Culinary Applications of Umami

Understanding umami and its applications can help food technologists increase consumer acceptance and preference in food selection.

Jacqueline B. Marcus, R.D.

Photos from Takeshi (2004), used courtesy of Umami Information Center, Tokyo, Japan.

Mushrooms add a deep, earthy, umami flavor to Eastern and Western dishes.

The author is Assistant Professor and Chair, Culinary Nutrition Program, Kendall College, Chicago, Ill., and President, Jacqueline B. Marcus & Associates, Food and Nutrition Consulting, 466 Central Ave., Northfield, IL 60093, fitfoodpro@aol.com.

Umami, the fifth basic taste, is an inexplicable, delicious taste sensation that differs from sweet, sour, salty, and bitter tastes by providing a meaty, savory sensation.

Chinese gastronomes have written about umami for 1,200 years, Japanese researchers identified dietary components that produce the umami taste almost a century ago, and others have long characterized umami by a variety of descriptors. Science is now catching up to what great cooks around the world have instinctively known: that foods and flavor enhancers with umami can be useful in contributing a savory taste and rounding out and heightening the flavor of foods.

Although many foods naturally contain components that impart an umami taste, and others form umami substances during curing, aging, or fermentation, understanding how to match inherent flavor attributes in foods with the appropriate use of ingredients that might further enhance the umami taste, such as monosodium glutamate or nucleotides, can provide food technologists and/or product developers with additional resources to deliver even more flavorful and satiating products. This knowledge can be applied to enhance current products or formulate new ones, and/or to develop recipes and menus featuring umami that promote maximum enjoyment in various food settings.

History of Umami Research

Although umami taste receptors have recently been confirmed (Chaudhari et al., 2000), from a culinary perspective the umami taste is not new. Fermented fish sauces and intense meat and vegetable extracts have been valued in world cuisines for more than 2,000 years (Ninomiya, 2002)—consider Roman *Garum* or *Liquamen*, Thai *Num Pla*, Vietnamese *Nuoc Mum Tom Cha*, Indonesian *Terasi*, Burmese *Ngapi*, Philippine *Pagoon,* and British Beef Tea and their concentrated flavors.

In 1825, the French gastronome Brillat-Savarin, in *The Physiology of Taste*, described a meaty taste as "toothsome," and predicted that the "future of gastronomy belongs to chemistry" (Brillat-Savarin and Fisher, 1978). His description of a meaty taste is similar to the Japanese interpretation of

umami as "deliciousness." It is the chemistry between foods with glutamate that helps create this umami perception.

Takechi (2004) described the scientific research on umami. Ritthausen identified glutamic acid—the amino acid that elicits a unique umami taste in human sensations—in 1866. Ikeda proposed umami as a separate, distinct taste in 1908. He was struck by the distinct flavor that *dashi*, a fish and seaweed broth, added to tofu when cooked together. The umami taste was attributed to the glutamate in the kelp and *kombu* (seaweed) and dried bonito flakes that flavored the *dashi.*

The seasoning monosodium glutamate (MSG) was formulated in Japan in 1909 and introduced into the United States in 1917, after which it opened a wealth of flavor-enhancement possibilities.

Kodama isolated the nucleotide inosine 5′-monophophate (IMP), also known as disodium inosinate, from dried bonito tuna in 1914. Kuninaka isolated the nucleotide guanosine 5′-monophosphate (GMP), also known as disodium guanylate, from shiitake broth in 1960. He also discovered a synergy between glutamate and inosinate or guanylate.

Chaudhari et al. (2000) discovered the L-glutamate taste receptor, taste-mGluR4, which regulates the so-called "firing" of taste-receptor cells. The researchers likened this discovery to "turning a key in a lock that then starts an engine." Nelson et al. (2002) discovered a "broadly tuned" amino acid receptor, T1R1+3, highly stimulated by L-oriented amino acids (of which free glutamate is a member); these receptors provide evidence for the evolutionary importance of detecting amino acids for nutritional survival.

International organizations and symposia on umami paralleled these discoveries. The Society for Research on Umami Taste was formed in 1982. The International Symposium on Umami was held in 1985 and 1990, and the International Symposia on Olfaction and Taste (ISOT) in 1993, 1997, 2000, and 2004.

Taste-Active Components

While umami has ancient roots, culinarians worldwide have incorporated its flavor-enhancing abilities and are experimenting with its versatility (Gugino, 2003). Still, there are culinary differences between Eastern and Western approaches, in both tradition and palate. This may be due in part to nomenclature.

Asian cuisine is based on traditional umami-rich ingredients such as *dashi* for fullness, depth of flavor, meatiness, inexplicable mouthfeel, complexity, versatility, and deliciousness. European and American cuisines have few traditional umami seasonings and umami-rich ingredients; they tend to favor fat for richness and fullness to help make food delicious. If Americans recognize umami at all, they tend to think of it as savory (Hegenbart, 1992).

According to Mark Miller, chef/owner of the Coyote Café in Sante Fe, N.M., "Westerners have a lineal palate, set up on sweet and salty tastes with few counterpoints and harmonies. In Asian cuisine, however, you use all tastes at the same time. You're eating circularly. You must train your mind to go after flavor characteristics and look for flavors in different parts of your mouth" (Labensky and Hause, 1999).

Globalization has provided opportunities to fuse Far Eastern and Western cuisines and philosophies. Culinarians around the world are now utilizing scientific research about umami in culinary applications. For example, wine specialist Tim Hanni, President and CEO of Wine Quest, El Cerrito, Calif., promotes the pairing of umami-rich food and wine. And chefs Jonathan Pratt of the Umami Café in Croton-on-Hudson, N.Y., Heston Blumenthal of the Fat Duck in Berkshire, UK, and Yoshihiro Murata of Kikunoi in Kyoto, Japan, integrate umami principles in their contemporary local cuisines.

Umami-rich fish sauce and shrimp enhances a bland, sweet food, such as rice.

• **Umami Activators in Asian Foods.** Asian condiments in *dashi* broth impart the umami taste with their taste-active ingredients: dried bonito flakes and bonito, with IMP; black mushrooms, with GMP; and seaweed, soy sauce, and fish sauce, with L-glutamate and adenosine 5′-monophosphate (AMP), also known as disodium adenylate.

• **Umami Activators in Western Foods.** Bouillon, originally formulated by Swiss flour manufacturer Julius Maggi, has been used in Western countries since 1982 as an inexpensive base for creating nutritious soup. Bouillon (from the French word *bouilli,* meaning boiled) is savory, meat-like, and concentrated. Similar to *dashi* broth, bouillon imbues its meaty, umami flavor from glutamate or nucleotides. Glutamate is most abundant in protein hydrolysates.

Westerners appreciate the flavor-enhancement ability of umami when glutamate is present in the "free" form (rather than bound with other amino acids), as in mushrooms (especially dried), aged cheese, cured ham, sun-dried tomatoes, peas, sardines, and anchovies.

Despite the frequent description of umami as "meaty," foods such as peas and aged cheese actually have a higher level of free glutamate than an equivalent amount of beef or pork. This is why foods cooked with tomatoes or blended with pungent cheese such as Roquefort or blue seem to have a rounder, fuller flavor than when consumed alone. Mackerel, sea bream, tuna, and aged beef are high in taste-active nucleotides, as are the shiitake, matsutake, and enokitake mushrooms common in Asian cuisine.

• **Other Umami Taste Activators.** Other umami taste activa-

tors are hydrolyzed proteins and MSG, the naturally occurring sodium salt of glutamic acid. MSG, extracted from seaweed or fermented from molasses or sugar beets, is composed of 78% glutamic acid and 12% sodium. It has been speculated that the sodium in MSG may activate the glutamate to produce the umami effect (Hegenbart, 1992).

When food containing taste-active components such as L-glutamate; nucleotides such as IMP, GMP, and/or AMP; and MSG are combined in a recipe or menu, there is a synergistic effect, and the umami character is magnified. Exactly how this synergy is achieved is debatable, but depending on the system, up to eight times the enhancing effect can be observed by using, for example, a 50:50 blend of MSG and IMP (Hegenbart, 1992).

Umami Formation in Processing

Concentrated flavors deriving from the natural processes of ripening, drying, curing, aging, and fermenting liberate glutamic acid and increase umami levels, as detected in cured pork products. These are popular in the U.S. and other countries, as exemplified by chorizo in Spain, pepperoni in Italy, kielbasa in Poland, and frankfurters in Germany.

A ripe tomato has ten times more glutamate than an unripe tomato. Dried shiitake mushrooms contain 1,060 mg of glutamate/100 g, compared to 71 mg/100 g in fresh shiitake mushrooms. During the salt-curing of fermented protein products, such as anchovies, the protein breaks down into a wide variety of free amino acids and nucleotides. Aged beef has more glutamate than fresh beef. Fermentation is used, in part, to imbue soy sauce, Asian fish sauce, hot sauce, and Worcestershire sauce with more umami. The fermentation in beer and wine has a similar effect.

Milk from cows, sheep, and goats is a rich source of glutamic acid. When milk is cultured with enzymes, bacilli, or molds, glutamic acid is liberated, as is the flavor. The harder and more aged the cheese, such as Parmesan or Gruyere, the higher the glutamate content and the better it is for flavoring. While yogurt and sour cream have less glutamate, they are both ancient and traditional sources of umami, as seen in Mediterranean and Middle Eastern cuisine.

Food processing methods that break down food into smaller units of flavor help make tastes easier to detect. Simply expressed, cooking increases umami by deconstructing it. A long, slow stew usually has a higher level of umami than a quick sauté. Oven-roasting or oven-drying unripe tomatoes concentrates their flavor and boosts umami. Adding a pinch of sugar to tomato sauce replicates the ripening process and also boosts umami (Gugino, 2003).

Consumer Aspects

While consumers may want great-tasting food, they may not understand why. This is where use of umami may be effective. By utilizing the flavor principles of umami, consumers can create homemade, well-rounded flavors with savory taste. These full-bodied flavors that convey hours of cooking time may help today's consumer who has little time to cook.

Umami may also be effective in food selection. Glutamate appears to drive the appetite for protein-rich foods, just as the sweet taste probably drives the appetite for carbohydrates, and the salty taste for minerals. This may be similar to what ancient man experienced, but this evolutionary function is difficult to prove (Yuan, 2003). Some people are very fond of glutamate-rich foods and will select them before others. It may be that one's liking for high-glutamate food is directly related to individual perception and appreciation of glutamate itself (Yuan, 2003).

Umami is useful in sodium reduction. This is because umami highlights the sweetness and saltiness in a salty food, such as soup, without actually increasing the salt content. The sweetness partially counterbalances the saltiness. Umami also lessens the bitterness in foods that contain some sweetness. These functions provide one of the more important consumer applications of umami: its effectiveness in sodium-reduced diets. Umami can contribute up to 50% salt reduction in foods while retaining desirability. Soup without glutamate does not become palatable until the salt concentration reaches 0.75%. With glutamate, however, the same soup may be palatable with a salt concentration of just 0.4%. In an average serving of soup (200 g or 1 cup), this represents a 0.7 g reduction of sodium. This attribute of umami may have great implications for both consumers and food scientists because hypertension worldwide is a growing global concern (Devika, 2005).

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How Umami Enhances Flavor

According to Michael Roberts, former chef at Trumps in New York City, "Primary flavors are those that are obvious. Secondary flavors are secret ingredients that make a dish more quintessential and complex" (Roberts, 1988). Umami can be considered a "secret ingredient" that partners, layers, balances, and acts as a flavor catalyst to synergistically make a dish or a product more interesting and desirable. It can partner with other flavors to create a new flavor, balance flavors, or act as a flavor catalyst.

- **Flavor Partner.** As a flavor partner, umami helps create something new or superior to an original dish or product. For example, a standard seafood bisque is a combination of seafood, potatoes, and cream. An umami-enhanced seafood bisque may partner seafood's natural umami with fortified wine and umami-rich mushrooms to maximize flavor. The synergy is accomplished by natural glutamate, nucleotides, and wine.
- **Flavor Layerer.** As a flavor layerer, umami helps different flavors peak at dfferent times, then combine. For example, ordinary cocktail sauce is a combination of tomato products and heat, such as ketchup and chili sauce. An umami-enhanced cocktail sauce, with natural umami from tomatoes, reveals first a tomato taste, then sharpness from wasabi, boosted by soy sauce (with its own umami) for a hot/savory, unified finish.
- **Flavor Balancer.** As a flavor balancer, umami highlights flavors by contrasting, canceling, or balancing. Chinese five-spice powder, curry powder, and garam masala are pungent, as are garlic and ginger. If they are combined with Asian sauce or soy sauce (both containing umami), and a touch of sugar, they mellow, and their hot/savory taste, rather than their pungent taste, is magnified. Their unique characteristic pungency is balanced by umami for the greater good of the dish.
- **Flavor Catalyst.** As a flavor catalyst, umami provides the backbone flavor in a dish and keeps primary flavors from disappearing. For example, a standard grilled steak tastes delicious because of the umami in the beef. To uplift the umami in the steak, use aged beef and enhance it with truffle butter (containing umami), a squirt of lemon, and a touch of salt. The rich umami flavor of the meat is boosted by this combination of ingredients, and the umami increases the salty perception. Italian chefs achieve this blending of flavors in the dish *bistecca alla Fiorentina*.

Umami

Desirability is key in food acceptance and enjoyment. The umami taste is hard to recognize, but easy to enjoy. In the U.S., the popular Caesar salad and salad dressing are good examples. In a Caesar salad, umami in aged Parmesan cheese helps make relatively tasteless romaine lettuce tastier. Anchovy, used in very small quantities, provides functional amounts of nucleotides. The resultant taste is amplified and synergistic.

Umami may also be the reason why Americans love pizza and pasta with Parmesan cheese, why they find French fries and hamburgers so much more savory with ketchup, why tomatoes are present in most ordinary lettuce salads, and why glutamate helps consumers select foods that are "just right," because it is a measure of produce readiness. Sweet peas and corn have two of the highest levels of free glutamate when very fresh and ripe, as opposed to vegetables that have lingered long in the fields and for an extended time after picking or have undergone cooking. This importance to consumers cannot be understated: the enhanced smell and taste of umami-rich ingredients stimulate the palate, imply that strong flavors will follow, and increase the desire for tasty, nutritious food.

Food Technology Aspects

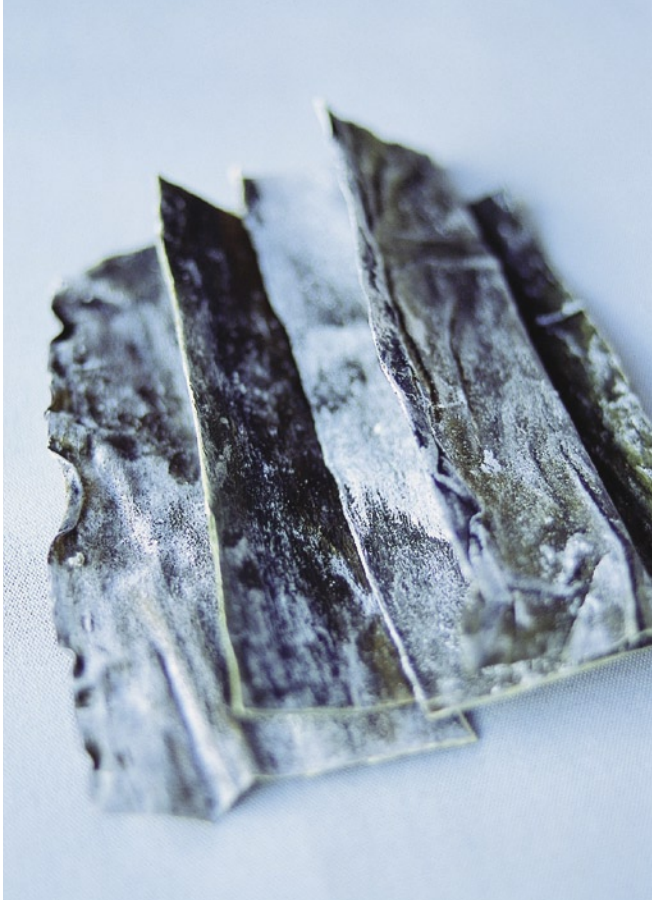
Understanding of umami is useful for food technologists because umami helps improve flavor in product development. Foods cooked in steam kettles may not achieve the full, meaty, and savory flavors that are available to the home cook, so addition of umami-rich ingredients can help fill out flavor profiles, as when a little soy sauce is added to a formula for chicken or beef entrees, soups, and cured meats. Umami is also economical, since its natural flavor may allow for a reduction of more-expensive umami-rich ingredients. For example, by using flavor enhancers with umami, one might be able to reduce the amount of expensive dried mushrooms that are called for in a soup or entrée (Frank, 1999).

Together, MSG, glutamate, and nucleotides may help provide food technologists with the "missing links" in recipes. This is because they work in synergy to round out food flavors when a food is missing something that is not clearly identifiable. They can also help make a finished product taste "more than a sum of the ingredients" (Frank, 1999). An unbalanced product tends to create taste fatigue. It may taste good initially but lose its appeal after a few bites. This can give the eater the impression that the food does not taste good, unless there are delicious, lingering after-effects which umami activators may provide. The imbalances may be so great that reformulation is required. This situation may occur with low-sodium foods and low-fat foods. An umami-rich taste-activator such as MSG can be used to impart fuller flavor with less total sodium and calories.

Umami-Rich Ingredients

The inherent flavor attributes of foods can be matched with umami-rich ingredients for maximum flavor, acceptance, and preference:

• **Soy Sauce.** Cooks have long appreciated the umami taste of soy sauce, with its 300 flavor compounds, including glutamic acid and volatile aromatic substances, that impart a meaty taste and light color to meat, soups, and sauces. Soy sauce has an affinity to sweet food such as fish, and works well to balance acidic taste, such as when soy sauce is served at the same meal with sake. Soy sauce also enhances the sweetness in bitter foods, such as stir-fried broccoli or Chinese greens. When soy sauce is added to tomato sauce, the umami sensation increases.



Glutamate in dried seaweed (*kombu*, above), dried shiitake mushrooms, and dried bonito (katsuobushi) provides the umami taste.

• **Parmesan and Other Pungent Cheeses.** Four ounces of Parmesan cheese contains 0.42 oz of natural free glutamate. Its salty, umami nature adds appeal to bland, sweet foods such as pasta and rice and depth to sour dishes, such as bolognese sauce. A sprinkle of pungent cheese lifts the blandness of ordinary macaroni and cheese. Parmesan cheese reduces bitterness by accentuating any sweetness in bitter foods, such as when it is mixed with basil in pesto sauce.

• **Salt + Umami.** Although salt does not impart an umami taste, umami appears to work together with salt to increase a salty perception. A touch of preserved food, such as artichoke hearts, capers, olives, or gherkins adds an instant salty note without a significant increase in sodium content. For more-sophisticated taste, a small amount of ingredients such as the following can be added to a recipe, but they may also add bitter notes: anchovies (fresh, dried), bacon, bresaola, capers, caper berries, caviar, chorizo, clams or clam juice, *dashi*, dulse, fermented black beans, fish sauce (*nam pla* or *nuoc nam*), glasswort (also samphire), ham, lox, MSG, *niboshi* (Japanese dried sardines), nori, olives, oysters or oyster sauce, prosciutto, roe (lobster, shad, or salmon), salt cod (baccala), salted nuts or seeds (pumpkin or sunflower), salt pork, *sambal* (Southeast Asian chili paste), sardines, sea urchins (also uni), seaweed, shrimp paste, soy sauce, tamari, and/or Worcestershire sauce.

• **Seaweed.** Kelp, wakame, and nori are rich in iodine and glutamic acid and add a complex umami taste to recipes. Japanese still use kelp (*kombu*) in savory *dashi* stock with dried bonito flakes. Seaweed's salty taste enhances sweet ingredients such as prawns and tofu, and bittersweet foods such as shiitake mushrooms (with nucleotides) or eggplant. Seaweed tastes sweeter if combined with other salty foods, such as soy sauce.

• **Anchovies/Smoked Fish.** The salty fishiness of chopped or

mashed anchovies in olive oil or butter brings out the sweetness of pasta and bittersweet foods, such as cauliflower, zucchini, or fennel, by offsetting the bitterness. When anchovy butter is topped over glutamate-rich steak, poultry, or fish, the umami is boosted. Minced anchovies or anchovy paste added to tomato sauce will also boost umami. The sauce will benefit from both the salt-cured and oily characteristics of the anchovies.

Umami-rich smoked fish, such as smoked haddock or salmon with delicate, salty taste, imbues a recipe with flavor. This may be why smoked fish is paired with relatively sweet, bland foods, such as rice, potatoes, butter, blinis, or bread to enhance flavor.

• **Tomatoes.** Tomatoes contain 0.0007 oz of free glutamate/4 oz of tomato, as well as sweet, sour, salty and bitter tastes. Cooked or raw tomatoes will enhance the flavor of most savory foods and bring out sweet, sour, and salty tastes while they counterbalance any bitterness. For this reason, some chefs even use tomatoes in desserts.

A classic tomato sauce is an easy way to add a savory, salty element to a variety of dishes. A small piece of ham further adds a salty/umami depth. If a tasteless alcohol, such as vodka, is added to the tomato sauce, the flavor is increased even more. Vodka acts as a solvent and releases the umami in the tomatoes. Because it has more alcohol than wine, vodka tends to be a more effective vehicle than wine for this purpose.

• **Bacon/Smoked Meat.** Bacon gains its salty, umami taste from curing with dry salt (dry cure) or brine (wet cure). Bacon's salty/umami nature enhances sweetness in eggs or peas (with umami). It intensifies the perception of sourness in wine sauce, and counteracts bitterness, as when bacon is cooked with game or cabbage.

• **Meat or Fowl Stock.** A homemade meat or fowl stock has natural umami and saltiness from protein that add a luscious depth. The bones and vegetables should be roasted before turning into stock to intensify the meaty taste.

• **Mushrooms.** Dried shiitake, matsutake, and enokitake mushrooms and fresh shiitake mushrooms are rich sources of nucleotides. The umami in mushrooms will intensify if roasted. Some mushrooms, such as portabella, have a pronounced meaty taste. That may be why they are popular in the U.S. as hamburger substitutes, enhanced by tomato products.

• **Wine + Umami.** According to food and wine specialist Tim Hanni, "If you understand what a particular taste will do to the taste of wine you want to drink, you can adjust the way food is seasoned or sauced in preparation so that a particular dish matches the wine. The wine doesn't change, but the perception about the wine has" (Hanni, 1996).

Sweet foods may increase the perception of acidity in wine. Sweetness comes not only from fruit and fruit juice, but also from hoisin, teriyaki, cocktail, and tomato sauces with umami. Acidic foods from vinegar, citrus, or dry wine reductions may also affect the sour taste in wine.

Tomatoes and Parmesan cheese with free glutamate add a savory element to plain pasta.

Bitter foods, such as endive, broccoli, and foods charred during cooking increase the perception of bitterness in wine. Umami also increases the perception of bitterness and astringency (tactile sensation) in wine. The judicious addition of salt and acid to food, especially sauces and other foods high in umami, can be useful to tone down both the bitterness and astringency of some wines and help the compatibility of some food and wine.

If a dish is balanced, the perception of the wine is that it "matches," such as long-cooking beef bourguignonne and aged Burgundy wine. If a recipe is high in umami, a young wine may taste bitter because of increased tannins; this may occur, for example, when matching umami-rich shrimp cocktail with a young Zinfandel or an aged steak with Chianti. But if salt and a squirt of lemon are added to the shrimp cocktail or steak, the tannins in the wine decrease, and the perception is that the wine and food have been paired correctly.

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How Chefs Are Using Umami

Chefs in the U.S. and abroad are developing menu items that utilize umami.

At the Umami Café in Croton-on-Hudson, New York, Chef Jonathan Pratt uses the common theme of umami in every dish. Examples include *Truffled Mac and Cheese* in a cream sauce of Gruyere and Fontina cheeses with black truffle butter and white truffle oil; *Pulled Pork and Foie Gras Panini* with smoked port, duck foie gras, and quince paste; and *Grilled Marinated Shrimp* with mushrooms and sweet soy glaze, served with coconut rice, umami vegetables, and sweet soy sriracha (Thai chili sauce) glaze.

At the Fat Duck in Bray, Berkshire, UK, Chef Heston Blumenthal combines seafood rich in nucleotides with Parmesan cheese rich in glutamate. Examples include *Marinated Squid with Parmesan Cheese* with just the right amount of Parmesan cheese to balance the umami in the squid; *Poached Sea Bream with Kombu Broth* for a dense, meaty taste; and *Green Bean and Tomato Salad with Soy and Fish Sauce Dressing* that transforms ordinary Western ingredients into a umami-rich melody.

Umami

Future of Umami

Scientists do not know the exact mechanism for how monosodium glutamate, nucleotides, and glutamate in food work synergistically, but they suspect they do (Yuan, 2003). When these ingredients are mixed with yeast-based enhancers, the synergy increases even more. The flavor profile is enhanced and lengthened, as when lower-sodium-containing IMP and GMP are added to vegetables. This may have implications for creating foods with nutritional enhancement for the aging population whose sharpness of taste has decreased due to longevity and/or medications.

Other formulation initiatives include soy sauce and yeast extracts, used to decrease sodium without losing the perception of salt in meat products, soups, sauces, gravies, rubs, and spice mixes. Wine powder and tomato products can be used in combination to increase the perception of sodium in sauces. Foods high in nutritional value, as bitter green leafy vegetables, can be manipulated to taste better to consumers who find them distasteful. Alapyridaine, a tasteless compound isolated from beef stock that relies on GMP synergism, augments salty, sweet, and umami flavors in food, and helps make bitter chocolate taste sweeter.

Americans are focusing on weight management, eating better, and making health-conscious choices that rival convenience in determining food purchases. They are avoiding or reducing the intake of some types of foods and/or seeking foods with nutritional enhancement (Sloan, 2004). The flavor-enhancing capabilities of umami can help drive selection of nutritional foods.

Great-tasting, highly flavorful foods with umami can be important tools in meeting expanding global food and nutritional needs. Also, because highly flavorful foods are satisfying, even in small quantities, the use of flavor-enhanced foods may play an important role in weight management.

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