensory and Nutritive Qualities of Food
Abstract

A modified quantitative descriptive analysis method was used to determine sensory profiles of eight soymilk products: three manufactured in Australia; three manufactured in Singapore, one manufactured in Malaysia, one manufactured in Hong Kong. A panel (n=7) was selected, trained in descriptive profiling of soymilk, and developed a soymilk language that was used to evaluate the flavor attributes of the soymilk products. A repeated-measure ANOVA showed highly reproducible panel performance, and significant differences in soymilk attributes among all soymilks. A Principal Component Analysis revealed two main groupings among the soymilks that corresponded to cultural origin: Australia and Asia (Singapore, and Hong Kong / Malaysia). Products from Australia were significantly stronger in milky, astringent, salty notes and pale in color, while products from Asia were significantly stronger in beany, cooked beans, sweet, and pandan notes (p<0.05). In addition, the Asian soymilks could be separated into two sub-groups, with Singaporean soymilks having deeper color, greater viscosity, and less green flavor than Hong Kong / Malaysia soymilks. Australian produced soymilk is dairy bovine-milk-like compared with Asian soymilk, presumably due to dairy bovine-milk being the primary source of milk in Australia. We conclude that culture-specific flavor preferences are a determining factor in flavor profiles of soymilks from geographically distinct regions.

Keywords: soymilk, descriptive analysis, flavor preference, sensory evaluation, cultural differences
Introduction

The use of soymilk in western cultures has been limited due to undesirable flavor characteristics usually described as beany, grainy, chalky, and dry (Wansink 2003a, Wansink 2003b), and a negative bias of perceived flavor (Wright and others 2001). Yet soymilk consumption has increased at tremendous rates over the past 15 years, and sales in the US alone projected to top one billion dollars by 2008 (Wrick 2003). This apparent dichotomy involving soy products in western culture is presumably due to non-sensory factors involved in food choice, including health claims (reduction of some cancers, reduction of cholesterol levels, and cardiovascular benefits) (Valachovicova and others 2004) economics, and ethics (e.g., animal rights), and cultural factors (Kittler and Sucher 2000).

Culture-specific variation in flavor preference is illustrated in acceptance of soymilk and soy products among peoples of Asian culture (Rozin 1996). Peoples of Asian origin grew up with soy as a primary milk beverage and developed a flavor preference for their local soymilks. Conversely, peoples from USA, Australia, New Zealand, and Europe who consume dairy as a primary milk beverage have developed a flavor preference for dairy milk (Mennella and Beauchamp 1994). Culturally determined flavor preferences are developed as flavor’s associated with mothers’ dietary patterns are transferred to the baby via amniotic fluid and breast milk. These early flavor experiences are built upon in weaning foods and early childhood foods (Mennella and Beauchamp 1991, Mennella and Beauchamp 1993, Mennella and Beauchamp 1999, Mennella and Beauchamp 2002, Mennella and Beauchamp 2005). Such culturally determined flavor preferences are a strong characteristic of ethnic groupings (Rozin 1996). Peoples of
Asian origin grew up with soy as a primary milk beverage and developed a flavor preference for their local soymilks. Conversely, peoples from USA, Australia, New Zealand, and Europe who consume bovine as a primary milk beverage have developed a flavor preference for bovine-milk. In both cases, the perceived flavor and liking of a particular type of milk is the result of complex stimulus-response interactions between the food matrix and human sensory, perceptual and cognitive processes (Keast 2004). Many flavor attributes are common to soymilks, but there is much variation in individual attribute intensity that give each soymilk a unique flavor profile (Day N’ Kouka and others 2004). There are myriad reasons for differences in flavor profile between soymilks, including: varieties of soybean, growing locations, rainfall, temperature, soil quality, sunlight (Min and others 2005), use of protein isolate or whole soybeans; variations in concentration of soy used in the milk; the processing of the soybean may vary; and the addition of additives such as sugar, oil, salt, maltodextrin, vitamins, minerals and flavors. To accurately assess key perceived flavor attributes of a soymilk using sensory evaluation techniques, a trained panel requires standardization and familiarization to a range of soymilks and their flavor attributes. Descriptive analysis techniques involve the detection and description of both qualitative and quantitative sensory attributes of consumer products by trained panel of judges (Meilgaard and others 1991). A trained panel should accurately evaluate and quantify the aroma, taste, aftertaste, texture, and appearance of products.

If cultural differences in flavor preferences for soymilks exist, Australia may produce soymilks typical of dairy-based milk, as opposed to soymilks produced in Asia where cow’s milk is far less common. Currently there are little or no qualitative
data examining the flavor profile of soymilk products in the market. The objective of this project was to profile the flavor of commercially successful soymilks from Australia, Singapore, and Hong Kong/Malaysia and assess if there are culture-specific differences in flavor profiles.
Materials and Methods

Panelists

Female panelists (n=7) between the ages of 26 – 49 participated in this study and provided informed consent on an approved Institutional Review Board form. The participants were asked to refrain from eating, drinking or chewing gum for one hour prior to testing. Prior to selection for this study, each panelist had completed between 120 – 180 hours of descriptive analysis training and testing, been exposed to a broad range of food products (savory, sweet, beverage, and dairy), and completed regular performance checks for repeatability and consistency.

Materials

Eight soymilk products were selected for this investigation. The criteria for selection of a soymilk was based on a review of consumer trends, analysis of the product range, identification of leading market brands, and elimination of soymilk products with added flavors. Eight products were purchased at the same time at local supermarket:

- Sanitarium So Good Regular Soymilk (Sanitarium, New South Wales, Australia),
- Australia’s Own Malt Free Natural Soymilk (So Natural Foods, New South Wales, Australia),
- Smooth White Soymilk (So Natural Foods, New South Wales, Australia),
- Vitasoy Soya Bean Milk (Vitasoy Holdings, Hong Kong) and Yeo’s Soy Bean Milk (Yeo Hiap Seng, Malaysia),
- Nutrisoy Fresh Soya Milk (Fraser and Neave, Singapore),
- Sobe Fresh Soya Milk (Fortune Food, Singapore) and Marigold Fresh Soya Milk (Malaysia Dairies, Singapore).

Abbreviations for soymilks are listed in Table I. The reference materials used to describe the attributes of the soymilk language are listed in Table II.
Panel Training

Sensory training of soymilk products were conducted over 12 three-hour sessions. During the initial phase of the research, soymilks were given to the panelists to familiarize them with the range of products to be evaluated, and to generate a set of terms sufficient to describe differences between the soymilks. Prior to a session, soymilks were shaken thoroughly, opened, and 20 ml was poured into a 30 ml plastic medicine cup (Solo, Urbana, Ill., U.S.A.), which was then covered with a lid to prevent release of volatile aromas. Samples were served at room temperature (22°C) and presented to the panelists in individual booths one at a time. Panelists tasted then wrote down the attributes present in the samples. The moderator was present at all times to answer any questions that arose. There was a five minute inter-stimulus-interval during which time panelists ate a cracker (Estra Plain Crackers, Johor, Malaysia) and thoroughly rinsed their mouths with distilled water. After all the samples were tasted by the panel, the moderator would take all of the panel inputs, displaying them on the white board and actively discuss with the panel which flavor terminologies were suitable to describe the range of soymilks. Consensus discussion among the panel refined the list of flavor attributes to 18 (Table II). Moreover, the panelists decided on the reference standards (type and quantity used) and verbal definitions that were used to anchor the attributes terms. Thereafter panelists were trained to be familiar and adept in the soymilk language they developed.

For the next phase of the training, panelists were given random soymilk samples, one at a time and the intensities of attributes for each sample (based on attributes in soymilk language) were scored under the supervision of the moderator. Paper ballots with
unstructured 15 cm line scales were used with “none” and “high” anchored on the extreme ends of the scale. Panelists were not allowed discussion to avoid influencing the scoring of attributes by other panelists. To avoid panelist fatigue, a 10-minute interval was scheduled after three soymilk samples were assessed. Distilled water and plain crackers were provided for panelists as palate cleansers between samples. The results of the training session were tabulated, averaged and graphed to illustrate the differences and similarities between the soymilk products at the end of the session. At the following training session, the graphs and corresponding soymilks were given to panelists and each was discussed before any consensus was reached. This procedure was repeated for all 18 attributes in the soymilk language and the eight soymilk products. The procedure was repeated until the panel consistently agreed on attributes and intensities of the soymilk samples (five 3-hour sessions).

**Profiling Method**

To evaluate whether the panel was sufficiently trained and consistent in their scoring, four of the eight soymilk products were selected and presented to the panel in a complete balanced block design with three replications in a trial. Conditions for the trial included; randomized serving order of samples for each panelist and each replication. Samples (20 ml) were presented in 30 ml plastic medicine cups labeled with three-digit random numbers. For testing, panelists sat in naturally lit individual booths fitted with computer screen, keyboard and mouse. Soymilk samples were served at room temperature (22°C), one at a time. Unstructured 15-cm line scales of 18 attributes were presented to the panelists on the computer screen, and attribute intensity data was
Flavor of Soymilks

collected using Compusense® five, version 4.6-SP2 program. There was a five minute
inter-stimulus-interval during which panelists ate a cracker and thoroughly rinsed their
mouths with distilled water. During the session, flavor references were available if a
panelist wanted to refresh their memory of a certain attribute. In order to ensure
freshness, soymilk products were opened and poured on the day of testing, just prior to
evaluation and covered with lids to avoid volatilization of aroma compounds. The trial
soymilk profiling sessions were carried out on three consecutive days.

The data collection of the flavor profile of the eight soymilks was conducted only
after the results of panel training were deemed satisfactory. The criteria for satisfactory
were: no significant difference in attribute intensity for a soymilk on repeated measures;
reproducibility for each attribute for each panelist with 25% of the mean for that attribute
(Keast and Breslin 2002); and no significant differences in attribute intensity rating for
each soymilk between the judges (p<0.05). The method of sample presentation and data
collection were the same for the flavor profiling as described in panel training with the
exception that all eight soymilk samples were included in the test.

Statistical Analysis

Data were analyzed using Xlstat-Pro, version 7.5.2 and SPSS for Windows,
version 12.0. Univariate and multivariate methods were used to analyze Quantitative
Descriptive Analysis (QDA) data. P-values less than 0.05 were considered statistically
significant. The mean scores for each attributes of each product were calculated, and two-
way repeated-measures ANOVA was applied to the data to assess the performance of the
panel and to determine whether significant differences for each attribute existed between
the products. Principal component analysis (PCA) was applied to the data to reduce the number of dependent variables (attributes) to a smaller set of underlying variables (factors).
Results and Discussion

Panel Training and Performance

A variety of soymilk samples were selected for the final phase of panel training. Panel performance was monitored by the use of two methods. The first method involved duplication of sample HK-04. The panel was unaware of the duplication, and the results were used to assess the reproducibility of the panel. There was a significant difference for only one of the 18 attributes (oxidized) between the two HK-04 samples ($p \leq 0.05$). The panel was retrained and questioned on the oxidized attribute, and subsequent testing proved the training was effective.

The second method of monitoring panel performance was assessing the standard deviation of each panelist for each sample and each attribute. While it is impossible to achieve absolute consistency of rating (Burdach and others 1984, Keast and others 2004, Shusterman 2002), the training phase significantly improved individual panelist performance to exceed preset maximum variation limits ($\pm 25\%$ individual panelist’s mean intensity over a minimum of three trials) (Chambers and others 2004, Keast and Breslin 2002).

Flavor Profile of Soymilks

The flavor profile of eight soymilks and a duplicate (HK-04) is shown in Table III. Similar to the trial profiling, the panel did not know there were two HK-04 samples. Repeated measures ANOVA showed there was no statistical differences between attributes of the duplicate HK-04 samples ($p \leq 0.05$) indicating excellent panel performance and consistency. Soymilk attributes that had the least variation among
samples were: fruity, green, hay, nutty, and wheat. The limited variation was due to attributes at very low levels or not present in some of the soymilks. There was much greater variation in other attributes: cooked beans, milky, oxidized, salty, sweet, and color.

The ‘beany’ attribute has limited the use of soy products in western cultures. ‘Beany’ has been attributed to degradation products of polyunsaturated fatty acids (linoleic and linolenic) induced by lipoxygenase enzyme in soybeans (Wang and others 1998). Other research has shown that lipoxygenase free soybeans still produce the beany characteristic in milk and tofu, thereby questioning the role of oxidation products as the source of beany attribute (Torres-Penaranda and others 1998, Vara-Ubol and others 2004). In the present study a correlation of oxidized and beany attribute data reveals a near significant (p=0.07) negative correlation (r=-0.67, p=0.07) between the attributes, strongly suggesting the two attributes are mutually exclusive when panelists are trained and instructed to rate both oxidized and beany attributes. The ‘beany’ attribute is not the result of a single chemical and involves multiple perceptual phenomena. Eliminating oxidation of polyunsaturated fatty acids via inactivation of lipoxigenase will eliminate some of the beany attribute, however the ‘beany’ flavor remains a problem for western cultures.

Principal Component Analysis (PCA) of soymilk flavor profile

Figure 1 shows the PCA of the data obtained from the profiling of the eight soymilk samples. Two factors accounted for 65% of the variation between the samples. Factor 1 was positively loaded with beany (0.867), cooked beans (0.964), sweet (0.873),
and pandan (0.792) attributes, and negatively loaded with milky (-0.828), astringent (-0.881), and salty (-0.853) attributes. The milky, astringent and salty attributes dominated groupings of the Australian soymilks AU-01, AU-02 and AU-03 (Sanitarium soymilk, Australia’s Own soymilk and Smooth White soymilk respectively), and these products were weak in attributes such as beany, cooked beans, sweet and pandan. The remaining samples, all from Asia were dominated by beany, cooked beans, sweet and pandan attributes, (HK-04, MA-05, SG-06, SG-07 and SG-08; Vitasoy soymilk, Yeo’s soymilk, Marigold soymilk, Sobe’s soymilk and Nutrisoy soymilk respectively). Factor 2 was positively loaded with texture (0.749) and oaty (0.704) attributes, and negatively loaded with the green (-0.667) attribute. Factor 2 allowed for separation of the Asian soymilks into two sub-groups, being Singaporean soymilks and Hong Kong / Malaysia soymilks. The PCA facilitated the grouping of the eight soymilks into three distinct groups, each group having distinct cultural origin: Australia, Singapore, Hong Kong / Malaysia.

The key differences between the groups of soymilk is shown in spider charts (Figure 2a,b,c). The spider charts show that within each grouping there were differences in other attributes that make each sample unique. For example, Figure 2a shows AU-01 was significantly stronger in beany, milky, oaty and viscosity attributes than the other AU samples, whereas AU-02 was significantly stronger in astringent, salty and oxidized attributes than the other two samples. AU-03 on the other hand, has nutty notes that were absent in the rest of the samples range.

Sugar and salt are prototypical stimuli for sweet and salty flavors respectively, and common additives in many foods. There was a distinct difference in sugar and salt additives between Australian and Asian (Singapore and Hong Kong / Malaysia)
soymilks. Australian soymilk added an average 50mg/100ml of salt to soymilks creating
a salty attribute. The Asian soymilks contained an average 5mg/100ml of salt, therefore
the salty attribute was very low or not present in those samples. However, the Asian
soymilks added an average 7.5g/100ml of sucrose to soymilks in comparison to an
average 1.3g/100ml in the Australian soymilk. As a consequence, the Asian soymilks
were sweeter than the Australian soymilks.

The color of the Australian soymilks was significantly lighter than the color of
Asian soymilks, presumably in an attempt to mimic the color of cow’s milk, the primary
source of milk in Australian culture. Flavor preferences within cultures develop as a
result of early exposure to a range of foods commonly available. In Australia (and many
western countries), dairy is the primary form of milk available to consumers and
preferences have developed for a dairy bovine-style milk beverage. However, peoples of
Asian cultures lack the lactase enzyme required to breakdown cow’s milk sugar, and
therefore find milk from cows unpalatable (Bolin and Davis 1969). As a result, there is a
difference in expectation and flavor preference between Australian and Asian cultures
which is presumably the reason for the color and other distinct flavor differences in
soymilks produced for Australian, or Asian markets.

Based on the range of soymilk products profiled and the results, there were
culture-specific variations in the flavor profile of soymilks. The samples from Australia
(AU-01, AU-02 and AU-03) have milky, astringent and salty as dominant attributes while
samples from Asia (HK-04, MA-05, SG-P06, SG-07 and SG-08) were strong in beany,
cooked beans, sweet and pandan attributes.

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Conclusion

The eight soymilk samples in this study had flavor profiles that allowed soymilks to be separated into two distinct groupings, Asia and Australia. In addition, the Asian soymilk could be further separated into Singapore and Hong Kong / Malaysia sub-group. We suggest that flavor preferences within Asian or Australian cultures are primarily responsible for the flavor differences, with Australian consumers preferring soymilk that is dairy-bovine-like in appearance and flavor.
References

Keast RSJ. 2004. Flavor is a complex issue. Pen and Palate Feb: 4-5
Mennella JA, Beauchamp GK. 1999. Experience with a flavor in mother's milk modifies the infant's acceptance of flavored cereal. Dev Psychobiol 35: 197-203
List of Tables

Table I The processing type and product codes used for the eight soymilk products

<table>
<thead>
<tr>
<th>Name of Product</th>
<th>Product Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanitarium So Good Regular Soymilk</td>
<td>AU-01</td>
</tr>
<tr>
<td>Australia’s Own Malt Free Natural Soymilk</td>
<td>AU-02</td>
</tr>
<tr>
<td>Smooth White Soymilk</td>
<td>AU-03</td>
</tr>
<tr>
<td>Vitasoy Soya Bean Milk</td>
<td>HK-04</td>
</tr>
<tr>
<td>Yeo’s Soy Bean Milk</td>
<td>MA-05</td>
</tr>
<tr>
<td>Nutrisoy Fresh Soya Milk</td>
<td>SG-06</td>
</tr>
<tr>
<td>Sobe Fresh Soya Milk</td>
<td>SG-07</td>
</tr>
<tr>
<td>Marigold Fresh Soya Milk</td>
<td>SG-08</td>
</tr>
</tbody>
</table>

Abbreviations are as follows AU (Australia), HK (Hong Kong), MA (Malaysia) and SG (Singapore).
### Table II
Attributes and definitions used by panel to describe the sensory properties of soymilk samples

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Attribute Definition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flavor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>astringent</td>
<td>A drying sensation typically associated with tasting tannin (in water), strong black tea and young red wine</td>
<td>0.1% tannin acid (Sigma-Aldrich, USA) in distilled water</td>
</tr>
<tr>
<td>beany</td>
<td>Aromatic associated with soy beans, green beans and red beans</td>
<td>50g soy beans (First Choice, Singapore) in 400ml of water heating for 15 minutes</td>
</tr>
<tr>
<td>cooked beans</td>
<td>Aromatic associated with beans cooked at high temperature for a period of time</td>
<td>0.01% heptadienal-T2,T4 (Sigma-Aldrich, USA) in TA (Sigma-Aldrich, USA)</td>
</tr>
<tr>
<td>fruity</td>
<td>Ripe-fruity aromatic associated with ripe bananas</td>
<td>2% pentyl-iso acetate (Sigma-Aldrich, USA) + 2% ethyl butyrate (Sigma-Aldrich, USA) in PG</td>
</tr>
<tr>
<td>grain husk</td>
<td>Aromatic associated with the husk of rice grains</td>
<td>0.01% dimethyl-4,5 isobutyl-2 thiazoline (Sigma-Aldrich, USA) in TA</td>
</tr>
<tr>
<td>green</td>
<td>Aromatic associated with raw cereals</td>
<td>0.01% acetyl-2-pyridine (Sigma-Aldrich, USA) in TA</td>
</tr>
<tr>
<td>hay</td>
<td>Nutty, tobacco and hay-like aromatic associated with dry grasses such as hay and straw</td>
<td>tea extract black (Chia Meei Food Industrial, Taiwan)</td>
</tr>
<tr>
<td>milky</td>
<td>Taste of pasteurized milk</td>
<td>fresh milk pasteurized (Marigold fresh milk, Singapore)</td>
</tr>
<tr>
<td>nutty</td>
<td>A light, brown, slightly musty aromatic associated with nuts and certain whole grain</td>
<td>0.1% di-methyl pyrazine (Sigma-Aldrich, USA) in TA</td>
</tr>
<tr>
<td>oaty</td>
<td>Woody, tea-like and oat flake-like aroma associated with oats</td>
<td>1% ketoisophorone (Sigma-Aldrich, USA) in PG (Sigma-Aldrich, USA)</td>
</tr>
<tr>
<td>oxidized</td>
<td>Painty aroma associated aged oils. Reminiscent of oil-based paints, linseed oil, and aged peanut butter</td>
<td>20% linoleic acid (Sigma-Aldrich, USA) in PG</td>
</tr>
<tr>
<td>pandan</td>
<td>Aromatic associated with pandan leaves</td>
<td>1% acetyl-2 pyrazine (Sigma-Aldrich, USA) in TA</td>
</tr>
<tr>
<td>salty</td>
<td>Basic taste associated with table salt (NaCL) diluted in water</td>
<td>0.5% salt (First Choice, Singapore) in distilled water</td>
</tr>
<tr>
<td>sweet</td>
<td>Taste on the tongue stimulated by sugars and high potency sweeteners in solution</td>
<td>2% sugar (First Choice, Singapore) in distilled water</td>
</tr>
<tr>
<td>wheat</td>
<td>Aromatic associated with wheat flour</td>
<td>Wheat flour (Prima Flour, Singapore)</td>
</tr>
<tr>
<td><strong>Viscosity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>The mouth-feel of products from watery to thick</td>
<td>Whipping cream (Lim Siang Huat, Singapore)</td>
</tr>
<tr>
<td><strong>Texture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalkiness</td>
<td>The texture of products from smooth to chalkiness</td>
<td>Antacid tablets (3M Titalac, United Kingdom) ground into powder and blend with distilled water at a ratio of 1:10</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darkness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellowness</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations are as follows TA is triacetin and PG is polyglycerol
Table III: Summary of the panel’s mean scores of attributes for soymilk samples, ANOVA results and standard deviations of the panel for test profiling

<table>
<thead>
<tr>
<th>Attributes</th>
<th>AU-01</th>
<th>AU-02</th>
<th>AU-03</th>
<th>HK-04</th>
<th>HK-04#</th>
<th>MA-05</th>
<th>SG-06</th>
<th>SG-07</th>
<th>SG-08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astringent</td>
<td>61^A</td>
<td>86^A</td>
<td>49^C</td>
<td>20^E</td>
<td>20^E</td>
<td>20^E</td>
<td>23^E</td>
<td>35^E</td>
<td>37^E</td>
</tr>
<tr>
<td>Beany</td>
<td>49^B</td>
<td>16^B</td>
<td>20^B</td>
<td>53^B</td>
<td>52^B</td>
<td>81^A</td>
<td>69^B</td>
<td>69^B</td>
<td>70^B</td>
</tr>
<tr>
<td>Cooked Beans</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>80^B</td>
<td>80^B</td>
<td>56^A</td>
<td>89^A</td>
<td>84^A</td>
</tr>
<tr>
<td>Fruity</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>3^B</td>
<td>7^B</td>
<td>2^B</td>
</tr>
<tr>
<td>Grain Husk</td>
<td>20^B</td>
<td>16^B</td>
<td>17^B</td>
<td>4^C</td>
<td>10^B</td>
<td>1^B</td>
<td>41^A</td>
<td>9^B</td>
<td>10^B</td>
</tr>
<tr>
<td>Green</td>
<td>3^B</td>
<td>1^B</td>
<td>0^D</td>
<td>13^A</td>
<td>10^A</td>
<td>0^D</td>
<td>1^B</td>
<td>1^B</td>
<td>1^B</td>
</tr>
<tr>
<td>Hay</td>
<td>0^B</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>50^B</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
</tr>
<tr>
<td>Milky</td>
<td>107^A</td>
<td>80^B</td>
<td>79^B</td>
<td>24^B</td>
<td>26^B</td>
<td>28^B</td>
<td>38^B</td>
<td>42^B</td>
<td>48^B</td>
</tr>
<tr>
<td>Nutty</td>
<td>0^B</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
</tr>
<tr>
<td>Oaty</td>
<td>20^B</td>
<td>0^D</td>
<td>1^B</td>
<td>1^B</td>
<td>0^D</td>
<td>2^B</td>
<td>8^B</td>
<td>31^A</td>
<td>18^B</td>
</tr>
<tr>
<td>Oxidized</td>
<td>2^C</td>
<td>52^A</td>
<td>52^A</td>
<td>15^B</td>
<td>13^B</td>
<td>0^D</td>
<td>1^C</td>
<td>5^B</td>
<td>1^C</td>
</tr>
<tr>
<td>Pandan</td>
<td>0^B</td>
<td>0^D</td>
<td>0^D</td>
<td>38^B</td>
<td>37^AB</td>
<td>10^B</td>
<td>33^B</td>
<td>19^B</td>
<td>20^B</td>
</tr>
<tr>
<td>Salty</td>
<td>53^B</td>
<td>77^A</td>
<td>21^C</td>
<td>0^D</td>
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<td>1^C</td>
<td>15^B</td>
<td>14^B</td>
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<tr>
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<td>17^B</td>
<td>95^A</td>
<td>87^A</td>
<td>76^B</td>
<td>64^C</td>
<td>61^CD</td>
<td>53^B</td>
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<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>3^B</td>
<td>3^B</td>
<td>14^A</td>
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<tr>
<td>Viscosity</td>
<td>109^A</td>
<td>17^B</td>
<td>72^C</td>
<td>52^D</td>
<td>83^B</td>
<td>56^B</td>
<td>76^B</td>
<td>81^B</td>
<td>83^B</td>
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<tr>
<td>Texture</td>
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<td>0^D</td>
<td>0^D</td>
<td>0^D</td>
<td>18^B</td>
<td>0^D</td>
<td>4^B</td>
<td>14^B</td>
<td>18^A</td>
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<tr>
<td>Color</td>
<td>19^D</td>
<td>17^D</td>
<td>19^D</td>
<td>50^C</td>
<td>99^A</td>
<td>56^B</td>
<td>89^A</td>
<td>94^A</td>
<td>99^A</td>
</tr>
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</table>
For every product code, the values on the left represent panel’s mean scores and values on the right represent (standard deviation). The mean scores ranged from 0 to 150 and alphabets beside the mean scores were used to differentiate differences among the soymilk products. Mean scores with the same alphabets for an attribute were not significantly different at $p \leq 0.05$ Thus if two soymilk samples have the same letters, it would mean that they have similar mean scores for that particular attribute. The products codes were as follows AU-01 (Sanitarium So Good Regular Soymilk), AU-02 (Australia’s Own Malt Free Natural Soymilk), AU-03 (Smooth White Soymilk), HK-04 (Vitasoy Soya Bean Milk), HK-04# (Duplicate Vitasoy Soya Bean Milk), MA-05 (Yeo’s Soymilk), SG-06 (Nutrisoy Fresh Soya Milk), SG-07 (Sobe Fresh Soya Milk) and SG-08 (Marigold Fresh Soya Milk).
**List of Figures**

**Figure 1**   PCA chart of the eight soymilk samples profiled by the panel during the test based on 18 attributes. The x-axis represents factor one accounting for 37.59% of the variation and the y-axis represents factor two accounting for 27.22% of the variation. Factor 1 (x-axis) was divided into two dimensions consisting of astringent, salty & milky versus sweet, beany, cooked beans and pandan dimension. Factor 2 (y-axis) was divided into two dimensions consisting of fruity, oaty, wheat, viscosity and texture versus green dimension. The products codes were as follows AU-01 (Sanitarium So Good Regular Soymilk), AU-02 (Australia’s Own Malt Free Natural Soymilk), AU-03 (Smooth White Soymilk), HK-04 (Vitasoy Soya Bean Milk), MA-05 (Yeo’s Soymilk), SG-06 (Nutrisoy Fresh Soya Milk), SG-07 (Sobe Fresh Soya Milk) and SG-08 (Marigold Fresh Soya Milk). Solid circles represent groupings of soymilks based on flavor profile. Group 1 is Australian soymilks, Group 2 is Asian soymilks. Group 2 is divided into two subgroups (dashed circles): 2A Singaporean soymilks, and 2B Hong Kong / Malaysia soymilks.

**Figure 2a,b,c**   Spider charts of groups of soymilks determined by PCA. The panel’s mean scores of attributes are represented by points on chart. The range of score from 0 to 150, noting only 0 to 120 were shown as scores did not go beyond 120 points. The mean scores obtained were the result of three replications by seven panelists resulting in 21 independent scores for every attributes during the test.

2A Australian soymilks: The products codes were as follows AU-01 (Sanitarium So Good Regular Soymilk), AU-02 (Australia’s Own Malt Free Natural Soymilk) and AU-03 (Smooth White Soymilk).
2B Hong Kong / Malaysia soymilks. The products codes were as follows HK-04 (Vitasoy Soya Bean Milk) and MA-05 (Yeo’s Soymilk).

2C Singaporean soymilks. The products codes were as follows SG-06 (Nutrisoy Fresh Soya Milk), SG-07 (Sobe Fresh Soya Milk) and SG-08 (Marigold Fresh Soya Milk).
Flavor of Soymilks

- Astringent, salty & milky dimension
- Sweet, beany, cooked beans & pandan dimension

- Sanitarium Soy Milk
- Nutrisoy Soy Milk
- Vitasoy Soy Milk
- Yeo's Soy Milk
- Sobe's Soy Milk
- Marigold Soy Milk
- Smooth White Soy Milk
- Australia's Own Soy Milk
- Oxidized Soy Milk
- Grain Husk Soy Milk
- Pandan Soy Milk
- Cooked Beans Soy Milk

Colors:
- green
- oaty
- wheat
- viscosity
- texture

- axis F1 (37.59 %)
- axis F2 (27.22 %)

- axes F1 and F2: 64.81 %
Flavor of Soymilks

AU-01

HK-04

SG-06

Flavor of Soymilks

AU-02

MA-05

SG-07

Flavor of Soymilks

AU-03

HK-04 (duplicate)

SG-08

Flavor of Soymilks

42

43

44

45