Product Development for a Coffee Blend

The coffee business is in a process of change. No longer considered a commodity (a single dimensional product, like sugar), consumers are realizing that there are significant differences in flavor, uses, and value in coffee. In response to this, on the supply side, roasters and green coffee producers are seeking to distinguish their products to meet the needs of different market segments.

Driving this process has been the specialty coffee industry. Small roasters (and some which started out small, but became quite large, such as Starbucks and Peet’s) have been introducing products and exploring these new consumer needs. For years, the specialty coffee has been the fastest growing segment of the coffee industry. Noting these trends, larger corporations have been introducing more “upscale” coffee products. Among these have been McDonald’s (introducing a new coffee blend that will be brewed to a more “specialty” strength and sold at a higher price), Dunkin Donuts (introducing a successful line of espresso beverages), and Nestles (introducing Nespresso for home consumption). These are certainly signs of success, but specialty coffee vendors must continue to innovate to maintain and continue to grow their market share.

As the result of this change and evolution, the lines between the “specialty” and “commercial” segments of the coffee industry are becoming blurred. Historically, the “specialty” producer concentrates on unique flavor profiles that are the result of particular origins. The “commercial” producer has traditionally sought to maximize the value of what they offer, an important aspect of which is price. With this new landscape, the “commercial” producer often needs to know more about the flavor profiles of different origins and grades of coffees, while the “specialty” producer finds it difficult to restrict themselves to selling only top-line coffees.

Flavor is multi-dimensional; within the experience are many different possibilities of individual perception. There are different modes of experience: aromas (perceived in the olfactory lobe), tastes (perceived in various parts of the mouth), and tactile sensations (perceived physically). These act in combination with one another, directing the consumer’s attention to one aspect or another of the flavor experience. Other influences can also be a factor, such as temperature at which the beverage is consumed and in combination with additions (milk and sugar) or accompaniments (desserts or breakfast food). The flavor experience seemingly happens within an instant, but there is a time element that contributes to satisfaction as the liquid is consumed and various sensations follow one upon another, up until the aftertaste. While consumers rarely consider these while considering a purchase, the blend designer must consider all these aspects.
The key to designing a successful blend is to learn to think about the flavor attributes of coffee from two perspectives. First, the coffee blender must know what the individual flavor attributes of coffee are and the origins and roast styles that are most likely to produce those individual attributes. However, the appeal of a successful coffee blend is rarely explained only by summing up its individual attributes. The coffee blender must also learn to view the coffee holistically, not only as a group of various perceptions, but as a single entity with its own unique identity.

The coffee blender utilizes the individual components in order to build a blend, but the final and most important consideration is to consider that the individual attributes are dependent upon the context in which they are perceived. A certain type of acidity which adds to the overall perception of flavor in one context may be piercing, sharp, and unpleasant in another. The blend developer uses the individual flavor attributes as tools to attain the goal, but completes the process only upon analyzing the entire effect of the flavor.

Blending as process of product development

First of all, why bother blending coffees? If everybody liked the same things it would be easy. The following are the reasons that inspire development of blends.

1. Attaining a certain flavor profile not available with a single coffee. Single origins often emphasize a few flavor attributes, such as acidity, particular aromatics, or body, but not others. This is often part of their appeal; the heavy body of a Sumatra Mandheling or the unique aromatics of East African coffees, for instance. To appeal to a broader base, coffees are blended to have a wider range of flavor attributes.

2. Balancing flavor attributes of certain individual coffees. Some coffees have flavor attributes that can be improved, either through contrast effects or by changing the perceived concentration of the particular flavor attribute for emphasis.

3. Attaining consistency of flavor profile throughout the crop year. With the best coffee harvested once a year in most origins, the roaster must often adjust a blend mixture throughout the year to maintain a certain level of acidity or other flavor attribute.

4. Attaining a certain price point. Single origins are necessarily more expensive, since they are in greater demand, especially lots that are particularly good examples of that origin. By blending, a coffee can have particular flavor attributes (or suggest them) but offered at a more favorable price (though they may not have the same concentration of flavor as the single origin).
Stages of Blend Development

The product development cycle begins with an idea that gradually moves towards solid form, through the production of several prototypes, to final fulfillment and presentation.

**Concept:** Most typically, when one begins to develop a blend, there is a specific purpose for making this effort, and then a product is designed that is likely to meet that purpose. The following questions should be asked before undertaking product development:

- What should the coffee taste like? It is sometimes useful to develop a single-sentence description that can be easily communicated but conveys a certain impression.
- Who will buy this coffee, to whom is it most likely to appeal? Some blends intend to emphasize a certain flavor attribute, while others (such as house blends) are intended to have wide appeal. Others target certain preferences, such as dark roast or flavored coffees.
- How will it be used (espresso, home use, drip brew for a specific situation)? At what coffee-to-water ratio is it most likely to be brewed? The latter will directly affect how the eventual consumer perceives the balance of flavors.
- How much must be produced and how consistent can the developed flavor profile be? Some coffees have unique character, but are only produced in a limited volume. Some coffees are not available at certain times of the year or suffer in quality during particular seasons. Potential substitutions may need to be considered.
- What is the price point? The developer must consider not only the price per pound, but the cost per cup. They must also be aware of both green coffee and production costs.
- Of the determined goals of developing the blend, which are most important? Price point? Certain flavor attribute(s) (also referred to as “drivers of liking”)? Appeal to a certain market segment? This is often dictated by the potential customer or market segment. It may be useful to list these in order of importance.

Up to this point, it is all conceptual. Nothing has actually been produced; it is simply a thought process. However, this is an important aspect and, if properly done, will save a lot of time later in the process. It is important at this stage to bring in other opinions and departments as much as possible, including marketing, sales, production, and management.

**Design:** To get into the details of what is required, the designer notes what materials and processes are available to complete the design. Once there is a (however fuzzy) idea of the type of coffee that needs to be developed, the blend developer takes stock of what is available to them and what is most likely to meet the product requirements. For coffee, the technology is roasting and packaging. The raw materials are green coffee beans from various sources.

There are almost always several ways to attain a determined goal. The coffee’s taste will be the result of green coffees mixed together roasted to a particular degree. These
components can mixed together before roasting (a pre-roast blend) or after (post roast blend), which themselves have advantages and disadvantages (a post-roast blend is more expensive to produce, but one has more control over roast degree). Having determined a set of goals, one sets out different combinations of green coffees at different roast levels that are likely to accomplish these goals.

Prototypes: Once potential designs for the new coffee have been determined, several prototypes are produced. These are usually first tested in the lab with the designer (or team of designers), and then submitted to increasingly large populations, possibly even the final consumers.

Bringing it home: The next stages are beyond the scope of this presentation. They include introducing the product to the client or rolling it out on a retail level, ongoing marketing activities, and advertising. The focus of this presentation is on the process of developing the flavor attributes of the coffee.

Blending Coffee: Designing from the Ground Up

While the goal is a blend where all flavor attributes work together to constitute a well-knit blend, the blend developer uses the individual constituents as building blocks. They have two major sources from which to derive the flavors they wish to use:

1. Green coffee. Flavor attribute variability is due to origin, climate, type of plant used to grow the coffee, and how the coffee is processed, transported, and stored.
2. Production techniques. Most obvious is degree of roast, but other aspects, such as technical roast parameters (heat applied over time) and packaging (which will affect freshness and shelf life) should also be considered and specified.

Coffee is complex in how its various flavor attributes work with and against one another. This is why it is important to have definite goals in mind as one goes through the product development process. There will inevitably be trade-offs; it may not be possible to create exactly the intended product at the intended price. There are typically several iterations that must take place before the final coffee is produced.

Perhaps most difficult is visualizing the concept and how it will work. Since we have been trained to consider design concepts mostly in terms of visualization, it is useful to develop charts that seek to express or suggest the desired flavor experience.

Visualizing the goal

A flavor profile chart is a radar chart (also referred to in some literature as a spider-gram) that can be easily produced in Excel. The chart lists the flavor attributes clockwise in order of perception. The distance from the center indicates the intensity of the particular attribute. An example of a typical Guatemalan Extra-prime can be seen in Figure 1.
Figure 1: Flavor profile of Extra-prime washed coffee.

This profile was determined by examination of multiple samples of this type and its veracity is important. By examining this profile, the blend developer can see that there are a considerable amount of desirable coffee aromatics and flavors. However, there are other aspects that are less desirable (green, vegetal and bitter aspects) and limited acidity. If greater intensity or complexity of acidity is desired, another component must provide it and less desirable aspects must be dealt with to achieve a more ideal combination of flavor.

One can use such a chart both to detail individual components and to visualize an ideal potential product. Such a chart must include enough detail to fulfill the goals and important flavor highlights, including level of roast, but not be so detailed as to be unattainable (or unreadable).

Besides individual flavor attributes, one must consider how these attributes relate to one another. A useful tool in visualizing flavor attribute relationships is the Principal Component Analysis (PCA). This is a 2 (or 3) dimensional map of how flavor attributes (the Principal Components) work together and how specific coffees occupy that space. It is sometimes referred to as a “flavor map”. They are not as detailed as the radar charts, but can provide useful information as to which components to add to attain a desired flavor combination. An example of a PCA regarding roast degree can be seen in Figure 2.
This particular PCA deals only in degree of roast and how it affects certain flavors. The lines represent the flavor attributes and how they relate to one another. When a line is closest to parallel in angle, it indicates that when one attribute is found, the other is also found. In Figure 2, one can see that when acidity is perceived, fruit is more likely to be perceived (since the two lines are close in angle to one another). However, since dark roast is at almost a 180° to acidity, in this set of samples when one finds fruit and acidity one does not find dark roast flavor. Sweet, chocolate, and body have different relationships.

Individual samples are then mapped upon this space. At its lightest (Agtron 80), the cereal-like taste is prominent, though there is some acidity. Agtron 60 is balanced between sweetness and acidity, chocolate and fruit (not surprisingly, a common Agtron standard for usual-good-quality blends meant for wide appeal). As the sample is roasted darker (Agtron 50 and 40), more chocolate, body, and spicy attributes are emphasized. Finally, at the darkest roasts, the dark roast taste dominates.
Use of charts in blend development: In developing a blend, the blend developer first draws the radar chart as an “ideal”. Similar charts can be drawn for blend components, especially if use of certain coffees has already been specified. Referring to these charts, the blender can determine a number of combinations of green coffees and roast degrees that will be likely to meet this “ideal”. Once the prototypes have been produced and cupped, the results can be compared to the “ideal” and mapped using the PCA to determine other potential iterations (if necessary).

The Flavor Balancing Act

Since blending coffees can be so complex, it is useful to have a little knowledge about what flavor attributes exist in coffee and how they work together. As with any aspect of sensory science, these generalizations may not always apply and exceptions make the rule. However, the blender will find this to be useful knowledge, even if it does not apply 100% of the time. The references given indicate where more detailed knowledge can be found if it is necessary.

Flavor Attributes of Coffee

The “flavor profile” is a descriptive summation of the sensory flavor attributes of any food or beverage in terms of its qualities and intensities. Human beings perceive flavor attributes through three main mechanisms: aromatics, tastes, and tactile sensations. These combine and can reinforce one another, contrast with each other, or even cancel out one another. Coffee is especially complex, since it contains thousands of active sensory chemicals. Most coffee is consumed in liquid in concentrations of approximately 1% and small amounts of flavor active chemicals can significantly alter the consumer’s perception.

Aromatics

The most pronounced, varied, and unique flavor attributes of coffee are its aromatics. A 1996 study\(^1\) lists a total of 841 and many others specific to roasting conditions, specific origins or regions, or off-flavors continue to be found (the list is now several thousand). For an aroma to be perceived, it must make contact with the olfactory lobe located at the top of the nasal cavity. The compound must be volatile and carried in a gas. It can enter either through the nose or retro-nasally through the cavity connecting the mouth and the nose. Since so much aromatic stimulus occurs in the case of coffee, only a small fraction of these volatiles are consciously perceived.

The aroma commonly referred to as “coffee” is actually a combination of many aromatics. A significant number of these, arguably most of the important constituents, are the result of roasting. In preparing a sample, it is important to assure reasonably good replication of roast in terms of relative darkness, time, and applied temperature.

\(^1\) Nijssen et al, *Volatile compounds in Food, Qualitative and Quantitative Data, 7th edition*, 1996, TNO nutrition and Food Research Institute, Zeist, The Netherlands, p. 72.
Aromatics also change significantly as the result of storage, especially in the presence of oxygen; it is also important to analyze a sample when it is reasonably fresh.

Since there are so many potential aromatics in coffee, it is typical to classify them into groups. One suggested general model for coffee is suggested by Mayer et al\textsuperscript{2} includes:

1. Sweet/caramel
2. Earthy
3. Sulphurous/roasty
4. Smoky/phenolic
5. Fruity
6. Spicy

A more recent and expanded system is suggested by the International Coffee Organization\textsuperscript{3}.

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<tr>
<th>Animal-like</th>
<th>Ashy</th>
<th>Burnt/smoky</th>
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<tr>
<td>Chemical/medicinal</td>
<td>Chocolate like</td>
<td>Caramel/malty/toast-like</td>
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<td>Earthy</td>
<td>Floral</td>
<td>Fruity/citrus</td>
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<td>Grassy/green/herbal</td>
<td>Nutty</td>
<td>Rancid/rotten</td>
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<td>Rubber</td>
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<td>Winy</td>
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Tastes

Due to the wide diversity of type and concentration of aromatics, sensory panelists (including those responsible for grading coffee) find it easier to agree on the presence and strength of tastes. The basic taste of coffee is a combination of sour, sweet, bitter, and salt compounds. The balance of these often determines the classification of coffee in terms of its cup quality.

One must consider tastes in a multi-dimensional fashion as well as its constituent parts when composing a blend. For example, adding additional acidity will not only brighten the coffee, but will affect how bitterness, sweetness, and saltiness are perceived.

Acidity: The main taste in coffee is sourness, which coffee tasters define in a number of ways. If the coffee has a pleasant tartness, it is referred to as “acidity” or even “fine acidity”. However, if the sourness is not pleasant, is perceived in concert with undesirable aromatics, or is too dominant, it is referred to negatively as “sourness”. The following general classifications of acidity are found in coffee:

1. Fruit acids: These are carboxylic acids that are also found in different fruits. The dominant acid of this type is citric acid, the acid commonly found in citrus fruits.


Depending upon the altitude and cultivation of the coffee plant, other fruit acids, such as malic (apple) and tartaric (grape) can also be found. These (along with the inorganic phosphoric acid discussed below) are apparently the main contributors to what cuppers refer to as “fine acidity”.

2. **Aromatic acids:** As the name suggests, these can be perceived aromatically as well as through taste. The dominant acid of this type is acetic acid, known as vinegar in its pure form. While all coffees have some amount of this acid, too much can cause a coffee to taste sour or, in combination with certain aromatics, to taste fermented. Lactic acid, commonly found in yogurt, buttermilk, and sour cream, is another example of an aromatic acid found in roasted coffee.

3. **Chlorogenic and quinic acids (also referred to as “phenolic” acids):** Chlorogenic acid is found in high concentrations in coffee (as compared to other beverages and foods). Upon roasting, it degrades into phenols (aromatics) and quinic acid. There are several isomers (chemical variations) of chlorogenic acids, including the di-chlorogenic acids present in greater concentrations in green and black beans and thought to be responsible for astringent taste in coffee. Quinic acid is perceived as sour/bitter and present in quinine or tonic water. Caffeic and cinnamic acids are also included in this group. These are further degraded by dark roasting.

4. **Inorganic acids:** The most important of these has been recently found to be phosphoric acid, used in many commercial beverages including most cola formulations. As a strong acid, it adds to the overall perception of acidity and affects the perception of salt. It is usually perceived as “pure” acidity, where the perception of other acids will be affected response to other compounds.

**Sweetness:** Coffee is not a sweet beverage in the sense that there is normally a large concentration of sucrose (unless added by the consumer), but sweetness is an important determinant of overall flavor and perceived quality. The major sugar in green coffee is sucrose, common table sugar that is sublimated into caramel and Maillard reactions during roasting that are perceived as aromatics. Despite the importance of sweetness in so many foods, it is one of the weakest perceived flavors and a relatively large concentration is necessary for clear perception. These compounds are water soluble and an important component in the coffee beverage. While the amount of sucrose present in coffee is small, the effects upon perceived coffee flavor attributes, including balancing the acidity and increasing perception of aromatics and body, is significant.

**Salt:** Potassium is the main mineral constituent of coffee. Other mineral constituents include calcium, magnesium, and sodium, all found in much smaller amounts. These are thought to contribute to the “rough” taste that can either balance or dominate acidity and

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7 Clarke, “Water and Mineral Contents”, Coffee Volume 1:Chemistry, p. 72
8 Ibid, p. 72-73

sweetness. The effect and contribution of these compounds to overall perception of flavor has not been well studied, but seem to have considerable significance to quality perception. Higher concentrations of potassium and calcium have been shown to have an effect on cup quality (with higher levels resulting in lower quality)

Bitter: There are two sources of bitterness in coffee, one from the green bean that is gradually degraded as roasting proceeds and roast degree darkens, and another that arises as the result of roasting, especially dark roasts. Contributors to the former include chlorogenic acid, trigonelline, caffeine, and other compounds. Bitterness that is the result of roasting is attributed to protein and carbohydrate degradation, along with the presence of other bitter compounds (caffeine and trigonelline) not degraded during roasting.

The interactions of these tastes are important to the overall perception. For example, sweetness tends to enhance the quality of all of these aspects, while salt and sour directly contrast with each other.

The following are typical effects of taste combinations according to current sensory analysis research.

- Acidity reduces perception of saltiness. This is an important reason to include high altitude (higher acidity) components in a blend that will have lower grown (and typically cheaper) components that naturally have more potassium.
- The appearance of bitterness inhibits the perception of sweetness.
- Conversely, sweetness decreases perceived level of bitterness and sourness.

These generalizations are usually based upon testing humans with specific substances such as table salt (salty), citric acid (sour), sucrose (sweet), and quinine (bitter) and may not hold true for all of the substances in coffee producing the same sensations. Temperature also has a profound effect on perception and prototype coffee products should be tasted at all temperatures. A great deal also depends on the relative strength of these sensations; strong acidity may reduce the perception of strong saltiness, but the overall result may be undesirable.

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11 Ibid, p. 54
12 GustPhysinfo

Tactile Sensations

Where the aromatics and tastes are chemically sensed, tactile sensations are the direct physical response perceived as the liquid comes into contact with mouth tissue. In this report, all of these perceptions are referred to as “mouth feel”.

The mouth feel of a liquid and how it is perceived has been the subject of much recent study. Traditionally, this is analyzed in terms of “body”, most often defined as the sense of heaviness of the liquid. With the advent of espresso as a widely used brewing method, mouth feel is defined in a number of other ways. Feeling of oiliness, granularity, smoothness, viscosity, and syrupiness have been reported. The “after-feel” that is left once the liquid is swallowed or expectorated is defined as “mouth-clinging”.

Another element physically affecting tactile sensations is astringency\(^\text{15}\). Literally, astringency is a quality that dries out the salivary glands. Some systems define this as a separate component or even as a taste since it is a chemical reaction, the result of phenols and other compounds. Here it is defined as a physical sensation due to its effect on the feeling of liquid in the mouth. This sensation is sometimes confused with bitterness and is mostly due to di-chlorogenic acid compounds and phenyl residues of other isomers of chlorogenic acid\(^\text{16}\).

An interesting phenomenon regarding mouth feel is that there has been no correlation found between measurement of liquid density of coffee and the corresponding rating of “body” and other mouth feel measurements. This seems to imply that the sensation is a combination of many stimuli, perhaps including tastes.

**Flavor:** Flavor is the combination of tastes and aromatics. These two chemical senses combine in such a way that certain foods are recognized. For example, citric acid, sweetness, and certain aromatics combine in such a way as to remind one of an orange. Recent research shows that taste perceptions often make one more sensitive to certain aromas.

As the blend developer makes the difficult leap from considering the individual elements to evaluating the coffee as a whole, flavor can be a key. While more aromatics are experienced, humans tend to remember the total experience of foods in terms of flavors, how certain combinations of tastes and aromatics produce a flavor experience. For example, “lemon” immediately calls to mind a certain level of acidity and sweetness along with a certain aroma. Closely considering the flavor can help the blend developer bridge the gap between the parts of the blend and the whole experience.

Perception of taste has been found to be odor dependent. In an experiment at the University of Cincinnati, it was found that the odor of strawberry caused subjects to rate

\(^{15}\) Breslin, Gilmore, et al, “Psychophysical evidence that oral astringency is a tactile sensation”, research paper published by Monell Chemical Senses Center, 3500 Market Street, Philadelphia, PA 19104-3308, USA.

\(^{16}\) Clifford, “Chemical and Physical Aspects”, p. 354

their perception of sweetness higher than when the odor of peanut butter was submitted with the same sweetness concentration. Not unexpectedly, the strawberry odor did not enhance the perception of saltiness\textsuperscript{17}. This indicates the importance of matching up aromatics and tastes so they will be perceived at the desired intensity.

\textit{Aftertaste or finish:} After swallowing or expectorating the liquid, the combinations of sensations that remain are the finish. Coffee’s aftertaste can be challenge because the taste perception with the longest onset is bitterness, but it is also the taste that lasts the longest. This can be somewhat modified in the presence of acidity and sweetness. The finish should be considered from two perspectives, its quality (what is perceived) and its length (how long the sensation lasts).

\textbf{Mixing it all up}

The phenomenon of perception is more than just the building blocks themselves. These various flavor attributes interact in numerous ways.

\textbf{Taste Interaction}

The primary tastes discussed earlier interact with one another in ways that can call greater attention to or disguise certain components. The usual interactions involve levels of sweetness and acidity, with sweetness enhancing the enjoyment of acidity. Without sweetness, acidity is perceived as “sour”. Favorable fruit-like acidity can negate the effect of too much potassium (also sometimes referred to as “roughness”, a slightly salty character.

A certain amount of potassium can balance a coffee and make its sweetness more readily perceptible, but by itself or in too great a concentration will negate acidity and add to the perception of bitterness.

All coffee has some bitterness, but how that bitterness is perceived is influenced by the other taste aspects present. Excessive potassium will unfavorably emphasize bitterness, while sweetness will pleasantly balance it (think of beer, a combination of bitter hops and sweet malt). Acidity will make the bitterness less perceptible, especially in combination with sweetness.

If one wishes to experience a taste in its pure form, there are a number of single chemicals that can cause a certain taste phenomenon. Salt (salt), sucrose (sugar), citric acid (sour), and caffeine (bitter) are used to train panelists to identify these sensations. Mixing these various solutions can demonstrate the effect that they have on one another.

\textsuperscript{17} Frank and Byram, “Taste–smell interactions are tastant and odorant dependent”, 1988, Chemical Senses Volume 13: 445-455

Taste Modifiers

There are a number of other conditions present in the coffee that will have an effect upon one’s perception of the beverage.

Trigeminal sensations: Just as the mouth has nerve endings that can perceive textural qualities (with the resulting tactile sensations), there are also present nerve endings that produce a level of pain. This is not always unpleasant, more of a pungency (or as some would say an “oomph”).

Some of these are chemicals that can directly modify the perception of taste, however. The capsicum found in hot-tasting foods is an example, as is the cooling effect of menthol. This can apply not only to taste, but to pungent odors as well; those that “tickle” the nose are having a direct physical affect that will either enhance or cancel the other odors present.

One of the most important chemical sensations (discussed above as a tactile sensation as well as a trigeminal sensation) is astringency, the result of tannins and phenols present in the liquor. Astringency is the literal drying of the mouth due to the effect on the salivary glands and has an effect on the perception of aromas and tastes as well as tactile sensations. All coffee has some degree of astringency, but immature coffees and those with an excess of black or frost-damaged beans will have a higher degree of astringency. Some of the most successful companies in the specialty segment of the market have distinguished their product by having a foundation of a minimum of astringency and a maximum of sweetness in addition to other flavor attributes.

Tactile effects: The viscosity of a liquid can affect how flavor attributes are perceived. It has been shown in coffee that higher viscosity depressed the perception of flavor and aroma\(^{18}\). This effect is especially important when designing espresso beverages.

Taste/Aroma Interaction

Studies show that when perceiving certain harmonious (or often encountered) combinations their combination has more of a intense impact. For instance, the flavor “lemon” is a combination of sweetness, acid (mainly citric), and certain particular aromatics. If one received such a concentration of citric acid, it would usually not be as readily or intensely perceived as in combination with one another. This is why the flavor perception (a combination of aromatic and taste elements) of a coffee blend plays such an important function in consumer acceptance and liking. The effect is magnified when using a complex substance with many flavor components, such as coffee\(^{19}\). Sometimes, when only one or two parts of a component are present, it is enough to suggest the particular flavor and the brain will “fill in” the missing aspect.


In making a mixture of flavors, there are three possible outcomes:

- **Individual flavor attributes will contrast with one another.** This can result in a stronger perception of one or both (or several) attributes. An example is the combination of salt and sugar; a little bit of salt can emphasize the apparent sweetness of the sugar.

- **In combination, certain flavor attributes build upon one another.** This is especially common in the combination of aromatics and tastes commonly defined as “flavor”. The appearance of certain combinations of sweetness, acidity, and aromatics can suggest the flavor experience of certain fruits, for instance. Certain aromatics (caramel) will emphasize tastes (sweetness) that are present. The presence of astringency will tend to heighten and sharpen the perceived intensity of acidity.

- **Various flavor attributes can cancel one another out.** For example, studies show that a certain “peasy, green” aromatic in coffee is always present, but is not perceived in the presence of sulfurous mercaptans that are inherent in quality coffee aroma. Addition of salt can reduce the perception of acidity (and vice-versa) even as it heightens the experience of sweetness.

### Sources of Coffee Flavor: the Blender’s Toolbox

#### Green Coffee

Every stage of green coffee production affects its flavor. It is useful for the blend developer to know just what effect each stage will have so that appropriate choices of greens can be made. The primary stages affecting flavor are the species and variety of the plant, the agricultural conditions under which it is grown (including soil, climate, and cultivation techniques), processing method, and storage/transport issues.

*Species and variety of plant:* The original variety and species to emerge from Africa was a Typica variety of the species *Coffea Arabica*. The plant was carried across the Red Sea to what is now Yemen. From there, it spread throughout the world, to the East Indies by the Dutch and to the Americas by the French. Another variety spontaneously emerged in Reunion Island that was bushier and hardier; this is known as the Bourbon variety. Most Arabica coffees in the world can trace their genetic history back to these roots.

The effect of the variety on the flavor attributes of a coffee is much studied and can be controversial. Plants gradually adapt to their surroundings over time and seeds are taken from the healthiest plants. Spontaneous mutations, such as the Caturra, a dwarf-variety of the Bourbon discovered in Brazil, sometimes occur or intentional hybrids are produced, such as the Catimor types that put together various Arabicas with Variedad Timor to increase disease resistance and increase productivity. This will no doubt be of greater issue in the future as genetic methods are employed.

The other species commercially grown is the Robusta plant, scientifically known as *Coffea Canephora*. The plant is much more productive, more disease resistant, and easier
to grow, but its flavor is generally not as desirable. It has 50% less sugar (so is less sweet) and 100% more potassium and minerals (so is perceived as saltier). Flavor associated with Robusta include “rubbery, burnt, woody”, which can have their place within the context of a blend, but should not dominate. Many blenders have report that Robusta adds a desirable crema and body to espresso blends. Otherwise, they are mainly used as a means to achieve certain price points.

In places where it is known that several varieties or species are grown, the blend developer will need to know (as far as it can be known) and specify the required species and/or variety so as to ensure the quality they desire. This information should also be included when specifying prototype blends.

**Agricultural conditions of growing:** One of the major effects on flavor is the altitude at which the coffee is grown. At higher altitude, the coffee will typically display the following flavor attributes:

- More intense and complex acidity
- Potentially more sweetness (assuming that enough nutrients and light for photosynthesis are present)
- Less roughness (result of potassium salt and other minerals)
- More oils produced, possibly affecting perception of smoothness and body

Another important origin aspect is the amount of time between the first flowering and the final harvest. The longer this period of time, the more a chance the coffee has to develop sweetness, acidity, and complexity of flavor. This helps to explain the effect of high altitude on coffee flavor (higher altitudes tend to have longer growing seasons), but this effect is noted in other micro-climates as well if there is, for example, extensive cloud cover much of the year. Growing under shade also tends to improve the flavor by extending the growing season.

All of these are put into practice through the hard work of the coffee farmer. Trees must be replanted and pruned, weeds and pests must be minimized or eliminated, and proper soil conditions must be maintained to optimize the inherent conditions of the coffee origin.

**Processing:** Once the coffee is grown, it must be harvested and the fruit separated from the seed. If the coffee is harvested when it is too immature (or if the fruit does not fully develop due to climactic conditions), the resulting coffee typically has less sweetness and higher astringency.

Processing (separating the seed from the fruit) of the coffee is one of the aspects that affects the balance of flavors the most. There are three types of processing in current use (and some that are hybrid methods): wet process, natural (sometimes called the “dry” process), and semi-pulp.

Natural processing allows the fruit to dry to the cherry, followed by the dried out fruit being removed before final drying of the seed. Coffee produced by this method is
perceived to be less acidic and tends to have higher levels of trigonelline (bitterness) and the chlorogenic acid responsible for astringency. As a result, the mineral-salt aspects may seem to be more emphasized and the sweet aspects less so. The aromatic qualities are likely to be characterized more by earth, chocolate, nutty, buttery, spicy, and caramel attributes. Natural process coffees often have heavier body. The extended contact with the fruit can result in an “over-ripe fruit” flavor that some find desirable in certain concentrations, but if this attribute is too strong, the coffee can taste vinegary and unclean. In general, natural processed coffees have heftier, stronger flavors.

In wet processed coffees, the cherry is removed from the seed (“pulped”), and then the sticky mucilage degenerated by means of naturally occurring enzymes in a tank filled with water. This results in a coffee with higher acidity and sweetness, but if allowed to go too far (or in the presence of microbial contamination), off flavors of various intensities will result. The aromatic qualities are often more herbal, floral, fruit-like, and complex. The aromas of the best Arabicas tend to be more delicate and can be obscured if blended with other components with strong aromatics. Despite the danger of off-flavors if the process is not carried out correctly, overall wet process coffees are more even in flavor and better selected, resulting in more even and consistent flavor.

A newer hybrid method seeks to combine the best of both processes in a more efficient process known as the semi-pulped (or semi-washed) method. In this method, the coffee is pulped as in the wet process method, and then allowed to dry (rather than allowing the mucilage to degenerate in the tanks). The result is the greater selectivity and sweetness that occurs with the wet method, while attaining a greater variety of aromatics. It is also less acid than a fully wet processed coffee. This reduction in acidity and maintenance of sweetness results in extensive use of these coffees in espresso blends.

**Roasted Coffee**

Where green coffee contains all potential flavor, coffee must be roasted to taste like “coffee”. By manipulating the roast parameters and degrees of roast, certain flavor attributes can be emphasized or disguised. The relative roast level has much to do with consumer preference and a coffee’s identity in the consumer’s mind often is the result of roast degree (“French Roast”).

**Degree of roast and its Effect on Flavor**

One of the main tools of the coffee blender is degree of roast. By varying roast degrees, one can maximize the best qualities of a particular coffee and appeal to definite market segments with well-defined taste preferences. The process of roasting is complex, with many different degrees of degradation and flavor formation occurring at each stage. Along the way, different aspects of the coffee experience are emphasized. Figure 3 illustrates how this occurs.
Figure 3: Progression of roast and emphasis of flavor.

As the green bean turns to gold, sugar browning processes start. At this stage, much of the vegetal/green/bitter flavor has not yet degraded, the acidity is increasing as the sugar browns, and typical “coffee flavor” is just beginning to form. As further browning continues, the acidity begins to degrade and the unique sugar browning flavors are emphasized. “Body”, the result of the loosening of the cell wall making it more soluble, begins to be more perceptible as the roast darkens. Finally, the unique “dark roast” flavor makes an appearance as the sugars completely degrade. The roasting process creates and unveils certain flavor attributes and changes the emphasis of acidity and body as the roast progresses. The blender must consider the overall balance of flavor attributes that they wish to achieve and the level of roast where this will result.

Roast techniques: An often neglected aspect of flavor relates to the time of roast and the amount of heat applied at certain points during the roast. The blender should include this in their specifications and keep good roasting records during production of a prototype so that the blend can be effectively duplicated.

The physical condition of the bean will determine how quickly the coffee takes on heat and the progression (rate) of the roast. These parameters include density, moisture content, and bean size. The rate of roast determines how (or if) potential flavor attributes come into contact with each other, for how long, if certain processes (such as sugar browning) take place at all, or if enough heat is absorbed to cause certain attributes to degrade. If too much heat is applied, the outside of the bean can char and those beans with more available moisture will absorb heat faster than others, resulting in an uneven roast. Too little heat applied will not allow enough heat to be absorbed by the coffee and

when browning begins, it will not occur at the necessary rate to create coffee’s distinctive aromas and flavors (roasters refer to this as “baked”).

It is possible for the blend developer to use roasting techniques to ensure that certain flavors and aromas occur. This is where a blend developer must partner with an experienced roaster.

As important as roasting is, the blend developer must keep in mind that the precursors of the flavor attributes are in the green bean; it is not possible to roast into a coffee any “origin” flavors.

*When to blend:* There are two potential strategies for blending coffees: blending them before roasting (pre-roast blending) or blending them after individual components are roasted (post-roast blending). Since post-roast blending is more expensive, it must be justified by better cupping results.

Green coffees have different densities and so roast at different rates. By roasting the individual components, roasters can adhere to closer standards, ensuring that certain particular flavor attributes are attained.

Besides the obvious financial advantage, there are some who believe that pre-roast blending allows the blend to be perceived in a more unified way. Some blends of dark and light coffees can clash with one another, with the bitter aspects of the dark roast not working well with the more acidic aspects of the light roast.

**A Strategy for Development**

Having visualized what the blend should taste like and what flavor attributes it has, the blender can use their knowledge of coffee flavor and its sources to produce those attributes. A suggested method is as follows:

1. Start with the roast degree. If the blend is being developed for a certain customer, they will have a roast degree in mind. Blends for a specific purpose (such as espresso) often have a certain roast degree associated with them. The roast degree plays a significant factor in any consumer perception. A combination of roast degrees is also possible.
2. Using the roast degree as a context, the blender decides which green components will contribute the necessary flavor elements.
3. Produce an initial set of prototypes. The initial set should be two dimensional, with one set to examine the variability of the roast and another to work with the variability of the greens. One set of the same roast degree, with the green components slightly varied is produced and another of the “average” set of greens with the roast level slightly varied. This set should be then submitted to a panel of tasters. The panel is informed of the goals and specific flavor attributes that should be expressed by the blend (this can be drawn up as a form for this particular cupping) and the primary purpose of the session is to determine whether
or not those flavor attributes are present to the degree necessary. A subsequent discussion can focus on needed directions for future prototypes.

4. It is possible that one of the prototype blends was close to the desired flavor profile, but a small manipulation of roast parameter or slight adjustment of amounts of greens could get it closer. In this case, a second set of prototypes can be produced, including the original, a variation on one side (for example, moving the Agtron number 5 degrees darker or adjusting the most acidity green coffee component by 10%), and a third iteration that takes the same proposed change a little further (in the example, moving the Agtron a little darker still or using 15% more of the acidic coffee). The panel response to this will let the blender know if they are on the right track.

5. If the panel response is “Back to the drawing board”, the process begins again

6. Once the “target” has been achieved, the prototype coffee should be prepared as it would be prepared by the target consumer in the proposed concentrations using the assumed brewing method. This is especially important in the case of an espresso blend; the concentration of flavor attributes dramatically affects their perception. When developing espresso blends, the best practice is to consistently cup prototype samples prepared as espresso along with standard cup preparation.

Record Keeping

An important part of this process is good record keeping. Often, a cupping panel will work for days to achieve a great blend and at the end not know the recipe. It is also important to thoroughly know which coffees are being used in the prototype, their grades, their origins, and their current physical conditions (bean size distribution, moisture content, and density). This will be especially important when the blend is finally completed and specifications for production must be written.

In some cases, it may be useful to compile the results and comments from panelists to determine the next direction in producing a blend. The use of multi-dimensional statistics, the most common of which is the Principal Component Analysis shown in Figure 2, can be particularly useful to see how different flavor attributes are correlating with one another. Once such an analysis is performed, a point for the “ideal” originally intended flavor profile can be plotted and one can perhaps determine a next step.

Conclusion

As can be seen from this review, coffee blending is not simply a matter of throwing together a few different types of beans and hoping for the best. The product development process is one which must be carefully thought out, prototypes built, and panels of cuppers analyzing the results. The major considerations and most difficult aspects are to understand the complexity of how all the flavors of coffee can work together and will be most appealing. Once this is accomplished, however, a well crafted blend with standardized specifications can allow precise communication to green providers and roasters so as to produce consistent results. This hopefully results in greater sales due to
repeat business and confirmation that the coffee retailer has a solid, dependable, and sophisticated knowledge of coffee.

The final steps in bringing the blend to fruition is

1. Consumer testing of the coffee within the target market. There are two major kinds of testing, general preference testing in which large numbers of consumers compare or rank the coffee in comparison to others, such as competing brands. The other more qualitative approach uses fewer consumers but seeks to draw them out about what they like or dislike about the coffee and what they expect from a coffee generally (focus groups are an example).

2. Writing specifications for the blend. This should include the coffees that will be used, their grades and physical standards, and the flavor attributes that should be present. The roasting degree should be specified and a reasonably detailed flavor profile should be drawn up.

As a natural product, coffee is a challenge particularly in terms of its consistency. Blending coffees can help produce a consistent product that consumers will recognize and repurchase. The key is defining the parameters of the blend in terms of its flavor attributes for the consumer side and defining the parameters of its components for the production side. Using one’s coffee knowledge to do this helps ensure that one will be successful in this increasingly competitive marketplace.