The Quest for Freshness
A Scientific Approach to Coffee Freshness

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The Coffee Freshness Handbook

Edition No. 3

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The SCA Water Quality Handbook

Part One: A Systematic Guide to Water Fundamentals
The secret to great coffee is the people who make it

It All Began ... when Alfred Peet opened Peet's Coffee & Tea in Berkeley, 1966
His coffee was unlike anything Americans had ever tasted before – small batches, fresh beans, ...

His philosophy: to have the shortest distance between roaster and customer
Peet taught roasting to Jerry Baldwin, Zev Siegl and Gordon Bowker
⇒ Founded 1971 Starbucks in Seattle

... selling fresh-roasted whole beans to local customers
Why do we care about freshness?

- Is the at the origin of the specialty coffee movement
- Is a highly sought-after quality for coffee
- Has become a competitive advantage
How do we define freshness?

Freshness is often defined by the *process*:

How can one measure freshness of coffee?
Markers of Freshness: CO$_2$ and Aroma

Freshness is best defined

- as having original unimpaired qualities
- by the level of closeness to the original product
Measuring CO$_2$ and aroma along their journey

- from creation in roaster
- to impact in the cup
Measuring freshness by weighing - A gravimetric method

Probatino drum roaster (1kg-batch)

Mimics degassing from pack with a release valve

Capillary to release degassed CO₂

VST 15 g basket filter
Measuring freshness by weighing - A gravimetric method
Whole Beans

$\text{CO}_2$

Whole Beans
### Experimental plan – whole beans (Arabica, El Salvador)

<table>
<thead>
<tr>
<th></th>
<th>Fast</th>
<th>Medium</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 - 6 min</td>
<td>9 - 10 min</td>
<td>11 - 13 min</td>
</tr>
<tr>
<td></td>
<td>300 – 360 s</td>
<td>540 – 600 s</td>
<td>660 – 780 s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roast Level</th>
<th>Fast</th>
<th>Medium</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Roast</strong></td>
<td><strong>5 - 6 min</strong></td>
<td><strong>9 - 10 min</strong></td>
<td><strong>11 - 13 min</strong></td>
</tr>
<tr>
<td>(CT 130Pt)</td>
<td><strong>300 – 360 s</strong></td>
<td><strong>540 – 600 s</strong></td>
<td><strong>660 – 780 s</strong></td>
</tr>
<tr>
<td><strong>Medium Roast</strong></td>
<td><strong>5 - 6 min</strong></td>
<td><strong>9 - 10 min</strong></td>
<td><strong>11 - 13 min</strong></td>
</tr>
<tr>
<td>(CT 100Pt)</td>
<td><strong>300 – 360 s</strong></td>
<td><strong>540 – 600 s</strong></td>
<td><strong>660 – 780 s</strong></td>
</tr>
<tr>
<td><strong>Dark Roast</strong></td>
<td><strong>5 - 6 min</strong></td>
<td><strong>9 - 10 min</strong></td>
<td><strong>11 - 13 min</strong></td>
</tr>
<tr>
<td>(CT 80Pt)</td>
<td><strong>300 – 360 s</strong></td>
<td><strong>540 – 600 s</strong></td>
<td><strong>660 – 780 s</strong></td>
</tr>
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</table>
Weight loss of Arabica whole beans

Specific mass loss / (mg/g)

Time / h

18 days

Medium to dark roast (85 Pt; Colorette)

18 days of degassing

10 mg/g corresponds 1 % weight loss
Degassing of whole beans

*Arabica – impact of roast profile (speed)*

- **6 minutes roast time**
- **10 minutes roast time**
- **15 minutes roast time**

The faster the roast, the more CO₂ is released during storage.
Degassing of whole beans

- The lighter the roast → The less $\text{CO}_2$ is released
- The faster the roast → the more $\text{CO}_2$ is released during storage
Degassing of whole beans
Arabica – impact of roast profile (variable speed – same roast colour)

Roast degree

- Strong impact of roast degree on degassing
  - 8-12 mg/g dark roast (1 %)
  - 5-7 mg/g medium roast (0.5 %)
  - 2-3 mg/g light roast (0.25 %)
- Impact of roasting speed on degassing: the faster the roast the more degassing

Degassing measured up to 20 days – still further degassing occurring after this period
Roast & Ground Beans
Degassing of ground coffee $\rightarrow$ gravimetric measurement of loss of freshness - Arabica
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Total amount of weight loss after 90 hours

- Above 95 Pt (medium roast) no further increase
- Robusta has 40% more CO₂
Implications on

- **Processing**
- **Cup**

- 87% CO₂
- 7.3% H₂O
- 5.3% N
- VOC₅(s) (aromatics)

- 1-2% CO₂
- 1-2% H₂O

- VOC₅ CO₂
- aromas
Degassing of R&G from whole beans stored in freezer at -25 °C / -15 °F

- Cooling (freezing?) roasted coffee beans greatly reduces the degassing rate.
- The process does not appear to impact the amount and the kinetics of degassing from R&G coffee.
Degassing of whole beans after stored in a freezer (-25 °C / -15 °F)

Coffee stored for 70 days at -25 °C releases the same amount of gas as freshly roasted coffee stored at 35 °C for 2 days.

~2 faster per 10 °C increase

Coffee stored at -25 °C still does degas ... but significantly slower than at 35 °C

- Freshly roasted whole beans
- Whole beans degassing at 35 °C
- Stored at –25 °C for 70 days
Freshness and espresso extraction

Impact of freshness on crema formation
Freshness and espresso extraction

Impact of freshness on crema formation.

Fresh roast

10 days

2 months

1 year
Aroma formation: from precursors to aroma compounds

**Green Coffee Precursors**
- Sugars (sucrose, glucose, fructose & arabinogalactans)
- Amino Acids (Strecker active amino acids)
- Trigonelline
- Organic Acids
- Lipids
- Carotenoids
- Chlorogenic Acid

**Roasted Coffee**
- Formic acid
- Glycolic acid
- Acetic acid
- Lactic acid
- Diketones
- Aldehydes
- Pyrazines
- 2-Furfurylthiol
- 3-Mercapto-3-methylbutyl-formate
- Vanillin
- Guaiacols
- Caffeic acid
- Ferulic acid

**Green Coffee Precursors to Roasted Coffee**
- Caramelization
- Carboxyls
- CO₂
- Maillard Reaction
## Chemical markers: “Freshness indices” related to coffee aroma

### Ratio 1: Dimethyl disulfide / Methanethiol

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Odor</th>
<th>Volatility</th>
<th>Reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,3-Butanedione</td>
<td>buttery, creamy, fatty, oily, sweet, vanilla, caramel</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Dimethyl disulfide</td>
<td>sulphurous, onion, garlic, burnt rubber</td>
<td>medium</td>
<td>high (ox.)</td>
</tr>
<tr>
<td>Methanethiol</td>
<td>sulphurous, rotten eggs, fish, cabbage, garlic, cheesy</td>
<td>high</td>
<td>very high (ox.)</td>
</tr>
<tr>
<td>2-Methylfuran</td>
<td>burnt, ethereal, gasoline, acetone, chocolate</td>
<td>very high</td>
<td>very low</td>
</tr>
</tbody>
</table>
Dimethyldisulfid and Methanthiol (Medium roast degree: Pt 95)

- Dimethyldisulfid
- Methanthiol

Storage time / weeks

Ratio 1: Dimethyldisulfid / Methanthiol
Chemistry of freshness index - Dimethyl disulfide / Methanethiol

Methionine

\[
\begin{align*}
\text{NH}_2 \\
\text{H}_3\text{C} - \text{S} - \text{NH}_2 \\
\text{OH}
\end{align*}
\]

→

Methional

\[
\begin{align*}
\text{CH}_3 \\
\text{S} - \text{S} - \text{CH}_3
\end{align*}
\]

DMS + DMTS

\[
\begin{align*}
\text{H}_3\text{C} & - \text{S} - \text{S} - \text{CH}_3 \\
\text{H}_3\text{C} & - \text{SH}
\end{align*}
\]

Dimethyldisulfid (DMDS)

Methanethiol

\[
\begin{align*}
\text{H}_3\text{C} & - \text{S} \\
\text{H}_3\text{C} & - \text{MeS}
\end{align*}
\]

Freshness Index = \( \frac{\text{DMDS}}{\text{MeSH}} \)
Storage of whole beans: aluminium packaging with valve

- Ethiopian Limu, Washed, Grade 2, Arabica
- Roasted on a 1-kg batch size Probatino
- Roast degree 93 Pt (Colorette), medium roast
- 65 g roasted whole beans in each pack
- Packaging: plastic composite film with thick aluminum layer
- Valve
- Heat sealed
- Stored at 22 °C and 50 °C
Evolution of ratio: Dimethyl disulfide / Methanethiol

stored 22 °C and 50 °C

- ~ 10-fold increase when going from 22 °C to 50 °C
- Sensitive freshness index: significant changes within 1 week (suited for specialty coffee)
Vertical Roasters, Switzerland
San Jerónimo, Guatemala
Catuaí, Espresso Roast

Ditting KR 805
grinding fineness: 5

(4.00 ± 0.01) g samples

storage

3 oxygen concentrations:
0 % (V/V), 10 % (V/V), 20 % (V/V)

2 temperatures:
30 °C, 50 °C
Ratio Methanethiol (1) / Dimethyl disulfide (2) of 30 °C-samples
Ratio Methanethiol (1) / Dimethyl disulfide (2) of 50 °C-samples

\[ \frac{A_1(\Delta t)}{A_2(\Delta t)} \]

\[ \Delta t / \text{d} \]

0 % O₂
10 % O₂
20 % O₂
Ratio Methanethiol (1) / Dimethyl disulfide (2) of 0 % O₂-samples

\[ \frac{A_1(\Delta t)}{A_2(\Delta t)} \]

\( \Delta t / d \)

- 30 °C
- 50 °C
Freshness roasted whole beans

Chemical markers

- Freshly roasted *coffee arabica* from Guatemala, 250 g roasted whole beans, stored at room temperature
- Packed in four different packaging materials (with valves except for paper packaging)
**Freshness in single serve capsules (ground coffee)**

*Chemical markers*

<table>
<thead>
<tr>
<th>Code</th>
<th>Capsule</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Delizio (Ø40x26)</td>
<td>Body: PP/EVOH/PP; Cover: PP/EVOH/PP; thickness: 0.1 mm; Barrier-properties integrated into capsule and cover</td>
</tr>
<tr>
<td>C2</td>
<td>Dolce Gusto (Ø53.5x39)</td>
<td>Body: PP/EVOH/PP; Cover: PP/EVOH/PP; thickness: 0.12 mm; Barrier-properties integrated into capsule and cover</td>
</tr>
<tr>
<td>C3</td>
<td>Denner (Ø37x31)</td>
<td>Body: PP (injection molding without barrier-properties); Cover: Paper with aluminum coating; thickness: 0.03 - 0.05 mm; Barrier-properties integrated into capsule and cover</td>
</tr>
<tr>
<td>C4</td>
<td>Nespresso (Ø37x31)</td>
<td>Body: 99% aluminum, with thin coating of food-grade shellac; Cover: aluminum foil; thickness 0.03 - 0.05 mm; Barrier-properties integrated into capsule and cover</td>
</tr>
</tbody>
</table>

**Graph:**

![Graph](image)

- **a) dimethyl disulfide / methanethiol**

- **Ratio**

- **time / weeks**
Freshness Index = DMDS / MeSH for Nespresso Lungo Fortissio

Storage Temperature: 22 °C

Lungo Fortissio (Nespresso)

Graph showing the change in DMDS, MeSH, and their ratio over storage weeks.
Take-away messages

• Freshness gives a competitive advantage in the specialty coffee segment → for whole beans, for capsules

• By making freshness measurable & comparable it becomes an objective concept → it can be improved and communicated

• We introduced and applied two complementary dimensions of freshness: → Freshness Indices and loss of CO$_2$.
  → They are related but not identical

• Measuring both Freshness Indices and loss of CO$_2$ represent practical and effective means to assess the impact of process parameters, packaging and storage conditions on loss of freshness

• We are in the process of developing a tool (gravimetric method) to measure degassing
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- Head Coffee Excellence Centre
- Head Analytical Technologies

Origin
Dr. Sebastian Opitz

Transformation
Dr. Samo Smrke

Extraction
Dr. Marco Wellinger

Aroma
Dr. Anja Rahn

Continuing Education & Sustainability
MSc Sabine Stauffacher
Evaluation Forms

Please Complete An Evaluation Form After This Lecture

Coordinator: Room Host
Questions, Discussions ... ?