Improving the Consumer Acceptance of Soluble Coffee by Varietal Coffee Steaming and Aroma Distillation

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Steam stripping of roasted coffee is applied to the production of soluble coffee in an attempt to increase the aromatic quality of the product. This practice, however, has two drawbacks which partially negate the benefits. Firstly, the addition of the aroma condensate to the coffee extract results in dilution which adversely affects aroma retention during drying. Secondly, the aromatics derived from Robusta coffee sometimes reduce consumer acceptance of the soluble coffee product. Two methods were investigated in this research as a route to overcoming these difficulties. Distillation of the steam aroma was examined as a means of concentrating and rebalancing the aromas. "Partial Steaming", wherein only the Arabica portion of the blend is stripped to recover aromas, was also explored. Products made by these techniques were evaluated by our expert panelists and ordinary consumers. Products containing fractionated steam aroma showed an overall improvement in quality and a reduction in sourness and harshness. The "Partial Steaming" process enabled us to enhance desirable Arabica coffee characteristics in the soluble coffee while reducing Robusta flavor notes. Consumer testing of samples prepared using these methods confirmed that both techniques resulted in an improvement in overall product preference.

The authors reported in the previous paper that a continuous steaming system enables us to deliver characteristics of a regular brewed coffee with minimizing generation of acids during steaming. The soluble coffee to which steam aroma was added showed a so called "Floral" note typically perceived in a Colombian brewed coffee and was evaluated close to regular brewed coffee by the expert panelists.

When a large amount of condensate is recovered and added back to the concentrate obtained from the steamed coffee, the concentrate fed to the drying process is diluted with the condensate, which results in lower aroma retention during drying.

The distillation method, which is commonly used especially in the flavor industry, is considered as an appropriate method not only to fractionate the steam aromas to prevent the extract from being diluted but also to manipulate flavor characteristics.

Arabica coffee is commonly recognized as a high grade coffee. The variety is not usually solely used in commercial products, but several varieties are blended to manipulate the flavor. Robusta is another variety commonly used in commercial products. Arabica coffee is usually used for the blend to enhance aroma and Robusta coffee is used for delivering "body" and bitterness to the cup. When steam aromas are applied to commercial soluble coffee products having such a blend of coffee, the aromatics derived from Robusta coffee recovered in the steam aroma sometimes show a negative effect on preference of the coffee.

Steaming coffee by variety (solely steamed Arabica coffee was blended with non-steam Robusta coffee following the extraction of soluble solids) was expected to be one of the ways to improve flavor.

In this study, gas-chromatographic analysis was carried out to determine the volatiles material balance when distillation of steam aroma was employed. The effects of distilla-
tion of steam aroma and of steaming by coffee
variety on flavor characteristics, as examples
for commercial application of steam aromas,
were evaluated both by expert panelists and
ordinary consumers. The results of the con-
ssumer test were analyzed by multivariate sta-
tistical analysis (factor analysis method) to
characterize those operations.

Materials and Methods

Equipment

a) Steam aroma recovery

Steam aromas were recovered with the con-
tinuous equipment which was described in the
previous paper1).

b) Distillation

The steam condensate was distilled with an
ordinary continuous evaporator with a plate
type heat exchanger under 625mm Hg vacuum.

Materials

For steam aroma recovery, roasted Colom-
bian coffee (a typical variety of Arabica),
which had 20°C with a colorimeter and 3 000
µm mean particle size were fed to the equip-
ment. The steamed Colombian coffee was
blended with non-steamed Ivory Coast coffee
(a typical variety of Robusta) having the same
roasting degree and mean particle size, then
loaded into a conventional percolator set to
extract soluble solids.

Analyses

The steam aroma obtained with the con-
tinuous equipment was directly injected onto
the gas chromatograph (Hewlett Packard : HP-
5840) having a packed column (SP-1000 on
Chromosorb W-AW) and Flame Ionization
Detector (FID). The chromatogram was divid-
ed into three regions, “Lights”, “Mediums”
and “Heavies” as described in the previous
paper1). The unit for the chromatographic re-
sults was FID counts per gram of dry coffee.
The acids in the steam aromas were titrated by
0.1 N sodium hydroxide solution to an end
point of pH 8.1. The unit was milliequivalent
per gram of dry coffee.

Organoleptic Evaluation

The steam aromas were added back to the
concentrated extract from the respective steam-
ed coffees and freeze dried to obtain soluble
coffee samples for flavor evaluation by five
expert panelists. The attributes evaluated
were aromatic impact, “Floral” note which is
typical for Colombian coffee, “Earthy” which
is a note like soil, a harsh note and sourness.
The intensities for the attributes were rated in
13 degrees.

Consumer Evaluation

Eighteen (18) non-expert people working in
Suzuka plant of Ajinomoto General Foods, Inc.
volunteered to evaluate the flavor of the freeze
dried coffee samples to which various steam
aromas were added back. The order for the
samples were randomized and each panel
evaluated one sample a day. The attributes,
evaluated by the consumers, were eleven (11)
for preference of the samples and ten (10) for
strength as shown in Table 3.

Statistical Analysis

The rating on the 21 attributes by the con-
sumers were analyzed by the factor analysis
method to characterize the flavors of the
samples. The flavor characteristics of the
coffee samples were represented by a small
number of factors7)8) and the effects of distilla-
tion and “Partial Steaming” method on flavor
were evaluated.

Results and Discussion

1. Volatile material balance during distilla-
tion

Table 1 shows the material balance of volati-
les in the pilot scale distillation of steam
aroma of 0.46 DOF (Draw Off Factor; the
amount of steam condensate recovered by
steaming of roasted coffee), when 22% distil-
lates were collected. Components in the
“Lights” region such as acetaldehyde, diacetyl
and 2,3-pentanedione, which are presumably
desirable for coffee flavor9), were recovered
almost 100% in the distillate, though “Medi-
ums” and “Heavies” were recovered only 17%
and 27%, respectively. The components in
those regions are assumed to have low volatility
and not to be very important to coffee flavor.

Only 13% of acids were recovered in the
distillate. These results suggest that the
Table 1 Material balance of Volatile aromas and acids across flash distillation

(Unit: %)

<table>
<thead>
<tr>
<th>Stream</th>
<th>Lights</th>
<th>Mediums</th>
<th>Heavies</th>
<th>Total</th>
<th>Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Distillate</td>
<td>106</td>
<td>17</td>
<td>27</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Residue</td>
<td>2</td>
<td>83</td>
<td>57</td>
<td>66</td>
<td>83</td>
</tr>
</tbody>
</table>

distillation process could manipulate flavors of the coffee products to which steam aromas are applied, since the balance of volatiles and acids could be altered by distillation.

2. Change in flavor with distillation

Figure 1 shows the comparison of flavor characteristics of the sample to which the distilled steam aroma was added and the sample to which the bulk steam aroma (non-distilled) was added. Although the aromatic impact for the distilled sample was less than the reference, the rating for the “Floral” note, which is typical for Colombian coffee, did not change. This suggests that the volatiles in “Lights” may contribute to this preferable aromatic. A less “Harsh” note, an undesirable aromatic, was also perceived, which may correlate with the reduction of “Mediums” and “Heavies” by distillation. The intensity of sourness was also less than the reference, this corresponds to the reduction of acids by the process.

This indicates that the distillation is an effective unit operation to manipulate aromatics and sourness, which are important attributes of quality for soluble coffee.

3. Partial steaming (steaming by coffee variety)

It is commonly recognized that Arabica coffee delivers preferable aroma, “Floral”, and strong sourness to the cup of coffee. On the other hand, Robusta gives a “body” and bitterness to the cup, though an “Earthy” or harsh note is perceived in the cup. It is also known that Robusta results in higher concentration when it is percolated. Commercial soluble coffee products are designed with combinations of the varieties using their characteristics.

We thus devised a process flow to achieve desirable aromas of Arabica coffee and good “body” and bitterness of Robusta in a soluble coffee to which steam aroma was applied, as described in Fig. 2. Steam aroma was recovered from Colombian coffee, the steamed coffee was blended with non-steamed Ivory Coast coffee which had the same weight (dry basis) as the Colombian, and the coffee was fed to a conventional percolator to extract soluble solids. The extract was concentrated by an ordinary evaporator to obtain a concentrate to which the steam aroma of Colombian coffee was added back. Then the concentrate was freeze dried.
Figure 3 shows change in organoleptic characteristics of soluble coffee to which the partial steaming was applied, compared with the reference (steaming both Colombian and Ivory Coast coffee) evaluated by expert panelists. Overall aromatic impact in the cup did not change when the partial steaming was applied. The sample to which the partial steaming was applied showed a "Floral" note characterizing Colombian coffee. Less "Earthy" and no "Harsh" notes were perceived in the cup. The "Floral" note was assumed to exist even in the cup to which steam aroma from the blend of Colombian and Ivory Coast was added back, but the "Floral" note may be masked by "Earthy" and "Harsh" notes recovered from Ivory Coast coffee.

The partial steaming was also determined to be an effective technique to manipulate aroma in a cup of steam aroma applied coffees.

4. Multivariate Analysis of Consumer Test

The six samples listed in Table 2 were evaluated by eighteen (18) ordinary consumers. The samples were prepared with a combination of the conditions: distillation, partial steaming and DOF. As described in Table 3, eleven (11) attributes in preference and ten (10) attributes in strength of the samples were rated in five degrees. The average rating for each attribute is shown in Table 3 and the result was analyzed with the factor analysis method to describe the characteristic of each sample.

Table 4 shows cumulative % contribution (coefficient of determination) of each factor and factor loading for each attribute obtained with the factor analysis. The first factor showed a positive correlation with "preference of aroma" and negative correlations with "strength of astringency", "strength of bitterness" and "strength of aftertaste". This factor may represent "preference of aroma and strength of taste". The second factor positively correlated with "overall preference", "preference of freshness", "preference of body" and "preference of cup strength" (strength of

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**Table 2 Description of samples for consumer evaluation**

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Distillation</th>
<th>Partial steaming</th>
<th>DOF</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Applied</td>
<td>Applied</td>
<td>0.46</td>
</tr>
<tr>
<td>#2</td>
<td>Applied</td>
<td>Not applied</td>
<td>0.22</td>
</tr>
<tr>
<td>#3</td>
<td>Not applied</td>
<td>Applied</td>
<td>0.46</td>
</tr>
<tr>
<td>#4</td>
<td>Not applied</td>
<td>Not applied</td>
<td>0.22</td>
</tr>
<tr>
<td>#5</td>
<td>Not applied</td>
<td>Applied</td>
<td>0.10</td>
</tr>
<tr>
<td>#6</td>
<td>Not applied</td>
<td>Not applied</td>
<td>0.052</td>
</tr>
</tbody>
</table>
Table 3 Average rating for attributes in consumer evaluation

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1</td>
</tr>
<tr>
<td>Preference</td>
<td></td>
</tr>
<tr>
<td>(1) Overall</td>
<td>3.06</td>
</tr>
<tr>
<td>(2) Aroma</td>
<td>3.06</td>
</tr>
<tr>
<td>(3) Freshness</td>
<td>3.00</td>
</tr>
<tr>
<td>(4) Regular like</td>
<td>2.78</td>
</tr>
<tr>
<td>(5) Bitterness</td>
<td>2.78</td>
</tr>
<tr>
<td>(6) Body</td>
<td>3.00</td>
</tr>
<tr>
<td>(7) Mellowness</td>
<td>2.72</td>
</tr>
<tr>
<td>(8) Soursness</td>
<td>3.34</td>
</tr>
<tr>
<td>(9) After taste</td>
<td>2.78</td>
</tr>
<tr>
<td>00 Total balance</td>
<td>2.89</td>
</tr>
<tr>
<td>01 Cup strength</td>
<td>2.94</td>
</tr>
<tr>
<td>Strength</td>
<td></td>
</tr>
<tr>
<td>02 Aroma</td>
<td>2.56</td>
</tr>
<tr>
<td>03 Astringency</td>
<td>3.06</td>
</tr>
<tr>
<td>04 Cup strength</td>
<td>3.17</td>
</tr>
<tr>
<td>05 Soursness</td>
<td>3.17</td>
</tr>
<tr>
<td>06 Bitterness</td>
<td>3.39</td>
</tr>
<tr>
<td>07 After taste</td>
<td>3.12</td>
</tr>
<tr>
<td>08 Harshness</td>
<td>3.22</td>
</tr>
<tr>
<td>09 R &amp; G like</td>
<td>2.67</td>
</tr>
<tr>
<td>10 Peculiar taste</td>
<td>2.83</td>
</tr>
<tr>
<td>11 Peculiar aroma</td>
<td>2.89</td>
</tr>
</tbody>
</table>

coffee). This factor may reflect "overall preference".

The factor scores for the six samples were plotted on the coordinate of the first and the second factors, shown in Fig. 4. Four samples except #5 and #6 (with low DOF aroma add–back) little "move" on the first axis, and the second factors were thought to explain well the characteristics of the samples. Sample #2 (Non-partial steaming, Distillation) was located at the positive side on the second axis compared with sample #4 (Non-partial steaming, Non-distillation). Sample #1 (Partial steaming, Distillation) was located at further positive side on the axis. Sample #1 was also located at the positive side on the axis compared with sample #3 (Partial steaming, Non-distillation). Those results suggest that the two operations, distillation and partial steaming, are effective for improving overall preference which is represented by the second factor.

Sample #5 (Low DOF, Partial steaming, Non-distillation) was located at slightly positive sides on the second axis compared with sample #6 (Low DOF, Non-partial steaming, Non-distillation). Sample #5 was located at rather negative side on the first axis compared with sample #6, which represented that sample #5 had less "preference of aroma" than sample #6. Since the lower amount of total volatiles was recovered with lower DOF than with higher DOF condition, volatiles recovered only from Colombian coffee with the partial steam-
ing would not be sufficient enough to achieve good score on “preference of aroma”. On the other hand, for the other four samples with larger DOF, both distillation and partial steaming resulted in the higher score on overall preference, because distillation reduced acids and partial steaming gave an preferable aroma “Floral” derived from Colombian coffee.

The % contribution of the third factor was 22% and this factor showed a high negative correlation with “preferences of regular-coffee-likeness and bitterness” and also showed a negative correlation with “strengths of aroma and peculiar aroma” as shown in Table 4. This factor, therefore, may represent “strength of regular-coffee-like flavor enhanced by steam aroma” or “strength of typical steam aroma flavor”.

The factor scores for the samples are positioned on the coordinate of the third and the fourth factors as shown in Fig. 5. Partial steaming resulted to locate the samples #4, #2 and #6 at the negative side on the third axis. Distillation, however, resulted to locate #3 and #4 at the positive side on the axis. Those may be attributed by less volatile recovery by distillation as previously cited and weakened aromatic strength.

Table 4  Factor loading for each attribute

<table>
<thead>
<tr>
<th>Coffee Characteristics</th>
<th>Cumulative %</th>
<th>Factor</th>
<th>The first</th>
<th>The second</th>
<th>The third</th>
<th>The fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference</td>
<td></td>
<td>29.91</td>
<td>58.04</td>
<td>80.07</td>
<td>91.55</td>
<td></td>
</tr>
<tr>
<td>(1) Overall</td>
<td></td>
<td>-0.014</td>
<td>0.996</td>
<td>-0.030</td>
<td>0.079</td>
<td></td>
</tr>
<tr>
<td>(2) Aroma</td>
<td>0.861</td>
<td></td>
<td>0.229</td>
<td>0.250</td>
<td>0.379</td>
<td></td>
</tr>
<tr>
<td>(3) Freshness</td>
<td>-0.312</td>
<td>0.876</td>
<td>0.143</td>
<td>-0.340</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Regular like</td>
<td>-0.312</td>
<td>0.279</td>
<td>-0.908</td>
<td>-0.010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Bitterness</td>
<td>0.019</td>
<td>-0.068</td>
<td>-0.996</td>
<td>-0.056</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Body</td>
<td>0.021</td>
<td>0.942</td>
<td>-0.335</td>
<td>-0.020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Mellowness</td>
<td>0.500</td>
<td>0.003</td>
<td>-0.456</td>
<td>-0.737</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Sourness</td>
<td>0.206</td>
<td>0.850</td>
<td>0.361</td>
<td>-0.324</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(9) After taste</td>
<td>0.724</td>
<td>0.430</td>
<td>-0.335</td>
<td>-0.406</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Total balance</td>
<td>0.281</td>
<td>0.470</td>
<td>-0.272</td>
<td>-0.791</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(11) Cup strength</td>
<td>0.078</td>
<td>0.819</td>
<td>-0.517</td>
<td>0.235</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Aroma</td>
<td>0.016</td>
<td>-0.019</td>
<td>-0.910</td>
<td>-0.413</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(13) Astringency</td>
<td>-0.970</td>
<td>0.153</td>
<td>0.020</td>
<td>0.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14) Cup strength</td>
<td>-0.733</td>
<td>0.451</td>
<td>-0.299</td>
<td>0.412</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(15) Sourness</td>
<td>0.149</td>
<td>-0.078</td>
<td>-0.304</td>
<td>0.965</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(16) Bitterness</td>
<td>-0.921</td>
<td>0.322</td>
<td>0.213</td>
<td>0.043</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(17) After taste</td>
<td>-0.964</td>
<td>0.018</td>
<td>-0.261</td>
<td>-0.260</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(18) Harshness</td>
<td>-0.273</td>
<td>0.855</td>
<td>0.180</td>
<td>-0.403</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(19) R &amp; G like</td>
<td>-0.309</td>
<td>-0.387</td>
<td>-0.656</td>
<td>0.569</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(20) Peculiar taste</td>
<td>-0.714</td>
<td>-0.436</td>
<td>-0.512</td>
<td>0.196</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(21) Peculiar aroma</td>
<td>-0.053</td>
<td>0.084</td>
<td>-0.973</td>
<td>0.210</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The explanation of each factor

- Preference of Aroma and Strength of taste
- Overall Preference
- Typical steam aroma flavor
- Intensity of Sourness and Preference of Total balance
Fig. 4 Position of each sample on the coordinate of the first and the second factors

#1: Partial steaming & Distilled
#2: Steaming Colombian/Ivory Coast & Distilled
#3: Partial steaming
#4: Steaming Colombian/Ivory Coast
#5: Low DOF, Partial steaming
#6: Low DOF, Steaming Colombian/Ivory Coast

The fourth factor showed a positive correlation with "strength of sourness" and a negative correlation with "preferences of mellowness and total balance" as shown in Table 4. However, the factor would not be very important to describe the characteristics of the coffee samples, since the attributes could not be represented with a single flavor characteristic and a low % contribution (11.5%) and the small "moves" of the samples on the fourth axis for each sample were observed.

Those results suggest that the two operations, distillation and partial steaming are effective means to improve consumers' preference, when steam aroma is applied to soluble coffee products. When the organoleptic evaluation by the expert panelists is taken into account, the enhancement of a typical Colombian coffee aromatic, "Floral", and the reduction of "Earthy" and "Harsh" notes may have led to the improvement of consumers' preference.

Fig. 5 Position of each sample on the coordinate of the third and the fourth factors

#1: Partial steaming & Distilled
#2: Steaming Colombian/Ivory Coast & Distilled
#3: Partial steaming
#4: Steaming Colombian/Ivory Coast
#5: Low DOF, Partial steaming
#6: Low DOF, Steaming Colombian/Ivory Coast

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7) OKUDA, T., et. al.: Zoku Tahenryo Kaiseki-
水蒸気によって回収した香気成分の添加による
インスタントコーヒーの嗜好性の改善

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インスタントコーヒーの製造において、焙煎コーヒー

の水蒸気蒸留物を添加するとコーヒー濃縮液の濃度が低下し、乾燥時に香気成分の保持率の低下を引き起こす。
減速蒸気によって回収されるロバスタ種コーヒーの香りは必ずしも消費者に好まれない。これらの問題点を解決するために、水蒸気により回収した香気成分の蒸留と、
水蒸気蒸留物はアラビカ種コーヒーのみから回収する「バーチャルスチーミング」を検討した。蒸留により香気成分の組成と酸の量は変化し、雑味を伴う香りと酸味
が減少した。また「バーチャルスチーミング」によってアラビカ種コーヒーの特徴を再現できた。消費者テスト
の結果に基づく因子分析において、蒸留、「バーチャルスチーミング」共にインスタントコーヒーの嗜好性を改善させることができたかとなった。