TOBACCO FLAVORING FOR SMOKING PRODUCTS

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TOBACCO FLAVORING FOR SMOKING PRODUCTS

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INTRODUCTION

The use of tobacco products for smoking enjoyment in the Western Hemisphere predates the discovery of America by hundreds of years (14, 21, 33, 55, 69). The native Indians had long known of the pleasure and satisfaction to be derived from chewing or smoking (in pipes and cigarillo form) the leaves of *Nicotiana.* In fact, when Cortez's Mexican Expedition landed at Tabasco in 1519, the use of tobacco in a very advanced form–the flavored cigarillo- had apparently been a long time tradition. It is known that the Indians of this area, smoking the forerunner of today's cigarette, often flavored their tobacco with the oil of citrus peels. The advent of European explorers to the New World opened new vistas for tobacco. Over the next 150 years a brisk international trade developed with Europe, the Indies and China through the efforts of sailing captains and trading companies in search of new commodities.

Today, the tobacco industry stands as one of the world's leading businesses in both volume and revenue, exceeding such commodities as coffee, cocoa, tea, nylon and rayon (19). The two largest producers of tobacco are the United States (819,000 metric tons) and China (776,000 metric tons), followed by India and the Union of Soviet Socialist Republics (19). Consumer tobacco products commonly manufactured throughout the world are cigarettes, pipe tobaccos, cigars and cigarillos as well as other forms of tobacco such as snuff and chewing tobaccos. This monograph will be limited to a short discussion of the major types of tobaccos and primarily to the vast amount of data accumulated over many years on flavoring components useful in smoking products.

The smoking flavor of a tobacco product is due primarily to the types, grades and blends of tobacco employed. The flavor specialist has the task of improving, mellowing and modifying the tobacco aroma and taste to fit the desires of the consuming public. Just as the blends and types of tobaccos used are determining factors in the design of a product, the flavorings which are added greatly influence the quality and acceptability of the finished product.

TOBACCOS AND BLENDS USED IN SMOKING PRODUCTS
(2, 15, 122, 126, 127)

The major types of tobaccos commonly used in smoking products are Burley, flue-cured (Virginia, bright leaf), Oriental (Turkish, Greek, Yugoslav), cigar types and, to a lesser degree, Maryland. In addition to these major classes, Latakia, Perique and various types of fire-cured and air-cured tobaccos are employed to impart special types of flavors to smoking products.

The blends of tobacco used in cigars, cigarettes and pipe tobaccos vary considerably in different countries and much of the characteristic flavor of the finished product is imparted from the types of tobacco used. The smoking flavor of tobacco leaf, even of the same type, may vary considerably depending on the location in which it is grown, seasonal climatic conditions, agricultural and post-agricultural practices employed and the location of the leaf on the tobacco stalk. The tobacco farmer often separates the leaf according to its stalk position and, at the time of sale, these groupings of tobacco are given specific quality grades by leaf buyers representing the major tobacco manufacturers. The leaf buyer is trained to recognize the quality of tobacco leaf by appearance. A good buyer can easily identify tobaccos with good filling capacity (i.e., the weight of tobacco required to firmly fill a cigarette), high flavor and can even estimate the percentage of nicotine content by rapid inspection of a pile of tobacco.

Flue-cured tobacco comprises about 60 percent of the tobacco grown in the United States and derives its name from the "flues" of the heating apparatus originally used in the curing barns (122). Flue-cured is often referred to as Virginia or bright leaf due to the characteristic golden or yellow coloring. Flue-cured tobacco is principally used in cigarettes and its smoke possesses a "sweet" aromatic character and slightly acidic taste. Flue-cured contains significantly higher levels of reducing sugars than the common light air-cured tobaccos (i.e., Burley and Maryland). It blends well with these latter tobaccos because, on smoking, the presence of sugar in flue-cured smooths and "neutralizes" the more "basic" (pH) smoke of air-cured varieties.

Burley is a light air-cured tobacco which normally is light brown to reddish brown in appearance and possesses excellent smoking characteristics for blended cigarettes and pipe tobaccos. It provides somewhat greater filling capacity in cigarettes than flue-cured. The flavor and aroma of Burley tobacco smoke may be described as having a "chocolate, nutty, protein, winey" character and is more "basic" (pH) than the smoke of flue-cured tobacco. Burley more readily accepts casing (sauce materials) than tobaccos which have a higher volatile oil content (i.e., flue-cured and Oriental). Because Burley is low in sugars (which are metabolized during the slow air curing process) it is usually necessary to add sugars or blend with flue-cured tobacco to compensate for this deficiency, thus mellowing its "basic" (pH) smoke characteristic.

Maryland is a light air-cured tobacco considered in many quarters to be ideal in its burning qualities in finished cigarette products. Its smoke has a

flavor similar to burley but is somewhat milder and lighter in taste. Maryland tobacco is particularly desired in certain European countries (e.g., Switzerland) where straight "Maryland" cigarettes are popular.

Cigar tobaccos are all air cured and the *cigar filler* class is a medium to heavy bodied tobacco. The *cigar filler* is so-called because it is used as the "core or body" of the cigar. In recent years, the *Cigar Binder* tobaccos in which the *filler* is encased have gradually been replaced in large part by reconstituted tobacco sheet (see page 6). *Cigar Wrappers* for the outside of cigars are the most costly of tobaccos and are thin-bodied, smooth, unblemished leaves of high quality. Wrappers are usually "shade grown" under a cloth screening which protects the tobacco from direct sunlight, temperature changes and strong winds which might damage the wrapper. Although cigar tobacco is air-cured, much of the characteristic flavor and taste is developed through special, carefully controlled fermentation techniques in which the tobacco is moisturized, bulked, and allowed to ferment, with resulting temperatures of 115-120° F. being reached during the process. During fermentation, basic compounds (such as ammonia) are released and the color of the leaf darkens as the "characteristic" cigar aroma and taste develop.

Oriental tobaccos (also called "Turkish" and "aromatic") are characterized by their relatively small leaf size and highly aromatic character on smoking. These tobaccos are produced principally in Greece, Turkey and Yugoslavia. Oriental tobaccos are valued for their use in blended cigarettes and, due to their high content of volatile flavor oils, give a rich flavor effect. The smoke of Oriental tobaccos ranges from a highly aromatic acid aroma (e.g., similar to isovaleric) to a rich resinous-cedar character; these flavor variations are largely characteristic of the producing region.

Miscellaneous tobaccos such as *Fire-cured* types (which are smoked over slow burning fires during curing) and *Latakia* tobacco (produced in a similar manner) are used primarily for the introduction of "smoky" notes in pipe tobaccos. Similarly *Perique* tobacco, which is produced exclusively in St. James Parish, Louisiana, by a unique process of packing the dried leaves in casks under great pressure for about nine months, produces a rich strong characteristic (yeasty) aroma and taste in smoking products.

While cigar tobaccos and Perique are specially processed to develop strong characteristic flavors, all tobacco undergoes slow change on storage and it is not uncommon for major tobacco manufacturers to store their tobacco supplies for a number of years (usually 2-6 years) to improve smoking quality and serve as an inventory buffer.

Blends of various tobaccos are commonly used in smoking products to insure consistency in the final product mixture. The blending, casing and flavoring of tobaccos are necessary to compensate for variations in the chemical composition of the tobaccos used (i.e., the relative presence or deficiencies of certain classes of constituents such as sugars, acids, volatile oils and alkaloids). Using certain chemical analyses and flavor evaluations of grades and crop years, blends for cigarettes (or other smoking products) are

made based on the taste preference of the intended customer as well as cost and availability of the tobaccos. This topic is discussed in some detail by Abdallah (2) and we will not attempt to review it here except to point out as an example the particular types of tobaccos employed in the ever increasingly popular American type blends.

Typical American Cigarette Blend Compositions

Flue-Cured Tobaccos	40 - 60%
Burley Tobaccos Maryland Tobaccos	10 - 35%
Oriental Tobaccos	5 - 35%

Many manufacturers also use *reconstituted tobacco* sheets in their tobacco products. These are prepared by converting tobacco "fines and dust" accumulated in tobacco processing operations to a tobacço sheet in a paper making-type operation. Such reconstituted sheets, because they are primarily tobacco, provide economies in manufacture and are of such good quality that they may be substituted for other tobacco leaf in cigarette and cigar blends. Reconstituted tobacco sheets also find wide usage as *cigar binders* and, in the case of cigarillos, as the outside *wrapper.*

Pipe tobacco blends in the U.S.A. are usually made predominantly from Burley tobacco. Some lesser amounts of flue-cured, Latakia, Perique and Turkish are often added to modify the taste and appearance of these products. Outside of the United States, however, higher percentages of tobaccos other than Burley are incorporated into pipe tobacco blends.

In summary, it should be apparent that the selection and blending of tobaccos are very complex. The manufacturer must possess a complete understanding of the many types of tobaccos and the chemical and flavor variations within types due to stalk position, climatic and geographic variations, changing agronomic practices as well as curing and processing procedures employed subsequent to harvesting of the tobacco. This knowledge, coupled with changing world trade conditions, availability of the types and grades desired and economics gives rise to the final combination which makes up each tobacco blend.

THE ROLE OF CASINGS IN FLAVORING OF SMOKING PRODUCTS (2)

Casing or sauce materials are added to tobaccos to enhance their quality by balancing the chemical composition and to develop certain desired flavor characteristics. For example, if a tobacco or tobacco blend is low in sugar (e.g., in the case of air-cured tobaccos), the smoke will often be alkaline and give a harsh and irritating effect. Sugar is added to restore a chemical equilibrium between the acid forming and base forming constituents of the smoke. This balance of sugars, acids and alkaline constituents varies by types of tobacco and must be carefully adjusted by the tobacco manufacturer to produce a mellow, full-bodied smoke.

Although each tobacco manufacturer carefully guards the secrets of his casing (and flavor) formulas, it is well known that casings for smoking products often contain sugar, licorice, cocoa or chocolate liquor and sometimes natural extracts. Of these, licorice deserves special mention. Just as sugar is used in "casing" the tobacco to mellow and smooth the smoke, licorice is used as an adjunct to boost the sweetness of tobacco products (64, 65). The taste of licorice to the smoker is that of a mellow sweet-woody note which, at proper use levels, greatly enhances the quality of the final product.

The amounts of casing applied to the smoking product depend on whether the tobacco is destined for cigarette manufacture or pipe tobacco manufacture. In general, pipe tobacco blends receive considerably more casing than cigarette blends, but again this is a matter of "balancing" the taste of the finished product (2).

The casing mixture may be applied in several ways--the tobacco is either dipped in the aqueous casing solution or the casing is applied by spraying. Some manufacturers prefer to case the total tobacco blend while others case specific tobacco types prior to blending. Whichever methods are used, the tobacco must be dried prior to further processing.

THE ROLE OF TOP FLAVORING MATERIALS IN SMOKING PRODUCTS: SCIENCE AND ART

The aforementioned areas are intended to serve as an introduction and background for the main purpose of this paper, that is, to disclose in some depth the role that top flavorings play in the development and manufacture of smoking products. By "top flavorings" is meant the final flavoring solutions added at the end of the processing operations (see page 61). Without an understanding of the history of tobacco products, the types of tobaccos commonly employed and the preprocessing of tobacco prior to the addition of the final flavoring materials, the tobacco flavorist would be at a severe disadvantage.

The following example will demonstrate that a thorough knowledge of the base material to be flavored is important. If a flavorist makes a dilute simple syrup solution, adds a small amount of lemon or lime flavor and then tastes the resultant product, he perceives only a very weak oily citrus taste quite unlike the natural fruit beverage. But, if he adds a requisite amount of an acid such as malic or citric acid (as is present in the natural citrus juice), he perceives the distinct citrus (lemon, lime) taste similar to that of the natural juice. Similar principles apply to tobacco. If lemon oil is applied to tobacco products at a level where the lemon flavor can be detected, only an oily, terpeny-lemon character is perceived with no "natural" lemon taste. This, of course, should be obvious because the acid level in the mouth is not sufficient to interact with the taste receptors to make the lemon taste natural. Moreover, there is no practical way to provide the smoker with sufficient amounts of the strong acid needed to enhance a natural citrus flavor perception without completely unbalancing the smoking product.

Therefore, an understanding of the tobacco base is necessary for the tobacco flavorist to develop flavoring mixtures which blend well with the base and yet will be perceived as improving and modifying the natural tobacco aroma and taste.

Just as the perfumer and food flavorist have come to rely on a knowledge of the composition of the aroma and flavor of natural materials, so does the flavorist working with tobacco. Over the last twenty years much effort has been devoted in scientific circles to the analysis and identification of the components of tobacco and tobacco smoke as well as other flavor materials that are present in various fruits, essential oils, chocolate, coffee and tea. For example, we can mention the outstanding contributions of industry in the U.S.A., Europe and Japan in the areas of tobacco and smoke composition (1, 7, 8, 13, 16, 20, 28, 29, 37, 38, 45, 46, 50, 51, 78, 80, 81, 98, 116) and to the efforts of many groups to the isolation and synthesis of aromatics from natural flavor oils and extracts (18, 22, 76, 83, 105, 115, 120). These advances in scientific technology, which have been brought about by the common use of gas chromatography in combination with infrared, ultraviolet, nuclear magnetic resonance and mass spectroscopy, have laid a solid foundation for future progress. We cannot review here these fundamental research efforts but wish only to provide the references so useful to the flavorist in his more applied technology.

In order to grasp the complexity of modifying the taste of smoking products, it is helpful to inspect the classes of chemical substances that naturally occur in smoke. A chart (page 9), prepared by Dr. Alan Rodgman of the R. J. Reynolds Tobacco Company, graphically illustrates the gross composition of total cigarette smoke (98). Information of this type, gained from compositional studies on the specific entities present in both tobacco and smoke, is important to the manufacturer in evaluating blend changes, effects of smoke filtration and the contribution of flavor additives to his smoking products.

The tobacco flavorist has a wealth of chemical knowledge available to assist in the selection of desired flavor notes; with the aid of compositional data and reported taste and aroma correlations (4, 5, 12, 26), it is often possible to predict the effect of certain flavorants on tobacco. But even with the tremendous advances in the chemistry of aromatic compounds, essential oils and other natural flavoring materials, it still remains to evaluate added flavor materials on tobacco, adjust use levels, and obtain expert flavor opinions from trained smoking panels (2, 3) before positive judgment can be made as to the utility of specific flavorants for tobacco. Even then, individual flavor evaluations of synthetic materials or natural extracts may sometimes be misleading because the added flavorants may undergo some changes on aging due to the varied climatic conditions to which the finished product is subjected prior to use.

TYPICAL CIGARETTE SMOKE COMPOSITION (98)

(Percentages shown are on a weight/weight basis and the amount of whole smoke obtained is approximate for an unfiltered tobacco rod weighing one gram.)

500 Milligrams Whole Smoke Per Cigarette

Nitrogen	Vapor Phase Components	Oxygen	Total Particulate Matter (wet)	Carbon Monoxide	Methane and Carbon Dioxide	Hydrogen and Argon
62%	13.5% (67.5 mg.)	13%	4.5% (22.5 mg.)	4%	2%	1%

Carbon Dioxide	Water	Other Compounds
80%	10%	10% (6.75 mg.)

Hydrocarbons	45.0%
Aldehydes	20.0%
Ketones	12.0%
Nitriles	9.0%
Heterocyclic compounds	2.0%
Alcohols	2.0%
Acids	1.5%
Esters	1.0%
Miscellaneous compounds	7.5%

Unidentified compounds	16.5%
Water	16.0%
Carboxylic Acids	13.0%
Aldehydes and Ketones	11.0%
Alcohols	8.0%
Nicotine	6.0%
Other Alkaloids	3.5%
Alkanes	5.0%
Terpenoid Hydrocarbons	5.0%
Smoke Pigment	4.0%
Phenols	3.5%
Esters	3.5%
Miscellaneous compounds	5.0%

EVALUATION OF SPECIFIC FLAVORING MATERIALS

Since the introduction of the first smoking product by R. J. Reynolds in 1895, "flavor and quality" have been key words within this company. Over the years an intensive effort has been made in research relating to the evaluation of potentially useful flavoring materials. This monograph is intended as both a short review and a disclosure of results accumulated on the organoleptic and taste properties of numerous substances used in the compounding of tobacco flavors (Tables I - XVIII).

Evaluations of flavoring substances may be carried out in several ways. Preliminary screening of flavorants is often done by preparing dilute aqueous and/or alcohol solutions and either injecting the materials uniformly by syringe into cigarettes of known blend composition or by applying the solution uniformly along the cigarette paper. These procedures are used for cigarettes, pipe tobaccos (rolled into cigarette form) and cigars/cigarillos. As evaluation progresses, different concentrations of the flavor are sprayed by means of an atomizer onto the cut tobacco blend prior to manufacture into cigarettes, cigars/cigarillos or packaging of the tobacco in the case of pipe tobacco blends. The products are then ordinarily allowed to age for a period of time prior to expert smoking panel evaluation. The evaluations reported in the following tables were generally carried out by these procedures. In instances where solubility problems were encountered, a slurry was employed in a manner similar to casing materials. It is well known that the definition or characterization of flavor and aroma is purely subjective to each individual smoker and that different smoking panelists may sometimes define the same flavor or effect quite differently. The system of flavor terms employed in the tables is one that is commonly used by our panelists and may not be the same used by others in the industry. The terms tobacco flavoring material and tobacco flavorant employed in this monograph mean a substance useful for improving or modifying the flavor of tobacco and tobacco substitutes of natural or synthetic origin by application to the smoking product, cigarette papers, cigar wrappers, filters and the like.

The tables of flavor evaluation (I - XVIII) have been systematically divided into chemical classes (alcohols, acids, etc.) or natural products. In cases of multifunctional chemical substances the material will generally be listed by the group of highest functionality defined as follows: acids > esters > ketones > aldehydes > alcohols. Certain exceptions to this classification system will be noted in the case of ethers and nitrogen heterocyclics. The numbers shown in parentheses following many of the compound names given in the tables refer to references listed in the bibliography.

A number of patents have issued which deal with the use of higher molecular weight derivatives of various tobacco flavorants in tobacco products. These derivatives are less volatile than the free flavorants and are designed to release the flavorants upon smoking thus improving the smoking quality of the tobacco products. Among the derivatives which have been used in this manner are labile esters of polyhydroxy compounds, enolic compounds and *l*-menthol as well as Diels-Alder adducts of certain unsaturated flavorants. For further discussion of such materials, the reader is

referred to references 6, 11, 40, 41, 42, 47, 48, 72, 100, 101, 102 and 117 in the bibliography.

Many miscellaneous tobacco additives have been referred to in the literature for which no description of the exact composition or the smoking flavor is given. These additives have not been included in the listings which follow; however, the reader may wish to consult references 9, 24, 30, 35, 39, 54, 66, 71, 111 and 121 for information concerning these additives.

It should be understood that listing of the various chemical substances in the following tables is not to be construed as a recommendation for or an endorsement of the use of such substances as tobacco additives.

Following the tables of flavor evaluations, a general discussion of tobacco flavorings will be found.

TABLE I – ORGANIC ACIDS

Compound	Smoke Taste	Smoke Aroma
Acetic acid (70)	pungent, acrid	pungent, sour
Abscisic acid	weak, sweet	- -
Aconitic acid	green, acrid	weak
Adipic acid	sour, acrid	acrid
Anisic acid	sweet, nutty, spicy	sweet
Ascorbic acid	weak	weak
Benzoic acid (96)	weak, smoothing	weak
3-Benzyl-2-methylmalic acid (23)	mild, sweet balsamic, cinnamon	balsamic
3-Butyl-2-methylmalic acid (23)	weak, sweet	weak
Butter acids	waxy, fatty, sour cheese, fruity	warm, fatty
Butyric acid (70)	smoothing, buttery, fruity	smoothing, buttery
Chlorogenic acid	weak, green	- -
Cinnamic acid	smoothing, weak balsamic	weak balsamic
Citric acid	adds body, smoothing	adds body
Citramalic acid	smoothing, sweetens	smoothing
Crotonic acid	caramel, buttery, adds body	sweet, caramel, mellowing
Cycloheptanecarboxylic acid	smoothing, sweet, fatty, floral	mellowing
Cyclohexaneacetic acid	sharp, acrid, buttery	mellowing
Cyclohexanecarboxylic acid	green, sour vegetable, cheese	green, herbaceous, cheese

Compound	Smoke Taste	Smoke Aroma
3-Cyclohexanepropionic acid	sweet, balsamic, styrax	sweet, balsamic, vanilla
Cyclopentaneacetic acid	fruity, sweet	fruity
Cyclopentanecarboxylic acid	sour, powerful cheese, buttery, nutty	sweet, cheese, buttery
3-Cyclopentanepropionic acid	sweet, weak balsamic, mellowing	mellowing, weak balsamic
3-Cyclopentanoylpropionic acid (99)	camphoraceous	– –
Decanoic acid	fatty	fatty
3,7-Dimethyl-6-octenoic acid	green, fatty-waxy	fatty-waxy
2,4-Dimethyl-2-pentenoic acid	sweet, buttery-fruity, caramel	smoothing
2,3-Dimethylmalic acid (23)	sweet, spicy, heavy caramel	– –
2,3-Dimethylsuccinic acid	weak, musty	weak
Erythrobic acid	acrid	caramel
2-Ethylbutyric acid	smoothing, cream	smoothing
2-Ethyl-3-methylmalic acid (23)	sweet, nutty-buttery, sour cream	weak sweet
Ethyl vanillic acid	weak vanilla	weak
Formic acid	pungent, acrid	pungent
Fumaric acid	smoothing, slightly acrid	weak acrid
2-Furoic acid	weak, sweet, nutty	weak, nutty
Glycolic acid	smoothing	smoothing
Heptanoic acid (96)	weak, sweet butter, cream	smoothing
Hexanoic acid (96)	waxy, cream, maple	smoothing
trans-2-Hexenoic acid	green, fruity, chemical	– –
3-Hexenoic acid	adds harshness, honey note	– –
4-Hydroxy-3-methoxy-cinnamic acid	adds body, phenolic	phenolic
2-Hydroxy-2,5,5,8a-tetramethyldecahydro-naphthaleneacetic acid (106)	cedar	woody, cedar

Compound	Smoke Taste	Smoke Aroma
Isobutylmalonic acid (47)	valeric acid type, cheese	cheese, Oriental tobacco-type note
Isobutyric acid	smoothing, cheese, fruity	smoothing, buttery
2-Isopropyl-5-keto-hexanoic acid	sweet, mellowing	sweet
2-Isopropylmalic acid (23)	nutty, caramel	sweet, musty
2-Isopropyl-3-methylmalic acid (23)	sweet, smoothing	smoothing
Isovaleric acid (96)	sweet, winey, fruity, cheese, adds body	smoothing, cheese, Oriental tobacco-type note
4-Ketodecanoic acid (99)	light mushroom	– –
4-Keto-5-methyloctanoic acid (99)	camphoraceous	– –
4-Ketononanoic acid (96, 99)	pungent, earthy-mushroom, adds body	smoothing, adds richness
Lactic acid	buttery-cream, smoothing	sweet, cream
Lauric acid	waxy-fatty, smoothing	waxy-fatty
Levulinic acid	sweet, caramel, adds body	adds body
Linoleic acid	waxy, adds harshness	waxy
Linolenic acid	waxy, adds body, harshness	waxy
Malic acid (23)	smoothing, acrid	weak, acrid
2-Mercaptopropionic acid	hot, sulfuraceous	'sulfate' turpentine-type note
2-Methyl-3-benzylmalic acid (23)	smoothing, sweet	smoothing
2-Methylbutyric acid	smoothing, cream-butter, nutty	smoothing, sweet cream
2-Methyl-3-butylmalic acid (23)	green, nutty, adds harshness	adds body
3-Methylcrotonic acid	fatty, herbaceous, caramel	fatty, caramel
2-Methyl-3-ethylmalic acid (23)	adds harshness, nutty	adds body
2-Methylheptanoic acid	fatty, weak fruity	fatty
5-Methyl-2-furoic acid	adds body, harshness	peppery
trans-5-Methyl-2-hexenoic acid (96)	clove, spicy	– –
2-Methylmalic acid (23)	sweet, caramel	– –
3-Methylmalic acid (23)	heavy fruit (prune), caramel	smoothing

Compound	Smoke Taste	Smoke Aroma
2-Methyl-3-propylmalic acid (23)	mellowing, balsamic, caramel	adds body
2-Methyl-3-isopropyl-malic acid (23)	adds body	adds body
2-Methylvaleric acid	sour, cheese, smoothing	smoothing
3-Methylvaleric acid	sweet, cheese, fruity	cheese, fruity, Oriental tobacco-type note
Myristic acid	smoothing, sweet, waxy	sweet, mild
Nonanoic acid (96)	fatty, waxy	fatty, waxy
cis-3-Nonenoic acid (96)	fatty	fatty
Octanoic acid (96)	sweet, waxy, smoothing	waxy, smoothing
Oleic acid	waxy, fatty, smoothing	waxy, smoothing
Palmitic acid	waxy, sweet, adds body	waxy, sweet
4-Pentenoic acid	harsh, caramel, nutty	sweet, nutty
Phenoxyacetic acid	sweet, hay	hay, sweet
Phenylacetic acid (70, 96)	sweet, honey	sweet, honey
3-Phenylpropionic acid	sweet, hay, vanilla, balsamic	sweet, hay, vanilla
Propionic acid	pungent, acrid	pungent
Pyroligneous acid	smoky (hickory)	smoky
Pyruvic acid	caramel, nutty, fruity, adds body	adds body
Salicylic acid	weak	weak
Sebacic acid (96)	fatty	fatty
Sorbic acid	adds body, sweet	weak, sweet
Stearic acid	waxy, nutty	waxy
Tartaric acid	acrid	acrid
Tiglic acid	adds body, caramel, mellowing	adds body
Trimethylmalic acid (23)	weak balsamic, sweet herbaceous	- -
Undecanoic acid	fatty, waxy, smoothing	fatty, waxy
10-Undecenoic acid	fatty, waxy, smoothing	fatty, waxy, smoothing
Valeric acid (85)	sweet, fruity, cheese, buttery	cheese, smoothing
Vanillic acid	weak vanilla	weak vanilla

TABLE II – AMINO ACIDS

Compound	Smoke Taste	Smoke Aroma
DL-Alanine	sweet, adds body	sweet
L-Alanine	sweet, weak fatty	sweet
4-Aminobutyric acid	sweet, dry taste	sour
L-(+)-Arginine	green, adds body, burley character	adds harshness, burley notes
L-Asparagine	weak nutty, spicy, adds burley character	sweet, nutty, spicy
DL-Aspartic acid	smoothing, sweet	sweet, flue-cured note
L-Aspartic acid	smoothing, sweet	sweet, flue-cured note
L-(+)-Citrulline	spicy, nutty, sweet, adds body	spicy, nutty, adds body
L-Cystine	earthy, adds body, burley character	adds body
L-(+)-Glutamine	earthy, adds body, burley character	nutty, adds body
Glutathione	smoothing, mild flue-cured character	sweet, flue-cured note
Glycine	adds harshness, burley character	harsh, burley notes
4-Hydroxy-*L*-proline	weak, peppery, caramel	caramel, cellulosic
L-Leucine	adds harshness, peppery, burley character	peppery
DL-Methionine	sweet, cereal, bran	sweet, cereal, roast aroma
L-Phenylalanine	sweet, floral-fruity, adds body	smoothing, sweet
L-(+)-Proline	bitter, harsh	protein (burnt hair)
L-Serine	adds harshness, peppery	adds harshness
L-Threonine	woody, adds harshness	woody, sour, peppery
L-(–)-Tryptophan	green, herbaceous, burley character	green, adds body
Tyramine	harsh, peppery	harsh, burley notes
L-Tyrosine	smooth, spicy, adds burley character	smoothing, enhances smoke aroma
L-Valine	bitter, sweet, peppery	sweet, nutty, flue-cured note

TABLE III – ALCOHOLS

Compound	Smoke Taste	Smoke Aroma
Amyl alcohol	weak, nutty, oily	weak, sweet
α-Amylcinnamyl alcohol	weak, leafy-floral	weak floral
Anisyl alcohol	sweet, vanilla, floral	sweet, floral
Benzyl alcohol (96)	weak floral, smoothing (bitter at high conc.)	smoothing
Bisabalol	smoothing	weak
Borneol	woody, camphoraceous, cooling	woody, camphoraceous
Butyl alcohol	weak, green, sour, oily	green, leathery
l-Carveol (*cis* & *trans*)	sweet, minty (spearmint), weak green	mild, sweet
Caryophyllene alcohol	woody, cedar	woody
Cedrol	strong cedar, woody	cedar, woody
Cinnamyl alcohol	adds body, spicy-balsamic	sweet, spicy, balsamic
Citronellol (85)	floral, green, fatty, soapy	floral-citrus, green, fatty
1-Decanol	fatty-waxy, green, citrus	green, fatty-waxy, adds body
d-Dihydrocarveol (mixture of isomers)	earthy, sweet	sweet, mint, earthy
Dihydro-β-ionol	floral, sweet	floral
Dihydronopol	sweet, green, floral	green, floral
2,6-Dimethyl-4-heptanol	green, fatty	fatty
3,7-Dimethyl-1-octanol	floral, waxy-fatty	floral, waxy
α,α-Dimethylphenylethyl alcohol	herbaceous, floral	adds body, floral, woody
Ethyl alcohol	mellowing	mellowing
2-Ethyl-1-hexanol	green	floral, green, sweet
Farnesol (30)	floral, weak green, smoothing	sweet, floral, green, reminiscent of linalool
Fenchyl alcohol	pine, bitter	pine
Furfuryl alcohol	cereal, bran, oily, adds body	adds body
Geraniol (85, 125)	floral-soapy, green, musty	floral

Compound	Smoke Taste	Smoke Aroma
Glycerol	very weak, sweet, smoothing	weak
Heptyl alcohol	sweet, floral, winey	mild, floral-soapy
1-Hexadecanol	mild, smoothing, waxy	smoothing, waxy
trans-2-Hexenol	green, sweet	green
cis-3-Hexenol (43, 96)	green, leaf-like	leafy green
Hexyl alcohol	smoothing, buttery, nutty, winey	smoothing, winey, buttery
Hydroxycitronellol	sweet, floral	sweet, floral
6-Hydroxy-4,4,7a-trimethyloctahydro-benzofuran	light, mild	– –
4-(3-Hydroxy-2,6,6-trimethyl-1-cyclohexen-1-yl)-3-buten-2-ol	adds body, spicy	adds body
Isoamyl alcohol	green, brandy-fruity	green, harsh
Isoborneol	camphoraceous•	musty, camphoraceous
Isobutyl alcohol	sweet, buttery, green	weak green
α-Isobutylphenylethyl alcohol	green, floral	weak, green, floral
Isopropyl alcohol	weak, medicinal	weak
p-Isopropylbenzyl alcohol	spicy, herbaceous	peppery
α-(3-Isopropylcyclopentyl)-ethanol	spicy, dry, floral	herbaceous, spicy, floral
Isopulegol	bitter, herbaceous, resinous	woody, floral
Lauryl alcohol	adds body, waxy, nutty	sweet, adds body
Linalool (85, 96, 125)	sweet, floral, citrus	floral, sweet, citrus
l-Isomenthol	musty, camphoraceous	musty, camphoraceous
l-Menthol	cooling	cooling
d-Menthol	musty, very weak cooling	musty, resinous
dl-Menthol	cooling, musty	musty, cooling, resinous
d-Neomenthol	pine, camphoraceous	musty, pine, camphoraceous, weak
1,8-*p*-Menthadien-7-ol	herbaceous, woody, spicy	woody, floral
trans-*p*-Menth-1-en-3-ol	musty, mint	herbaceous
α-Methylbenzyl alcohol	dry, green, herbaceous, adds body	herbaceous

Compound	Smoke Taste	Smoke Aroma
3-Methyl-2-buten-1-ol	weak, cooling, mint, floral, sweet	weak, sweet
6-Methyl-5-hepten-2-ol (96, 112)	green, sweet	green
β-Methylphenylethyl alcohol	herbaceous, floral, adds body	sweet, herbaceous, floral
Nerol	floral-rose, sweet	floral
Nerolidol	woody, floral	floral, woody
2,6-Nonadien-1-ol	green, vegetable, citrus	green, citrus
Nonyl alcohol	floral	floral
Nopol	weak, musty-pine	weak, musty-pine
1-Octanol	floral, fruity	sweet, floral, fruity
2-Octanol	floral, sweet, bitter	floral, green
1-Octen-3-ol	earthy, sweet	sweet, earthy, floral, woody
4-Phenyl-2-butanol	floral	citrus, floral
4-Phenyl-3-buten-2-ol	sweet, fruity	fruity, sweet
β-Phenylethyl alcohol (85, 96)	floral-rose	floral-rose
1-Phenyl-1-propanol	smoothing	smoothing, balsamic
3-Phenyl-1-propanol	sweet, spicy-balsamic, floral	sweet, spicy, floral
Phytol	green, slightly peppery	green
Propyl alcohol	sweet, light	weak
Propylene glycol	weak	weak
α-Propylphenylethyl alcohol	sweet, herbaceous	sweet, herbaceous
Rhodinol (125)	floral	floral, sweet
Santalol	sweet, woody, floral	sweet, woody, floral
Sclareol	sweet, smoothing, slightly waxy	smoothing
Solanol (96)	sweet, floral, smoothing	smoothing
Sorbitol	weak, bitter	weak, cellulosic
α-Terpineol (85)	pine, sweet, musty	smoothing, musty, pine
Terpinene-4-ol (58)	green, earthy-musty	weak, green, musty
Tetrahydrofurfuryl alcohol	hay, adds body	adds harshness, body
Tetrahydrolinalool	floral, sweet	floral, sweet
4-Thujanol	terpeny, peppery	peppery, spicy
p,α,α-Trimethylbenzyl alcohol	sweet, floral	mild

Compound	Smoke Taste	Smoke Aroma
3,5,5-Trimethylcyclohexanol	cooling, musty, camphoraceous	camphoraceous
3,5,5-Trimethyl-2-cyclohexenol	mint, camphoraceous	camphoraceous
2-Undecanol	fatty, smoothing	smoothing, fatty
1-Undecanol	floral, citrus, smoothing	floral, sweet

TABLE IV – ALDEHYDES, ACETALS

Compound	Smoke Taste	Smoke Aroma
Acetaldehyde	pungent, weak fruity	pungent, acrid
Acetaldehyde, diethyl acetal	adds body, green, weak fruity	sweet, adds harshness
Acetaldehyde, phenylethyl butyl acetal	sweet, herbaceous, fruity	sweet, fruity
Acetaldehyde, phenylethyl *n*-propyl acetal	rose-floral, hay	musty, floral
α-Amylcinnamaldehyde	leafy, citrus peel, floral	citrus, floral
α-Amylcinnamaldehyde, dimethyl acetal	pungent, green-leafy	floral
Benzaldehyde (70, 96)	almond, cherry	sweet, fruity, enhances tobacco aroma
Benzaldehyde, dimethyl acetal	green	weak green
Benzaldehyde, glyceryl acetal	weak nutty, almond-cherry	weak green
Benzaldehyde, propylene glycol acetal	oily	oily
Butyraldehyde	harsh, green, chemical	herbaceous, green
Cinnamaldehyde	cinnamon, spicy, sweet	sweet, spicy
Citral	lemon, citrus, terpeny	citrus
Citral, diethyl acetal	citrus, sweet	citrus, sweet
Citronellal	floral, rose, soapy, fatty-green	floral, soapy, fatty-green
Citronelloxyacetaldehyde	sweet, floral	sweet, rose-floral
Cuminaldehyde	green, spicy, herbaceous (cumin-curry)	green, herbaceous
Cyclamen aldehyde	light herbaceous, green vegetable, citrus	sweet, citrus
β-Cyclocitral	sweet, adds body and harshness	sweet

Compound	Smoke Taste	Smoke Aroma
Cyclohexanecarboxaldehyde	aldehydic, pungent	mellowing
Cyclopentanecarboxaldehyde	chocolate, nutty, burley note	cheese
2,4-Decadienal	intensely fatty-waxy, green, floral	fatty-waxy, floral
Decanal	green, citrus	green, waxy-fatty
Decanal, dimethyl acetal	chemical, green, citrus	waxy, coconut, green
2-Decenal	fatty, green	fatty
2,4-Dimethoxybenzaldehyde (96)	sweet, hay-like	- -
2,6-Dimethyl-5-heptenal	powerful green-melon, vegetable, smoothing	sweet, melon-like, vegetable
2,6-Dimethyloctanal	sweet, green, vegetable-fruity	green, fruity
2,4-Diphenylcrotonaldehyde (112)	sweet, floral, smoothing	sweet, floral, smoothing
2-Dodecenal	warm, nutty, citrus, adds body	very sweet
p-Ethoxybenzaldehyde	sweet, smoothing, floral	sweet, floral
2-Ethylbutyraldehyde	chocolate, nutty, burley note	adds body, weak chocolate, green
Ethyl vanillin (70, 125)	sweet, strong vanilla	sweet, vanilla
Furfural	sweet, yeasty-bread, buttery	sweet, yeasty, bread
Furylacrolein	sweet, spicy, nutty, fruity	sweet, spicy
Heptanal	fatty, green	fatty, green
Heptanal, dimethyl acetal	sweet, musty-green, fatty	sweet, fatty, floral
2,4-Heptadienal	weak fatty	fatty, mellowing
2-Heptenal	green, fatty, floral	floral, fatty, green
cis-4-Heptenal	green vegetable	green
Hexanal	spicy, green-apple, fatty-waxy	green, fatty
trans-2-Hexenal	pungent, spicy-green	green, weak fruity
trans-3-Hexenal	green	green
cis-3-Hexenal	leafy-green, warm, spicy	sweet, leafy-green
2-Hexylcinnamaldehyde	adds body, nutty, herbaceous, floral	herbaceous, floral, fruity
Hydroxycitronellal (125)	soapy-floral, sweet, bitter	floral-soapy

Compound	Smoke Taste	Smoke Aroma
Hydroxycitronellal, dimethylacetal	citrus, floral, woody	woody, floral
5-Hydroxymethylfurfural	sweet, floral, adds body, flue-cured note	sweet, adds body
Isobutyraldehyde	sweet, chocolate, nutty, green	sweet, chocolate, adds body
p-Isopropylphenyl-acetaldehyde	sweet, green, bitter	green, sweet
Lauric aldehyde	waxy-fatty	waxy-fatty
p-Menth-1-en-9-al	green, hay	green, hay
p-Methoxybenzaldehyde (125)	sweet, floral, hay, anise	sweet, hay
o-Methoxybenzaldehyde	cinnamon, spicy	spicy
p-Methoxy-α-methyl-cinnamaldehyde	sweet, floral	sweet, floral
2-Methylbutyraldehyde	sweet, chocolate, adds body, burley note	adds body, nutty
3-Methylbutyraldehyde	adds body, buttery-nutty, chocolate	adds body
α-Methylcinnamaldehyde	spicy, sweet, warm	spicy, hay
5-Methylfurfural (109)	sweet, adds body	sweet, adds body
2-Methyloctanal	fatty, pungent	fatty, weak nutty
2-Methyl-4-phenylbutyral-dehyde	earthy, sweet, floral	sweet, floral, smoothing
5-Methyl-2-formylthiophene	sweet, floral, adds body	sweet, floral
3-Methylthiopropionaldehyde	meaty, bouillion	meaty, potato, strong
2-Methyl-3-tolylpropion-aldehyde (mixture of isomers)	sweet, fruity, balsamic	sweet, fruity
2-Methylundecanal	earthy	musty
Myristaldehyde	sweet, adds body, waxy	sweet, smoothing
Nonanal	fatty, floral, waxy	fatty, floral, waxy
2,4-Nonadienal	fatty, waxy, green vegetable	fatty, earthy
2,6-Nonadienal	vegetable, green	green
Octanal	fatty, sweet	fatty
Octanal, dimethyl acetal	smoothing, weak fatty-green	smoothing
Perillaldehyde	cumin, spicy, herbaceous	cumin, herbaceous
Phenylacetaldehyde	intense floral-soapy	floral
Phenylacetaldehyde, 2,3-butylene glycol acetal	sweet, spicy-woody,floral	floral, sweet

Compound	Smoke Taste	Smoke Aroma
Phenylacetaldehyde, dimethyl acetal	floral, spicy	floral
Phenylacetaldehyde, glyceryl acetal	floral	floral
2-Phenylpropionaldehyde	floral	sweet, floral
3-Phenylpropionaldehyde	sweet, warm, spicy	sweet, weak nutty
2-Phenylpropionaldehyde, dimethyl acetal	musty, spicy, green, nutty	spicy, green
Phytal	floral, smoothing, adds body	smoothing, weak woody
Piperonal (87, 125)	sweet, floral, cherry-vanilla undertone	sweet, light floral-vanilla
Propionaldehyde	pungent, nutty, resinous	adds body
Pyruvaldehyde	adds body, pungent, caramel	strong, sweet, caramel
Salicylaldehyde	acetophenone-like, harsh cherry, chemical	harsh, acetophenone-type note
Tolualdehyde, glyceryl acetal	fruity, green	sweet, weak fruity
Tolualdehyde	strong, cherry, adds body	sweet, cherry, adds body
2-(*p*-Tolyl)-propionaldehyde	green, sweet	sweet, woody, green
2-Tridecenal	citrus, fatty, adds body	citrus, fatty
2,4-Undecadienal	green	green, musty-earthy
Undecanal	fruity, sweet, waxy-floral	sweet, fruity-fatty
9-Undecenal	fatty	fatty
Valeraldehyde	chocolate, fruity	fruity
Vanillin (70, 87, 96, 125)	sweet vanilla	sweet vanilla

TABLE V – AMIDES, AMINES

Compound	Smoke Taste	Smoke Aroma
Acetamide	musty, harsh, chemical	– –
Adipamide	chemical, pine	- -
Isobutyramide	musty, chemical	- –
Isovaleramide	harsh, chemical	– –
N-Nonanoyl-4-hydroxy-3-methoxybenzylamide	pungent, bite	harsh, bite
Propionamide	earthy-musty, harsh, chemical	- –

Compound	Smoke Taste	Smoke Aroma
1-Pyrrolidine-carboxaldehyde (44)	weak	weak
Succinamide	oily, harsh	- -
Isopentylamine	sweet, adds body, flue-cured note	sweet resinous
Phenylethylamine	sweet	sweet, floral
Piperidine	alkaline, fresh, sweet	green, floral
Piperine	pungent, bite	harsh, bite

TABLE VI – ANHYDRIDES

Compound	Smoke Taste	Smoke Aroma
3-Benzyl-2-methylmaleic anhydride	musty-earthy, bitter	- -
n-Decenylsuccinic anhydride	peppery, hot	peppery
Diethylmaleic anhydride (79)	reminiscent of wood smoke, Oriental tangy character	- -
Dimethylmaleic anhydride (79, 96)	sweet honey, hay-like, adds body	sweet, honey-hay
α,α-Dimethylsuccinic anhydride	adds harshness, chemical taste	harsh
α,β-Dimethylsuccinic anhydride	sweet, adds harshness and body	sweet, adds body
Ethylmaleic anhydride (79)	pleasant aromatic, enhances tobacco flavor, slight leather character	- -
Isopropylmaleic anhydride	winey, nutty, bran, adds body, burley character	adds body, sweetness
Isopropylsuccinic anhydride	sweet, nutty, fruity, some Oriental character	sweet
Itaconic anhydride	sweet, smoothing, enhances tobacco flavor, adds body	sweet, adds body
Maleic anhydride (79)	dry fruity, tangy freshness	- -
Methylmaleic anhydride (79)	tangy freshness, slightly sweet with savor of Turkish tobaccos	- -

Compound	Smoke Taste	Smoke Aroma
Methylethylmaleic anhydride (79, 96)	caramel (burnt sugar), sweet, adds body	sweet, caramel
α-Methyl-β-ethylsuccinic anhydride	sweet, adds richness, green	- -
Octenylsuccinic anhydride	peppery, harsh	peppery
n-Octylsuccinic anhydride	adds body, burley character	hot, chemical

TABLE VII – ESTERS

Compound	Smoke Taste	Smoke Aroma
Allyl anthranilate	chemical, grape	chemical
Allyl butyrate	weak, buttery-fruit	smoothing
Allyl cinnamate	spicy, adds body	sweet, spicy, styrax
Allyl cyclohexaneacetate	fruity	fruity, sweet
Allyl cyclohexanepropionate	sharp, fruity	sweet, fruity, chemical
Allyl 2-ethylbutyrate	fruity, peach	sweet, fruity
Allyl 2-furoate	fatty-waxy, heavy fruit	smoothing
Allyl heptanoate	sharp, green	leafy-green, weak fatty
Allyl hexanoate	green, musty, fatty	sweet, green-fruity, weak fatty
Allyl nonanoate	sweet, nutty-fruity	sweet, green, fatty, fruity
Allyl octanoate	spicy, nutty, fruity	fruity, weak fatty
Allyl phenoxyacetate	waxy, heavy, sweet	floral, honey, sweet
Allyl Phenylacetate	sweet, green, honey-citrus	citrus-honey
Allyl propionate	pungent, sweet-sour, fruity	sweet
Allyl sorbate	sweet, nutty-fruity	sweet, green, nutty, winey
Allyl 10-undecenoate	fruity, green, chemical	nutty, fatty, herbaceous
Allyl isovalerate	bitter, fruity-rum	leathery, fruity
Amyl butyrate (70, 125)	weak, sweet, fruity	sweet, weak fruity
Amyl formate (70, 125)	sweet, weak green-winey	sweet
Amyl 2-furoate	earthy	earthy
Amyl heptanoate	green, peppery	green, fatty-waxy
Amyl hexanoate	green, floral	green, floral

Compound	Smoke Taste	Smoke Aroma
Amyl laurate	bitter, weak	weak
Amyl myristate	sweet, adds body	adds harshness
Amyl octanoate	nutty, musty, floral, winey	sweet, perfume-floral
Anisyl acetate	sweet, fruity-floral	sweet, fruity-floral
Anisyl butyrate	sweet, floral-fruity	sweet, adds body
Anisyl formate	sweet, green-floral	green, floral
Anisyl propionate	floral, weak anise	sweet, floral, anise
Benzyl acetate (125)	winey, sweet, buttery, floral	floral
Benzyl acetoacetate	green, herbaceous	weak, green, cherry
Benzyl benzoate (125)	green, floral, balsamic	green, fresh, balsamic
Benzyl butyrate	sweet, green, fruity	strong, fruity-green
Benzyl isobutyrate	heavy fruity (plum)	yeasty
Benzyl cinnamate	sweet, spicy-balsamic	mild balsamic-spicy
Benzyl formate	green, earthy	sweet earthy, floral
Benzyl phenylacetate	honey, floral	sweet, light honey-floral
Benzyl propionate	floral	floral
Benzyl salicylate	sweet, light floral	very floral
Benzyl isovalerate	fruity	sweet, floral, fruity
Bornyl acetate (125)	camphoraceous, woody	slight cooling, adds body, camphoraceous
Bornyl formate	camphoraceous	camphoraceous
Bornyl valerate	herbaceous, pine	mellowing, weak woody
Bornyl isovalerate	herbaceous, pine, woody	mellowing, weak woody
Butter esters	green, fatty	fatty
Butyl acetate	weak fruity, harsh	sweet, toasted note
Butyl acetoacetate	green, chemical, winey	green, bread-type note
Butyl anthranilate	weak, bitter, fruity	peppery, fruity
Butyl butyrate	sweet, buttery, green-winey	buttery, fatty
Butyl isobutyrate	sweet, fruity	sweet, fruity, floral
Butyl butyryllactate	buttery, fatty, harsh	fatty, buttery
Butyl cinnamate	sweet, floral, spicy-balsamic	spicy, sweet
Butyl ethyl malonate	nutty, peppery	chemical, adds body
Butyl formate	toasted nut, fruity, winey	green, sweet

Compound	Smoke Taste	Smoke Aroma
Butyl heptanoate	nutty, green, fruity	nutty, green, fruity, adds body
Butyl hexanoate	green, fruity, adds body	leafy green, weak sweet
Butyl *p*-hydroxybenzoate	adds body, harshness, sweet	sweet, weak fruity
Butyl lactate	heavy fruity, buttery	sweet, buttery, fruity
Butyl laurate	weak, fatty, fruity	sweet, fatty
Butyl levulinate	heavy fruit (prune)	rich, adds body
Butyl phenylacetate	sweet, honey, caramel	honey, caramel
Butyl propionate	fatty, rum, fruity	weak rum, fruity, fatty
Butyl stearate	weak waxy-fatty	waxy-fatty
Butyl 10-undecenoate	fatty, peach	fatty
Butyl valerate	smoothing, winey	smoothing
Butyl isovalerate	harsh, winey, oily	toasted note
l-Carvyl acetate	sour, green	mild, mellowing
l-Carvyl propionate	herbaceous	mild, sweet
Caryophyllene acetate	woody	woody, resinous
Caryophyllene propionate	weak woody	mild, weak
Caryophyllene butyrate	weak woody	mild, weak
Caryophyllene isovalerate	weak woody	mild, weak
Cedrol isovalerate	sweet	sweet, weak
Cinnamyl acetate	sweet, floral-balsamic	sweet, smoothing, floral-balsamic
Cinnamyl anthranilate	harsh, fruity	harsh
Cinnamyl butyrate	green, weak balsamic	green-leafy, weak floral-balsamic
Cinnamyl isobutyrate	deep fruity, smoothing, balsamic	fruity, winey
Cinnamyl cinnamate	balsamic, weak spicy, adds body	sweet, spicy-balsamic
Cinnamyl formate	green, herbaceous, weak balsamic	spicy-green
Cinnamyl furoate	sweet, spicy, musty	smoothing
Cinnamyl propionate	green, fruity, floral	fruity, floral, smoothing
Cinnamyl isovalerate	adds body, sweet, balsamic, floral-fruity	winey
Citronellyl acetate	sweet, rose-floral	sweet, rose-floral
Citronellyl butyrate	fruity, sweet, floral	sweet, fruity, floral

Compound	Smoke Taste	Smoke Aroma
Citronellyl isobutyrate	sweet, floral-rose, fruity	fruity, sweet, floral
Citronellyl formate	sweet, fruity, floral, green	sweet, fruity, floral, green
Citronellyl phenylacetate	sweet, honey, herbaceous	sweet, herbaceous
Citronellyl propionate	sweet, floral	sweet, floral
Citronellyl valerate	green, sweet, floral, fruity	smoothing, sweet, green
Cyclohexyl acetate	fruity (banana-pineapple), chemical	chemical, fruity
Cyclohexyl anthranilate	weak fruity, adds body	adds body, heavy fruit note
Cyclohexyl butyrate	fruity	fruity, floral, sweet
Cyclohexyl cinnamate	fruity, sweet	fruity, floral, sweet, balsamic
Cyclohexyl formate	chemical, bitter	green, pungent
Cyclohexyl propionate	sweet, floral, fruity	green, floral
Cyclohexyl isovalerate	nutty, adds body, fruity	sweet, floral, fruity
Decyl acetate	fatty, green	fatty
Decyl butyrate	weak fatty, smoothing	weak fatty
Decyl propionate	weak fatty, green	weak fatty
Dibutyl sebacate	bitter	weak
Diethyl malate	winey	weak, winey-fruity
Diethyl malonate	sweet, adds body, harsh, fruity	sweet, floral, fruity
Diethyl sebacate	sweet, green, weak winey	green, sweet
Diethyl succinate	weak, smoothing	mellowing
Diethyl tartrate	weak sweet, green	weak
Dihydrocarvyl acetate	chemical, herbaceous, minty, floral	herbaceous
α,α-Dimethylphenylethyl acetate	sweet, floral	sweet, floral
α,α-Dimethylphenylethyl butyrate	weak, herbaceous, peppery	adds body
α,α-Dimethylphenylethyl formate	fruity, sweet, weak, bitter	adds body, weak herbaceous
Dimethyl succinate	weak, sweet	adds body
Ethyl acetate (70)	weak fruity, chemical	adds body
Ethyl acetoacetate	mild, weak sweet	mild
Ethyl 2-acetyl-5-ketohexanoate	sweet	sweet

Compound	Smoke Taste	Smoke Aroma
Ethyl acrylate	pungent, irritating	harsh
Ethyl anisate	sweet, floral	sweet, floral
Ethyl anthranilate	grape	grape, sweet
Ethyl benzoate	adds body, weak bitter	floral, fruity
Ethyl benzoylacetate	green, hay-honey, sweet	smoothing, hay note
Ethyl butyrate (70)	sweet, fruity, winey	sweet, fruity
Ethyl isobutyrate	fruity, sweet, rum	sweet, fruity
Ethyl cinnamate	sweet, fruity, honey-balsamic	sweet, honey, fruity, balsamic
Ethyl cyclohexaneacetate	sweet, fruity	fruity, sweet
Ethyl decanoate	sweet, adds body	smoothing, adds body
Ethyl *trans*-2-*cis*-4-decadienoate	green, fatty, bitter	green, weak fatty
Ethyl formate	rum	weak fruity
Ethyl 2-furanpropionate	green, fruity	fruity, green
Ethyl heptanoate	sweet, fruity, winey	sweet, fruity
Ethyl hexanoate	fruity, sweet	weak fruity
Ethyl lactate	smoothing, weak	weak
Ethyl laurate	sweet, smoothing	smoothing
Ethyl levulinate	green, fruity	sweet, fruity
Ethyl 2-methylbutyrate	green-apple	sweet, fruity, enhances tobacco notes
Ethyl methyl phenylglycidate	fruity	sweet, fruity
Ethyl myristate	smoothing, adds body	smoothing
Ethyl nonanoate	fatty-waxy, smoothing	fatty-waxy
Ethyl 2-nonynoate	sweet, waxy, green, smoothing	green, waxy
Ethyl octanoate	smoothing, waxy, adds body, flue-cured note	smoothing, waxy
Ethyl oleate	sweet, nutty, waxy, flue-cured note	sweet, smoothing
Ethyl palmitate	sweet, smoothing	smoothing
Ethyl phenylacetate	sweet, honey, fruity	sweet, honey, mellowing
Ethyl 4-phenylbutyrate	sweet, heavy fruity	sweet, buttery
Ethyl 3-phenylglycidate	fruity (strawberry)	fruity
Ethyl 3-phenylpropionate	weak floral, bitter	floral
Ethyl propionate	pungent, fruity	sweet, fruity, nutty

Compound	Smoke Taste	Smoke Aroma
Ethyl pyruvate	caramel, fruity, spicy	nutty, spicy, fruity
Ethyl salicylate	mint (wintergreen), fresh, floral, spicy	minty, floral, spicy
Ethyl sorbate	smoothing	over-ripe fruit
Ethyl tiglate	pungent, caramel, fruity	winey, nutty
Ethyl (*p*-tolyloxy)acetate	sweet, minty	woody
Ethyl 10-undecenoate	fatty, waxy, winey	fatty, waxy
Ethyl valerate (70)	sweet, winey, fruity	winey
Ethyl isovalerate	sweet, winey, rum, nutty	winey, nutty
Eugenyl acetate	sweet, floral	floral, fruity
Furfuryl acetate	herbaceous, spicy, adds body	herbaceous, adds body
Furfuryl thioacetate	sulfuraceous, metallic	sulfuraceous
Geranyl acetate	green, floral, adds body	sweet, floral
Geranyl benzoate	green, floral, peppery	green, floral
Geranyl butyrate (85)	weak fruity, adds body	burnt nut
Geranyl isobutyrate	weak floral, adds body	floral
Geranyl formate	weak, sweet, green-floral	sweet, floral
Geranyl phenylacetate	bitter, floral-honey, adds body	sour, nutty, floral
Geranyl propionate	smoothing, floral	sweet, floral
Geranyl tiglate	sweet, floral	sweet, weak floral
Geranyl isovalerate	nutty, herbaceous	sweet, floral
Glucose pentaacetate	bitter, harsh	greasy
Glyceryl monostearate	smoothing, waxy	smoothing, waxy
Guaiacyl phenylacetate	adds body, harshness, enhances burley notes	sweet, adds body
Heptyl acetate	fruity, green, floral	weak fruity, floral
Heptyl butyrate	sweet, green, floral, fruity	green
Heptyl isobutyrate	fruity, sweet	fruity, floral
Heptyl cinnamate	mild, floral, sweet	sweet, floral
Heptyl formate	sweet, fruity, fatty	sweet, fruity
Heptyl octanoate	green	mild
trans-2-Hexenyl acetate	sweet, fruity, green	fruity, green, sweet
cis-3-Hexenyl acetate	green, fruity, apple	green, fruity
cis-3-Hexenyl benzoate	floral, sweet	floral
cis-3-Hexenyl butyrate	sweet, fruity, green	mild, sweet

Compound	Smoke Taste	Smoke Aroma
trans-2-Hexenyl butyrate	sweet, green	green
cis-3-Hexenyl 2-methylbutyrate	fruity, green	fruity, green
cis-3-Hexenyl phenylacetate	green, honey	green, honey
cis-3-Hexenyl propionate	fruity, green-apple	fruity
cis-3-Hexenyl pyruvate	sweet, floral	floral
cis-3-Hexenyl tiglate	earthy, fruity	earthy
cis-3-Hexenyl isovalerate	green, herbaceous, fruity-winey	floral, winey
Hexyl acetate	sweet, fruity	heavy sweet, fruity
Hexyl butyrate	smoothing, waxy-fatty	smoothing
Hexyl formate	adds body, burley-type note	adds body, harshness
Hexyl 2-furoate	smoky, meaty, earthy	earthy, meaty
Hexyl hexanoate	smoothing, weak green	hay-green
Hexyl octanoate	sweet, green, woody, flue-cured note	waxy, fatty, oily
Hexyl propionate	herbaceous, adds body, burley note	sweet, earthy, fruity
β-Ionyl acetate	sweet, woody, floral	sweet, woody, floral
Isoamyl acetate (70)	weak, sweet, banana	weak, banana
Isoamyl benzoate	balsamic, sweet	sweet, balsamic, fruity
Isoamyl butyrate	fruity, weak winey	weak fruity
Isoamyl cinnamate	balsamic	sweet, balsamic
Isoamyl formate	weak, green, harsh	weak green
Isoamyl hexanoate	sweet, fruity	weak sweet, fruity
Isoamyl laurate	weak, fatty, buttery	weak, buttery-fatty
Isoamyl nonanoate	nutty, sweet, coconut	weak, sweet
Isoamyl octanoate	sweet, smoothing, waxy, winey	waxy, smoothing
Isoamyl phenylacetate	honey, sweet, floral	sweet, honey-floral, buttery
Isoamyl propionate	sweet, fruity	sweet, fruity
Isoamyl pyruvate	fruity, rum	sweet, fruity
Isoamyl salicylate	sweet, balsamic, woody, floral	sweet, balsamic, woody, floral
Isoamyl isovalerate (70)	sweet, winey, fatty, buttery	sweet, fatty-winey
Isobornyl acetate	camphoraceous, cedar	sour, woody
Isobornyl formate	weak camphoraceous, cedar, resinous	sweet resinous

Compound	Smoke Taste	Smoke Aroma
Isobornyl propionate	cedar	woody, sweet
Isobornyl isovalerate	woody-pine, sweet, earthy	woody, earthy
Isobutyl acetate	sweet, fruity	sweet, nutty-fruity
Isobutyl acetoacetate	green, weak sweet, fruity undertone	green, mild
Isobutyl angelate	sweet, floral	sweet, floral
Isobutyl anthranilate	sweet, candy-fruity	sweet
Isobutyl benzoate	bitter, chemical	peppery, chemical
Isobutyl butyrate	weak, sweet, fruity	weak fatty, fruity
Isobutyl isobutyrate	weak fatty, fruity, adds body	fatty, weak green
Isobutyl cinnamate	buttery, sweet, chocolate	weak, sweet, chocolate, buttery
Isobutyl formate	sweet, adds body-harshness	sweet, buttery
Isobutyl furoate	weak, sweet, green	sweet, green
Isobutyl 2-furanpropionate	sweet, floral, fruity, nutty	floral, cinnamon-spicy
Isobutyl heptanoate	sweet, fruity, nutty, floral	sweet, fruity, floral
Isobutyl hexanoate	light, fruity	sweet, fruity
Isobutyl phenylacetate	sweet, honey-floral	sweet, honey-floral
Isobutyl propionate	sweet, weak rum	weak fruity
Isobutyl salicylate	sweet, woody-floral, mint (wintergreen)	sweet, floral, weak mint
Isoeugenyl acetate	sweet, spicy (clove)	sweet, vanilla, weak floral
Isoeugenyl phenylacetate	sweet, adds body, spicy	sweet, vanilla, spicy
Isopropyl acetate	sweet, weak, fruity	weak
Isopropyl benzoate	honey, balsamic	honey
Isopropyl butyrate	sweet, fruity	weak, sweet, fruity
Isopropyl cinnamate	sweet, balsamic	balsamic
Isopropyl formate	bitter, fruity	sweet, fruity-floral
Isopropyl propionate	sharp, fruity	smoothing, citrus-fruity
Isopropyl tiglate	sharp, fruity	mild
Isopulegyl acetate	green, minty, herbaceous	weak green, herbaceous, floral
Lauryl acetate	waxy, nutty, adds body	adds body, sweet
Linalyl acetate (96, 125)	sweet-sour, citrus-floral	woody, sage
Linalyl anthranilate	fruity, bitter	fruity, sweet

Compound	Smoke Taste	Smoke Aroma
Linalyl benzoate	sweet, heavy, fruity-floral	sweet, oily
Linalyl butyrate	weak fruity	sweet
Linalyl isobutyrate	weak fruity, adds body	smoothing
Linalyl cinnamate	sweet, balsamic	sweet, balsamic
Linalyl formate	sweet, floral, green-herbaceous	harsh, pungent, floral
Linalyl hexanoate	mild	green, fatty, adds body
Linalyl octanoate	sweet, floral, fatty, fruity	sweet, weak floral
Linalyl propionate	floral, nutty, sweet	floral
Linalyl isovalerate	spicy, nutty, tea, adds body	rich, adds body
l-Menthyl acetate	sweet, floral, herbaceous, weak fruity	sweet, floral, herbaceous
Menthyl isovalerate	weak fruity, adds body	adds body, nutty
Methyl acetate	dry, chemical, fruity	fruity, chemical
Methyl anisate	sweet, spicy, green	sweet, nutty, floral
Methyl anthranilate (85)	sweet, fruity, bitter	sweet, fruity (grape)
Methyl benzoate	weak, smoothing	sweet, weak balsamic
α-Methylbenzyl acetate	green-floral	musty, green
α-Methylbenzyl isobutyrate	sweet, floral, fruity	intensely floral, sweet
α-Methylbenzyl propionate	sweet, herbaceous, floral	herbaceous, floral
Methyl *p-tert*-butyl-phenylacetate	green, sour, citrus	fresh, green
Methyl butyrate	fatty, buttery, fruity	sweet, fruity, fatty
Methyl isobutyrate	fruity, nutty, buttery, rum	sweet, fruity
Methyl cinnamate	spicy, fruity, balsamic	sweet, green, floral
Methyl decanoate	smoothing, flue-cured note	smoothing, adds body
Methyl 2-furoate (27)	sweet, woody, enhances tobacco taste	sweet, adds richness
Methyl heptanoate	weak, fatty-waxy	weak, fatty-waxy
Methyl hexanoate	weak green, adds body	weak, adds body
Methyl 2-hexenoate	fruity, floral	sweet, floral
Methyl *p*-hydroxybenzoate	weak	weak, mild
Methyl laurate	sweet, adds flue-cured note	sweet, smoothing
Methyl linoleate	sweet, smoothing	sweet

Compound	Smoke Taste	Smoke Aroma
Methyl linolenate	sweet, adds body	adds body
Methyl *N*-methylanthranilate	sweet, fruity, bitter	sweet, fruity
Methyl 2-methylbutyrate	sweet, fruity-apple, floral	fruity-apple
Methyl 2-methylthiopropionate	rich, sweet, fatty-oily	sweet, warm
Methyl myristate	smoothing	smoothing
Methyl nonanoate	fruity, fatty, peppery	adds body, harshness
Methyl 2-nonenoate	mild, fatty-green	weak
Methyl 2-nonynoate	cucumber, vegetable	fresh, cooling, vegetable
Methyl octanoate	smoothing, adds body	smoothing, adds body
Methyl 2-octynoate	green, nutty, adds harshness	sweet, chemical
Methyl oleate	weak	weak
Methyl palmitate	smoothing	smoothing
Methyl phenylacetate (70, 87)	honey, floral, resinous	sweet, floral, honey
α-Methylphenylethyl butyrate	sweet, floral	floral, herbaceous
2-Methyl-4-phenyl-2-butyl acetate	floral, sweet	fresh, floral
Methyl propionate	pungent, buttery-nutty, fruity-floral	sweet, caramel, nutty, fruity
Methyl salicylate	mint (wintergreen), sweet	sweet, mint (wintergreen)
Methyl 9-undecenoate	smoothing, green, earthy	smoothing, floral, green
Methyl valerate	winey, fruity, buttery	winey-fruity
Methyl isovalerate	fruity, winey	sweet, fruity, winey
Myrtenyl acetate	green	green, harsh
Myrtenyl isobutyrate	terpeny, green	green, harsh
Myrtenyl formate	grass-green	green, harsh
β-Naphthyl anthranilate	adds body, bitter, harsh, fruity	sweet, fruity
Neryl acetate	green, floral, adds body	sweet, floral
Neryl butyrate	weak fruity, floral, adds body	fruity, nutty, floral
Neryl isobutyrate	green, floral-fruity	sweet, floral-citrus
Neryl formate	sweet, floral, green-herbaceous	sweet, green
1,3-Nonanediol acetate (mixed esters)	floral	floral, citrus
Nonyl acetate	green, leafy	green, adds harshness
3-Octenyl acetate	green, herbaceous, sweet	green, herbaceous

Compound	Smoke Taste	Smoke Aroma
Octyl acetate	green, fruity, fatty	weak fruity
Octyl butyrate	green	green, weak
Octyl isobutyrate	sweet, green	sweet, weak earthy
Octyl formate	green, woody, sweet, floral	sweet, woody-floral
Octyl phenylacetate	resinous	resinous
Octyl propionate	herbaceous, green	green, warm
Perillyl acetate	floral, sweet, herbaceous	sweet, floral
Phenylethyl acetate (125)	floral, honey	floral, honey
Phenylethyl anthranilate	sweet, weak floral	sweet floral
Phenylethyl benzoate	sweet, green, floral	sweet, green, floral
Phenylethyl butyrate	sweet, floral	floral, sweet
Phenylethyl isobutyrate	nutty, fruity, floral, musty	sweet, fruity, floral, musty
Phenylethyl cinnamate	woody, balsamic, spicy	balsamic, green, spicy
Phenylethyl formate	green, herbaceous, floral	sweet, floral
Phenylethyl 2-furoate	sweet, caramel, fruity, floral	sweet
Phenylethyl hexanoate	green	sweet, green
Phenylethyl octanoate	fatty, green, herbaceous	green
Phenylethyl phenylacetate	sweet, nutty, balsamic	sweet, floral, balsamic
Phenylethyl propionate	floral	floral
Phenylethyl salicylate	green, balsamic	smoothing
Phenylethyl senecioate	sweet, honey, nutty	sweet, honey
Phenylethyl tiglate	floral, winey	floral
Phenylethyl isovalerate (87)	green, floral, sweet	floral, smoothing
2-Phenoxyethyl isobutyrate	peppery, floral	floral
3-Phenylpropyl acetate	weak green	green, musty, floral, balsamic
2-Phenylpropyl butyrate	sweet, fruity (peach)	fruity (peach)
2-Phenylpropyl isobutyrate	sweet, floral, fruity	sweet, floral
3-Phenylpropyl isobutyrate	sweet, balsamic, fruity	sweet, fruity
3-Phenylpropyl cinnamate	spicy, floral, balsamic	sweet, floral, spicy-balsamic
3-Phenylpropyl formate	sweet, herbaceous, spicy-balsamic	spicy-balsamic, sweet
3-Phenylpropyl propionate	sweet, spicy, caramel, balsamic	sweet, caramel, balsamic
Piperonyl acetate	sweet, floral	sweet, floral

Compound	Smoke Taste	Smoke Aroma
Piperonyl isobutyrate	sweet, fruity (berry-like)	sweet, fruity
Propyl acetate	sweet, fruity, adds body	sweet, fruity
Propyl benzoate	hay, balsamic	adds body
Propyl butyrate	sweet, fruity	weak, sweet, fruity
Propyl isobutyrate	sweet, fruity	nutty, winey, smoothing
Propyl cinnamate	sweet, balsamic	sweet, balsamic
Propylene glycol monoacetate (mixture of isomers)	smoothing, adds body	peppery
Propyl formate	rum, winey	weak
Propyl 2-furanacrylate	sweet, smoothing, fruity-caramel	sweet
Propyl 2-furoate	nutty	sweet, herbaceous
Propyl gallate	weak, metallic, bitter	weak
Propyl heptanoate	winey, green	green
Propyl hexanoate	fruity, sweet	weak, sweet
Propyl *p*-hydroxybenzoate	weak	weak
Propyl laurate	fatty, waxy	fatty, waxy, smoothing
Propyl myristate	sweet, adds body	adds body, smoothing
Propyl phenylacetate	floral	green, floral
Propyl propionate	sharp, fruity	sharp, fruity
Propyl isovalerate	smoothing, fruity, nutty, winey	walnut
Rhodinyl acetate	green, leafy, floral	sweet, floral
Rhodinyl formate	sweet, citrus, fruity, floral	sweet, floral, citrus
Rhodinyl phenylacetate	sweet, woody-nutty-honey, floral, herbaceous	sweet, honey, herbaceous
Rhodinyl propionate	sweet, floral	sweet, hay, floral
Rhodinyl isovalerate (87)	floral, fruity, nutty	floral, fruity
Santalyl acetate	sweet, woody, floral	sweet, woody, floral
Sucrose octaacetate	bitter, woody	woody
Terpinyl acetate	smoothing, woody-floral	woody, citrus, terpeny
Terpinyl anthranilate	bitter, floral	floral
Terpinyl butyrate	smoothing, sweet	sweet, smoothing
Terpinyl isobutyrate	bitter	smoothing, spicy, pine
Terpinyl formate	adds body, peppery	smoothing
Terpinyl propionate	smoothing	sweet, citrus
Tetrahydrofurfuryl acetate	adds body	adds body, burley note

Compound	Smoke Taste	Smoke Aroma
Tetrahydrofurfuryl propionate	adds body, caramel, fruity, floral	smoothing
o-Tolyl acetate	green, banana-fruity	fruity, sweet floral
p-Tolyl acetate	harsh, green, herbaceous	chemical
p-Tolyl isobutyrate	harsh, green	green, oily
p-Tolyl phenylacetate	sweet, floral	floral, sweet
Triacetin	weak	weak
Tributyl acetylcitrate	weak, sweet	weak, fruity
Tributyrin	sweet, weak fruity	sweet, weak
Triethyl citrate	winey	weak
Tripropionin	sweet, weak fruity	sweet, weak
Triisovalerin	weak fruity	weak fruity
10-Undecen-1-yl acetate	fatty	fatty
Vanillin acetate	weak vanilla	weak vanilla

TABLE VIII – ETHERS, PYRONES

Compound	Smoke Taste	Smoke Aroma
2-Amyl-5(or 6-)-keto-1,4-dioxane	sweet, weak fruity (peach-apricot)	fruity
Anethole (86, 87)	sweet, anise	sweet, anise
Anisole	sweet	adds body
Benzyl butyl ether	floral, sweet	floral
Benzyl ethyl ether	weak, fruity	sweet
sec-Butyl ethyl ether	sweet, buttery	sweet, buttery
2-Butyl-5(or 6-)-keto-1,4-dioxane	sweet, fruity	sweet, fruity
l-Carvone oxide	weak spearmint, herbaceous	mint, herbaceous
Caryophyllene oxide	woody, cedar	woody, cedar
Cedrene epoxide	woody, cedar, pine	woody, pine
Cedrol methyl ether	woody	woody, cedar
Dodecahydro-3a,6,6,9a-tetramethylnaptho-[2,Ib] pyran (25)	woody, amber, cedar	woody, cedar
Diphenyl ether (112)	sweet, floral, soapy	sweet, floral, soapy
2,5-Diethyltetrahydrofuran	minty	minty, herbaceous
m-Dimethoxybenzene	sweet, floral, smoothing	sweet, floral
p-Dimethoxybenzene	spicy, sweet, adds body	sweet, spicy
3,4-Dimethoxystyrene	adds body, peppery	- -

Compound	Smoke Taste	Smoke Aroma
Estragole; (methyl chavicol) (86)	sweet, woody, anise, herbaceous	sweet
Ethyl maltol	sweet	sweet
Eucalyptol; (1,8-cineole)	pine, medicinal	pine
Eugenol methyl ether	sweet, weak, woody, spicy, earthy	woody, weak
2-Hexyl-5(or 6-)-keto 1,4-dioxane	warm fruity, herbaceous	adds body
3-Hydroxy-4-pyrone	sweet	sweet
5-Hydroxy-2-methyl-4-pyrone	sweet	sweet
Isoeugenol ethyl ether	sweet, weak spicy	spicy, adds body
Isoeugenol methyl ether	sweet, vanilla, floral	sweet, floral, vanilla
Isolongifolene epoxide	pine, camphoraceous	pine, woody
Isophorone oxide	harsh, adds body	adds body
Limonene epoxide (mixture of isomers)	sweet, citrus	sweet, citrus
Maltol (96)	sweet	sweet
Manool oxide	weak, adds body	weak
p-Menth-1-ene epoxide (mixture of isomers)	smoothing, mint, sweet	smoothing, sweet
Menthofuran	bitter, harsh	bitter, herbaceous
o-Methyl anisole	floral, smoothing, cream	sweet, floral
p-Methyl anisole	sweet, woody, floral	sweet, woody, floral
2-Methylfuran	adds body, sweet	adds body
Methyl phenylethyl ether	sweet, floral	sweet, floral-rose
β-Naphthyl ethyl ether	sweet, floral	floral, sweet
Phenylpropyltetrahydrofuran	green, nutty, fruity	sweet, weak-floral
p-Propyl anisole	sweet, anise	sweet
Rose oxide	sweet, floral	floral, smoothing
Rum ether; (ethyl oxyhydrate) (70)	rum, winey	weak
4,5,6,7-Tetrahydro-3,6-dimethylbenzofuran	sweet, mint, cooling	sweet, mint
1,2,3-Trimethoxybenzene	burnt note, musty	– –
o-Vinylanisole	mild	mild
2,3,4a,5,6,6a,7,8,9,10, 10a,10b-Dodecahydro-3,4a,7,7,10a-pentamethyl-1(H)naphtho[2,1b] pyran (34)	cedar, cooling	cedar

Compound	Smoke Taste	Smoke Aroma
Dodecahydro-3a,6,6,9a-tetramethylnaphtho[2,lb]-furan-2-ol (107)	cedar	cedar

TABLE IX – IMIDES

Compound	Smoke Taste	Smoke Aroma
Caffeine	harsh, nutty	harsh
α,β-Ethylmethylmaleimide (67)	sweet, adds body, flue-cured note	sweet
α,β-Ethylmethylsuccinimide	sweet, nutty, bran, flue-cured note	sweet
α,β-Dimethylmaleimide (67)	buttery, sweet, flue-cured note	sweet
α,β-Dimethylsuccinimide	sweet, smoothing, adds body	adds body
α,α-Dimethylsuccinimide	sweet, green hay, adds body	sweet, hay, adds harshness
3-Methylglutarimide	bitter, harsh, chemical	chemical
N-Methylsuccinimide	phenolic, adds body, flue-cured note	sweet phenolic
α-Isopropylmaleimide	weak musty, sweet, flue-cured note	sweet
α-Isopropylsuccinimide	sweet, adds harshness, green-hay, toasted, musty	green, musty, adds harshness
Succinimide	phenolic, flue-cured type note	adds body

TABLE X – KETONES

Compound	Smoke Taste	Smoke Aroma
Acetanisole	sweet, hay, harsh	hay, chemical
Acetoin	sweet, buttery, fatty	sweet, buttery, sharp
2-Acetonyl-4-methyltetrahydropyran (96, 112)	sweet, fruity, nutty	sweet
2-Acetonyl-3-isopropyl-6-methyltetrahydropyran (2 isomers) (96)	sweet, phenolic, woody	sweet, flue-cured notes
2-Acetonyl-3-isopropyl-tetrahydrofuran	sweet, fruity-green, nutty, floral	sweet, fruity, flue-cured note
Acetophenone (96)	sweet, pungent, ketonic (cherry-hay)	sweet, musty, cherry

Compound	Smoke Taste	Smoke Aroma
α-Acetylbutyrolactone	nutty, green	sweet, floral
2-Acetylfuran	green, herbaceous, adds harshness	adds body, chemical
2-Acetyl-5-methylfuran (96, 109)	sweet, aromatic, spicy, enhanced burley note	adds body
Allyl α-ionone	strong floral, woody	floral, woody
Benzoin	green, spicy	weak nutty, spicy
Benzophenone	pungent, green	pungent
Benzyl dimedone	weak	weak
2-Butanone	sweet, ketonic	sweet, mellowing
4-(1,3-Butadienyl)-3,5,5-trimethyl-2-cyclohexen-1-one (92, 96)	spicy, peppery, adds body	adds body
4-(2-Butenylidene)-3,5,5-trimethyl-2-cyclohexen-1-one (4 isomers) (96, 103, 104)	spicy, peppery, adds body	adds body
d-Camphor (10, 70)	pine, camphoraceous, cooling	camphoraceous, cooling
l-Carvone (87)	sweet, spearmint, herbaceous	weak mint, adds body, herbaceous
d-Carvone (87)	green, weedy, herbaceous	adds body
2-Cyclopentenone	floral, peppery, harsh	– –
2-Decanone	harsh, chemical	harsh
Diacetyl (70)	buttery, sweet	buttery, smooth
Dihydrojasmone	sweet, floral	floral
Dihydroxyacetone (39a)	buttery, nutty, adds body	buttery, green
2,4-Dimethylacetophenone	green, pungent, hay	green, hay
3,5-Diisobutyl-2-hydroxyacetophenone (49)	sweet, green, floral	– –
3,5-Diisopropyl-2-hydroxyacetophenone (49)	enhanced aroma, burley, cocoa notes	– –
2,5-Dimethyl-4-hydroxy-3(2H)-furanone	sweet	sweet
3,5-Dimethyl-2-hydroxyacetophenone (49)	improved aroma and balance	– –
1,3-Diphenylpropanone	weak, sweet, honey, hay	mellowing
Ethyl cyclopentenolone	sweet, maple	sweet
2-Ethyl-4(and 3-)-methyl-2-carbethoxycyclopentanone (isomer mixture)	sweet, adds body, flue-cured note	sweet

Compound	Smoke Taste	Smoke Aroma
2-Ethyl-5-methyl-2-cyclopenten-2-ol-1-one	adds body	adds body
Farnesylacetone	green, sweet flue-cured note	smoothing, green
d-Fenchone (10)	camphoraceous, medicinal	harsh, medicinal, camphoraceous
4-(2-Furyl)-3-buten-2-one	sweet, spicy, weak woody	spicy, slight sweet
(2-Furyl)-hydroxymethyl ketone, acetate	buttery, smoothing, adds richness	smoothing
(2-Furyl)-hydroxymethyl ketone	smoothing	smoothing
Geranylacetone (27, 96)	green, adds body	green
2,3-Heptanedione	buttery, sweet	buttery
2-Heptanone	sweet, fruity	sweet, floral, fruity
3-Heptanone	sweet, sharp fruity, weak chemical	fruity, chemical
4-Heptanone	sweet, fruity, green, weak chemical	fruity, weak chemical
2,3,6,7,8,8a-Hexahydro-7-keto-2,5,5,8a-tetramethyl-5(H)-1-benzopyran (110)	Oriental tobacco-type note, woody, ionone note	- -
Hexahydro-2,5,5,8a-tetramethyl-7-chromanone (96, 97a)	camphoraceous	- -
3,3a,4,5,7,7a-Hexahydro-4,4,7a-trimethyl-6(2H)-benzofuranone (96)	mild	- -
2,3-Hexanedione	buttery	buttery
2-Hexylidene cyclopentanone	floral, green	floral, green, fruity
2-Hydroxyacetone	smoothing, winey	smoothing
m-Hydroxyacetophenone	smoothing, sweet, adds body	smoothing
p-Hydroxyacetophenone	bitter, weak	weak
3-Hydroxy-2,3,4,5,6,7-hexahydro-3,3a,7,7-tetramethylinden-2-one (96)	sweet	sweet
4-Hydroxyisophorone (97b)	sweet, flue-cured note	sweet, floral
4-(1-Hydroxy-4-keto-2,6,6-trimethyl-2-cyclohexen-1-yl)-3-buten-2-one	sweet, enhanced flue-cured taste, nutty	sweet

Compound	Smoke Taste	Smoke Aroma
4-(4-Hydroxy-2,6,6-trimethyl-1-cyclohexen-1-yl)-2-buten-4-one; (4-hydroxydamascone)	green, rose-floral, sweet, burley note	adds body
2-Hydroxy-4-keto-isophorone (96)	slight nutty, chocolate	adds body
2-Hydroxymethyl-5-methyl-4-hydroxy-3(2H)-furanone	sweet, nutty, adds richness, flue-cured note	flue-cured note
4-Hydroxy-2,6,6-trimethyl cyclohexanone (96, 97b)	weak ketonic	– –
5-Hydroxy-4-octanone	nutty, buttery	buttery
4-(*p*-Hydroxyphenyl)-2-butanone	sweet, intense fruity (raspberry)	sweet, fruity (raspberry)
1-Indanone	sweet, green, chemical	– –
1,3-Indanedione	astringent, bitter	– –
α-Ionone	sweet, floral, woody, smoothing	floral, woody
β-Ionone	sweet, woody, floral, smoothing	woody, floral
α-Irone	sweet, floral	sweet, floral
α-Isomethylionone	woody, cedar, adds body	woody, sweet, floral undertone
Isophorone (96, 97b)	earthy, adds body	earthy, harsh, burley note
p-Isopropylacetophenone	herbaceous, woody	sweet, woody
3-Isopropenylcyclopentyl methyl ketone (60, 61, 96)	sweet, pungent	– –
3-Isopropylcyclopentyl methyl ketone (60, 61)	strong burley note, adds body	adds body
2-Isopropenyl-3,5,5-trimethyl-2-cyclo-hexen-1-one	smoothing, sweet burley note	smoothing
5-Isopropyl-2-methyl-1,3-nonadien-8-one; (Solanone) (27, 96)	smoothing, ketonic	– –
3-Isopropyl-5-methyl-2-hydroxyacetophenone (49)	smoothing, chocolate, oily	– –
5-Isopropyl-3-nonen-2,8-dione; (Norsolanadione)(96)	sweet ketonic	sweet
cis-Jasmone	spicy, floral, herbaceous	spicy, floral
4-Ketoamyl-1-acetate	sweet, harsh	adds body

Compound	Smoke Taste	Smoke Aroma
4-(4-Keto-2-6,6-trimethyl-2-cyclohexen-1-yl)-butan-2-ol	green, floral	floral
4-(4-Keto-2,6,6-trimethyl-2-cyclohexen-1-yl)-3-buten-2-ol	sweet, adds body, flue-cured notes	sweet
4-(4-Keto-2,6,6-trimethyl-2-cyclohexen-1-yl)-butan-2-one	fruity, green, floral, harsh	adds body
4-(4-Keto-2,6,6-trimethyl-2-cyclohexen-1-yl)-3-buten-2-one	sweet, floral	sweet, floral
4-(3-Keto-2,6,6-trimethyl-1-cyclohexen-1-yl)-3-buten-2-one	sweet, light, adds richness, flue-cured note	sweet, flue-cured note
4-(3-Keto-2,6,6-trimethyl-1-cyclohexen-1-yl)-3-buten-2-ol	adds body, burley character	adds body, burley note
4-Ketodihydroisophorone (96, 97b)	weak, sour	-- --
4-Ketoisophorone (96, 97b)	sweet, ionone character	-- -
4-Keto-2,6,6-trimethyl-2-cyclohexenylidene-acetaldehyde (96)	adds body, enhances taste	adds body, burley note
1-(2-Ketopropylidenyl)-3,5,5-trimethyl-2-cyclohexene (2 isomers, *cis/trans*)	smoothing, sweet	smoothing, sweet
p-Menthan-2-one (10)	sweet, smoothing	sweet, smoothing, weak herbaceous
p-Menthan-8-thiol-3-one	sulfuraceous	wine-like
l-Menthone (10)	mint, adds body, harshness	mint, herbaceous, adds body, sour
4-(*p*-Methoxyphenyl)-2-butanone	sweet, floral, fruity	floral, sweet
1-(*p*-Methoxyphenyl)-1-penten-3-one	spicy, peppery	spicy, green
1-(*p*-Methoxyphenyl)-2-propanone	hay, adds body	adds body
p-Methylacetophenone (27, 70)	cherry, sweet hay	cherry, almond, adds body
3-Methyl-3-cyclopenten-1,2-dione	dry, musty, harsh	harsh
Methyl cyclopentenolone	sweet, maple	sweet

Compound	Smoke Taste	Smoke Aroma
Methyl cyclopentenolone butyrate (102)	maple, weak fruity	weak
Methyl cyclopentenolone propionate (102)	weak, acrid	acrid
3-Methyl-2-cyclopentenone	sweet, chemical	– –
4-(3,4-Methylenedioxy-phenyl)-2-butanone	sweet, floral	sweet, floral, woody
4-Methyleneisophorone (96, 97b)	isophorone-like	– –
6-Methyl-3,5-heptadien-2-one	sweet, spicy, buttery	sweet
6-Methyl-2,5-heptanedione (96, 112)	ketonic, smoothing	burley note
6-Methyl-5-hepten-2-one (27)	smoothing, adds body, green	smoothing
5-Methyl-2,3-hexanedione	sweet, adds body, buttery	sweet
2-Methyl-1-indanone	musty, weak nutty, roasted note	– –
Methyl α-ionone	nutty, woody, floral	nutty, floral
Methyl β-ionone	mild, sweet, nutty, woody, floral	sweet
Methyl γ-ionone	woody, adds body	woody
Methyl β-naphthyl ketone	floral, citrus	floral, sweet, fruity
4-Methyl-2-pentanone	weak fruity	weak
4-Methyl-1-phenyl-2-pentanone	sweet, woody, spicy	woody, spicy, fruity
3-Methyl-4-phenyl-3-buten-2-one	nutty, adds burley note	adds burley note
1-(Methylthio)-2-butanone	rubbery, thiol, hot	floral, sweet
Nootkatone	bitter, weak grapefruit	– –
2-Nonanone	sweet, fruity	fruity
2-Octanone	very fruity	sweet, fruity
3-Octanone	fruity	sweet, fruity, woody, earthy
2,2,3,3,4-Pentamethylcyclo-pentanone (10)	camphoraceous, medicinal	camphoraceous
3,4,4,5,5-Pentamethyl-2-cyclopentenone	green, leafy	green
2,3-Pentanedione	buttery	buttery, nutty
2-Pentanone	ketonic, fruity, sweet	adds body, sweet
4-Phenyl-3-buten-2-one	adds body, chocolate	adds harshness

Compound	Smoke Taste	Smoke Aroma
1-Phenyl-1,2-propanedione	sweet, bitter, balsamic	sweet
d-Piperitone	minty, herbaceous, spicy, adds body	adds body, herbaceous
Piperitenone (53)	enhanced flavor, smoothing	- -
d-Pulegone	herbaceous, minty	herbaceous
Tetrahydrojasmone (10)	fatty, floral	floral, fatty
4,5,7,7a-Tetrahydro-4,4,7a-trimethyl-6(2H)-benzofuranone (96)	pleasant, mild	- -
4,4a,5,6-Tetrahydro-4,4,7-trimethyl-2(3H)-naphthalenone (62, 63, 91, 96)	pleasant, weak, green, woody	- -
3,4,7,8-Tetrahydro-4,4,7-trimethyl-2(6H)-napththalenone (96)	weak woody	- -
Tetramethyl ethylcyclohexenone (mixture of isomers)	caramel, spicy	spicy, nutty
Theaspirone (32)	sweet, woody	enhanced burley notes
β-Thujaplicin	musty	musty
4-(2,6,6-Trimethyl-1-cyclohexen-1-yl)-2-buten-4-one; (damascone) (56)	adds body, floral	adds body
4-(2,6,6-Trimethyl-1,3-cyclohexadien-1-yl)-2-buten-4-one; (damascenone) (56)	adds body, burley note	adds body
Zingerone	sweet, balsamic, spicy, adds body	balsamic, spicy

TABLE XI – LACTONES

Compound	Smoke Taste	Smoke Aroma
1,2-Benzodihydropyrone	nutty, hay, honey, spicy	spicy, sweet, hay
Benzopyrone	sweet, hay, coconut, honey	sweet, coconut, hay
γ-Butyrolactone	adds body, burley notes	adds body
Decahydro-3a,6,6,9a-tetramethylnaphtho[2,1b]-furan-2(1H)-one; (Sclareolide; Noram-breinolide) (50, 106)	cedar, woody	cedar
γ-Decalactone (119)	peach, sweet	sweet, peach
δ-Decalactone (114)	smoothing, sweet buttery	sweet, smoothing
4,4-Di-*n*-butyl-γ-butyro-lactone (113)	weak, adds body	adds body
Dihydroactinidiolide (7, 96)	slight cooling	
2,2-Dimethyl-3-hydroxy-γ-butyrolactone	adds body, peppery	adds body
γ-Dodecalactone (119)	sweet, peach	sweet, peach
δ-Dodecalactone (114)	sweet, fruity	sweet
3-Ethyl-γ-butyrolactone (108)	adds body, fruity, sweet, rich	adds body
5-Ethyl-3-hydroxy-4-methyl-2(5H)-furanone (17)	sweet, maple	sweet
Gluconic acid, δ-lactone	sweet, nutty, flue-cured note	smoothing, sweet
γ-Heptalactone (119)	nutty, hay, coconut	adds body, sweet, nutty
ω-6-Hexadecenlactone; (Ambrettolide)	musk, perfume	musk, perfume
γ-Hexalactone (96, 119)	adds body, nutty, burley notes	adds body
2-Hydroxy-γ-butyrolactone	adds body, richness, harsh	adds body
2-Hydroxy-3,3-dimethyl-γ-butyrolactone	smoothing, sweet, buttery	smoothing, sweet

Compound	Smoke Taste	Smoke Aroma
2-Hydroxy-4-methyl-γ-butyrolactone; (2-hydroxy-γ-valerolactone)	sweet, adds body, richness	adds body
4-Hydroxy-4-methylhexanoic acid, γ-lactone; (4-methyl-γ-hexalactone) (96, 113)	green, sweet	– –
4-Hydroxy-4-methyl-5-hexenoic acid, γ-lactone; (4-vinyl-γ-valerolactone) (96, 113)	weak, fruity, mint	– –
2-Hydroxy-2,6,6-trimethyl-3-cyclohexenylacetic acid, γ-lactone (96)	spicy, sweet fruity	– –
5-Hydroxy-3-isopropyl-2-pentenoic acid, δ-lactone (114)	coconut, sweet	– –
4-Hydroxytetradecanoic acid, γ-lactone (119)	weak peach	– –
4-Isobutyl-γ-butyrolactone (118)	enhanced tobacco flavor	– –
2-Isopropyl-γ-butyrolactone (96, 108)	weak, sweet, mint, woody	– –
3-Isopropyl-γ-butyrolactone (96, 108)	sweet, light burley note	– –
2-Isopropyl-δ-hexalactone (114)	sweet, smoothing, spicy	smoothing
3-Isopropyl-δ-hexalactone (114)	adds body	adds body
3-Isopropyl-δ-valerolactone (96, 114)	coconut, sweet, smoothing	smoothing
6-Methylbenzopyrone	sweet, green hay	sweet, hay, floral
3-Methyl-γ-butyrolactone (108)	smoothing	– –
3-Methyl-δ-hexalactone (114)	musty	mild
2-Methyl-γ-valerolactone (113)	sweet, spicy, coconut	– –
3-Methyl-γ-valerolactone (mixture of isomers)(96, 113)	sweet, caramel, adds body	adds body
3-Methyl-δ-valerolactone (114)	sweet, spicy-apple, light flue-cured note	sweet
γ-Nonalactone (119)	coconut	coconut
Octahydrobenzopyrone (90)	enhanced tobacco flavor	– –
γ-Octalactone (96, 119)	coconut	coconut

Compound	Smoke Taste	Smoke Aroma
ω-Pentadecalactone	lifting, musk, animal, floral	musk, floral
Phthalide (96)	adds body, weak	weak
3-Propylidenephthalide	sweet, buttery, caramel, bitter aftertaste	celery, herbaceous
Scopoletin	weak, sweet	sweet
γ-Undecalactone (70, 119)	sweet, peach	sweet, peach
γ-Valerolactone (96, 119)	sweet, light, resinous flue-cured note	sweet

TABLE XII – PHENOLS

Compound	Smoke Taste	Smoke Aroma
Carvacrol	adds body, burnt note, bitter	adds body, burnt note
p-Cresol	phenolic, harsh	harsh
2,6-Dimethylphenol	sweet, adds body	sweet
2-Ethyl-4,5-dimethylphenol	adds body	– –
4-Ethylguaiacol	sweet, warm, adds body	sweet, vanilla
Eugenol (125)	spicy, clove	spicy, clove
Guaiacol	sweet	sweet
Isoeugenol	spicy, clove, woody	spicy, woody
2-Isopropyl-4-methylphenol	sweet, earthy, smoothing	sweet, earthy
2-Methoxy-4-methylphenol	vanilla, sweet	caramel, vanilla, sweet
o-(Methylthio)phenol	sweet, phenolic, weak cooling	sweet, phenolic
Phenol	sweet, medicinal, burnt note	sweet, medicinal
Propenylguaethol	sweet, vanilla	very sweet, vanilla
6-Propyl-*o*-cresol	adds body, peppery	– –
Thymol	bitter, adds body, flue-cured and burnt note	sweet, burnt note
2,3,4-Trimethylphenol	adds body, phenolic	– –
2,3,5-Trimethylphenol	adds body, weak	– –
2,3,6-Trimethylphenol	harsh, phenolic	– –

TABLE XIII – PYRIDINES, QUINOLINES, INDOLES

Compound	Smoke Taste	Smoke Aroma
6-Hydroxynicotine	weak flavor, adds body	weak, smoothing
Indole	smoothing, floral	floral, smoothing
Isoquinoline	sweet, balsamic	sweet
4-Methylquinoline	sweet, chemical, enhances tobacco notes	sweet, nutty
Skatole	sweet, fecal	sweet, fecal
3-Acetylpyridine	buttery, harsh	harsh
2-Ethylpyridine (59)	enhances burley character	– –
3-Ethylpyridine (59)	adds cigar aroma	– –
4-Ethylpyridine (59)	enhanced tobacco flavor	– –
2,4-Dimethylpyridine (59)	weak, enhanced tobacco flavor	– –
2,5-Dimethylpyridine (59)	weak, enhanced tobacco flavor	– –
2,6-Dimethylpyridine (59)	enhanced burley character	– –
3,4-Dimethylpyridine (59)	adds body, enhanced burley character	– –
3,5-Dimethylpyridine (59)	enhanced flue-cured character	– –
2-Hydroxypyridine	smoothing, sweet nutty	sweet, smoothing
3-Hydroxypyridine	green	green
2-Hydroxy-6-methylpyridine	chemical, adds body	sweet
3-Hydroxy-6-methylpyridine	musty, adds body	peppery
4-(β-Methoxyethyl)pyridine	smoothing, phenolic	– –
3-Methylpyridine (59)	adds body, enhanced burley character	– –
4-Methylpyridine (59)	adds body, enhanced burley character	– –
2-Methyl-5-isopropyl-pyridine (112)	adds body, burley character	– –
Pyridine	adds flue-cured note, sweetness	– –
3-Pyridylacetic acid (as Hydrochloride salt)	sweet, chocolate	harsh, musty
2,4,6-Trimethylpyridine (59)	adds body	– –
2-Pyridinemethanethiol	smoothing	mild

TABLE XIV - PYRAZINES, DIHYDROPYRAZINES

Compound	Smoke Taste	Smoke Aroma
2-Acetylpyrazine (95, 96)	buttery, nutty	popcorn
2-Acetyl-6-methylpyrazine (95, 96)	buttery, nutty	popcorn
2-Butylpyrazine (89)	earthy, herb-like character, aromatically mild	- -
2-*sec*-Butylpyrazine (89)	somewhat dull, soft, aromatic character	- -
2-Cyclopentylpyrazine (89)	slightly amino-like, burley character, not penetrating	- -
2,5-Diethylpyrazine (89)	slightly amine-like sweetness with amplified smoke character	- -
2,3-Dimethylpyrazine (89)	bread-like, roasted	nutty, earthy
2,5-Dimethylpyrazine (89)	likable earthy character	- -
2,6-Dimethylpyrazine (89)	dull herbal sweetness	- -
2-Ethylpyrazine (89)	aromatic earthy depth of flavor	- -
2-Ethyl-3,5(or 6-)-dimethylpyrazine (mixture of isomers) (89)	burley-like character, musty	burley character
3-Ethyl-2,6-dimethyl-pyrazine (89)	burley character, nutty, chocolate	nutty, chocolate
2-Ethyl-5-propylpyrazine (89)	amplified, more vigorous smoke impression	- -
2-Furylpyrazine (89)	fresh tangyness	- -
2-[β-(2-Furyl)ethyl] pyrazine (89)	filled out savor, refreshing character	- -
2-Isobutylpyrazine (89)	dull-vigorous	- -
2-Isobutyl-3-methoxy-pyrazine	potent musty, vegetable-like note, adds burley character	musty, chocolate, burley
2-Isopropylpyrazine (89)	burley-like flavor imparted, vigorous	- -

Compound	Smoke Taste	Smoke Aroma
2-, 5- or 6-Methoxy-3-methylpyrazine (mixture of isomers)	roasted nut (peanut)	nutty
2-Methylpyrazine (89)	dully sweet, aromatic	- -
2-Methyl-3-butylpyrazine (89)	dull bread-like flavor, slightly mellowed, on the whole slightly emphasized	- -
2-Methyl-5-butylpyrazine (89)	slightly roasted character, dull sweetness	- -
2-Methyl-5-*sec*-butyl-pyrazine (89)	burley character, slightly roasted	- -
2-Methyl-3-ethylpyrazine (89)	roasted, nut-like character, natural flavor given greater depth	- -
2-Methyl-5-ethylpyrazine (89)	mellow depth in harmony with tobacco	- -
2-Methyl-6-ethylpyrazine (89)	dry sweet character, somewhat resiny	- -
2-Methyl-3-furylpyrazine (89)	somewhat dull fruity tonation, pronounced general impression	- -
2-Methyl-5-furylpyrazine (89)	pleasantly fruity smoke flavor, slight amine-like sweetness	- -
2-Methyl-6-furylpyrazine (89)	fruity-resiny impression, soft sweetness	- -
(5-Methylfuryl)pyrazine (89)	pronounced tangyness with a fruit-like freshness	- -
2-Methyl-5-furylethyl-pyrazine (89)	slight amine-like burley character, slightly fruity	- -
2-Methyl-3-, 5- or 6-furfurylthiopyrazine (mixture of isomers)	sweet, adds body	caramel note
2-Methyl-3-isobutyl-pyrazine (89)	dull emphasis of overall impression, more pronounced	- -
2-Methyl-5-isobutyl-pyrazine (89)	bread-like impression with slight burley character	- -
2-Methyl-3-phenyl-pyrazine (89)	dull nut-like character, deepening of the natural flavor	- -

Compound	Smoke Taste	Smoke Aroma
2-Methyl-3-phenylethyl-pyrazine (89)	bread-like dull roasted flavor	- -
2-Methyl-3-propylpyrazine (89)	ground nut-like	- -
2-Methyl-5-propylpyrazine (89)	dully toned flavor impression, vigorous character	- -
2-Methyl-6-propylpyrazine (89)	pine-like character, soft	- -
2-Methyl-3-, 5- or 6-methylthiopyrazine (mixture of isomers)	sweet, nutty	nutty
2-Methyl-3-vinylpyrazine (89)	fresh roasted flavor, somewhat dull and softly toned	- -
2-Methyl-5-vinylpyrazine (89)	dull amine-like impression with improved vigor	- -
2-Pentylpyrazine (89)	deeply pronounced depth	- -
2-Phenylpyrazine (89)	dully aromatic, pronounced tangyness	- -
2-Propylpyrazine (89)	dully aromatic, blunt sweetness	- -
Pyrazineethanethiol	herbaceous	mild
Pyrazinyl methyl sulfide	mellowing	mild
2,3,5,6-Tetramethyl-pyrazine (89)	burley note, smoothing, mellowing	burley note, smooth
2,3,5-Trimethylpyrazine (89)	burley character, sweet, adds body	burley note, adds body
2-Vinylpyrazine (89)	fullness of flavor, deep flavor impression, somewhat earthy character	- -
2-Ethyl-3,5 (or 6-)-dimethyl-5,6-dihydropyrazine	burley character, smoothing, adds body	adds body, burley character
2-Methyl-3-propyl-5,6-dihydropyrazine	nutty	adds body
2,3,5,5-Tetramethyl-5,6-dihydropyrazine	burley note, adds body, nutty, winey	burley note, adds body
2,3,5-Trimethyl-5,6-dihydropyrazine	sweet, buttery-chocolate, adds body, burley character	chocolate, burley notes

TABLE XV – PYRROLES

Compound	Smoke Taste	Smoke Aroma
2-Acetylpyrrole (68, 96)	floral, green, winey, adds body	burley note, adds body
2-Formylpyrrole (68, 96)	sweet, smoothing	– –
1-Methyl-2-acetylpyrrole	sweet, floral, adds body	floral, adds body
5-Methyl-2-acetylpyrrole (68, 93, 96)	sweet, imitation cherry-like	sweet
1-Methyl-2-formylpyrrole (94, 96)	sweet, cherry, adds body	adds harshness
5-Methyl-2-formylpyrrole (68, 93, 96)	cherry, adds body	adds harshness
2,5-Dimethyl-3-acetyl-pyrrole	sweet, adds body	sweet, adds body

TABLE XVI – SULFUR COMPOUNDS

(not listed elsewhere)

Compound	Smoke Taste	Smoke Aroma
Allyl disulfide	garlic, nutty	garlic
Butyl sulfide	floral, oily	fatty
Furfuryl mercaptan	coffee, adds body, chemical, bitter	adds body
Furfuryl methyl sulfide	adds body, harsh, onion-garlic	harsh
Furfuryl isopropyl sulfide	strong, harsh, sulfuraceous	harsh
Phenyl disulfide	harsh, sulfuraceous	harsh
Propyl disulfide	sulfuraceous, garlic, pungent	pungent, sulfuraceous
o-Toluenethiol	sulfuraceous, rubber	sulfuraceous

TABLE XVII – HERBS, ESSENTIAL OILS, EXTRACTS

Compound	Smoke Taste	Smoke Aroma
Alfalfa, extract	green, herbaceous	green, herbaceous, hay-floral

Compound	Smoke Taste	Smoke Aroma
Allspice, oil	spicy, peppery, adds body	peppery, adds body
Allspice, oleoresin	green, sweet, herbaceous, spicy	floral, earthy
Almonds, bitter, oil (70)	cherry, almond, warm, sweet	sweet
Aloe, extract	irritating	harsh, chemical
Ambergris, tincture	sweet, woody, amber, earthy	sweet, woody, amber
Ambrette, absolute	strong musk	musk
Ambrette, essence	strong musk	musk
Angelica root, oil	weak musk	musk (macrocyclic type)
Angelica seed, oil	sweet, green, herbaceous	green, adds body
Angelica root, extract (70)	herbaceous, adds body	herbaceous
Anise, oil	sweet, anethole	sweet, anethole
Anise, Star, oil	sweet, anethole	sweet, anethole
Apricot kernel, oil	sweet, fatty, fruity	fatty
Asafetida, oil	pungent, adds body, harshness	harsh, peppery
Balsam Fir, oil	sweet, balsamic	sweet balsamic
Balsam, Peru (70, 87)	sweet, spicy-resinous, balsamic	very sweet, spicy, balsamic
Basil, oleoresin	green, herbaceous	smoothing
Basil, oil	green, herbaceous, spicy	green, herbaceous, spicy
Bay leaves, West Indian, oleoresin	spicy, clove-eugenol	green, woody, clove, resinous
Bay leaves, West Indian, oil	spicy, clove-eugenol	spicy-eugenol
Bay, sweet, oil	fatty, spicy, resinous	heavy, woody, spicy,
Beeswax, white	smoothing	smoothing
Benzoin, resin	sweet, balsamic	sweet, balsamic
Bergamot, oil (87)	sweet, floral	soapy-floral
Birch, sweet, oil	sweet, mint (wintergreen)	sweet, mint, weak cooling
Bois de Rose, oil	floral, soapy (geraniol)	floral-rosy
Boronia, absolute	sweet, floral-fruity	sweet, floral
Buchu leaves, oil	cedar, pine	pine-woody
Cade, oil (Juniper tar)(70)	smoky, phenolic, latakia notes	smoky, latakia notes
Cajeput oil	camphoraceous-cineole	spicy, camphoraceous

Compound	Smoke Taste	Smoke Aroma
Camphor, Japanese, white, oil	cooling, camphoraceous	camphoraceous
Cananga, oil	sweet, woody, floral, spicy	sweet, floral-balsamic
Caraway, oil	strong, weedy, herbaceous, fatty	harsh, herbaceous, woody
Cardamon seed, oil (70)	sweet, spicy, floral	sweet, spicy-citrus, floral
Carob bean, extract (70)	sweet, nutty	adds body
Carrot seed, oil	sweet, fatty, earthy	sweet, fatty
Cascara, bitterless, extract	bitter	chemical
Cascarilla bark, oil (70, 87)	spicy	spicy, adds body
Cassia, oil (87)	cinnamon-spicy, warm, sweet	spicy
Cassie, absolute (87)	floral, sweet	sweet, weak floral
Castoreum, absolute	intensely sweet, leather, smoky, animal notes	sweet
Cedar leaf, oil (87)	intense, sharp cedar, bitter	cedar, weak spicy
Cedarwood, Virginia, oil (87)	woody, adds flue-cured note	woody, smoothing
Celery seed, oil (70)	sweet nutty, fatty, celery, weak bitter	nutty, fatty, celery
Celery seed, extract	bitter, fatty, herbaceous	fatty, celery
Chamomille flower, Roman, oil (70)	strong tobacco, hay, sweet, fatty, adds body	strong tobacco enhancement, fatty
Chamomille flower, Roman, absolute	strong tobacco, sweet hay notes	sweet, weak floral-herbaceous
Chamomille flower, Hungarian, oil (70)	strong heavy tobacco note	enhances tobacco aroma
Chamomille flower, Hungarian	very sweet, herbaceous	sweet, herbaceous
Cherry bark, wild, extract	weak, bitter	sweet, herbaceous
Chicory, absolute	weak, adds body	weak, adds body
Cherry laurel, oil	adds body, harshness	fruity, balsamic, fatty
Cinnamon	spicy, sweet, warm, adds body	sweet, spicy, adds body
Cinnamon bark, oil (70)	spicy, sweet, warm	sweet, spicy, adds body
Cinnamon leaf, oil (70, 87)	spicy, sweet, warm	sweet, spicy, smoothing
Citronella, oil	green, citrus, floral, bitter	floral, soapy, burnt citrus peel
Civet, absolute	intensely sweet, fecal	sweet, animal-like, musk
Clove bud, oil (87)	spicy, eugenol, tangy, sweet, adds body	sweet, spicy

Compound	Smoke Taste	Smoke Aroma
Clove bud, oleoresin	spicy-eugenol, tangy, sweet, adds body	sweet, spicy
Clove leaf, oil (87)	spicy-eugenol, tangy, sweet, adds body	sweet, spicy
Clove stem, oil (87)	spicy-eugenol, tangy, adds body, sweet	sweet, spicy
Clover tops, red, extract	sweet, hay, adds body	sweet, hay
Cognac, green, oil	sweet, pungent, oily, green	adds body, pungent
Cognac, white, oil	weak fatty, green	fatty, green
Coriander, oil (70)	floral, citrus, light spicy	sweetens, light floral
Corn silk, extract	sweet, nutty, green, adds body	sweet, adds body
Costus root, oil	musty, animal notes	musty, buttery
Cubebs, oil	warm, sweet, peppery-woody	adds body, spicy
Cumin, oil	powerful, green, spicy-herbaceous, curry-like	green, spicy-herbaceous
Curacao peel, oil	citrus peel, bitter	citrus, sweet
Currant buds, black, absolute	green, woody	weak green
Dandelion root, extract	sweet, bitter aftertaste	sweet, herbaceous
Davana oil	sweet, fruity (blueberry), blends well	sweet, fruity
Dill, oil	spicy, warm, weedy	weedy, green
Doggrass, extract	sharp, drying	weak
Elder flowers, extract	sweet, anisic, herbaceous	sweet
Elemi, oil	citrus, peppery, terpeny	citrus, terpeny
Erigeron, oil	herbaceous, bitter	sweet, spicy
Estragon, oil	green, herbaceous, woody, bitter	anise note
Eucalyptus, oil	piney, camphoraceous, medicinal	camphoraceous
Fennel, sweet, oil	sweet, anise (anethole)	sweet, anise, woody
Foenugreek, extract (70)	adds body, nutty, maple, sweet	adds body, woody-maple
Fusel oil, refined	oily, green	green, fruity, harsh
Galbanum, oil	green, herbaceous	green, herbaceous, bell pepper odor

Compound	Smoke Taste	Smoke Aroma
Galbanum, oleoresin	herbaceous	herbaceous
Garlic, oil	garlic, harsh, pungent	garlic
Genet, absolute	sweet, hay, flue-cured notes	sweet, hay, flue-cured notes
Gentian root, extract	adds body	weak sweet
Geranium, Algerian, oil (70, 87)	sweet, floral	adds body
Ginger, extract	adds body, spicy	spicy, sweet
Ginger, oil	adds body, spicy	sweet, spicy
Ginger, oleoresin	smoothing, sweet	smoothing
Grapefruit, oil	bitter, citrus, green, terpeny	sweet
Guaiac, wood, oil	adds body, harshness, woody	woody-nutty
Haw bark, black, extract	peppery, hot	nutty, sweet
Hemlock, oil (Spruce oil)	bitter, sweet	woody, sweet
Hops, extract	sweet, spicy, warm	smoothing, green
Hops, oil	spicy, herbaceous, bitter	minty, burley character, adds body
Horehound, extract	floral, sweet	smoothing, sweet
Hyssop, oil	camphoraceous, spicy	sweet, camphoraceous, herbaceous
Immortelle, extract	weak herbaceous, hay	adds body, weak fruity, herbaceous
Jasmine, absolute (87)	sweet, floral	sweet, floral
Jasmine, oil	sweet, floral	fresh floral
Juniper berries, extract	sweet, smoothing	sweet
Juniper, oil	green, sweet balsamic, floral	sweet, green-woody, floral
Kola nut, extract	adds body, harshness, herbaceous, sweet, nutty	adds body, burley character
Labdanum, oil	sweet, animal-like, woody, herbaceous	sweet, herbaceous
Labdanum, oleoresin	very sweet, animal-like, herbaceous	sweet, green, herbaceous
Laurel leaves, extract	spicy, green, herbaceous	sweet, green
Lavandin, oil	spicy, floral, herbaceous	sweet, leafy green
Lavender, absolute	green, floral, adds body	floral, green
Lavender, concrete	smoothing, hay, floral	sweet, hay, floral
Lavender, oil (87)	floral, green, adds body	sweet, floral

Compound	Smoke Taste	Smoke Aroma
Lemon, extract	green, citrus-lemon	green, citrus
Lemon oil (70, 87)	weak lemon-citrus, terpeny	citrus-terpeny
Lemon oil, terpeneless (70, 87)	lemon-citrus, terpeny	citrus-terpeny
Lemongrass oil	green, citral-lemon, somewhat floral-herbaceous	stale citrus-terpeny
Licorice extract	sweet, woody, smoothing	woody
Licorice extract, powder	sweet, woody, smoothing	woody
Lime oil	weak lime-citrus, terpeny	citrus-terpeny
Lime oil, terpeneless	lime-citrus, weak terpeny	citrus
Linaloe wood, oil	woody, nutty	adds richness and body
Lovage, oil (70)	nutty, spicy, sweet, maple, fatty	nutty, sweet
Lovage, extract	spicy, sweet, nutty	sweet, nutty
Mace, oil (70)	sweet, spicy-nutmeg, adds body	sweet, spicy
Mace, oleoresin (70)	spicy, sweet, adds body	spicy (nutmeg), sweet
Mandarin, oil	sweet, pungent-bitter citrus	sweet, citrus
Marjoram, oleoresin	smoothing, adds body, spicy	sweet, woody
Marjoram, sweet, oil	spicy-nutty, bitter	sweet, warm
Mimosa, absolute	green, woody, floral	woody, floral, sweet
Mountain maple, extract	bitter, sweet	sweet, cellulosic
Musk, tonquin	bitter	musty, musk
Mustard, oil	green, very harsh, pungent, sour	pungent
Myrrh, oil	sweet, herbaceous, bitter	sweet, herbaceous
Neroli Bigarde, oil (70, 87)	light, sweet-floral	light, sweet, smoothing
Nutmeg, oil (87)	sweet, spicy	sweet, spicy
Nutmeg, oleoresin	sweet, spicy	sweet, spicy
Oak chips, extract	sweet, floral, hay	sweet, floral
Oakmoss, absolute	sweet, hay	sweet, pine
Olibanum, oil	green, spicy-woody	sweet, green, 'incense'
Onion, oil	onion, floral, adds body	onion, nutty
Orange blossoms, absolute (87)	weak	weak, sweet, floral
Orange leaf, absolute	green, citrus	sweet, mellowing
Orange oil	citrus-terpeny	weak, terpeny
Orange oil, terpeneless	orange-citrus	citrus
Orange peel, bitter, oil	terpeny	weak

Compound	Smoke Taste	Smoke Aroma
Orange peel, sweet, oil (87)	citrus, adds body	weak citrus
Orange peel, sweet, oil, terpeneless (87)	citrus, adds body, orange	sweet, orange-citrus
Orange peel, sweet, extract	citrus, musty-terpeny, adds body	sweet, weak citrus, adds body
Origanum, oil	woody, herbaceous, phenolic	woody, citrus, herbaceous
Orris, concrete, liquid oil	fatty, floral	fatty, floral
Orris root, extract (87)	floral-woody, enhances tobacco notes	floral-woody, adds body
Palmarosa, oil	citrus, floral	floral
Parsley, oleoresin	woody, herbaceous	green, spicy-herbaceous
Paprika, oleoresin	weak floral	sweet, pleasant
Patchouli oil (87)	sweet, intensely woody	sweet, woody
Pennyroyal oil	bitter, adds body, herbaceous, woody	woody, floral
Pepper, black, oil	sweet, spicy	spicy, sweet
Pepper, black oleoresin	harsh, bite, spicy-nutty	stinging, spicy
Pepper, white, oil	sweet, spicy	spicy, sweet
Peppermint leaves	minty, herbaceous	herbaceous
Peppermint, oil	minty, adds body, weak herbaceous	adds body, minty
Pettitgrain, lemon, oil	citrus, sweet, lemon	citrus, sweet
Pimenta leaf, oil (70)	spicy-clove	spicy, green
Pine needle, dwarf, oil *(Pinus pumilio)*	sweet, woody-pine	sweet, green-pine
Pine needle, oil	terpeny, pine-woody	sweet, pine-woody
Pine, Scotch, oil *(Pinus sylvestris)*	sweet, green, woody-pine	sweet, woody-pine
Pipsissewa leaves, extract	yeasty	weak
Quassia, extract	sweet, vanilla note	sweet
Rhatany, extract	sweet, herbaceous	weak, sweet
Rose, absolute (87)	floral, rose	sweet, floral, rose
Rose, Bulgarian, true otto, oil (70, 87)	rose-floral	floral, sweet
Rose Hips, extract	sweet, smoothing	sweet, floral
Rosemary, oil	herbaceous	herbaceous
Rue, oil	herbaceous, acrid, bitter	herbaceous
Sage, Clary, concrete *(Salvia sclarea)*	sweet, green, herbaceous, floral, smoothing	sweet, green, herbaceous, floral

Compound	Smoke Taste	Smoke Aroma
Sage, Clary, oil *(Salvia sclarea)*	sweet, green, hay, floral	sweet, green, hay, floral
Sage, Clary, absolute *(Salvia sclarea)*	sweet, green, floral, hay, herbaceous	sweet, floral, hay
Sage, Dalmatian, oleoresin	adds body, spicy, herbaceous	herbaceous-woody
Sage, Dalmatian, oil	sweet, spicy, herbaceous	sweet, herbaceous, nutty-woody
Sage, Spanish, oil	spicy, herbaceous, camphoraceous	sweet, herbaceous, spicy
Sandalwood, yellow, oil (87)	intense sweet, woody, green, floral, balsamic	sweet, floral-woody, balsamic
Sarsaparilla, extract	weak sweet, adds body	weak sweet
Savory, oil	woody, green, herbaceous	woody-cedar
Schinus Molle, oil	sweet, light, spicy	sweet, adds body
Snakeroot, Canadian, oil (70)	spicy, warm, herbaceous	spicy, woody
Spearmint leaves	minty, herbaceous, weedy	minty, herbaceous
Spearmint oil	minty, herbaceous, weedy, adds body	minty, herbaceous
Spearmint, concrete	sweet, minty, herbaceous	minty, herbaceous
Spike, lavender, oil	camphoraceous, herbaceous	woody
Spruce, oil	woody, sweet, floral	woody, floral
Styrax, oil (70)	adds body, balsamic, sweet	balsamic, sweet
Styrax, Honduras, extract	smoothing, woody, balsamic	sweet, balsamic
Tagettes, oil	fruity, adds body	fruity
Tangerine, oil	bitter, orange-citrus peel	citrus peel
Tarragon, oil	smoothing, herbaceous	smoothing, spicy
Thyme, white, oil	bitter, herbaceous, spicy, medicinal	spicy, herbaceous
Thyme, Tunisian, oil	bitter, herbaceous, spicy, medicinal	spicy, herbaceous
Tolu, Balsam, gum (70)	woody, sweet, balsamic	woody, sweet, balsamic
Tolu, Balsam, extract (70)	sweet, balsamic	sweet, balsamic
Tuberose, oil (87)	oily, intense floral	sweet, floral
Tumeric, extract	spicy	light, spicy
Turpentine	pine-terpeny	fresh, pine notes
Valerian root, extract (70)	enhances tobacco taste, adds body, woody	sweet, woody

Compound	Smoke Taste	Smoke Aroma
Valerian root, oil (70, 85)	enhances tobacco taste, some Oriental tobacco character, woody	sweet, woody
Vanilla, extract (87)	sweet, vanilla	sweet, vanilla
Vanilla, oleoresin (87)	sweet, vanilla, smoothing	sweet, vanilla
Violet leaves, absolute	green, vegetable	green, herbaceous
Wintergreen, oil	mint, sweet	sweet, mint, weak cooling
Wormwood oil	herbaceous, green	herbaceous
Ylang Ylang, oil	powerful floral, sweet woody	sweet, floral, woody

TABLE XVIII – HYDROCARBONS AND MISCELLANEOUS

Compound	Smoke Taste	Smoke Aroma
Camphene	sweet, camphoraceous	strong, sweet, woody
β-Caryophyllene	spicy, woody, sweet	woody, adds body
Cedrene	weak woody	weak woody
Clovenes	woody, spicy	spicy
p-Cymene	terpeny, bitter	fatty, terpeny
Dodecahydrobiphenyl (77)	enhanced flavor, mild peppery background	– –
Eremophilene	mild, woody	weak woody
Glycyrrhizin, ammoniated	sweet (sugar-like), woody	sweet, woody, smoothing
α-Gurjunene	sweet, earthy	sweet
d-Limonene	smoothing	smoothing
Longifolene	mild, flue-cured note, somewhat acrid-type taste	woody, herbaceous
5-Methylquinoxaline	earthy, musty	musty
1-Methyl-3-cyclohexyl-cyclohexane (77)	fruity-resin-like character	– –
1-Methyl-4-isopropenylbenzene	styrene-kerosene note	chemical
Musk ambrette (85)	musk	musk
Myrcene	sweet, musty, terpeny	musty, terpeny
α-Phellandrene	green, sweet, terpeny	green, sweet
α-Pinene	pine-woody, turpentine	pine-woody, terpeny
β-Pinene	sweet, woody, turpentine	woody, terpeny

Compound	Smoke Taste	Smoke Aroma
Perillartine	sweet (sugar-like), cumin aftertaste	weak
Terpinolene	terpeny, woody	peppery

SELECTION OF FLAVORING MATERIALS

Tobacco Top Flavorings (General)—Historically the tobacco industry has used common herbs and botanicals either in their natural state, as extracts, or as essential oils for fortifying and/or altering the tobacco taste. Materials such as Orange, Lemon, Patchouli, Rose, Neroli, Tonka, Deer Tongue, Vanilla, Valerian, Orris, Bergamot, Cardamon, Cinnamon, Coriander, Cedarwood, Mace, Lavender, Cascarilla, Sandalwood, Lovage, Styrax, Balsam Peru, Balsam Tolu, Foenugreek, Rum, and Geranium are old favorites (70, 75, 85, 87, 123, 124, 125). But, progress in the chemistry of flavorings now allows one to choose also from a variety of individual chemical substances which possess specific desired flavor notes. From the preceding tables, one may select the useful materials which will fulfill particular needs.

The use of any given flavoring material is dependent upon several factors:

1. Is the material readily available at reasonable cost?
2. Does it blend well and enhance the smoking flavor of the specific tobacco base to which it is added?
3. What is the optimum use level?
4. What is its effect on package aroma?
5. Is it stable on storage?
6. Is the method of applying the flavoring material to the tobacco base compatible with acceptable manufacturing operations?
7. Is the material safe from a toxicological standpoint?

Cigarette Flavorings—In general, the types of flavors used on cigarettes are designed to enhance or modify the natural flavors in the individual tobacco types present without upsetting the "balance" of the blend. The following are examples of materials which have found wide use in the development of cigarette flavorings, but the experienced flavorist can select many more from the preceding tables.

Herbs, extracts, essential oils		Flavor chemicals
Valerian	Bergamot	2-Acetylpyrazine
Mace	Geranium	γ-Undecalactone
Rose	Clove	Vanillin
Coriander	Lavender	*l*-Menthol
Vanilla	Chamomille	β-Phenylethyl valerate
		Phenylacetic acid

Cigar Flavorings--The flavoring of cigars requires a somewhat different approach than that for cigarettes as the natural cigar aroma and flavor is stronger and of different character than that produced by cigarette type blends. In addition, it is often desirable to provide the product with a unique and distinctive taste different from the natural cigar aroma. The following are useful examples of materials that blend well with cigar tobaccos.

Herbs, extracts, essential oils	Flavor chemicals
Vanilla	Ethyl vanillin
Cedarwood or Cedar Leaf oil	Sclareolide
Sandalwood	4-(*p*-Hydroxyphenyl)-2-butanone
Balsam Peru	Propenylguaethol
Cascarilla	γ-Decalactone
Clove	Eugenol
Rum	Santalol
Davana	Cedrol
	Isoamyl cinnamate

Pipe Tobaccos--There are several types of pipe tobaccos marketed and they can generally be classified as straight or regular, mild aromatic and aromatic. The "straight or regular" pipe tobacco blends employ flavors similar to those classically used on cigarettes, that is, the top flavorings are usually designed to enhance and modify the natural smoking flavor of the pipe blend. The "mild aromatic" and "aromatic" blends use highly flavorful and powerful aromatic materials to produce a distinctive pack and smoke aroma; the major difference between these latter two categories is often simply the amount of flavoring used. Rum (and more recently whiskey) has classically been employed as the carrier in which flavors are applied in many major pipe tobacco brands. The following are some examples of materials useful in the development of pipe tobacco flavors.

Herbs, essential oils, extracts	Flavor chemicals
Rose	Piperonal
Vanilla	Ethyl vanillin
Anise	Methyl salicylate
Orange	γ-Nonalactone
Cassia	Ethyl valerate
Clove	Trimethylpyrazine
Balsam Peru	Benzaldehyde
Patchouli	

FLAVORANT USE LEVELS

The use level of any given flavorant depends to a large extent on the taste and aroma threshold perception level of the flavor material and the degree to which the flavorist wishes the consumer to detect it. In addition, the flavor characteristics of many materials change somewhat depending on the final concentration in the tobacco product. For example, 2-isobutyl-3-methoxypyrazine (Table XIV) has an extremely low aroma perception threshold and at low concentrations (e.g., .0000001%) enhances the burley character of the smoke while at increasing use levels (e.g., .001%) it possesses a strong green bell pepper-musty-herbaceous taste and aroma. On the other end of the scale, *l*-menthol is not perceptible to most as producing a cooling sensation at levels below .03% in tobacco and is commonly used at levels up to .45% in mentholated cigarettes. *l*-Menthol, however, is useful at levels down to about .001% for synergistically enhancing other flavor materials. In general, the individual top flavoring components in tobacco are used at levels of .000001–.5% to achieve the desired results.

l-Menthol also possesses the interesting characteristic of "lifting" certain flavors in a manner similar to the previously mentioned use of acids for fully developing citrus juice flavors in solutions. For example, if a cigarette is designed to give an orange flavor through application of orange oils, only the oily-orange-terpeny note is ordinarily perceived; however, addition of *l*-menthol to the same product, at levels where a perceptible cooling effect is noted, synergistically "lifts" the orange character and a truer orange-like taste is perceived by the smoker. Such synergistic interactions of individual flavorants, although poorly understood from a scientific viewpoint, are an important characteristic in the development of tobacco flavorings.

The chemistry of taste and olfaction is still a fledgling science (31, 57, 73, 74, 82, 84, 105), but several factors regarding the use of menthol in tobacco products relate directly to the human flavor (= taste and aroma) receptor systems. It has long been known by tobacco flavorists that at the levels commonly employed in mentholated cigarettes the use of *d*-menthol or *dl*-menthol does not give the same degree of pleasant cooling sensation as *l*-menthol. In addition, a distinct "musty note" is detected with *d*- or *dl*-menthol which is not present in *l*-menthol (Table III). The stereoselective activation of the so-called "cold" receptors to one optically active form in preference to its enantiomer is paralleled in other flavor systems by only a few chemicals (e.g., *l*-carvone-spearmint note, *d*-carvone-caraway note and the taste threshold levels of the enantiomeric nootkatones) (82, 84).

The methods of application vary somewhat with individual manufacturers but common methods are to incorporate flavorants either into the casing or to spray them as top flavorings onto the finished cut tobacco in alcohol-water solutions prior to cigarette or cigar making and/or packaging. The solubility of the flavoring material often dictates which method of application is employed. Recent innovations for incorporating flavor materials directly into cigarette paper or on the paper by use of films which retain flavorants are of interest (36, 52). Other methods for introduction of

flavors are the use of encapsulated flavors in the tobacco (88) or the introduction of flavors into the filter tow of filter tipped cigarettes and cigarillos (86). The use of chemical precursors of low volatility which are stable on tobacco but release active flavorants on smoking has been discussed previously on page 10.

In summary we hope this publication will serve as a comprehensive reference to a number of flavor materials useful for flavoring tobacco and as a guide to the current state of the art–as it passes from the realm of an "art" to that of the world of modern "science."

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