Tobacco Flavoring: An Overview*

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International tobacco products have some very interesting scientific, product development and marketing aspects. In this article, I'll describe the tobacco plant and its combustion chemistry. Then we'll look at two traditional systems and several novel systems for delivering flavor in tobacco products.

In terms of flavored tobacco products around the world—at least in terms of legal ones—we probably can identify six main product categories, each utilizing various types of tobaccos, various types of product presentation and many different flavor tonalities:

- Cigarettes
  - American blended (e.g., Marlboro, Camel)
  - Virginia (e.g., Dunhill, B & H, State Express 555)
  - European (e.g., Gauloise, HB, MS)
  - Indonesian (Kretek)
  - Indian (Bidis)
- Pipe tobacco
- Cigars
- Chewing tobacco
- Snuff (moist/powder)
- Water pipes
  - North African/Middle Eastern (Nargileh)

At first view, the tobacco blend is of primary importance in the organoleptic performance of any of the products. Adding various flavoring systems obviously will round off—ice the cake, if you like—the total flavor impact of the product.

Various tobaccos and tobacco blends are used in different countries. We'll look at two distinct, internationally recognized cigarette tobacco blend types.

The Virginia blend is flue cured. It is the blend typically used in English-style cigarettes.

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Grading by leaf position on the stalk of a flue-cured (Virginia) tobacco plant

- The B Group (Leaf) contains leaves grown at or above the mid-portion of the stalk. These leaves have pointed tips, tend to fold, are heavier in body than leaves of the other groups and show little or no ground damage.
- The H Group (Smoking Leaf) contains leaves grown above the mid-portion of the stalk having similar characteristics as the B Group, but overripe, thinner in body, lean in oil and usually associated with a sweet smell.
- The C Group (Cutters) contains leaves grown at or just below the mid-portion of the stalk. They have a tendency to roll, concealing the stem or mid-rib. They have rounded tips, are thin to medium in body and show some ground damage.
- The X Group (Lugs) contains leaves normally grown near the bottom of the stalk. They usually have a blunt tip and open face. They show more ground injury than the B, H and C Groups.
- The P Group (Primings) contains round-tipped leaves from the lowest portion of the stalk. They ripen prematurely as a result of starvation and show a noticeable amount of ground injury.

Figure 1.

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The American blend uses Virginia tobacco (which has a high sugar content), air-cured burley tobacco (which has a low sugar content) and oriental tobacco (from Turkey and Greece).

In addition to these flue-cured and air-cured blends, one finds sun-cured and shade-cured blends produced in Latin America, Africa and the Far East.

As we begin to build the various blends, we have already begun to introduce various subjective flavor changes in the product. Even at this stage, we can indicate some chemical reasoning for the differences in perceived flavor characters.

The Tobacco Plant

The historical study of the various *Nicotiana* species has been useful to the tobacco industry from a raw material point of view, but let us not forget the many years spent by phytologists and plant geneticists probing the general constitution and mutations of the genus *Nicotiana*, from which much of the early plant viral theories were formed.

Plant growers and the tobacco companies who purchase from the farmers have a system for grading the leaves of the tobacco plant. It depends on the type and strain of tobacco used. It generally is based on the leaf positions on the stalk and identifies five groups of leaves, illustrated in Figure 1.

Obviously, the color, shape and size of the leaves depends on the age (maturity) of the plant. Also remember that as a typical biological system, certain chemical constituents vary with the leaf position. For example, nicotine content is greater toward the top of the plant. Sugar content is greatest in leaves in the middle of the plant. However, this is the realm of the phytobiologist and is a separate topic.

We have only glanced at the tobacco plant, genus *Nicotiana*, but perhaps you can appreciate the highly complex biological product that is the raw material for the tobacco manufacturing industry.

The Chemistry

If all goes well during the growing and manufacturing processes, the end product will be a graded, mixed, prepared tobacco blend packaged neatly into a paper rod, probably with a filter on one end. Then we set fire to it.

The burning of a cigarette involves several highly complicated, physico-chemical processes that produce from an integrated biomass an extremely complex chemical mixture.

The processes include distillation, sublimation, pyrolysis and combustion. Any of these may occur at various locations, depending on temperature and chemical environment. According to Grob in 1973,[1] there are nearly 2,600 chemical components in tobacco smoke. Other analyses done during the period 1930-1950 identified more than 3,000 chemical components in the burning tobacco leaf and more than 4,000 chemical components in its smoke.

Several chemical reactions are involved. Among the non-enzymatic browning reactions are both Maillard and Strecker. They produce heterocyclic aromatics, such as pyrazines, oxazoles and thiazimes. The β-carotene degradation reaction produces thunberganes, cembranes, megastigmatrienones (ionones), ketoisphorone and solanone.

Thus, pyrolysis and browning reactions generate many chemical species that are wholly or partly responsible for the characteristic flavor performance of various tobacco types.

Among the so-called tobacco essential oils, early research revealed the following:

- 309 components in the volatiles of burley tobacco.
- 118 components in the volatiles of oriental (Turkish) tobacco. There were 93 CO_2Hs in the acid fraction of Turkish tobacco.
- 346 components in the volatiles of Virginia tobacco.

Certain of what I call "character identity compounds" (after my old companion Dr. G. Ohloff's definition) also have been found in various tobacco types. For example, analysis of oriental tobacco leaves from Turkey and Greece found iso-valeric acid, β-methyl valeric acid, sclareolide, sugar esters (such as methyl valeryl-β-D-glucopyranose), and methylbutanoic and methylpentanoic acids. These special chemical structures are unique in their ability to give specific flavor characteristics to this so-called oriental tobacco leaf. Certain Turkish oriental leaf varieties are being used as the world benchmark for "classic oriental notes."

From both a chemical and a flavor point of view, certain key molecules and molecular families are known to contribute to the overall flavor profile of tobaccos.

For example, the terpene family includes the following:

- Labdanoids
- Cembranoids
- Carotenoids
  - Lutein
  - β-Carotene
  - Neo-xanthin
  - Violazanthin

Furthermore, with the advent of various analytical techniques and synthetic organic chemistry, we now have available particular chemical classes of compounds that are known to contribute to particular parts of the tobacco flavor profile. For example, more than 80 products have been developed from transformation and fragmentation of carotenoids, yielding the woody-like, cedar impression of β-ionone, and the woody, floral, fruity, sweet character of the β-damascone and β-damascenone. Fragments with nine carbon atoms give a hay- and tea-like character.

So far we have discussed the chemistry and combustion of the various varieties of tobacco. But we also must remember that the post-harvest treatment of the tobacco leaf is, by itself, an extremely complex biophysical interaction. The intra- and inter-molecular chemical reactions include hydrolysis (enzymatic or acid-catalyzed, with starch being converted to sugar), photolysis, photooxygenation, autoxidation, dehydration and condensation. Then, after

Table I. Effects of some casing materials on tobacco taste

Material	Effect
sugars (fruit syrups)	affects smoke pH, therefore irritation levels
humectants (P.G., glycerol)	retains moisture in tobacco
ameliorants (DAP, citric, tartaric, lactic acids)	reduces harshness
combination agents (potassium citrate)	improves combustibility
preservatives (sorbic acid, potassium sorbate)	protects products in conditions of high temperature and high humidity
aroma components (cocoa, licorice)	affects smoking quality and "pack aroma"

Formula 1. Application levels of casings for U.S.-style cigarettes

Burley portion	
sucrose	8.0%
invert sugar glucose	2.0
licorice	5.0
cocoa (12% butter fat)	1.0
glycerol	5.0
propylene glycol	2.7
Virginia portion	
sucrose	2.0%
honey (Mexican)	3.3
glycerol	3.3
propylene glycol	3.3

all this, pyrolysis and combustion occur.

These days the cigarette industry also utilizes, for certain commercio-technological reasons, parts of the tobacco plant that historically were not so frequently used. These by-products include:

- Reconstituted tobacco from the sheet. By "reconstitution" we mean fabrication of a tobacco "sheet" (single layer) by a process similar to paper manufacturing.
- Expanded tobacco.
- Tobacco leaf stem.
    - Rolled
    - Expanded

We can also use the remaining by-products—the stem from the lamina and the dust from the factory.

The use of these by-products has been based mainly on economic decisions (cost reduction policies), and overall has resulted in several challenging areas for flavorists, who must address some of the product performance negatives that these by-products have introduced.

Tobacco Taste

In this article I'll limit the discussion to the primary factors influencing the taste of cigarettes:

- Tobacco blend
    - Types of tobaccos
    - Percentage of each tobacco type in the blend
    - Proper aging of tobaccos
- Flavorants
    - In the casing
    - In the "top flavor"
- "Tar" and nicotine
    - Regulated by filtration
    - Regulated by dilution
    - Regulated by burning rate
    - Regulated by tobacco column length
- Other
    - Age of cigarettes
    - Proper packaging

The aspect of so-called casings and top flavors is all-embracing to my story of the "icing on the cake." Both of these factors will be defined carefully as they represent the overt addition of flavoring compounds to those materials given to us by Mother Nature in the tobacco leaves.

Casings

Early in the manufacturing process, the casings are applied to the strips of tobacco leaf-lamina.

Casings usually are applied by spraying or dipping a portion of the leaf or the entire leaf. They are composed of water, sugars (fruit extracts and honey), humectants and flavor (cocoa and licorice). Their purpose is to promote retention of moisture, to aid in achieving a good cut and to improve the performance of cigarette-making machines.

The casings have several effects on tobacco flavor:

- They "round out" the rough edges.
- They add complexity and fullness (with their heavy base notes).
- They minimize small differences due to grade and class variations.
- They add sweetness.
- They may add distinction.

Table I shows some specific casing materials and their effect on tobacco taste. Many of these materials have been used in cigarette manufacturing for many decades.

Formula 1 shows a typical casing sauce for application to U.S.-style blended cigarettes.

Top Flavors

Top flavors are flavor systems that are applied toward the end of the manufacturing processes to the cased, cut tobacco. They normally are sprayed onto the tobacco as it rotates in a cylinder. They have an alcohol or rum base and may contain aromatic chemicals, natural extracts, essential oils and/or specialties (such as captive molecules).

Top flavors are used for several reasons:

- They adjust pack aroma.
- They affect smoke flavor to achieve product

distinction by:
- Enhancing the base notes from the cased blend.
- Imparting "top" notes.
- Serving as the "condiment" for tobacco.
- They serve as a vehicle for application of menthol and other distinct flavor types.

Engineering Cigarette Design

The area of psychophysical response to cigarette smoking is a branch of sensory assessment techniques that has developed throughout the industry, worldwide. Most of the big multinational tobacco companies have whole psychophysics departments devoted to research, product development and, finally, consumer acceptance. For our needs today, I have tried to identify a few key parameters that play an integral part in influencing the major taste of cigarettes.

Here we consider some of the flavor- and non-flavor-related cigarette properties that are major parameters for consumer acceptability. They are the cigarette's physical characteristics, taste characteristics and packaging.

Consumer satisfaction depends on the physical characteristics of cigarettes:

- Burning rate and characteristics
- Ash appearance and coherence
- Firmness
- General appearance (ends, uniformity, etc.)
- Ease of draw (pressure drop)

Consumer satisfaction also depends on taste characteristics of the cigarette:

- Must fit product image
- Aroma and flavor
- Aftertaste
- Uniformity of taste
- Must "wear" well

Finally, satisfaction depends on packaging:

- Must provide reasonable shelf life (retain moisture, flavorants, aroma)
- Must not contaminate products
- Must not deform under temperature and humidity variations

Now let us examine some of the physical—or what I call "engineering"—aspects of the cigarette's design. These include the smoke solids and nicotine, the efficiency of the filter, and the cigarette's firmness.

Smoke solids ("tar") and nicotine can be "engineered" with the following physical characteristics:

- Efficiency of the filter
- Amount of dilution of the smoke
  - Perforations in the filter
  - Perforations in the paper
  - Inherent paper porosity

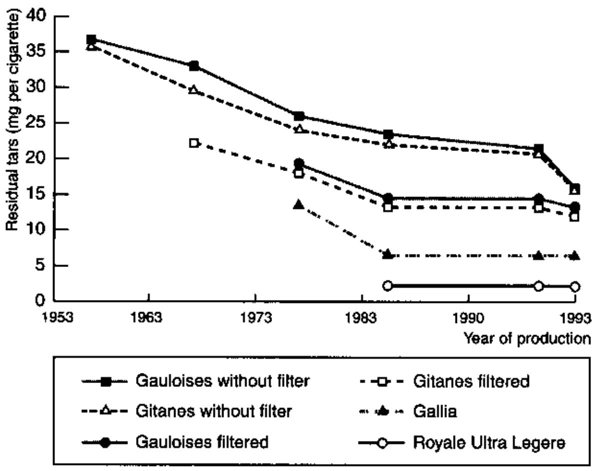

Figure 2. Reduction of tars in the smoke of selected cigarette brands manufactured in France by Seita

- Burning rate of the cigarette
- Length of tipping paper
- Length of tobacco column
- Tobacco blend

Please remember that all of these engineering parameters not only affect the tar and nicotine deliveries, but also greatly change the intensity of the body, viscosity and overall taste of the smoke.

Efficiency of the filter is determined by these physical characteristics:

- Filter material
  - Cellulose acetate
  - Paper
  - Charcoal-paper or charcoal acetate
- Length of filter
- Diameter of filter
- Pressure drop of filter

Finally, the cigarette's firmness is determined by the filling power of the blend and by the density of the tobacco column.

You see a conflict between the so-called "filtration efficiency" (i.e., dilution of the mainstream smoke) and the cigarette firmness (which increases with the physical amount of tobacco in the rod). This also relates to the amount of flavor from tobacco and non-tobacco flavoring materials.

Basically due to high dilution levels of the mainstream smoke—25-35% dilution is common—establishing the required add-back of tobacco-compatible flavor character has challenged tobacco flavorists and product developers to their limits, and will continue to do so well into the next century.

In one area of cigarette design engineering we've seen some recent advances. That area is methods of ventilating cigarettes. "Ventilation" is the process of diluting the mainstream smoke by the use of perforations in the filter tip.

Cigarette paper now provides several ventilating alternatives: naturally porous, electrostatically perforated, pin holes and combinations. The tipping—with or without ventilated plugwrap—can be ventilated by any of these techniques: naturally porous (tea bag), electrostatically perforated, mechanically perforated, pin holes or laser perforation.

With these and other "engineering" achievements we've been able to obtain a consumer-acceptable product even with decreased tar/nicotine content, as illustrated by several brands of French cigarettes over a 50-year period (Figure 2).

The advent of low-delivery cigarettes (i.e., reduced tar and nicotine) in various product types around the world has resulted in some of the greatest research, design and production challenges in the history of cigarette manufacturing. Furthermore, we have encountered, in the flavor acceptability area, some of the toughest challenges in attempting to maintain tobacco-like character with an ever-decreasing number of permitted materials.

Regulatory Requirements

The tobacco industry has been working closely with certain areas of the flavor industry in order to address tobacco's ever-increasing need for more sophisticated flavor systems in both the casings and the top flavors. Meanwhile, there have been other technological advances in terms of flavor usage in the filter, paper and packaging applications. Other unique developments will be discussed shortly.

However, I need to make the important point that any flavor development work carried out within the tobacco industry is now, and has been for some years, under very heavy regulatory requirements.

The United States has its FEMA/GRAS and "599" lists. In Europe, tobacco flavor regulations are issued separately by the Council of Europe, Belgium/France, Germany and the U.K. (Hunter/DHSS). Finally, individual customers have their own requirements (multi-national COS). So flavorists developing tobacco products for the international market have to work in an environment regulated by a minimum of 18 different lists.

The "599" list is a recent development in the U.S. During the first half of 1995, U.S. Congressman Henry Waxman held hearings in Congress on the tobacco industry. One result was the first publication of the list of 599 "additives" used on cigarettes sold in the U.S. This list, which had been around for a number of years, had been kept under lock and key at the Centers for Disease Control in Atlanta, Georgia. Now, any tobacco flavor being developed for use in U.S. market brands must comply with this 599 list and with the FEMA/GRAS list. In addition, the flavor must run the gauntlet of each individual tobacco company's regulatory requirements.

Europe has been complying with the various country lists plus the combined Council of Europe lists for many years. Emerging countries of the developing world also are crafting their requirements. Normally these are an adaptation of one of the existing systems—thankfully.

I support tight controls on the safety of the products we develop and market. But I'm sad to observe that within the sphere of commercial tobacco flavor activity one has to comply with so many lists worldwide. These requirements, however, lead to a constant challenge to creativity, product usage, computer software systems and, sometimes, the flavorist's patience and scientific belief.

Novel Flavor Delivery Systems

Now I'd like to briefly mention two flavor delivery innovations for cigarettes. These are what I call smoking product designs.

Flavored filters: These are compartmentalized filters with flavor stored in one of the compartments. This gives you the ability to produce a filter with any flavor you choose. Both menthol- and anise-flavored filtered cigarettes are currently on the market (in France under the brand name "Royale"). In each case the flavor uses an inert magnesium silicate base. This technique introduces flavor directly into the mainstream smoke and relies basically on steam distillation.

"Heated and not burned": In this family of products, the filter is at one end of the cigarette and the heat source is at the other, as usual. However, an insulator separates the heat source from the tobacco and other components that occupy the middle of the rod. The tobacco is heated but not burned, so no ash is produced. This "heated and not burned" tobacco product ("Eclipse" from R. J. Reynolds) is still in the market test stage in the U.S. and Sweden.

Conclusion

We have taken a brief look at some of the major areas of the tobacco industry and how flavoring and the many aspects of flavor development are key parameters to product performance and consumer acceptability.

We all are aware that the tobacco industry has had a very important role in the past for its product users, product developers and product legislators. I feel sure that tobacco products will be with us for many years—probably in different forms and flavor profiles in different parts of the world. But let us congratulate ourselves for our successes, and recognize the uniqueness of the tobacco flavorist. Who else could sit back with a satisfied warm glow after seeing his best scientific, engineering, agricultural, economic and political efforts go up in smoke?

References

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1. K Grob, *Chem and Ind (London)* **6** 248-252 (1973)