## ROASTING CURRICULUM: Intermediate

<table>
<thead>
<tr>
<th>Title of module</th>
<th>Roasting</th>
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<tbody>
<tr>
<td>Level</td>
<td>Intermediate</td>
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<tr>
<td>Recommended course hours</td>
<td>21 hours, including exams</td>
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<tr>
<td>Course aim</td>
<td>This course will provide a more detailed understanding of the roasting process and the different kinds of heat transfer at work.</td>
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<tr>
<td>Information for trainer</td>
<td>Pre-requisites for participation in the Intermediate certification process: Roasting Foundation, Sensory Foundation and Green Coffee Foundation</td>
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<table>
<thead>
<tr>
<th>Code/subject</th>
<th>Sub code</th>
<th>Knowledge/Skills</th>
<th>Objective</th>
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<tbody>
<tr>
<td>1.01</td>
<td>1.01.01</td>
<td>Measurements that can be collected on green and roasted coffee.</td>
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<tr>
<td></td>
<td></td>
<td>1. Bulk density</td>
<td>Recognizing, recording, and controlling variables that impact roast profiles.</td>
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<td></td>
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<td>2. Screen size</td>
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<td>3. Moisture content</td>
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<td>4. Color</td>
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<td>Data to collect and analysis required to support profile roasting.</td>
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<td>1. Date roasted</td>
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<td>2. Ambient environmental data</td>
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<td>3. Identifying details on the coffee</td>
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<td>4. Charge weight</td>
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<td>5. Time, temperature, and control measurements</td>
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<td>6. Roasted weight and percent weight loss</td>
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<td>7. Evaluation forms</td>
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<td>Heat vs. Temperature</td>
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</table>
|   | Recognize information that commonly accompanies a roast profile. This is the first step in repeatability, which is critical for quality control for commercial roast production, as well as communicating through the coffee chain of custody.  
Able to document a roast profile with sufficient information to later replicate that roast and support hypotheses for possible modifications to that roast profile. |
|---|---|
|1.01.02 | Color is a common metric of roast consistency.  
Consistently roast coffee to a desired color. | Ability to control and match color. |
|1.01.03 | Awareness of a range of roast colors from light to dark.  
Cupping for profile is different than cupping for green coffee evaluation.  
Describe the differences and key factors: consistency and documentation.  
Distinguish different roast colors by flavor. Recognize results of a roast profile related to variables through consistent tasting practices and documentation.  
Discipline to conduct tastings consistently and regularly is an essential proficiency of a roaster.  
Understanding how different profiles impact flavor supports an ability to hypothesize changes to a roast profile to produce specific changes if these are needed. | Discriminate by sensory analysis different roasting profiles of different colors |
| 1.01.04 | Discipline to conduct tastings consistently and regularly is an essential proficiency of a roaster. Understanding how different development times impact flavor supports an ability to hypothesize changes to a roast profile to produce specific changes if these are needed. Distinguish differences in flavor for different development times to reach a common end color. Recognize results of a development time/end color related to variables through consistent tasting practices and documentation. Awareness that the same end color can be achieved in different ways. Cupping for profile is different than cupping for green coffee evaluation. Describe the differences and key factors: consistency and documentation. To be able to discriminate by sensory analysis differences in development time for coffees of the same end color, as well as differences in end color for the same coffee. |
| 1.02 | Define terminology common to profile roasting. Discuss roast profiles using vocabulary that is commonly understood in the industry. Use of measurement technologies such as moisture meters, roast profiling and logging software, and color meters. Common use of terms throughout the chain of custody of coffee will help advance the industry. Attain a conceptual framework for considering coffee roasting, the options that roasters have in creating roast profiles, and the tools and techniques available to document, replicate, and verify roasting operations. Terminology: 1. 1st and 2nd crack 2. Charge and Drop temperature 3. Cooling phase/cooling time Create, discuss, and analyze profiles using terminology from the keyword list. |
4. Development time (from 1st crack to end of roast)  
5. Drying phase  
6. End temperature  
7. Rate of change  
8. Roast air temperature vs. product temperature  
9. Roast degree/roast color  
10. Roast profile (time x temperature)  
11. Roasting curve  
12. Roasting cycle  
13. Slow roast vs. flash roast  
Turning point (minimum profile temperature)

| 1.03 | 1.03.01 | Rate of change is the speed of the roast at any given point of interest of the roast curve and is calculated as the speed of temperature change in the local area of that point. It can be calculated manually by putting a ruler on that point of interest and then measure the slope of the ruler in degrees/minute.  
Physical and chemical changes during roasting can impact rate of change independent of control settings.  
Difference between endothermic and exothermic chemical reactions.  
Anticipate future changes to rate of change.  
Understanding how rate of change changes during the roast provides useful information for consistently replicating a roast profile. | Perform rate of change projection based on current bean temperature and current rate of change and knowledge of first crack temperature. |
<p>| 1.03.02 | Calculate percentage change of weight and volume for a batch of coffee. Comparing weight loss and volume change across batches can be used to recognize when a roast profile may not have been followed accurately or note that the coffee or roasting environment has changed. Percent weight loss formula: [ L = \frac{G - R}{G} \times 100 ] Percent volume change formula: [ V = \frac{G - R}{G} \times 100 ] Know that roasting causes a decrease in weight (mass) and an increase in volume. | Calculate percent weight loss and percent volume change. NOTE: Volume change is a training tool for the classroom to demonstrate how coffee's volume changes and is not intended as a daily metric for consistency in a production setting. |
| 1.04 | 1.04.01 | Use common terminology in describing a coffee roaster, its operation, and changes that occur during the roasting process. Identify common design elements of coffee roasters. Identify how heat is transferred to the coffee during roasting. Able to discuss coffee roasting and roasting equipment with other roasters and manufacturers using vocabulary that is commonly understood in the industry. Able to describe how air and coffee move through a roasting system and how control manipulations can affect the roast. Able to describe basic thermodynamics of coffee roasting. Identify equipment and parts of drum and fluid bed roasters in the main areas of green coffee transfer, roasting, heat source, bean temperature probe, cooling, destoner, roasted coffee transfer, airflow, air cleaning, and exhaust. |</p>
<table>
<thead>
<tr>
<th><strong>Common roaster parts and design elements. Names of processes and changes. Options for surrounding machinery for green and roasted coffee transfer, cooling, exhaust, and emissions control.</strong></th>
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<tbody>
<tr>
<td><strong>Modes of heat transfer in roasting:</strong></td>
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<tr>
<td>1. Convective</td>
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<tr>
<td>2. Conductive</td>
</tr>
<tr>
<td>3. Radiative</td>
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</tbody>
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<table>
<thead>
<tr>
<th><strong>1.04.02 Clearly and concisely define workplace safety and be able to list specific examples where danger can exist in a coffee roasting facility.</strong></th>
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<tbody>
<tr>
<td><strong>Recognize common dangers involved in the roasting process and describe preventative measures and corrective actions.</strong></td>
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<tr>
<td><strong>Correctly identify correct and incorrect safety protocols.</strong></td>
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<td><strong>Develop a preventative maintenance protocol designed to minimize the risk of fire and maximum roaster operational time.</strong></td>
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<td><strong>Definition of safety and workplace safety. Working definitions of personnel safety, product safety, equipment safety, and facility safety.</strong></td>
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<tr>
<td><strong>List areas of danger in a coffee roasting facility.</strong></td>
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<tr>
<td><strong>Common dangers in the roasting process</strong></td>
</tr>
<tr>
<td>1. Roaster fires</td>
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<tr>
<td>2. Personnel safety</td>
</tr>
<tr>
<td><strong>The most likely locations of a fire in a drum coffee roaster, what to do in the event of a roaster fire, how to avoid a roaster fire.</strong></td>
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<td><strong>Appropriate ventilation.</strong></td>
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<td><strong>Able to identify areas in their coffee roasting facility where potential danger to personnel, product, equipment, or facility may exist.</strong></td>
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</tbody>
</table>

<p>| <strong>Addressing and designing preventative maintenance plans for primary dangers in a roasting facility in the areas of fire in the drum, fire in the chaff collector, fire in the exhaust system, fire in the chimney, food safety and handling, and personnel and facility safety.</strong> |</p>
<table>
<thead>
<tr>
<th>1.04.03</th>
<th>Able to discuss the value of having a sample roasting program and the equipment and materials required for sample roasting.</th>
<th>Purpose of a sample roasting program in your business including sample taking, preparation, and equipment needed.</th>
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</thead>
<tbody>
<tr>
<td>1.04.03</td>
<td>Measuring green coffee weight and volume.</td>
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<td>1.04.03</td>
<td>Documentation of sample roasting processes.</td>
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<td>1.04.03</td>
<td>Representative sample</td>
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<tr>
<td>1.04.03</td>
<td>Reasons to have a sample roasting program.</td>
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<tr>
<td>1.04.03</td>
<td>Required equipment and materials to support a sample roasting program.</td>
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<tr>
<td>1.04.04</td>
<td>Drum and fluid bed sample roasters can both be used for sample roasting.</td>
<td>Distinguish the different types of sample roasters and how to use one.</td>
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<tr>
<td>1.04.04</td>
<td>Recognize different types of sample roasters.</td>
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<tr>
<td>1.04.04</td>
<td>Safely operate a sample roaster to roast coffee samples consistently.</td>
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<td>1.04.05</td>
<td>Roasting and cupping samples consistently enables comparison of coffees from one season to the next and facilitates communication through the coffee chain of custody.</td>
<td>Roast samples to best practices and evaluate them using the official sample roasting evaluation form.</td>
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<tr>
<td>1.04.05</td>
<td>Using a sample roaster to roast samples consistently to a specified color in a given amount of time.</td>
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<tr>
<td>1.04.05</td>
<td>Sensory evaluation of roasted samples.</td>
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<tr>
<td>1.04.05</td>
<td>Working practices for a sample roasting protocol.</td>
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</table>
| 1.04.06 | Size, density, and moisture changes during roasting.  
Glass transition temperature.  
Progression of major chemical changes that can occur during roasting.  
Storage conditions to keep green coffee stable.  
Name common decaffeination methods and describe how coffees are decaffeinated by these methods concisely.  
Different processing methods allow coffee to be dried with differing types and amounts of material still surrounding the seed.  
Mycotoxins  
Discuss different processes that a coffee has gone through prior to roasting.  
Describe how a coffee changes both chemically and physically during roasting.  
Recognize how storage conditions may impact green coffee.  
Understanding different processes a coffee has gone through prior to roasting can help inform roasting plans.  
Proper storage minimizes risks to customer health, equipment, and improves production consistency.  
Understanding chemical changes during roasting enables intentional changes to roasting plans to achieve specific desired results. | Recognizing different physical and/or chemical changes of green coffee: density, moisture, size, glass transition, decaf, processing methods. |
| 1.05 | 1.05.01 | Production efficiency and quality control plan implementation.  
Developing a systematic and efficient method for the elimination of waste and errors in production operations.  
Techniques available to analyze and improve material and time efficiency in roasting operations.  
Recognize production inefficiencies and ways to reduce or eliminate these.  
Consideration of trade-off’s between freshness standards and efficient operation allows optimized production schedules.  
Appropriate use of corrective, preventative, and predictive maintenance to minimize impact on production efficiency. |
Glossary of Keywords

- 1st and 2nd crack
- After burner
- Air (drum environment) temperature probe
- Airflow, chimney
- Bean temperature probe
- Buildup in chimney - Fire risk!
- Chaff, Chaff collector
- Charge (start) / Drop (End) temperature
- Conduction/contact/diffusion, radiation and convection (heat transfer)
- Cooling phase / cooling time
- Cooling tray
- Dark roast high bitterness low in acidity. Opposite relationship for light roasts
- Decaffeinated green coffee
- Density (green and roasted)
- Destoner
- Development time (from 1st crack to end of roast)
- Drum rotation
- Drying phase
- Electrostatic filter
- End temperature
- Endothermic
- Evaporation is endothermic
- Exhaust filtration
- Exothermic
- Fire extinguisher (water vs. CO2)
- Fire in the chimney
- Fire in the drum
- Fluid bed roaster
- Grade, Screen, Bean size variation
- Heat vs. temperature
- Maillard reactions
- Moist vs. dry period
- Moisture in green beans (~9-12%)
- Moisture meter
- Mycotoxins
- Organic acids creation and degradation
- Percentage change (weight and volume)
- Pre-blending vs. post-blending
- Processing
- Production Efficiencies (ex. Lean production)
- Profile logging software
- Pyrolysis
- Quality Control
- Quenching
- Rate of change
- Roast air temperature vs. product temperature
- Roast colour / development meter
- Roast defects (scorched, baked, underdeveloped)
- Roast degree / roast colour
- Roast gases
- Roast logging system
- Roast loss, Volume increase, density decrease
- Roast profile (time x temp)
- Roasting curve
- Roasting cycle
- Roasting drum
- Roasting process
- Silver skin
- Slow roast vs. flash roast
- Storage conditions 12% bean moisture vs 60% RH in storage room
- Turning point (minimum profile temperature)
- Ventilation
Objectives with related activities

- **Coffee Roasting**
  - Recognizing, recording, and controlling variables that impact roast profiles. (Lecture and Activity)
  - Ability to control and match color. (Activity)
  - Discriminate by sensory analysis different roasting profiles of different colors. (Activity)
  - Discriminate by sensory analysis different roasting profiles of the same color with varying development time and rate of change. (Activity)
  - Create, discuss, and analyze profiles using terminology from keyword list. (Lecture and Activity)
  - Perform rate of change projections based on current bean temp and current rate of change and knowledge and 1st crack temp. (Activity)
  - Calculate weight loss percentage and volume percentage change for training purposes (not a recommended analysis on production size roasters). (Activity)
  - Identify equipment and parts of drum and fluid bed roasters in the main areas of green coffee transfer, roasting, heat source, bean temp probe, air temp probe, cooling, destoner/roasted coffee transfer, airflow, air cleaning, and exhaust. (Lecture and Activity)
  - Addressing and designing preventative maintenance plans for primary dangers in a roasting facility (Lecture)
    - Fire in drum, chaff collector, exhaust system and chimney.
    - Food safety and handling
    - Personnel and facility safety

- **Sample roasting**
  - Define a sample roaster: small roaster of around 100g (50-500g) batch size that is capable of roasting consistently according to time and end color.
  - The final use of the coffee dictates the roast style (including color) as defined by the intended customer for that coffee. Since practically (for the business purposes of sample roasting) people are already doing this, there is no set standard for color or time when looking broadly on the international coffee business.
  - Purpose of sample roasting program in your business including sample taking, preparation, equipment needed. (Lecture)
  - Distinguish the different types of sample roasters and how to use one. (Lecture)
  - Roast samples that complies with the purpose of the roasted coffee and evaluate and log all important aspects of the process. (Activity)

- **Green coffee**
  - Recognizing different physical and/or chemical changes of green: Density, moisture, size, glass transition, decaf, processing methods. (Lecture and Activity)
Mandatory Activities

- Groups of maximum 4 people allowed on the mandatory activities. The maximum allowed for the practical exam is 2 per roaster.
- Calculate Temperature Midway Point with knowledge of 1st and 2nd Crack temperatures from the trainer.
- Perform at least 5 roasts (each roast should be repeated if the goal of the roast was not achieved). During the 5 roasts perform rate of change projections to predict the start of 1st Crack. Use provided “Intermediate” Roast Log. Calculate weight loss and volume gain percentage.
  - Roast 1: Perform roast with any profile to Temperature Midway Point (sample color creation).
  - Roast 2: Perform roast with similar profile to Midway Point of Roast 1 but continue to the start of 2nd Crack (and thereby resulting in a longer development time).
  - Roast 3: Roast coffee to the same profile to First Crack, then end at the same color with a longer development time (over 4 mins).
  - Roast 4: Roast coffee to the same profile to First Crack, then end at the same color with a shorter development time (under 1:30).
  - Roast 5: Roast coffee to the same profile to First Crack, then end at the same color with a 2-3 minute development time.
- Triangulation cupping of roasts to different colors.
- Triangulation cupping of roasts to same color with different development times.
- Sample Roasting
  - Sample roast multiple varieties/origins/processing methods on a sample roaster to class standards for sample roasting.
  - Cup samples following cupping protocols defined by the SCA.

Literature

- George, M.L. et al., 2005. The Lean Six Sigma pocket toolbook, McGraw Hill
- Enclosed compendium provided på your trainer on Percentage change calculations, Green coffee harvest schedule and profile analysis
- Bertrand et al. 2012; Huschke 2007
- Illy & Viani 2005; Jansen 2006
- Illy & Viani 2005; Morgan & Brenig-Jones 2012

Equipment required

- Minimum one coffee roaster pr 2 students
- Moisture meter for measuring moisture level in green beans and roasted coffee
- Volume measurement jug/pitcher/container for green coffee and roasted coffee volume measurement
- Roast colour measure meter