

April 1, 2001 John Diehl

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| **How Now Brown… Flavors?**  ***By John Diehl Contributing Editor***  Many wonderful sensations, including the aromas of Thanksgiving dinner and the sensory overload of passing downwind from a bread bakery, result from brown flavors as they develop in the oven or on the stovetop. However, the average consumer doesn’t know that brown flavors are the contributing factor, nor do they know what a brown flavor truly is.  Even when surveying flavor professionals, food technologists and chefs on the definition of brown flavors, there was some hesitation. Indeed, “brown flavors” is a somewhat nebulous category encompassing a large array of flavor types, both sweet and savory, derived from two basic thermal processes: caramelization and Maillard reactions.   **Defining the flavor** The knowledge base regarding sweet caramelized flavors is fairly advanced. Flavors in this group, such as caramel and maple, generally are compounded by flavor professionals and used by food technologists as a direct additive ingredient. Within the flavor industry, the key volatile components have been extensively studied for this group of flavors and are sufficiently characterized to allow a flavor manufacturer to duplicate almost any flavor profile desired. Hedy Kulka, flavor chemist, Flavors of North America (FONA), Carol Stream, IL, says that the essential components for these flavors largely fall into three groups of chemicals: cyclotenes, maltols and furaneols.  Caramelized brown flavors are largely derived during cooking from caramelization reactions, changes that occur in polyhydroxycarbonyl compounds (such as reducing sugars and sugar acids) that are heated to high temperatures. This process is independent of the presence of oxygen. The presence of carboxylic acids, the salts of the carboxylic acids, phosphates and metallic ions (one or more of which are commonly found in foods) accelerate carmelization reactions. Anyone who has had a pie filling cook out into the oven has experienced these reactions, watching the mess transform itself from sugar water to syrup to light caramel to dark caramel and finally, following almost complete dehydration, to charcoal.  Within the broad scope of the brown flavors category, the industry often focuses more on the Maillard group, those compounds largely responsible for savory brown flavors. Maillard reactions involve the reaction of aldehydes and ketones (most notably reducing sugars) with alpha-amino nitrogen (typically from free amino acids and small peptides) during heating. The resulting products then undergo a large array of rearrangement and degradation reactions — an area of considerable study in academia.   **Brown building blocks** Building a savory flavor is a lot like building a house. It is done in stages and, if done correctly, will leave a lasting legacy. The three key stages are formulation of the base, development of the desired flavor (gold-standard flavor) and the enhancement of the flavor profile.  **The base.** Chefs devote a great deal of time to developing and preparing bases for later use. In the kitchen, this consists of bones, fat, skin and trimmings, lightly roasted and then simmered in water with a combination of assorted vegetables, herbs, tomato and spices. A base is a versatile building block for a wide range of products — soups, sauces and entrées — contributing the nonvolatile portion of the flavor profile and often containing non-brown flavor notes, such as tomato, at various levels.   **The “gold standard” flavor.** This is the specific high-end flavor that the consumer will identify with the product, the flavor produced when a food is made using traditional culinary techniques. Typically, when asked to develop a specific savory brown flavor, an R&D flavorist will focus on matching a flavor made using a traditional culinary method, but in a reproducible and cost-efficient way by applying food technology to facilitate large-batch (sometimes continuous) processing.  **Enhancement.** Once the desired flavor profile is developed, the finished product should be optimized, or enhanced. This is not a part of the brown flavor per sé, but how a flavor is presented — both chemically and physically — affects the consumer’s perception of the flavor.  **Step one: brown base basics** Making a profile that is delicious to eat, reproducible on an industrial scale and within the cost boundaries essential for a product to be competitive on the retail shelf requires three basic steps. Of these, the least exciting, but perhaps the most important, is the construction of the base (or stock) that serves as the foundation of the entire flavor profile. The average food technologist often pays far too little attention to this step, but doing it right will add reproducibility to the end product, keep flavor costs in line and give taste quality that can be used as a marketing lever in the battle for the consumer’s attention.  This is especially true for savory brown flavors and can apply, with a twist, to the sweet ones as well. Unlike many traditional flavor systems, savory brown flavors must be built in parts to be both effective and culinary.  One of the true advances our food industry has made in the last decade or two is the improvement of the culinary quality of products manufactured and sold in the retail marketplace. Prior to 1980, most of the flavor technology and quality in the retail sector was for non-main-meal items — beverages, desserts and confections. This has changed considerably, fueled by a few important factors: microwave ovens in the home; employment of executive chefs with a high level of culinary training; a growing understanding of the Maillard reaction; a growing demand for convenient, yet enjoyable, entrées and side dishes; and more food manufacturers partnering in the R&D effort with key suppliers of value-added ingredients.  A base, or stock, is the nonvolatile portion of a savory flavor system that allows a company to create a range of base stocks used as production intermediates in their manufacturing scheme. A base stock can be made in advance and stored under refrigeration, especially if concentrated to a glacé, for months. A good starting point is the development of three bases: brown, white and fish stock.  Numerous companies now manufacture and sell these types of stocks to food manufacturers. Even multinational flavor manufacturers are paying attention to this segment of the flavor business. Classic stocks involve simmering raw meats or fish and bones with aromatic vegetables/herbs, peppercorns, water and a little salt. For a richly colored brown stock, the meat and bones are first roasted in the oven to brown them prior to simmering. This process does not lend itself to a food-processing operation unless a company has a reliable stream of crucial raw materials and is willing to dedicate the space and manpower to make stocks in-house. Since control of batch-to-batch variation is a very important aspect, some in-house culinary QC methodology would have to be established to minimize this.   Better yet, manufacturers can source these bases from a company dedicated to making them for industrial and foodservice use. As Kevin McDermott, Technochef™, Firmenich, Plainsboro, NJ notes, even if you have a reliable source of waste stream raw materials, you may not want to use it. Concerning the possibility of utilizing waste streams to make economical industrial flavor bases, McDermott suggests, “starting with good raw materials provides good finished products. Starting with bad gets you bad — not all waste is good waste.”  Other chefs think this is a good caveat. Culinary chefs in a single-kitchen environment can seemingly utilize a waste stream because they can establish a close working relationship with a single meat provisioner that can provide bones and other stock ingredients that have specifically been set-aside during butchering and meat cutting. However, on a larger scale this would be impractical. Base manufacturers can source reliable higher-grade meat and fish products, have scales of economy in both purchasing and production, and can combine these with yeast extracts, smoke and HVPs to produce a broad library of shelf-stable bases with good-to-excellent microbiology.   Many companies will partner with a food manufacturer to develop proprietary systems, often going beyond just making the base, but also flavoring that base to the gold-standard objective and enhancing the resulting flavor. This, plus the suppliers’ experienced chefs on staff, has led to the growing propensity for manufacturers and suppliers to partner in the development process.   A second player in savory bases is roux, a blend of butter and flour that has been cooked to produce flavor and color. It is the traditional thickener for culinary bases called the mother sauces — sauces mères. Commercial lines of culinary-quality roux products can be utilized as food ingredients. Combined with other brown-flavor system products, these can provide a starting point for many gravies and sauces. These, too, are developed by the kinetics of a thermal process. Chefs stress that the flavor of a roux comes from heating the flour — again, the application of kinetics to the system is essential.  Finally, as discussed above, there are sweet brown flavors as well. The sweet brown flavors — especially vanilla — often function as the base in sweet fruit and other flavors. Kulka explains that a nondescript praline-type brown flavor often is used as a modifier for fruit flavors to add ripeness and cooked character: “Brown flavors at low levels can modify numerous sweet flavors to yield desirable taste characteristics.” She also notes that the addition of a brown flavor note to butter for microwave popcorn makes the flavor more acceptable. The sweet brown flavors largely produced by caramelization — not Maillard reaction — can be compounded without a reaction or processing step (like the savory Maillard products).   Steve Shelton, Florida Treatt, Haines City, FL, mentions an ingredient that consists of a clear flavor distillate fraction of various sweet products, such as sucrose, honey and malt. This also could be utilized at low levels in sweet brown flavors to add depth and strength to the flavor profile.  The use of honey as a sweet brown flavor opens some interesting possibilities because of its antioxidants and flavonoids. May Berenbaum, entomologist, University of Illinois, Champaign-Urbana, has reported the antioxidant activity present in 19 honeys in a wide variety of locations and found, in general, that the lower-market-value dark honeys have higher antioxidant levels than the lighter honeys we tend to favor as sweeteners. In another study, Paul Dawson, Clemson University, Clemson, SC, demonstrated the use of honey as a part of the reducing sugar component of Maillard reactions in a turkey-roll model system. He indicates that the antioxidant compounds generated by the Maillard process were an added plus, as was the lower water activity (Aw) in the finished products.  **Step two: giving the flavor identity** According to McDermott, there is no set list of established gold standards; most chefs refer to it as a flavor created using a traditional culinary preparation. Flavor and base manufacturers often work one-on-one with their customer to define the gold standard(s) to be developed for a specific application. Often, the chef will prepare this flavor using traditional culinary practices and demonstrate this flavor to the potential customer. When the customer agrees that the chef has reproduced the target flavor, the chef then turns this over to the creative flavor and reaction chemists who develop the flavor system from there. Many flavor manufacturers have an in-house program for chefs to demonstrate and teach culinary techniques to the creative flavor staff.   One of the most difficult steps in the flavor development and sales process is the English-language description of the flavor desired. As the saying goes, “there is no accounting for taste,” and one person’s definition of a desired taste profile can be interpreted as something quite different by another person. This ability to make the target an actual taste experience, not verbiage, can certainly facilitate a shortening of the development process and make the flavors more acceptable in the finished application.  For savory brown flavors, the gold standard will almost certainly come from a Maillard-initiated thermal process. Increasing research focuses on Maillard reactions with regard to flavor manufacture, as well as their nutraceutical and pharmaceutical implications and relationship to in vivo aging processes (especially their relationship to diabetes). The level of academic research has increased considerably, but Dick Heinze, president, FKS, St. Louis, observes that it can be somewhat difficult to apply to industrial flavor applications because most work uses model systems that are not practical for food-production operations.  While model systems are difficult to apply to real-world situations, “they do furnish an excellent guide on where to start as well as provide excellent methods to make in-house flavor keys that can be added back to the flavor after the thermal reactions are completed,” says John Simmons, vice president, savory flavor creations, Quest International, Hoffman Estates, IL.  According to Mike Houlihan, manager, flavor processing, FONA, some of the issues when scaling model systems up to industrial size include:  • Is the equipment used comparable? • Can it be scaled up to commercial-size quantities?  • Are the essential substrates available as commercial products? • Will impurities in the commercial product cause undesirable side reactions?  More research and application studies are needed on using readily available protein hydrolysates, such as yeast extracts, HVPs, hydrolyzed milk solids, cultured whey, hydrolyzed meats and hydrolyzed fish and shellfish.  Most important reactions involving a food process depend on a small number of critical variables: substrate concentration; pH; Aw; temperature and pressure; and time.  Water activity can affect Maillard-reaction results. For example, in the kitchen, the characteristic roasted flavor of a meat does not start to develop until the surface area has dried considerably and mostly fat is present. Also, the underside of the meat lacks the roasted intensity of the top, sides and ends. “Choose a roasting pan that is just slightly larger than the food to be cooked. If the pan is too small, the roast will stew in the pan juices,” says the Cordon Bleu’s instructional cooking manual. “Brown flavors are achieved in the kitchen through different cooking methods like roasting, sautéing, deep-fat frying, and searing,” says Jeff Wagers, corporate chef, culinary development, Griffith Laboratories Inc. “These cooking methods cause chemical reactions to take place, such as Maillard browning and caramelization. When processors use cooking methods, like cook-in-the-bag and steaming, these reactions do not readily occur.”  However, Darleen Shaffery, savory flavorist, FONA, doesn’t believe that Aw is the defining variable; the success of the Maillard reaction is more a function of the concentration of the starting substrates reacted in a controlled way (time/temperature/pH) — in essence, all of the variables are important. Houlihan agrees on how important controlling the reaction parameters is to achieving the flavor desired — change the kinetic variables and the resulting flavor is ultimately changed as well.   Defining these variables and learning to control them is an important task for flavor chemists developing these reactions. Likewise, if a food technologist is looking to add a precursor system that will allow a flavor to develop during cooking by the consumer, they need the ability to guide the consumer into preparing the product correctly. Simmons lists the variables:  • **Substrates:** They must be the right and concentration.  • **Temperature:** It is crucial to reach a threshold temperature for a particular reaction to take place. Once the threshold temperature is reached, time/temperature and pressure become variables that are interrelated. Reactions are usually run in closed vessels (to maintain volatiles); hence, pressure is a subset of temperature.  • **pH:** This must be defined. Changing the pH environment sufficiently will alter the reaction mechanism and thus change the flavor.  • **Time:** It is important to let the reaction reach the point where the targeted flavor chemicals are maximized. The best way to track the progress is with color, but that can be difficult in a closed reactor. Time is the next best measurement.  • **Water Activity:** This is extremely important, especially when dealing with low water activities — a strong bias towards certain flavor components can be achieved.   The differences in observations between the culinary perspective and the scientific perspective are probably due in large part to different objectives. A chef wants the flavor to be completely developed when the cooking process is completed; a reaction-flavor chemist is looking for the generation of essential flavor chemicals that can be utilized further in flavor compounding and blending. Certainly, the understanding and ability to control these key variables is an issue when adding Maillard precursors to a food system and using the kinetics available in a cooking process to develop a desired flavor.  Lastly, a general consensus among flavor chemists is that fat doesn’t play a role in brown flavors. It serves as a medium for getting the kinetics to the reacting compounds, but they were not aware of it actually being a part of the reaction sequence.  **Step 3: making the flavor bigger** The third and final step in developing a brown flavor profile is enhancement. For the sweet flavors, enhancement is usually fairly simple, often requiring only adjustments in Brix:acid ratios, vanilla level and physical attributes, such as color and viscosity. Enhancing savory brown flavors can be a bit more challenging, thanks in large measure to the negative health implications of over-consumption of sodium and the perception many individuals have that they are glutamate-sensitive (most of whom can happily sit in an Italian restaurant consuming copious quantities of glutamate-containing tomato sauce smothered with glutamate-containing Parmesan cheese while they complain that MSG in Chinese food always affects them). While enhancement is not a flavor per sé, it does affect the culinary gold standard for these flavors, especially the concept of umami, a taste often associated with savory brown flavors.   In savory flavors, the best enhancer, especially if cost is considered, is sodium chloride. Glutamate will enhance the effect of the NaCl (allowing a reduction, but not elimination of the salt) and active nucleotides will enhance the glutamate (allowing reduction, but not elimination). Remember, when tasting systems containing active nucleotides, that these chemicals have a half-life in the mouth and the order of tasting can affect the outcome. When building flavors into developmental food prototypes at the R&D level, remember that texture and color subtly affect how we perceive a taste sensation.  **Microwave mania** One of the true challenges for companies attempting to generate savory brown flavors is finding systems that work in a microwave oven and yield a broiled, roasted or sautéed flavor to an entrée at the point of consumption. The microwave oven represents a tremendous tool for the convenient preparation of food products; however, as an industry, we have tended to focus on its speed and the resulting products, while improvements in quality still lack culinary excellence, especially those products that typically require a low Aw environment during cooking.   “The problem with microwave cooking and supplementing with flavors is texture and flavor distribution,” Hutchinson points out. “Microwaves distribute the heat of cooking more evenly throughout the product (described as inside-out), whereas in traditional cooking methods the food is cooked from the outside-in. This creates the ‘crust’ where the brown flavors are most concentrated. If you were to attempt achieving the roasted or charred notes from microwave cooking methods, you would end up with the entire product blackened beyond recognition.”  Packaging innovations will generate improvement in the ability to have precursor systems develop in the microwave oven. Hutchinson says that second-generation packaging with improved susceptor film layers are just now being introduced and these may bring some capability to this area. Dual-function microwave-convection ovens also can address this need.   Jeff Rozum, technology development manager, Red Arrow Products Company, Manitowoc, WI, notes that smoke — especially certain low flavor versions — is an excellent source of carbonyls. These precursors can both accelerate the rate of Maillard reactions and require lower temperatures for the reaction sequence to initiate (a problem in a microwave oven where the ability to get to high temperature is very limited).  “In smoke you have dicarbonyls, which are aldehydes and ketones,” explains Patrick Moeller, executive vice president of research and development, Hickory Specialties Inc., Brentwood, TN. “They participate in the Maillard reaction by reacting with the amine portion of a protein. The result is compounds that produce color and flavor. In regular smoke the flavor produced by the phenolics overpowers that. In some of the new products where those smoke flavors are minimized, the flavors that occur from the reaction with proteins become more noticeable. The resulting flavor typically connotes savory, oven-roasted and those type of notes.”  Sugar derivatives in the smoke product, labeled as caramel color, will produce a range of brown colors on the surface of a substrate during cooking based on concentration, time and temperature. Rozum indicated that the carbonyl compounds present cross-link with proteins present in breadings, other coatings or the food itself to yield an enhanced texture.   Because these low-flavor smoke products react with the nitrogen in a protein substrate, the result varies with the application, notes Moeller. It works very well with meat and gluten-containing baked goods, such as bread. But a french fry, being mostly carbohydrate, either requires a little added protein in the coating or careful choice of the potato. “If you have a pretty high-solids potato — one that’s on the low end on starch and higher in protein — you can get some browning; but that’s not a variety that’s commonly used,” he says.  **Biotech and other improvements** No food topic today is complete without some consideration of whether biotechnology holds any promise for improving the technology, costs or both. Biotechnology is already an important contributor in reference to the use of enzymes. Houlihan says breaking down protein using enzymes can make the product more reactive, but controlling the hydrolysis is important or the flavor can be perceived as “grainy.” Simmons points out that enzyme treatment can yield a better mix of precursor substrates.   There are several reasons why a brief hydrolysis with a protease is beneficial, notes Jack Harris, director of research, Valley Research Corporation, South Bend, IN: “It changes the geometry of the protein molecule making alpha-amino groups more available for reaction and, more important, it breaks the protein into smaller-chain peptides with more alpha-amino ends available to react.” But can a protease selectively hydrolyze peptide chains so that the more desirable amino acids were consistently the ones at the alpha-amino end of the chain? “In a model system with a highly purified protease, probably yes; however, in a real-world system with cost as a constraint, not really,” Harris continues. “Some of the carbohydrase enzymes could affect how a starch/sugar system would caramelize.” He also added that, while they don’t participate in the actual development of savory brown flavors, enzymes such as glutaminase and ribonuclease can optimize the presence of free glutamate and 5'-nucleotides, thus enhancing the system in the mouth by upping the umami sensation.  Sulfur is important in the sequence of Maillard reactions and the myriad of rearrangements and degradations that follow. Heinze notes that the GRAS-18 list consists largely of artifacts identified from Maillard reactions and that these sulfur compounds make up a large portion of the list.   Many refer to these savory brown flavors as Maillard reactions, but Simmons points out that, although the Maillard reaction has become an all-embracing term, it is really just a small subset of what goes on. “The degradations and rearrangements that follow the Maillard reaction are really the area of interest,” he says. Research will eventually develop a road map of reaction outcomes based on control of the key kinetic variables — concentration, time, temperature, Aw and pH. This is another area where the model systems will give guidance and then the food and flavor researchers will develop real-world systems.   As we learn more, we can progress from the trial-and-error approach that has been the basis of savory brown-flavor developments over the past few decades to a more science-based and predictable approach. Flavor and base manufacturers have not yet reached the culinary gold standard in these flavor systems. Matt Hutchinson, manager, R&D, Kikkoman International, Elgin, IL, says, “I think we’ve reached a point where we understand the process of creating the flavors, but I think we need to delve a little deeper into understanding the reactions. I still find it very easy to distinguish a product created with a flavor vs. a product prepared with traditional techniques.” But we’ve come a long way towards getting there.  **Final brown-ing points** When combining the cuisines of the world to bring cutting-edge flavors to products, brown flavors have considerable utility in facilitating this flavor fusion. Consistently, a brown flavor note can be used as the common link between the taste sensations you seek to combine, merging the taste sensation so that none of the parts stand out alone and only the fusion taste comes through.  So, as a food scientist designing products, should you create your own brown flavors for the products you are developing? The answer probably is no. Because of the QC nightmare (batch-to-batch consistency) that could ensue, a poor cost position on raw materials and a dilution of focus from the core business, you are better off partnering with a couple of base and/or flavor manufacturers. First determine what, if any, brown-flavor precursors are present in your formula before talking with the flavor professionals. This opens up the possibility of either adding a turn-key system that is ready for consumption or allowing you to merge a flavor system with the precursors already present in your product to yield the desired flavor during processing or cooking.  ***John H. Diehl has diversified experience in developing and implementing business plans in the food and flavor industries. He earned his M.B.A. in marketing from the University of Chicago, his M.S. in food science from Oregon State University and his B.S. in nutrition and food science from the University of California.*** |