Focused Flavor Creation

Using qualitative and quantitative sensory properties

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Historically, most flavorists have not received training on how to create flavors but have instead learned by observation, trial and error, and a strong desire to learn. This approach is very time consuming, costly, and inefficient.

In 1965 GRAS III contained 1,125 flavor ingredients. As of GRAS 20, there are 4,023 GRAS ingredients plus many additional natural botanical sourced ingredients. This large number of ingredients becomes difficult to utilize without some type of tool or organized system.

Introduction

Flavor creation involves two require–ments: ingredient selection and ingredient use level selection. Flavorists have addressed these requirements by:

- modifying existing formulas
- using previous experience
- reading literature
- odor evaluation
- external suggestions from suppliers or peers
- tasting and evaluating ingredients

However, these tactics do not guaran–tee success — there are positive and negative aspects to each of them.

Selection of ingredients by existing formulas or experience: This approach is useful because we know it has worked in the past, and provides a quick way to complete projects. Many times a quick modification is all that is needed to satisfy customer requirements. It also reduces or may eliminate trial and error, and the risk of failure. However, by using this ap-proach, flavor profiles may tend to be similar to previous ones using the same selection of ingredients. It may also suppress the freedom and creativity of using new untried ingredients.

Selection of ingredients by reading the literature: Since the mid 1950s, the progress in separation and identification technology has made a huge contribution to our knowledge of the flavor composition of foods. This has led to the FEMA/GRAS approval of many new chemi-cals. The quality of flavors has been signifi–cantly improved by the identification of chemicals in foods. However, the number of chemicals identified in foods of interest can become some–what overwhelming. I think all flavorists have unsuccessfully attempted to formulate a flavor from large numbers of chemicals found in specific foods. Using the literature is also very time consuming and can be somewhat expensive. In addition, many companies do not provide the resources to support this approach.

Selection of ingredients by odor: This approach is used because it is a quick way to evaluate an ingredient, but it has many limitations and can be misleading. One limitation is that many flavor ingredi–ents taste similar to their odor profiles, yet odor profiles are not a substitute for tasting the ingredient. Selection of ingredients by odor also does not provide the flavor (taste) profile or true intensity of the ingredient at various use levels. Ingredients that have an intense odor may not have the corresponding flavor intensity, e.g. acetaldehyde and isoamyl alcohol. However, selection by odor is effective as a screening tool for subsequent flavor evaluation, and overall makes a useful contribution to trial and error.

Selection of ingredients by supplier or peer recommendation: Ingredient suppliers provide most of the new ingredients that we become aware of through trade organization presentations.

Appearance of new GRAS ingredients on the market is typically slow because demand is an unknown variable. One cannot accurately predict the sensory properties from chemical structures. There are still chemicals not available from GRAS 18, and GRAS 20 was published just within the last year. At Chemical Sources Association meetings, flavorists have a hard time choosing chemicals that they want suppliers to offer because they do not know what the chemicals will taste like. GRAS ingredients originate from a variety of sources — some chemicals are useful as flavor ingredients, but other chemicals may be GRAS-designated for other reasons, like starting materials or reaction products in GRAS chemical reactions. Large flavor compa–nies can GRAS ingredients that do not become public for one to two years. This gives them an advantage. Having available all the approved ingredients for flavor creation is ideal for a flavorist.

Quantitative intensity ratings plus qualitative flavor descriptions at selected ppm levels provide an accurate approach to the selection of ingredients and ingredient use levels.

In addition to suppliers, peers may also be helpful in suggesting selected ingredi-ents for specific applications. These are the only sources available for ingredients (unless one produce one's own). Yes, suppliers are fallible, and they are trying to sell their products, but suppliers are also a valuable ingredient source for flavorists. In addition, some peers will help fellow flavorists, which is very helpful because of the lack of in-house flavor training programs.

Selection of ingredients by flavor (taste) evaluation: This is the most reliable and accurate approach in utilizing flavor ingredients for flavor creation. Flavor evaluation provides an insight on how each ingredient's flavor profile may vary at various use levels, measures confidence in use, reduces trial and error, provides a better esti–mate of use level and overall acts as a better way to assign an ingredient for use in flavors.

Analysis of 2,4-decadienal (FEMA# 3135, FCC, Bedoukian) **T-1**

Use level (ppm)	Intensity	Comments
0.01	3/10	8 fatty, 2 chicken fat, oily, nutty, cashew, earthy, vegetative, chicken broth
0.025	5	2 oily, 4 fatty, 3 chicken / peanut fat, 2 roasted
0.05	6	5 fatty, 3 oily, 3 rancid, 3 chicken fat
0.1	7	2 oily, 2 very fatty, 4 rancid, 2 level too high, cucumber, melon, cheesy, harsh green, Playdoh, cardboard

Ingredient Evaluation Criteria

Of course before ingredients are evaluated they should meet the specific purity criteria. Chemicals should be Food Chemicals Codex-listed where available, or meet FCC specifications. If FCC specifications are not available, chemicals should not contain impurities or contaminants that are not approved for food use and contribute to off flavors.

It is known that certain functional groups like aldehydes are very susceptible to oxidation. A variety of reactions can take place that noticeably affect the flavor description of that chemical or ingredient. Ageing can dramatically reduce the flavor intensity of ingredients, yet very few suppliers include a manufacturing date on ingredient samples. On the other hand, using fresh laboratory ingredients and outdated production ingredients can also produce obvious undesirable results.

The purity and ageing of an ingredient is a significant factor in duplicating or comparing sensory results from different authors, laboratories and the literature. Sensory evaluation is subjective to begin with and by adding variables to this process, it can make sensory results confusing and difficult to reproduce.

Quantitative Sensory Evaluation of Flavor Ingredients

Flavor ingredients are evaluated by various meth–ods in the industry. Typically, ingredients are tasted in ppm levels and described at one or more levels. The relative intensity of the ingredient at different use levels can vary significantly. The intensity rating of an ingredient can provide additional useful information and insight, on how the ingredient may be used in a formulation and at what use level. It is important to note: quantitative intensity ratings plus qualitative flavor descriptions at selected ppm levels provide an accurate approach to the selection of ingredients and ingredient use levels. This approach reduces trial and error dramatically.

Intensity Determination

In my organization we employ a subjective intensity range of 1 to 10 where 10 is most intense. Ingredients are tasted and described at threshold use levels up to high intensity use levels — in other words, to where the ingredient is too strong (chemical burn, bitter, etc). It is worth noting that often the most intense flavor is not at the highest ppm use level.

The ppm use levels of 0.1, 0.5, 1.0, 2.5, 5.0, 7.5 and 10.0 usually cover the evaluation range, depending upon the ingredient under evaluation. The intention is to determine threshold up to a level above where the ingredient is too strong for flavor use. Some ingredients require an expanded ppm range to accommodate very strong ingredients like sulfur compounds, etc.

When tasting flavor ingredients, a threshold rating may be rated at 0.1 to 0.5 range depending upon the level tasted. An intensity rating above 6 may be considered too high for flavors except if the ingredi–ent is a characterizing compound.

Intensity Rating Reproducibility

The intensity range (1 to 10) is a relative range, which can be related to food flavors. For example, milk

would have an intensity rating of about 3, blue cheese about 6.5, banana about 4. Most foods have a low intensity, although fruits have higher intensity due to fruit acids. On average, foods have a relative intensity rating of about 4 to 5.

An industry test was recently conducted to determine intensity rating reproducibility. Three flavor companies participated in the experiment, which included 13 participants. Each participant was asked to describe three flavor ingredients and determine their intensity at selected ppm use levels. Results showed good reproducibility be–tween the participants even though it was the first time they determined intensity ratings. The author has demonstrated that intensity ratings are repro-ducible within 10 percent. Intensity ratings are more reproducible than flavor descriptions of ingredients. Tasting is a subjective process. Three people can taste something and all describe it

differently, while all expressing the same sentiment. Looking at the flavor descriptors in T-1 (2,4-decadienal) and T-3 (ethyl butyl ketone), one can see a number of descriptors reflecting various people trying to describe the same ingredient. One person used the word "Playdoh." Those with children may identify with this descriptor, but those who have never smelled the substance could not possibly identify. People, as a rule, describe flavor based on cultural and experiences in tasting various foods. Intensity rating is a more manageable measure because it is relative and not reliant on a large descriptor vocabulary or tasting experience.

Intensity Profiles

Intensity profiles can be graphed by plotting intensity ratings against ppm use levels. Some ingredients, like hexanal, have a very narrow usage range, while other ingredients, like vanillin or ethylmethyl phenyl glycidate, have a very forgiving usage range. Many low chain alcohols and esters also fall into this category.

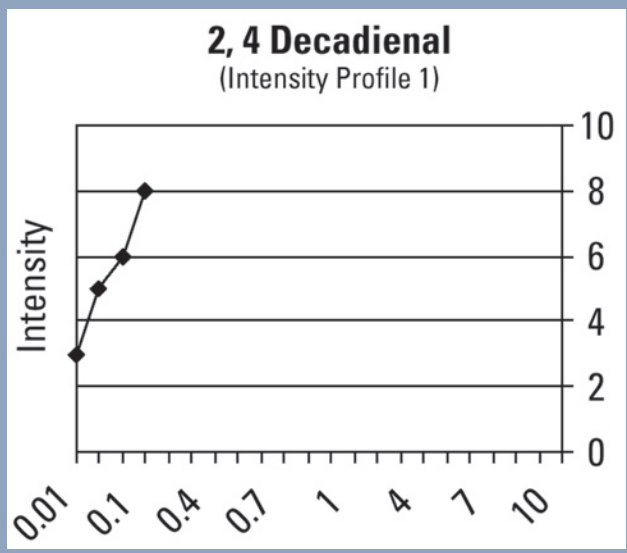
It appears that all ingredients fall into four inten–sity profiles

An example of an ingredient with an intensity covering a narrow usage range is 2,4-decadienal (FEMA# 3135, FCC, Bedoukian) (T-1).

T-1 shows the results of the sensory evaluation and intensity rating of 2,4-decadienal, by the industry test participants. The numbers preceding the flavor descriptors reflect the number of participants who described the ingredient with the same descriptor. Not all participants provided results at every ppm use level.

F-1 shows the usage range of 2,4-decadienal to be a little more than 0.1 ppm. The intensity covered the usable range within 0.1 ppm. Using this ingredient requires careful usage in a formula. This would also indicate that if the use level of the flavor containing this ingredient changed, the ingredient may not function as planned.

2,4-Decadienal usage range using qualitative sensory data **F-1**



2,4-Decadienal intensity ratings **T-2**

0.01 ppm	4, 4, 5, 3 4, 1, 3, 5, 2, 2, 4 = average 3.3
0.25 ppm	6, 5, 6, 5 2, 3, 3, 6, 6, 4.5, 6 = average 4.7
0.05 ppm	8, 6, 8, 6 2, 5, 3, 8, 7, 8 = average 6.1
0.10 ppm	10, 5, 10, 9, 8, 7, 5, 10, 9, 10 = average 8.3

The intensity ratings in T-2 show the actual 2,4-decadienal data provided by the industry participants. Additional experience in determining intensity ratings would improve results. The average number from the results are applied in F-3.

T-3 provides an example of an ingredi–ent — ethyl butyl ketone — with an intensity covering a broad usage range. An intensity profile of the material is provided in F-2. Ethyl butyl ketone's intensity ratings are presented in T-4.

An example of an ingredient with an intensity leveling off without getting stronger is 2-methoxy-4-propyl phenol. This material's intensity profile and use level/intensity figures are presented in F-3 and T-5, respectively.

An example of an ingredient with an intensity that peaks and then drops off is lemon oil, California type (F-4). This material's use level and intensity figures are presented in T-6.

Ethyl butyl ketone (3-Heptanone) (FEMA# 2545, FCC, Bedoukian): an example of an ingredient with an intensity covering a broad usage range **T-3**

Use level (ppm)	Intensity	Comments
1	1/10	3 nothing tasted, 2 weak, burning, non-descript, fatty, vegetable
2.5	4	3 cheese, 2 fruity , blue cheese, fatty, waxy, dairy, apple, green, nothing tasted, brown
5	6	2 blue cheese, 2 cheese, 2 waxy, 2 fruity, sour, lactone, dairy, coconut, Playdoh-like, nothing
10	8	2 blue cheese, 2 fruity, 2 slight chemical note, cheesy, sour, fatty, waxy, harsh, too high, Playdoh, floral

Ethyl butyl ketone intensity ratings **T-4**

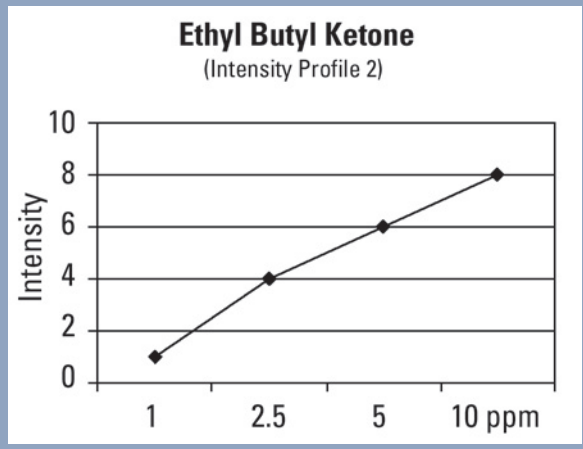
1 ppm	1 1 2 1 1 1 1 2 = average 1.25
2.5 ppm	3 5 5 3 5 3 3 4 = average 3.9
5.0 ppm	6 6 7 7 5 8 5 6 = average 6.3
10.0 ppm	8 8 8 9 5 9 6 8 = average 7.6

Summary of Intensity Flavor Profiles

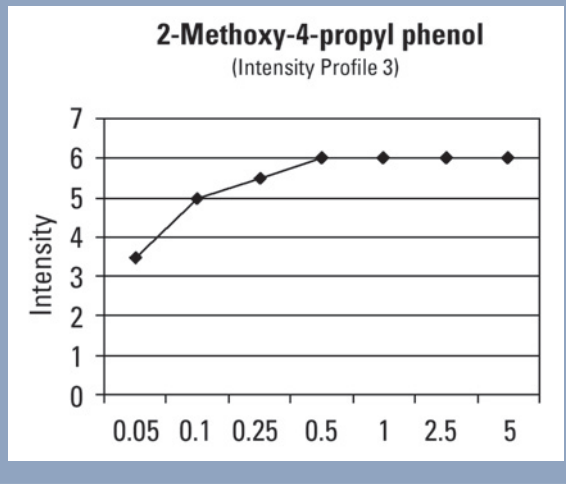
All ingredients appear to fall into four intensity profiles. Fortunately, most of the ingredients evaluated, such as ethyl butyl ketone, fall into the broad ppm range. The profiles break down into:

- 2,4-Decadienal — steep intensity profile
- 2-Methoxy-4-propyl phenol — profile below maximum

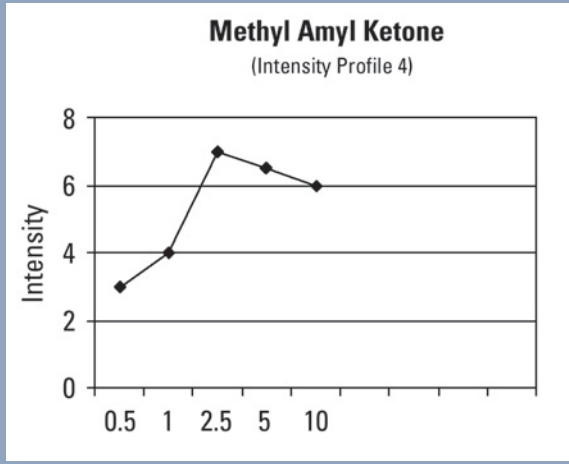
Ethyl butyl ketone intensity profile using quality sensory data **F-2**



2-Methoxy-4-propyl phenol intensity profile using qualitative sensory data **F-3**



Lemon oil (California type) intensity profile (CP, FCC) **F-4**



2-Methoxy-4-propyl phenol use level and intensity figures **T-5**

Use level (ppm)	Intensity
0.05	3.5
0.1	5
0.25	6
1.0	6

Lemon oil, California type, CP, FCC — use levels and intensity figures **T-6**

Use level (ppm)	Intensity
1	2
5	5.5
10	4.0

- Lemon oil — intensity peaks and then drops off
- Ethyl butyl ketone — gradual increase in intensity

Categorizing Flavor Ingredients for Flavor Applications

In 1995, Frank Fischetti publicized a flavor functionality that could be assigned to ingredients.[1] He defined three functions that categorized how ingredients can used for selected flavors.

According to Fischetti, characterizing compounds are defined as ingredients that taste like a particular food flavor. Examples would be benzaldehyde for cherry and methyl anthranilate for grape. Contributory compounds are defined as merely aiding the character of a flavor. Examples would be ethyl butyrate for grape, cherry, etc., and hexanal for banana, strawberry, etc. Differential compounds are defined as compounds that may alter a flavor profile to make it unique. This category is creatively useful in selecting ingredients that may not be obvious within a particular flavor target. Differential compounds may also be ingredients that can be tried at sub-threshold levels.

The steps to evaluate and document qualitative sensory data and quantitative intensity ratings are:

1. Taste ingredients at ppm ranges that cover sensory properties from threshold to high intensity level.

Flavor Creator-generated cherry juice flavor **T-7**

FEMA	ppm	% soln.	g added	Ingredients	Ingredient ppm use levels selected from sensory and intensity data Sensory and intensity rating data
				Characterizing ingredients	
2507	1.0	10	0.1	Geraniol (Adv. Biotech #1131)	1 ppm— sweet cooked cherries character, full bodied, intensity 3
3068	0.2	1	0.2	Tolyl aldehyde, para (Cit. & Allied #13068)	0.25 ppm — sweet, full-bodied, weak benzaldehyde-type character, intensity 5
				Contributory ingredients	
2444	2.5	10	0.25	Aldehyde, C-16 so called (Cit. & Allied #A19150)	2.5 ppm — sweet, full bodied, red fruit direction, intensity 4
2427	0.5	1	0.5	Ethyl butyrate (Adv. Biotech #1045)	1 ppm — light fruity note, apple-like, intensity 4
2911	0.2	1	0.2	Heliotropine (Cit. & Allied #A12911)	0.1 ppm—sweet full note, intensity 2
2560	0.2	1	0.2	Hexenal, *trans*-2 (Bedoukian #350)	0.25 ppm - weak green musty note, full note, intensity 1
3500	0.5	1	0.5	Hexyl isovalerate (Alfrebro #8805)	0.5 ppm — full, fatty, winey, intensity 0.5
2670	0.2	1	0.2	Methoxybenzaldehyde,p- (Adv. Biotech #120)	0.1 ppm—sweet full bodied red fruit note, intensity 2
			7.85	Solvent	
			10.0	Total	

2. Document flavor descriptors and intensity rating at each ppm level.
3. Assign ingredients to flavors where they may be useful as characterizing, contributory or differential.

Creating Flavors Using Qualitative Sensory Data and Quantitative Intensity Ratings

Using a focused approach to create flavors has many benefits. As an example, T-7 presents a cherry juice flavor formula created using flavor creation software.*

The formula in T-7 was created from a skeleton formula consisting of ingredients previously assigned to "cherry" flavor based on sensory evaluation of flavor ingredients. The ingredients and ppm use levels used in the formula were chosen from a list of ingredients with qualitative sensory data and quantitative intensity data that could be viewed while the flavor was being created. The column on the right side of the formula contains a portion of the sensory and intensity data that was used to select the ingredients and ppm use levels in the formula.

*FKS' Flavor Creator.

The flavor in T-7 does not use characterizing ingredients at high use levels, which would provide a flavor with more of a single flavor character. By using intensity data, the formula could be created with a balanced profile giving it more of a natural character.

This format provided a quick, flexible, and accurate selection of ingredients and use levels for any flavor. Most flavors can be created within one to three attempts, depending upon experience. In addition, any flavor can be created in a relatively short period of time even if it had not been created before. A library of ingredient sensory data is the only criteria.

Selecting ingredient ppm use levels is based on using the flavor at 0.1 percent. However, due to additive effects and synergisms, the flavor use level is normally between 0.05 percent and 0.1 percent in water. It appears that the more ingredients contained in the formula, the lower the use level. More studies need to be done to confirm this. Use levels may be higher depending upon the application. Evaluations should be con–ducted at 0.1 percent in water, or 0.15 percent in a solution of 3 percent sugar plus 0.03 percent citric acid.

Conclusion

To reiterate, the benefits of using qualitative sensory data and quantitative intensity data are:

- Reduction in trial and error
- Creation of flavors in a shorter time period than traditional methods
- Greater accuracy in ingredient selection
- Greater accuracy in determining use levels
- More insight into flavor ingredients
- Creation of higher quality flavors
- Increased utilization of a wide variety of ingredients
- Reduction in the use of extraneous ingredients
- Shorter formulations
- Potential reduction in manufacturing time
- Potential reduction in inventory
- Excellence as a training tool

Every flavorist has his or her own approach to creating flavors. However, whatever the approach, flavor ingredients and ingredient use levels must be selected to create the flavor. Using qualitative sensory data and quantitative intensity data provides an insight into the use of flavor ingredients and provides an efficient and effective approach to create flavors.

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References

1. Frank Fischetti, *Using the Categorizing Technique* to Make Flavors, Perfum. Flav., January/February 1995, p 23. ■