Givaudan TasteTrek®

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Abstract TasteTrek® is a Givaudan research program for exploring authentic aromas and novel ingredients. From rainforests to restaurants around the world, the TasteTrek® program has led to the creation of numerous aroma reconstitutions, and to the discovery of interesting flavor and taste components. The TasteTrek® success is facilitated by the development of innovative sampling, analysis, and reconstitution techniques. A discussion about this technology and its application as a scientific approach for flavor creation is presented.

Introduction The TasteTrek® program was initiated in 1999 as part of GivaudanÛs continuing research effort toward innovative creation of unique and authentic aroma profiles and discovery of novel flavor ingredients. In order to study little known botanicals, we have investigated the rainforests in Africa. The aroma of popular ethnic cuisine is a very important source of innovation. To capture such culinary aromas, we have visited restaurants in many cities in ten countries around the world. In the Givaudan laboratories, these flavor collections were thoroughly analyzed, and a number of flavors and unique ingredients were developed. Scientific approaches have been established to create truthful aroma copies from nature.

TasteTrek® in the Rainforests

TasteTrek® Gabon 1999

The Gabon rainforest has much bioJdiversity: 80% to 90% of the worldÛs plants, mushrooms, and animals can be found in the rainforestX a majority is living in the canopy. In western Africa, over 20% of the species discovered are found nowhere else on the earth. The rainforest is disappearing due to deforestation. Therefore, the opportunity for new discoveries in the rainforest becomes less feasible.

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In 1999 we went to Gabon to investigate the rainforest. This was the first time that the flavor division of Givaudan conducted aroma sample collection in a rainforest. Camp Makande (**Figure 3**), located in the middle of the forest, was the headquarters for the research activities of scientists from all over the world. The camp could host more than 30 people. They were botanists, entomologists, biochemists, chemists, journalists, professors, students, and the service staff of logistics. These activities were sponsored mainly by pharmaceutical companies, universities, and governments. Givaudan was the only company from the flavor and fragrance industry. We had two TasteTrek® teams: one from the United States and the other from Switzerland. Each team stayed in the forest for two weeks at different periods.

A hot-air balloon, belonging to a French organization "Pro Natura," was available for us to investigate the canopy. The trees in the rainforest could be from 50 to 60 meters tall. It was very difficult to see any fruits or flowers on the trees within the forest because it was very dense and dark, so the balloon was very useful for investigating and collecting samples from the canopy. The balloon could fly only in early morning when the temperature was not too hot. We awoke at 4:00 o'clock in the morning to inflate the balloon and fly over the canopy for 1 to 2 hours to collect flower and fruit samples (**Figure 5**). After breakfast, we walked into the forest to collect more samples. We also visited markets in the cities and villages to look for unique fruits and spices.

We established a portable lab in the field where the plant samples were evaluated and selected for aroma collection. Aroma concentrates of the flowers and fruits and botanical material were prepared. We successfully tested the aroma sampling techniques and established aroma reconstitution methods.

TasteTrek® Gabon 1999 produced 21 reconstitutions of rainforest fruit aroma and discovery of 14 unique flavor molecules, which have not been used for flavor creations before. The reconstituted aroma has drawn great attention from customers.

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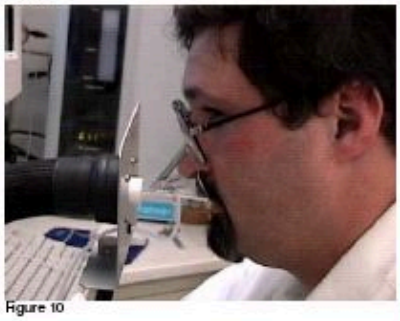

Figure 10

TasteTrek® Madagascar 2001

Encouraged by the success of TasteTrek® Gabon, we continued our rainforest exploration in Madagascar, which is considered by the international scientific and conservation community as one of the ecologically richest countries in the world. Of the estimated 12,000 plant species, over 80% are only found in Madagascar. In October and December 2001, the Givaudan TasteTrek® team, composed of scientists and flavorists from the United States and Switzerland, explored the aroma of the unique and peculiar plants, which grow in the Masoala National Park North east of Madagascar.

Madagascar is a beautiful country; it has gorgeous beaches and great mountains. The trees in the forest are shorter than the trees in Gabon. The Givaudan team explored the rainforest, looking for fruits, flowers, and aromatic plants. We used the same balloon system to collect samples from the canopy as that in Gabon, but it was largely improved with the support of Givaudan. A team of Malagasy scientists joined us in the rainforest exploration. There were several botanists teamed with us, and they were a great help for identifying the botanical species and their usages by the local people. During our TasteTrek mission in Madagascar (total four weeks for two teams) we evaluated more than 100 botanical samples and collected 52 flavor samples.

Analysis in the Laboratories

The samples were brought back to the Givaudan laboratories where a thorough analysis was conducted (**Figure 10**). According to the analytical results, each aroma was reconstituted using scientific approaches. The reconstituted aroma was then demonstrated to the flavorists, application chemists, and marketing staff. Many of the reconstitutions were found to have a high commercial value. Flavor creation and application teams fine-tuned the flavors to suit the market demands.

Here are some of our interesting findings:

A bark from a tree smelled very similar to onion. We first found it in a local market. The people roasted the bark and ground the bark to powder

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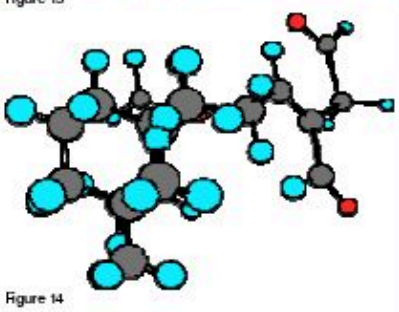

Figure 14

which was used to season their soup (**Figure 11**). In the forest, we found three different species of trees with the onion-like odor characteristics. Not surprisingly, we identified a lot of sulfur-containing compounds in the headspace of the bark by GC/MS analysis. The sulfur components 1-propanthiol, dimethyltrisulfide, trimethyl-thiomethane, 2,3,5-trithiahexane, and 2,4,5,7-tetrathiaoctane contribute to this balanced cooked garlic impression.

One of the interesting fruits we found in the jungle was called "drypetes." (**Figure 12**) The fruits are ca. 1 cm in diameter and have a thin shell and big seed inside. Around the seed is a white, translucent, and juicy flesh with sweet taste and unique aroma, which was described as durian-like, sulfury, and exotic. The analysis of the volatile compounds shows a remarkably high amount of methyl and ethyl esters of unsaturated fatty acids e.g., ethyl trans-2-cis-4-decadienoic acid, ethyl trans-2-decenoic acid, ethyl trans-2-octenoic acid and ethyl trans-2-hexenoic acid. The presence of isothiocyanates is found in the aroma.

In Gabon and in Madagascar, we often saw a beautiful plant called "wild ginger" by locals (**Figure 13**). It grows in humid valleys in the rainforest. The plant does not form a central stem, but several up to 5 meter long branches. The fruits grow directly on the ground, which makes harvesting very easy. They have the form of small onions with an intense red colour. Inside you find a white flesh, which covers numerous small black seeds. The plants in the rainforests of Gabon and Madagascar have very similar appearance, but they are different species of the genus Aframomum in the Zingiberaceae family, which includes the well known ginger. *Aframomum giganteum* found in Gabon is a little smaller than *Aframomum Angustifolium* found in Madagascar. They taste slight sour with refreshing fruity aroma, which is characterized by the impact of α-terpenylacetate, iso pinocamphone and the green terpeny notes of α-pinene, β-pinene, γ-terpinene. Caryophyllene and caryophyllene oxide add the woody character and linalool, linalylacetate and myrtenol round off the fruity impression. The seeds, when bitten, taste pungent. From the seeds, we isolated and identified the pungent principal as a diterpenoid which has no aroma but a pungent taste.

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From Jungle to Restaurant

The creation of authentic cuisine top notes has been a great challenge even for experienced flavorists, not only because of the complexity of the aroma composition, but also because of the difficulties in obtaining accurate analytical information from most of the cuisine samples. The success in the sampling and reconstitution of fruit and flower flavors from the rainforest led us to further develop the TasteTrek® technology for collection, analysis, and reconstitution of cuisine aroma.

Apart from the apparent different environments in jungle and in restaurant, there are subtle differences for sampling fruit and cuisine aroma. The moisture, elevated temperature, inhomogenity, limited stability, and strict conditions to maintain the desirable flavor are the factors affecting the collected aroma concentrate and subsequent analysis. We have developed techniques to capture, analyze, and reconstitute the complete aroma of authentic cuisine, which have been constantly improved since the first culinary trek. The TasteTrek® technology has greatly strengthened our capability in savory flavor creation and development, and has enabled us to create many cuisine top notes for key business opportunities.

TasteTrek® China

In 2000, the first experimental culinary TasteTrek was conducted in China. We had a single target: the "hot pot" (**Figure 17**) in Sichuan province. Hot pot is a famous Chinese traditional diet, which is known since the Shang Zhou Dynasty (16th-11th century B.C.). Sichuan Hot Pot originated on the bank of Yangtze River (Chang Jiang), invented by the boatmen. Then it was developed in the Chongqing area. Nowadays it becomes a popular dish in the country. People sat around a table with a boiling soup (hot, numbing, and salty) in a heated pot in the middle, and put sliced raw meat, vegetables, etc into the pot and ate together. Aroma developed during the cooling was studied. An interesting compound, 5-(methylthio) pentanenitrile, was found by GCO-MS analysis. The compound, although present in trace amount, has a potent mushroom odor.

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Through this project we have established unique techniques for cuisine aroma collection and have gained valuable experience. Although the aroma reconstitution of hot pot was not an exact copy of the original cuisine profile, the results were very encouraging. The reconstituted aroma was well rounded and possessed the main aroma characteristics of the target. Some experienced people could easily recognize the "hot pot" profile when they smelled the reconstitution. The hot pot top note attracted the attention of many customers and has been commercialized as a single flavor and in blends with other ingredients.

TasteTrek® Asia

In 2001 we expanded the TasteTrek activity to include other indigenous cuisine in Asia. Each Asian culture is unique, so is the cooking style and preferred taste characteristics of cuisine in different region. To understand authentic Asian flavors, a series of expeditions was conducted in Asian cities: Seoul (South Korea), Manila (Philippines), Ho Chi Minh City (Vietnam), and Bangkok (Thailand). The TasteTrek team visited local restaurants, fresh markets, and culinary institutions to sample local dishes, to capture the aroma, and to learn about the ingredients used to create the unique flavors. The team collected over 30 headspace aroma samples of Asian cuisine, and more than 10 samples of spices and fruits.

Some of the interesting dishes are described in the following:

Pho Bo (Vietnam). Pho (**Figure 22**) has been famous for its taste and at the same time, appreciated as a wholesome, nutritious meal. It has all the qualities a health-conscious eater would look for: fresh, natural and delicious. To appreciate Pho requires more than just loving to eat it, one would need to "know" everything about its preparation. What makes authentic Pho so stimulating is quite simple: long hours of simmering the choicest beef produces a broth that maintains a full and rich flavor that is delicately seasoned with seven different types of natural spices to give its very distinct aroma. The cuisine is served in a bowl of light-bodied broth ladled over beef, accompanied by fresh rice noodles and garnished with coriander and onions. Basil leaves, bean sprouts and green peppers sometimes also included as garnish. The

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Figure 26

aroma was distinguished by its high levels of methyl chavicol (15%) and anethole (11%). Other major components include limonene, eucalyptol, cis-3-hexenol, neral, carvone, and linalool. Dipropyl disulfide, methyl 1-propenyl trisulfide and trans-1-propenyl propyl disulfide were found at concentration of 0.1 to 0.5%.

Nam Prik Pow (Thailand). Nam Prik Pow (**Figure 23**) is referred to as "Roasted Chili Paste" or "Chilies in Oil". It is a mild hot and spicy paste made from roasted garlic, shallots, and chilies. This paste is commonly used to flavor soups or stir-fry dishes. Some people like to use it as a condiment for meats and vegetables. The paste will give your food a smoky, wok-charred flavor. The aroma of Nam Prik Pow had a high acid content: palmitic acid (16.6%), linoleic acid (14.5%), oleic acid (4.5%), lactic acid (3.4%), stearic acid (2.6%), myristic acid (2.5%), and palmitoleic acid (2.0%). The character impact components include diallyl trisulfide (5.8%), allyl methyl trisulfide (3.7%), hydroxydihydromaltol (2.6%), diallyl disulfide (1.9%), propyl 1-propenyl disulfide (0.5%) and di-1-propenyl trisulfide (0.5%). Trimethyl amine and dimethyl propyl amine were detected at low levels (<0.2%).

Kimchi Jengol (Korea). The fermented vegetables kimchi is an essential part of any Korean meal. Early kimchi dishes were relatively mild, spiced with fermented anchovies, ginger, garlic, and green onions. Koreans still use these ingredients today, but the spice most closely associated with modern kimchi is red pepper powder. Korea boasts more than two hundred types of kimchi, all rich in vitamins, minerals, and proteins created by the lactic acid fermentation of cabbage, radish, and other vegetables and seafood. The most abundant constituents of the Kimchi Jengol (**Figure 25**) top notes were sulfur containing compounds, including diallyl disulfide (7.3%), allyl methyl disulfide (4.6%), 2-vinyl-4H-1,3-dithiinhole (4.6%), dimethyl disulfide (4.0%), 3-vinyl-1,2-dithi-4-ene (2.9%), allyl methyl trisulfide (2.8%), and diallyl trisulfide (2.6%). Other major components include caryophyllene, limonene, 3-butenyl isothiocyanate, myrcene, and crotonaldehyde.

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Figure 23

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Figure 30

TasteTrek® Latin America 2002

While the TasteTrek technology has gradually reached a more mature status, additional Givaudan business regions have become interested to utilize its advantages. The aromas that make the Latin cuisine special and trendy around world became high value targets of the Givaudan TasteTrek. We chose Mexico, Brazil, Columbia, and Argentina for their local popular cuisine, food ingredients, and exotic fruits. TasteTrek Latin America created more than 40 flavors.

Some examples of the interesting dishes and fruits:

Tortillas (Mexico). Corn is the base and essence of many important food and beverages in Mesoamerica. Hot Fresh Hand Made Tortillas (**Figure 28**) is probably one of the most popular dishes in Mexico. The tortillas are made from corn cooked with slaked lime and turned into dough (nixtamalization process). The tortillas are cooked in a griddle. The flavor is cooked, roasted, and doughy. Nowadays, tortillas are made from different types of corn flour and are an important part of traditional and popular meals like Tacos, Burritos, Enchiladas, Tostadas, Tortilla chips etc. The major components in the headspace aroma of tortillas include hexanal, 2,3-pentanedione, isovaleraldehyde, limonene, and diacetyl. The sulfur-containing compounds and pyrazines impacted the main characters of tortillas. Dimethyl disulfide, dimethyl trisulfide, 2,5-dimethyl pyrazine, 2-ethylpyrazine, ethylmethyl pyrazine, and 2-ethyl-3,5-dimethyl pyrazine are identified.

Picaña (Brazil). Picaña (**Figure 29**) is a delicious barbecue type meat in Brazil. It is used to prepare "churrascos". Its triangular shape coming from the backside of the cow is grilled with wood coal giving the peculiar smoke, greasy, grilled and toasted flavor. The major aroma components are isovaleraldehyde (11.8%), 2-methyl butanal (9.4%), and acetoin (8.2%). Several sulfur containing compounds were detected including thiophene (0.04%), methyl thioacetate (0.18%), and dimethyl disulfide (0.08%). Several nitrogen containing compounds were also found: trimethyl amine (0.05%), pyridine (0.09%), 2-methyl pyrazine (0.21%), 2-ethyl pyrazine (0.02%), 2,3-dimethyl pyrazine (0.08%), and 2-ethyl-5-methylpyrazine (0.08%).

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Figure 27

Figure 28

Figure 29

Figure 30

Jalapeno, Pasilla C-hili

Figure 31

Figure 32

Figure 33

Figure 34

Chimichurri (Argentina). Chimichurri (**Figure 31**) is the typical meat seasoning in Argentina. It is prepared with parsley, garlic, basil, oregano, oil, vinegar, red pepper, and salt. There are several recipes to prepare it, which emphasize some of the ingredients, always adapted to the local taste. The aroma of Chimichurri was characterized by high levels acetic acid (40%) corresponding its vinegar base and diallyl disulfide (24%) from the green onion. Other important components include caryophyllene (15%), dimethyl trisufide (0.44%), dimethyl disulfide (0.01%), and diallyl sulfide (0.01%).

Fruits from the Garden of the World

The variety of fruits available in Latin America is amazingly large. Here are some examples:

Lucuma (Columbia). The edible part of this fruit is generally yellow with a floury, potato type consistency with strong almond and sweet aroma. It was an important fruit for the pre Hispanic cultures Nazca and Chimu in Peru. Now this natural pulp is used in dairy applications like ice cream and desserts. The aroma of Lucuma (**Figure 32**) contained a high percentage of acetoin (42.1%). In addition, relatively high amounts of diacetyl (7.4%), acetic acid (7.1%), butanal (5.9%), and ethanol (5.8%) were found. Minor components include ethyl acetate (4.1%), 2-pentanone (3.5%), crotonaldehyde (2.3%), and 1-butanol (2.2%).

Feijoa (Columbia) (**Figure 33**). This waxy, green colored fruit emits a strong long-lasting perfumy aroma. The thick, white, granular, and watery flesh and the translucent central pulp enclosing the seeds are sweet and subacid, suggesting a combination of guava, strawberry and pineapple type flavors. This fruit prefers moderate summers in Andean hillsides and the gaucho region. The major components found in the aroma were cis-3-hexenyl acetate (25.1%), methyl benzoate (16.6%), methyl butyrate (10.7%), ethyl butyrate (8.1%), ethyl caproate (4.4%), -ocimene (3.8%), methyl caproate (2.4%), cis-3-hexenyl butyrate (1.7%), hexyl acetate (1.6%), cis-3-hexen-1-ol (1.5%), and limonene (1.3%).

Cashew (Brazil) (**Figure 34**). This fruit has two main parts: The fleshy and juicy part has an apple-pear form with yellow or red skin that has an astringent,

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Figure 35

Figure 36

Figure 37

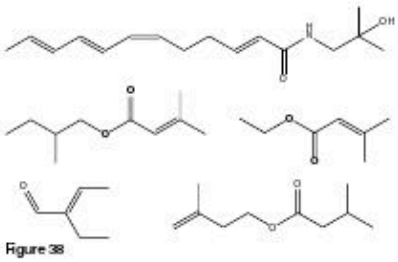

Figure 38

acid and tannic taste. In the base is a kidney shaped nut from where the famous cashew nut is recollected (**Figure 35**). The aroma of Cashew contained a large amount of ethyl esters including ethyl acetate (24.7%), ethyl crotonate (11.7%), ethyl isovalerate (7.7%), ethyl caproate (7.3%), ethyl tiglate (6.4%), ethyl butyrate (5.4%), and ethyl 2-methyl butyrate (5.1%). A relatively large percentage of acetoin (6.8%) was also found.

TasteTrek® with Customers

In 2003 one of our customers in China initiated a collaboration project asking Givaudan to develop a series of cuisine flavors for its new products using the TasteTrek technology. So we went to China, sampling the aroma of the customer-specified targets. It was an interesting trip, and the technical staff of the customer worked with us during aroma collection (**Figure 36**), verifying that the aromas we captured were exactly what they wanted.

Source of New Ingredients

TasteTrek® projects produced not only aroma reconstitutions, but also many interesting ingredients. Although the molecules are known, but they have not been used for flavor compounding. Some of these molecules have been patented for flavor applications by Givaudan.

Here are some examples of flavor ingredients and aroma molecules:

Hua Jiao (China). Hua Jiao (fruit of *Zanthoxylum bungeanum* Maxim) (**Figure 37**) is widely used as spice and medicine throughout Asia. In addition to it unique aroma, it has a unique trigeminal effect, which is described as "Ma", tingling, or numbing. Some people describe it as having electricity on your tongue when you bite it. Approximately ten unsaturated alkylamides have been isolated and identified in Hua Jiao. The principal tingling component of Hua Jiao is hydroxy-α-sanshool. We developed four products from this spice, and they have been granted as GRAS status.

Aroma compounds. The headspace aroma of many fruits from the rainforests contains a large number of unsaturated esters which provide the characteristics of tropical fruity notes. Many of these esters, such as 2-Methylbutyl senecioate, 2-ethyl crotonaldehyde, ethyl senecioate, and 3-

acid and tannic taste. In the base is a kidney shaped nut from where the famous cashew nut is recollected (Figure 35). The aroma of Cashew contained a large amount of ethyl esters including ethyl acetate (24.7%), ethyl crotonate (11.7%), ethyl isovalerate (7.7%), ethyl caproate (7.3%), ethyl tiglate (6.4%), ethyl butyrate (5.4%), and ethyl 2Jmethyl butyrate (5.1%). A relatively large percentage of acetoin (6.6%) was also found.

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Figure 35

Figure 36

Figure 37

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