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[54] **HOP VARIETY NAMED 'COLUMBUS'**

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[52] **U.S. Cl.** **Plt./236**

[58] **Field of Search** Plt./100, 236

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[57] **ABSTRACT**

A new and distinct variety of hop, *Humulus lupulus* L., named Columbus, has a superior yield of cones and a superior content of alpha acids in its resin. The new variety was cultivated as a result of a cross at a nursery near Prosser, Wash., United States, and has been asexually reproduced in and about Yakima, Wash., United States.

5 Drawing Sheets

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 08/159,859, filed Nov. 30, 1993, now abandoned.

TECHNICAL FIELD

The field of the present invention is hops.

BACKGROUND OF THE INVENTION

Of conventional hop varieties, there are at least twenty named commercially grown hop varieties in the United States today, and some seventy-five to eighty varieties that are grown around the world. The varieties differ as to assorted physical features such as vine color and structure, as well as cone number, location, size and shape.

Commercial varieties of hop are female hops that exist as a perennial rootstock that produces an annual flush of

above-ground, or aerial, vegetation. The perennial rootstock is comprised of a woody crown with a number of main roots and sub-roots that are used for water uptake, nutrient uptake, and winter starch storage. Over the winter, the woody crown supports many buds that develop into main vines (shoots) in the spring, emerge from the ground, and extend to produce the annual above-ground vegetation. In nature, with the onset of frosts in the fall, the above-ground portion of the plant "dies-back" to ground level, and only the perennial rootstock survives into the following year.

A main vine consists of a single flexible cylinder that produces pairs of leaves at nodes separated by variable distances along the length of the vine. The length of main vine between a pair of nodes is known as an internode. A bud is produced in the junction between leaf and vine, which junction is also known by the botanical term axil. Such a botanical term, as well as other botanical terms herein, are generally known to those of skill in the art, and can also be found in standard botanical texts such as Simon, E.W., et al., Lawson's Textbook of Botany—Revised, University Tutorial Press Ltd., London, England, 14th Ed. 1966. The bud

grows and develops into a lateral, also known as a side-shoot or side-arm, with the same basic vegetative structure as the main vine. The buds on the laterals develop into groups of flowers that later mature into cones (strobiles). Because the laterals produce and support the cones of the hop, the structure of the laterals strongly influences the number of cones produced and hence the ultimate commercial yield of a variety.

The cones are the useful brewing commodity, and are referred to as "hops" in the commercial industry. Each cone is a group of flowers (inflorescence) consisting of sepals and petals (bracts and bracteoles) mounted on a central strig (or rachis). The resultant structure resembles a small pine cone or fir cone but is non-woody and green in color. In nature, the bracteoles support the seed of the plant.

Complete descriptions of the botanical structure of the hop plant are given in Burgess, "Hops—Botany, Cultivation and Utilization," Weed Crop Series, Interscience Publishers, Inc., New York, 1964 and Neve, "Hops," von Nostrand Reinhold, New York, 1991.

A trellis of poles and wire, commonly 18 feet in height and known as a "high trellis," supports strings that the main vines climb. The main vines grow to the top of the trellis, where they produce the laterals that support the groups of flowers that develop into the cones. Typically, the laterals bear cones only in the upper parts of the plant (i.e., closer to the main vine); the distance from the main vine varies from one variety to another. Under an alternative growing system, the "HopUnion Low Trellis Hop Growing System," the vines are grown on a trellis of single rows of 10 feet in height, like wine grapes (the 10 foot trellis is referred to herein as a "low trellis"). (Lewis, "The HopUnion U.S.A., Inc.—Low Trellis Hop Production System," Proc. Tech. Comm. of the IHGC of the XXXVIIIth International Hop Congress, Hereford, U.K. Published Rijksstation voor Landbouwtechniek, Merelbeke/Gent, Belgium, 17–37, 1990.) Under either system, when the cones are physiologically mature (ripe), the cones are harvested, then dried and compressed into bales for market, where the cones are typically used for the productuion of beverages such as beers, ales and related alcohol-containing liquids.

Different varieties of hops have differences in the chemical constituents of the lupulin of their cones. Accordingly, chemical analysis of such differences can be useful in distinguishing one hop variety from another. Such analysis is generally performed by high pressure liquid chromatography ("HPLC") of the soft resins along with gas liquid chromatography ("GLC") of the essential oils. Recently, Kenny developed a key for differentiation of hop varieties based on chemical analysis of the soft resins. (Kenny, "Identification of U.S. Grown Hop Cultivars by Hop Acid and Essential Oil Analyses," *J. Amer. Soc. Brewing Chemists* *48*(1):3–8, 1990.) Further, Peacock and McCarty, as well as Kenny, have developed keys for the differentiation of hop varieties based on chemical analysis of the essential oils. (Peacock and McCarty, "Varietal Identification of Hops and Hop Pellets," *Master Brewer Assoc. of the Americas Technical Quarterly* *27*:81–85, 1992; Kenny, supra.) These keys are based on gross differences in the amounts of, and ratios between, major constituents, which differences are large enough to overcome variation inherent in the analytical analysis of biological material.

SUMMARY OF THE INVENTION

The present invention provides a new variety of hop (*Humulus lupulus* L.), which has been named 'Columbus'. The new variety comprises a superior yield of cones and, as discussed below, a superior content of alpha acids in its soft resins. Columbus is particularly suited for the production of beverages such as beers, ales and related alcohol-containing liquids.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a section of Columbus vine near harvest.

FIG. **2** depicts a low trellis planting of Columbus.

FIG. **3** depicts early season growth of Columbus with an internode length of about 3 inches.

FIG. **4** depicts Columbus on a low trellis and shows the density of the cones in the canopy (cones per lateral node).

FIG. **5** depicts the physical appearance of Columbus cones.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a new variety of hop (*Humulus lupulus* L.), named 'Columbus,' that has a superior yield of cones and a superior content of alpha acids in its soft resins. Columbus may be classed as a bitter hop (i.e., high in alpha acids content). Columbus was bred as the result of an open-pollination cross that was carried out in 1982 at a small hop nursery near Prosser, Wash. U.S.A, and was known by the identification number 9/17. Pursuant to growth, analysis, and testing, Columbus was identified and selected from numerous candidates arising from the cross. The exact parentage of Columbus is unknown. The breeding nursery that produced Columbus contained 20–30 female plants from which seed was collected en masse, and an approximately identical number of male plants were growing and flowering at the time that pollination occurred. Columbus is a diploid hop.

Set forth below are various characteristics that distinguish Columbus from conventional hop varieties. Columbus is initially distinguishable on the basis of its physical characteristics, including the location of its cones, the internode distance, number of cones per node, the yield of its cones, and the physical characteristics of the cones. Columbus is also distinguishable on the basis of its chemical characteristics, which are determined by chemical analyses of the soft resins and essential oils. Additionally, methods for asexual reproduction of Columbus are discussed.

I. Physical Characteristics of Columbus

A. Location of Cones

Columbus bears a high number of cones on its laterals down to a height of about 4 feet from the ground, when grown on a high trellis. A close-up Figure depicting in detail the vine structure of Columbus is presented as FIG. **1**. Conversely, most conventional hop varieties on a high trellis do not bear significant numbers of cones below about 8 feet from the ground.

On a low trellis, Columbus produces significant numbers of cones down to ground level, and cones can even be found on untrained side-shoots running along the ground. (FIG. **2**.) Conversely, most conventional hop varieties on a low trellis produce cones down to about 4 to 8 feet from the ground.

B. Internode Distance

The internode distance on a main vine of any hop variety is important to the yield of cones because the shorter the internode length, the greater the number of yielding laterals for a given length of main vine. Columbus has a shorter than average mature internode length, about 8" to 12", with an early season internode distance of about 3". (FIG. 3.) Conversely, in conventional hop varieties such as Nugget, the mature internode length varies from 10" to 16", with an early season internode distance of about 8". There are also "dwarf hops" in which the mature internode length varies between 5" to 8".

C. Growth Characteristics

Although the early season growth rate and length of time for hop vines to reach the top wire of a trellis vary widely due to factors such as climatic conditions and growth and harvest management, the early season growth of Columbus is generally faster than the most aroma hops (such as Tettnang, Perle, Centennial, Saaz, Spalt, Mt. Hood, Liberty, Hallertau, Hersbruck, and Fuggle), and also faster than the quicker-growing aroma hops such as Cascade and Willamette. Such aroma hops are generally first trained between May 7 and May 10, and reach the top wire between June 20 and June 30. The aroma hop Cluster and the bitter hops Galena and Chinook are typically trained about May 15 and reach the top wire from about June 20 to about June 30. The bitter hops Nugget, Olympic, Eroica, and Columbus are typically trained about May 25 and reach the top wire about June 27 to about July 7. Among this latter group, Columbus typically grows slower than the other hop varieties at first, but then accelerates its growth and can grow to the top faster than Nugget on occasion. In other words, Columbus is a late maturing hop, and has an early growth rate that is typical for bitter hops and for Cluster, but it is a slow starter.

D. Habit

In common with most other hop varieties, the main vines of Columbus are originally green in color but turn to dark red to purple as the season progresses. The main vines are ridged, and along the ridges are hooked hairs that adhere to the supporting trellis. A characteristic feature of Columbus vines, as discussed above, is the short internodes.

Although the lateral length of a hop variety can vary greatly due to factors such as climate and management practices, the laterals of Columbus are typically longer than those of aroma varieties, are typically similar in length to those of Galena and Nugget, and are typically shorter than Cluster, Chinook, Olympic and Eroica. A generalization of comparative lateral lengths is as follows:

TABLE 1

Hop Variety	Length of Lateral
Mt. Hood, Liberty, Saaz, Spalt, Perle, Hallertau, Tettnang, Hersbruck, Fuggle, Centennial	1'–2'
Cascade, Willamette	1.5'–2.5'
Columbus, Galena, Nugget	2.0'–3.0'
Cluster, Chinook, Olympic, Eroica	2.5'–3.5'

Although most commercial hops have longer laterals in the head and much shorter laterals in the lower reaches of the vine. Columbus tends to have approximately even length laterals along the length of the vine. The sub-branches of the laterals develop as bunches of cones, and as set forth below, Columbus has an unusually high number of cones in each lateral bunch, typically greater than any other commercial variety.

The head of the vine is also subject to variation depending on such factors as climatic conditions and management practices, but Columbus can be generally grouped with Cascade, Willamette, Nugget and Galena as having a moderate head, although the head of Columbus is slightly smaller and neater than typical. The head of Columbus also appears more dense than most other varieties, apparently because more laterals are developed from an equivalent vine length due to the short internode distance discussed above.

In terms of overall vine morphology, Columbus tends to be stronger than the aroma varieties but slighter than the other bitter hops and Cluster. As noted above, the overall vine morphology also gives the appearance of being more dense than other commercial hop varieties.

E. Leaf Morphology

The leaf morphology of Columbus is typical for most commercial hop varieties, and may be summarized as set forth in the table below.

TABLE 2

Character	Early Main Vine Leaves	Late Main Vine Leaves	Lateral Leaves
Number	2/node	2/node	2/node
Lobes	cordate - 3	35	cordate - 3
Width	3–5"	4–7"	1–2"
Length	3–5"	4–7"	1–2"
Upper Surface Texture	smooth	smooth	smooth
Lower Surface Texture	fairly rough	rough	slightly rough
Color	med-dark green	dark green	med-dark green
Margins	lightly serrated	moderately serrated	lightly serrated

The leaf color of Columbus is also similar to other commercial hop varieties, although in the early part of the growing season when Columbus is slower growing than other bitter hops and Cluster, Columbus has a darker leaf, while later in the season when Columbus is faster growing, the leaf of Columbus is similar to other hops in its class. The leaf of Columbus is typically not as dark as most of the slower growing aroma hops.

F. Number of Cones per Node

Typically, cones are found in high number clusters borne at nodes on a lateral that are close to the main vine ("basal lateral nodes"). Progressively fewer cones are found in the clusters located at nodes progressively farther away from the main vine. Ultimately, the lateral terminates in a tip bearing a single cone. Columbus yields a high number of cones at the basal lateral nodes as well as at nodes located farther away from the main vine. (FIG. 4.) The basal lateral nodes of Columbus have produced up to 42 cones. Conversely, conventional low yielding hop varieties typically bear clusters of about 8–16 cones at basal lateral nodes, while conventional high yielding varieties typically bear clusters of about 16–28 cones at basal lateral nodes.

G. Yield of Cones

Due to the above discussed characteristics, Columbus provides an outstanding hop variety comprising the follow-

ing: a plant bearing cones much lower down the main vine; a reduced internode length on the main vine, which results in a greater number of yielding laterals per given length of main vine; and, greater numbers of cones at each node, which results in greater numbers of cones on each of the yielding laterals. Accordingly, Columbus produces an outstanding yield of cones, whether grown on a high trellis or a low trellis.

Yield data for many hop varieties are compared with yield data for Columbus in Table 3. All hops were grown on a high trellis.

TABLE 3

Variety	Washington State Five-Year Average Yield (lb/acre)	HopUnion 1992 Average Yield (lb/acre)
Low yielding varieties		
Perle	1172	1366
Tettnang	970	1140
High yielding varieties		
Cluster	2018	2407
Chinook	1938	2216
Nugget	1950	2829
Galena	1926	2502
Columbus	—	3290

(Hop Growers of America, Inc., 1991–1992 Annual Statistical Report, 37th Annual HGA Convention, Portland, Oreg., 1993.)

Below in Table 4, yield data from low trellis hops grown at HopUnion farms for 1990 and 1992 are compared with experimental yield data for Columbus from 1991 and 1992.

TABLE 4

Yield Data for Low Trellis Hops

Variety	1990 Average Yield (lb/acre)	1992 Average Yield (lb/acre)
Perle	1557	1010
Tettnang	1062	800
Cascade	1415	1570
Chinook	1234	1017
Nugget	1712	1175
Galena	1800	1500
	(Year: 1991)	
Columbus	2832	3408

First year plantings of hops typically yield significantly less than mature plantings of the same varieties. However, a 1992 first year planting of Columbus on a low trellis yielded, over an area of about 4.5 acres, an average of 2547 lb/acre. Columbus produces such yields with a growth habit that presents no problems for ease of harvesting.

H. Physical Characteristics of the Cones

Cones are typically described by size (large, medium, or small) and by degree of compactness (loose, medium, or tight). Size and compactness are indicative of the degree of compression (internode length) between the nodes of the central strig that subtends (supports) the bracts and bracteoles. Also, cones are often described in terms of weight, most often expressed in milligrams (mg). Light cones are usually between 120 and 160 mg in weight, heavy cones usually between 160–220 mg (kiln dry basis). Often the description includes a brief comment on general shape of the cone, such as round, ovoid, plump, etc.

Columbus cones are normally medium in length, typically about 1.25", medium to tight in compactness, and typically about 1" in diameter. Further, Columbus cones are typically quite rounded and plump, and weigh about 180–250 mg (kiln dry basis) at maturity. (FIG. 5.) Conversely, Chinook cones typically have bracts with the tips turned backwards (reflexed). Fuggle cones are typically square in cross-section. Nugget cones are typically compact, tight, and firm. Columbus cones are typically more dense than other commercial hop varieties, and hence typically heavier on a per cone basis. Columbus cones have little or no propensity to shatter when fresh or when properly dried.

I. Disease and Pest Resistance

The susceptibility of Columbus to downy mildew (*Pseudoperunospora humuli*) is similar to Galena and Cluster, which are less resistant than most other commercial hop varieties. Columbus is apparently resistant to Verticillium wilt (*Verticillium dahliae*). Tests have indicated that Columbus can become infected with *Prunus necrotic* ringspot virus, hop latent virus and American hop latent virus, although it is also possible to free Columbus of these viruses by standard meristem culture techniques. Columbus has not shown any symptoms of infection when carrying these viruses, as is usual for most commercial hop varieties. Columbus shows no unusual tolerance or sensitivity to damson hop aphid (*Phorodon humuli*) and two spotted mite (*Tetranychus urticae*).

J. Quality Profile

Based upon sensory analyses of dried/baled leaf hop samples, Columbus has a quality profile that is similar to most other commercial hop varieties. Columbus has a mild, gentle aroma with no particular, peculiar character. However, Columbus is distinguishable from the commercial aroma varieties and Cluster by virtue of its higher resin content, which is indicated by visual inspection of the open cone and the much greater number of lupulin glands present in Columbus.

II. Chemical Characteristics of Columbus

A. Chemical Analyses in General

Chemical analysis of hops typically consists of analysis of the lupulin of the cones. The lupulin consists of the following chemical components and sub-components:

Soft resins	alpha acids (humulones) beta acids (lupulones)
Hard resins	
Uncharacterized resins	
Waxes	
Tannins	
Essential oils	hydrocarbons oxygenated compounds sulfur compounds

Of the above components, the soft resins and essential oils are of particular relevance to the differentiation of hop varieties. In regard to the soft resins, there are three analogues of the alpha acids, i.e., humulone, ad-humulone, and cohumulone, and there are also three analogues of the beta acids, i.e., lupulone, ad-lupulone, and colupulone.

Due to their chemical characteristics, some hop varieties are referred to as aromatic, or low alpha, hops and are known to contribute good hop flavor and aroma. Other hop varieties are high in bittering potential (i.e., high in alpha acids) and are referred to as bitter or high alpha hops. Columbus may be referred to as such a bitter or high alpha hop. Hop varieties in an intermediate varietal classification have medium levels of alpha acids and are referred to as dual-purpose hops.

B. Soft Resin Characteristics

Table 5 lists the total amount of alpha and beta acids, the ratio of alpha acids to beta acids, and estimates of the relative proportions of cohumulone and colupulone for several high alpha hops. This data was determined by HPLC analysis according to standard methods well known to those having skill in the art. (See, e.g., American Society of Brewing Chemists, "Hops Method 12: Analysis of Hops, Hop Powders and Hop Pellets by High Pressure Liquid Chromatography," in "Methods of Analysis," The Society, St. Paul, Mn., 8th ed. 1991.) Table 5 also gives data on storage losses, which indicate the loss of alpha acids by oxidation. The data are expressed as ranges to account for inherent biological variation from sample to sample.

TABLE 5

Parameter	Chinook	Nugget	Galena
Alpha acids (% w/w)	12.0–14.0	12.0–14.0	11.0–13.0
-cohumulone (%)	30–35	24–30	36–42
Beta acids (% w/w)	3.4–4.0	4.0–5.5	7.0–9.0
-colupulone (%)	55–66	50–55	60–65
Alpha/beta ratio	3.5–4.0	2.5–3.0	1.5–2.0
Oil content (mls/100 g)	1.5–2.3	1.2–2.0	0.7–1.2
Loss of alpha acids (%) -6 months storage room temperature	35–45	20–35	20–30

Parameter	Olympic	Eroica	Columbus
Alpha acids (% w/w)	11.5–13.5	11.0–13.0	14.0–16.0
-cohumulone (%)	27–34	38–43	30–35
Beta acids (% w/w)	4.0–6.0	4.0–5.5	4.5–5.5
-colupulone (%)	57–62	67–70	55–60
Alpha/beta ratio	2.0–2.7	2.2–2.8	2.7–3.3
Oil content (mls/100 g)	1.4–2.0	0.5–1.3	1.5–2.2
Loss of alpha acids (%) -6 months storage room temperature	40–55	35–50	60–80

Table 5 indicates the following: (a) Columbus has a higher content of alpha acids than the other high alpha hops; (b) Columbus' cohumulone and colupulone contents are higher than Nugget, lower than Eroica and Galena, and similar to Chinook; (c) Columbus' beta acid content is higher than Chinook and lower than Galena; (d) Columbus' alpha/beta ratio is higher than Galena or Olympic but lower than Chinook; and (e) Columbus more rapidly loses its alpha acids in ambient storage than the other varieties.

Table 5 shows that Columbus has an alpha acids content well in excess of 10% w/w. This distinguishes Columbus from the aromatic hops. Examples of such aromatic hops are listed in Table 6.

TABLE 6

Variety	Alpha acids content (% w/w of cone)
Cascade	4.5–7.0
Cluster	5.5–8.5
Fuggle	4.0–5.5
Hallertau	3.5–5.5
Hersbruck	3.5–5.5
Liberty	3.0–5.0
Mount Hood	5.0–7.5
Perle	7.0–9.5
Saaz	3.0–4.5
Spalt	3.0–5.5
Tettnang	4.0–5.0
Willamette	4.0–6.0

As discussed above, Kenny developed a key for identification of hop varieties based on the soft resin components. The application of the key of Kenny to Columbus is depicted in Table 7. At each decision point, certain varieties are eliminated according to a yes/no decision. The path to Columbus is shown by the double arrow. In the key depicted in Table 5, as well as in the other keys discussed herein, steps from the published key that did not eliminate any varieties in the present analysis have been deleted.

TABLE 7

			Major U.S. Variety Eliminations
1. Fresh alpha + beta > 15% and Fresh Alpha > 10% YES (High alpha hops)	→	NO	Cascade, Cluster, Fuggle, Hallertau, Hersbruck, Liberty, Mt. Hood, Perle, Saaz, Spalt, Tettnang, Willamette
2. Cohumulone > 40% NO	→	YES	Eroica
3. Colupulone > 60% NO	→	YES	Galena
4. Cohumulone < 30% NO	→	YES	Nugget
5. Alpha/beta ratio > 3.0	→	YES	Chinook (3.5–4.0)
	→	NO	Olympic (2.0–2.7)
Columbus(2.7–3.3)			

Table 7 relates to hops with a hop storage index, or HSI, well below 0.300, which indicates that the alpha and beta acids of the hops are fresh when analyzed. In Table 7, step 1 eliminates all the aromatic hops on the basis of their low content of alpha acids and low alpha plus beta acids. Step 2 eliminates Eroica on the basis of high cohumulone content. Step 3 eliminates Galena on the basis of high colupulone content. (Eroica is again eliminated at this step.) Step 4 eliminates Nugget on the basis of low cohumulone content. Step 5 eliminates Chinook on the basis of a high alpha/beta ratio, while Olympic is eliminated on the basis of a low alpha/beta ratio. Note, Chinook is also eliminated on the basis of its higher beta acid content.

Accordingly, Columbus is differentiated from all major U.S. varieties based on its soft resins content. Similarly, Columbus is distinguished from the minor U.S. hop varieties, except Aquila, Banner, and Centennial, based on soft resins content. However, Columbus is distinguished from Aquila, Banner, and Centennial by its essential oils content, as discussed below.

C. Essential Oils Characteristics

Detailed analysis of the essential oils allows a further differentiation of Columbus from other hops. Table 8 further

distinguishes some of the varieties discussed above in Table 7, while Table 9 distinguishes varieties not distinguished above.

Extraction and analysis of essential oils are performed according to methods well known to those having skill in the art. Preferably, the essential oils are extracted by steam distilling previously dried hops for about four hours (with the steam of the distillation condensed using a cold-finger condenser). The resultant essential oils are then examined by GLC analysis.

GLC analysis for various hops are presented as Appendices 1 and 2 hereto as follows:

Appendix 1: Detailed essential oil analysis results of many of the world's hop varieties including all U.S. grown varieties except Mount Hood. Columbus is the final entry.

Appendix 2: Detailed GLC traces and listings of constituent peaks from essential oils analysis. Columbus is compared with the other U.S. high alpha hops, Galena, Chinook, and Nugget.

As with the soft resins, keys can be used to differentiate by essential oils content. Only United States varietal differentiations are depicted below in Tables 8 and 9, but non-United States varietal eliminations are listed in Peacock and McCarty, supra, and can be readily utilized by those having skill in the art to distinguish between those varieties and Columbus.

TABLE 8

Key of Kenny

			Major U.S. variety eliminations
1. β-Farnesene content > 1%	→	YES	Cascade, Fuggle, Saaz, Spalt Tettnang, Willamette
NO			
2. Humulene/ β-Caryophyllene ratio > 1.5	→	NO	Eroica, Olympic
YES			
3. Presence of 2-Tridecanone/ presence of a peak @ 34.38 > 1.0%	→	NO	Galena (*see note in text)
NO			
4. β-Caryophyllene/ -copaene > 20	→	YES	Cluster, Nugget
NO			
Chinook (12.1) Columbus (13.4)			

Table 8 was prepared using the data provided in Appendix 1. As shown in Table 8, step 1 eliminates the high β-farnesene hops, i.e., Cascade, Fuggle, Saaz, Spalt, Tettnang, and Willamette. Step 2 eliminates the low humulene varieties, i.e., Eroica and Olympic. Step 3 eliminates Galena because Columbus is unique for having no 2-tridecanone, and Columbus lacks a large peak found in Galena at 34.38 minutes (the peak is greater than 1% of the measured components of Galena). Step 4 eliminates both Cluster and Nugget. The remaining varieties are Columbus and Chinook. As shown in Table 7, Columbus is differentiated from Chinook by Columbus' lower alpha/beta ratio. In regard to some other varieties, Perle is eliminated by virtue of its low alpha acids content, while Columbus is distinguishable from Hersbruck, Hallertau, Liberty, and Mount Hood because Columbus has a much higher alpha acids content.

TABLE 9

Key of Peacock and McCarty (1992)

			Major U.S. variety eliminations
Columbus			
1. Humulene present	→	YES	Aquila, Eroica
YES			
2. β-Farnesene > 5% Humulene	→	YES	Cascade, Fuggle Saaz, Spalt, Tettnang, Willamette
NO			
3. Humulene/Selinene > 20	→	YES	Banner, Hallertau, Liberty, Mt. Hood, Perle
NO			
4. Contains Eudesmol	→	YES	Chinook, Hersbruck
NO			
5. Cohumulone < 38%	→	NO	Cluster, Galena
YES			
Columbus, Nugget, Olympic			

Table 9 depicts the key of Peacock and McCarty, which differentiates Aquila, Banner, and Centennial. The data from Appendix 1 is used for all steps except step 4, for which the data in Appendix 2 (which quantifies eusdesmol) is necessary. In Table 9, Step 1 eliminates Aquila and Eroica. Step 2 eliminates the six high β-farnesene hops. Step 3 eliminates Perle, Banner, Hallertau, Liberty, and Mount Hood. Step 4 eliminates Hersbruck and Chinook. Step 5 eliminates Cluster and Galena. Table 7 does not distinguish Columbus from Nugget and Olympic. However, as discussed above, Nugget and Olympic are distinguished from Columbus by each of Table 7 and Table 8.

Finally, the variety Centennial has not yet been distinguished. The data in Appendix 1 show that Centennial has a β-caryophyllene level of 2.649, while Columbus has a β-caryophyllene level of 10.236. Therefore, the varieties are distinguished because they are at virtually opposite ends of the scale for β-caryophyllene.

III. Asexual Reproduction (Propagation) of the Plant

Columbus is asexually reproduced according to methods well known to those having skill in the art. Such methods generally comprise one of three procedures: (a) taking rootstock cuttings known as "roots" or "strap cuts;" (b) converting vine material into woody root-like material in the field and dividing this material into "layered cuttings;" or (c) the use of softwood cuttings, which are also known as "mist cuttings," of green vegetative or shoot material, usually under greenhouse conditions. Further, traditional methods can be applied to make a cell tissue culture from Columbus. Such a cell tissue culture can be stored for extended periods, and gives rise to clones (i.e., asexual progeny) of Columbus. Columbus has been asexually reproduced on ranches associated with HopUnion USA, Inc., located in and about Yakima, Wash. U.S.A.

A. Asexual Reproduction by Taking Rootstock Cuttings

In the field, when main vines die back in the fall, their bases turn woody and swell with the deposition of starch reserves. These bases produce buds at the sites where the main vine nodes were previously located. The bases, usually 4"–8" long and between one-half and two inches thick, are

removed by cutting with a sharp knife; other buds on the rootstock produce re-growth in the spring. The detached vine bases are then planted singly or in multiples, in pots or in the field.

Such a procedure typically provides up to a 15-fold increase over the starting number of plants. The increase may be lower where multiple rootstocks (up to 6–8) are to be planted at a single site, to form a single new composite plant.

B. Asexual Reproduction by Layered Cuttings

In the field, main vines are grown up a string, typically to a pre-determined height of about 10 feet. The string is then lowered and the newly grown main vines laid along the ground (for example, for about 8 feet). The string is then re-hung so that a portion of the main vines can renew vertical growth, but in a new location. Some main vines are left laying along the ground and are buried with soil, where the absence of light on the buried, green main vine stimulates it to turn woody, form buds at the nodes and swell with starch deposits. When the unburied portion of the vine has died back, the buried, now woody, portion is dug up and cut up into numerous layered cuttings, which are then replanted to give new plants. Such a procedure provides up to about a 50-fold increase over the starting number of plants.

In an alternative embodiment, new plants are placed at the bottom of deep, open trenches, preferably in a nursery. As the plants grow, soil is periodically pushed into the trench around the vines, thereby yielding layered cuttings in a vertical plane.

C. Asexual Reproduction by Softwood (Mist) Cuttings

Actively growing main vines of a plant are cut into sections comprising a half-node, a single node, or two nodes. Main vines for this purpose are preferably grown in a greenhouse, where growing conditions can be maximized. The cuttings are planted and stuck in a suitable medium, preferably with bottom heat and an intermittent water mist, further preferably under glass. The cuttings produce a rooted plant with new main vine growth about two to three weeks after removal from the original plant. These rooted softwood cuttings can be further grown in pots, in a nursery, or even in the final new plantation. Using such a procedure, it is possible to achieve up to about a 100-fold increase over the starting number of plants.

APPENDIX 1

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21223 AQUILA	21053 AURORA
6.42	9	A-PINENE	0.105	0.112
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.326
8.10	16	8-PINENE	0.898	0.817
9.11	18	MYRCENE	62.462	58.731
9.77	22	2-METHYL-BUTYL PROPANOATE	0.171	0.159
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.076
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.370	0.754
10.28	26	L-LIMONENE	0.243	0.228
10.62	27	B-PHELLANDRENE?	0.262	0.234

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

		C10H15		
11.59	32	trans-OCIMENE	1.542	0.207
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.445	0.656
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.069	0.160
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.230	0.264
15.98	51	METHYL OCTANOATE	0.317	0.506
16.26	55	NONANAL	0.048	0.083
19.41	73	METHYL NONANOATE	0.172	0.343
19.56	75	2-DECANONE, A-YLANGENE	0.139	0.379
19.93	77	A-COPAENE	0.121	0.161
21.00	83	LINALOOL	0.368	0.997
21.31	88	A-GURJUNENE	0.000	0.000
21.42	89	7-METHYL-2-DECANONE	0.062	0.218
22.56	93	C15H24 CALARENE?	0.000	0.000
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.239	0.408
23.01	96	2-UNDECANONE	0.448	1.402
23.10	97	2-DECANOL	0.000	0.160
23.44	99	8-CARYOPHYLLENE	4.104	4.403
23.84	102	METHYL DEC-4-ENOATE	1.608	1.286
24.03	103	MW168 2-OL? ME 43,81,110,108	0.000	0.181
25.18	114	B-FARNESENE	0.000	4.371
26.10	122	HUMULENE	1.193	14.141
26.16	123	METHYL DEC-4,8-DIENOATE	1.462	0.310
26.46	129	WILEY# 123998 MW 204 C15H24	0.341	0.635
26.59	131	2-DODECANONE	0.311	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.270	0.132
27.53	139	CAS# 030021-74-0	0.000	0.000
27.75	143	A-MUUROLENE	0.114	0.182
27.90	144	B-SELINENE	2.421	0.109
28.04	145	A-SELINENE	2.745	0.130
28.34	147	METHYL ?-UNDECENOATE	0.266	0.308
29.16	154	D-CADINENE	0.531	0.696
29.39	155	G-CADINENE	0.191	0.381
30.34	164	CAS# 016728-99-7 OR G-SELINENE	3.659	0.184
30.73	166	A-MUUROLINE	0.000	0.000
31.15	170	2-TRIDECANONE	1.620	1.080
31.36	171	GERANYL PROPANOATE	0.275	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.264	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	1.173	0.000
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.109	0.000
36.42	196	MW 210 ME 43,54,82	0.122	0.282
39.11	211	CARYOPHYLLENE OXIDE	0.121	0.083
40.23	221	HUMULENE MONO-EPOXIDE I	0.000	0.530
40.28	223	MW222 ME 43,82	0.177	0.000
41.07	225	HUMULENE MONO-EPOXIDE II	0.000	0.199
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.000
41.88	231	MW 222 ME 43,79,80	0.598	0.950
43.88	242	MW 220 ME 43,79,91	0.170	0.262
44.73	246	T-CADINOL	0.214	0.000
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.000

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.407	0.000

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21080 BACKA	21287 BANNER
6.42	9	A-PINENE	0.000	0.110
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.129
8.10	16	8-PINENE	0.275	0.842
9.11	18	MYRCENE	15.376	65.305
9.77	22	2-METHYL-BUTYL PROPANOATE	0.075	0.391
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.173
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.000	0.988
10.28	26	L-LIMONENE	0.108	0.243
10.62	27	B-PHELLANDRENE? C10H15	0.000	0.273
11.59	32	trans-OCIMENE	0.000	0.681
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.068
12.68	36	METHYL HEPTANOATE	0.281	0.381
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.298	0.093
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.000	0.413
15.98	51	METHYL OCTANOATE	0.090	0.269
16.26	55	NONANAL	0.939	0.037
19.41	73	METHYL NONANOATE	0.075	0.188
19.56	75	2-DECANONE, A-YLANGENE	0.497	0.051
19.93	77	A-COPAENE	0.420	0.173
21.00	83	LINALOOL	0.461	0.583
21.31	88	A-GURJUNENE	0.164	0.166
21.42	89	7-METHYL-2-DECANONE	0.384	0.000
22.56	93	C15H24 CALARENE?	0.382	0.069
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.000	0.243
23.01	96	2-UNDECANONE	1.442	0.046
23.10	97	2-DECANOL	0.685	0.173
23.44	99	8-CARYOPHYLLENE	10.792	5.478
23.84	102	METHYL DEC-4-ENOATE	0.588	0.910
24.03	103	MW168 2-OL? ME 43,81,110,108	0.394	0.000
25.18	114	B-FARNESENE	0.439	0.000
26.10	122	HUMULENE	37.338	13.256
26.16	123	METHYL DEC-4,8-DIENOATE	0.000	0.157
26.46	129	WILEY# 123998 MW 204 C15H24	1.342	0.475
26.59	131	2-DODECANONE	0.000	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.114	0.134
27.53	139	CAS# 030021-74-0	0.182	0.094
27.75	143	A-MUUROLENE	0.314	0.173
27.90	144	B-SELINENE	0.391	0.126
28.04	145	A-SELINENE	0.429	0.140
28.34	147	METHYL ?-UNDECENOATE	0.000	0.000
29.16	154	D-CADINENE	1.688	0.873
29.39	155	G-CADINENE	1.075	0.478
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.263	0.126
30.73	166	A-MUUROLINE	0.201	0.100
31.15	170	2-TRIDECANONE	0.871	1.945
31.36	171	GERANYL PROPANOATE	0.000	0.269
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.081
32.28	177	trans-GERANIOL	0.000	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.359	0.082

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.484
36.42	196	MW 210 ME 43,54,82	0.236	0.137
39.11	211	CARYOPHYLLENE OXIDE	2.753	0.097
40.23	221	HUMULENE MONO-EPOXIDE I	0.173	0.048
40.28	223	MW222 ME 43,82	1.201	0.113
41.07	225	HUMULENE MONO-EPOXIDE II	9.016	0.176
41.55	228	HUMULENE MONO-EPOXIDE III	0.124	0.000
41.88	231	MW 222 ME 43,79,80	1.910	0.213
43.88	242	MW 220 ME 43,79,91	0.500	0.113
44.73	246	T-CADINOL	0.403	0.070
46.08	255	T-MUUROLOL ME 95,121,204	0.209	0.040
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.333	0.000
48.69	268	FARNESOL	0.000	0.084

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21116 BREWERS GOLD	64100 BULLION
6.42	9	A-PINENE	0.117	0.110
7.46	14	ISOBUTYL ISOBUTYRATE	0.169	0.251
8.10	16	8-PINENE	0.988	0.934
9.11	18	MYRCENE	69.050	67.113
9.77	22	2-METHYL-BUTYL PROPANOATE	0.344	0.469
9.90	23	ISOAMYL ISOBUTYRATE	0.068	0.153
9.96	24	2-METHYL-BUTYL ISOBUTARATE	1.267	1.053
10.28	26	L-LIMONENE	0.260	0.254
10.62	27	B-PHELLANDRENE? C10H15	0.328	0.324
11.59	32	trans-OCIMENE	0.549	0.441
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.096	0.045
12.68	36	METHYL HEPTANOATE	0.298	0.543
12.91	40	ISOAMYL ISOVALERATE	0.000	0.038
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.000	0.089
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.105	0.205
15.98	51	METHYL OCTANOATE	0.206	0.174
16.26	55	NONANAL	0.049	0.040
19.41	73	METHYL NONANOATE	0.105	0.208
19.56	75	2-DECANONE, A-YLANGENE	0.040	0.070
19.93	77	A-COPAENE	0.166	0.149
21.00	83	LINALOOL	0.461	0.441
21.31	88	A-GURJUNENE	0.039	0.070
21.42	89	7-METHYL-2-DECANONE	0.000	0.000
22.56	93	C15H24 CALARENE?	0.085	0.064
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.105	0.154
23.01	96	2-UNDECANONE	0.000	0.119
23.10	97	2-DECANOL	0.179	0.156
23.44	99	8-CARYOPHYLLENE	6.305	6.054
23.84	102	METHYL DEC-4-ENOATE	0.566	0.837
24.03	103	MW168 2-OL? ME 43,81,110,108	0.000	0.044
25.18	114	B-FARNESENE	0.000	0.000
26.10	122	HUMULENE	10.326	10.525
26.16	123	METHYL DEC-4,8-DIENOATE	1.153	0.252
26.46	129	WILEY# 123998 MW 204 C15H24	0.433	0.396
26.59	131	2-DODECANONE	0.000	0.047
27.32	138	A-FARNESENE OR ZINGIBERENE	0.177	0.169
27.53	139	CAS# 030021-74-0	0.104	0.084
27.75	143	A-MUUROLENE	0.172	0.135

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

27.90	144	B-SELINENE	0.378	0.433
28.04	145	A-SELINENE	0.410	0.495
28.34	147	METHYL ?-UNDECENOATE	0.000	0.000
29.16	154	D-CADINENE	0.864	0.790
29.39	155	G-CADINENE	0.443	0.387
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.080	0.084
30.73	166	A-MUUROLINE	0.091	0.083
31.15	170	2-TRIDECANONE	0.348	0.802
31.36	171	GERANYL PROPANOATE	0.257	0.493
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	1.003	0.060
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.000	0.051
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.126
36.42	196	MW 210 ME 43,54,82	0.000	0.267
39.11	211	CARYOPHYLLENE OXIDE	0.082	0.084
40.23	221	HUMULENE MONO-EPOXIDE I	0.097	0.227
40.28	223	MW222 ME 43,82	0.047	0.107
41.07	225	HUMULENE MONO-EPOXIDE II	0.115	0.131
41.55	228	HUMULENE MONO-EPOXIDE III	0.057	0.000
41.88	231	MW 222 ME 43,79,80	0.073	0.469
43.88	242	MW 220 ME 43,79,91	0.000	0.265
44.73	246	T-CADINOL	0.078	0.073
46.08	255	T-MUUROLOL ME 95,121,204	0.046	0.044
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.586	0.472

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	56013 CASCADE	21507 CENTENNIAL
6.42	9	A-PINENE	0.098	0.155
7.46	14	ISOBUTYL ISOBUTYRATE	0.110	0.127
8.10	16	8-PINENE	0.933	1.125
9.11	18	MYRCENE	68.051	77.911
9.77	22	2-METHYL-BUTYL PROPANOATE	0.260	0.372
9.90	23	ISOAMYL ISOBUTYRATE	0.096	0.234
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.527	0.911
10.28	26	L-LIMONENE	0.233	0.324
10.62	27	B-PHELLANDRENE? C10H15	0.337	0.358
11.59	32	trans-OCIMENE	0.132	0.080
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.094
12.68	36	METHYL HEPTANOATE	0.210	0.333
12.91	40	ISOAMYL ISOVALERATE	0.043	0.126
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.055	0.114
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.091	0.168
15.98	51	METHYL OCTANOATE	0.093	0.193
16.26	55	NONANAL	0.051	0.000
19.41	73	METHYL NONANOATE	0.072	0.101
19.56	75	2-DECANONE, A-YLANGENE	0.044	0.000
19.93	77	A-COPAENE	0.118	0.088
21.00	83	LINALOOL	0.312	0.470
21.31	88	A-GURJUNENE	0.000	0.054
21.42	89	7-METHYL-2-DECANONE	0.000	0.000
22.56	93	C15H24 CALARENE?	0.070	0.000
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.275	0.050
23.01	96	2-UNDECANONE	0.110	0.000

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

23.10	97	2-DECANOL	0.175	0.009
23.44	99	8-CARYOPHYLLENE	4.059	4.649
23.84	102	METHYL DEC-4-ENOATE	0.333	0.809
24.03	103	MW168 2-OL? ME 43,81,110,108	0.000	0.000
25.18	114	B-FARNESENE	5.285	0.000
26.10	122	HUMULENE	10.063	5.699
26.16	123	METHYL DEC-4,8-DIENOATE	0.219	2.229
26.46	129	WILEY# 123998 MW 204 C15H24	0.325	0.239
26.59	131	2-DODECANONE	0.000	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.311	0.110
27.53	139	CAS# 030021-74-0	0.087	0.000
27.75	143	A-MUUROLENE	0.107	0.170
27.90	144	B-SELINENE	0.508	0.000
28.04	145	A-SELINENE	0.533	0.050
28.34	147	METHYL ?-UNDECENOATE	0.195	0.000
29.16	154	D-CADINENE	0.624	0.420
29.39	155	G-CADINENE	0.306	0.246
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.071	0.000
30.73	166	A-MUUROLINE	0.066	0.000
31.15	170	2-TRIDECANONE	0.836	0.565
31.36	171	GERANYL PROPANOATE	0.402	0.218
31.46	172	MW 212 METHYL ?-DODECENOATE	0.109	0.069
32.28	177	trans-GERANIOL	0.092	0.762
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.000	0.000
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.047	0.098
36.42	196	MW 210 ME 43,54,82	0.148	0.000
39.11	211	CARYOPHYLLENE OXIDE	0.075	0.072
40.23	221	HUMULENE MONO-EPOXIDE I	0.000	0.000
40.28	223	MW222 ME 43,82	0.064	0.000
41.07	225	HUMULENE MONO-EPOXIDE II	0.157	0.114
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.000
41.88	231	MW 222 ME 43,79,80	0.490	0.164
43.88	242	MW 220 ME 43,79,91	0.382	0.000
44.73	246	T-CADINOL	0.069	0.000
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.000
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.093	0.000

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21043 CHALLANGER	21226 CHINOCK
6.42	9	A-PINENE	0.078	0.102
7.46	14	ISOBUTYL ISOBUTYRATE	0.192	0.270
8.10	16	8-PINENE	0.765	0.768
9.11	18	MYRCENE	55.224	48.105
9.77	22	2-METHYL-BUTYL PROPANOATE	0.254	0.477
9.90	23	ISOAMYL ISOBUTYRATE	0.082	0.447
9.96	24	2-METHYL-BUTYL ISOBUTARATE	1.164	2.385
10.28	26	L-LIMONENE	0.204	0.210
10.62	27	B-PHELLANDRENE? C10H15	0.260	0.228
11.59	32	trans-OCIMENE	0.259	0.067
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.067	0.185
12.68	36	METHYL HEPTANOATE	0.631	0.200
12.91	40	ISOAMYL ISOVALERATE	0.000	0.398
14.31	43	METHYL 4-METHYL-	0.337	0.099

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	65103 CLUSTER L-1	65103 CLUSTER L-2
		HEXA-2-ENOATE		
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.241	1.211
15.98	51	METHYL OCTANOATE	0.323	0.199
16.26	55	NONANAL	0.076	0.043
19.41	73	METHYL NONANOATE	0.000	0.162
19.56	75	2-DECANONE, A-YLANGENE	0.189	0.158
19.93	77	A-COPAENE	0.164	0.530
21.00	83	LINALOOL	0.714	0.400
21.31	88	A-GURJUNENE	0.000	0.696
21.42	89	7-METHYL-2-DECANONE	0.076	0.079
22.56	93	C15H24 CALARENE?	0.109	0.186
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.094	0.156
23.01	96	2-UNDECANONE	0.793	0.127
23.10	97	2-DECANOL	0.227	0.453
23.44	99	8-CARYOPHYLLENE	5.394	6.439
23.84	102	METHYL DEC-4-ENOATE	0.760	1.180
24.03	103	MW168 2-OL? ME 43,81,110,108	0.105	0.044
25.18	114	B-FARNESENE	1.041	0.000
26.10	122	HUMULENE	17.304	14.547
26.16	123	METHYL DEC-4,8-DIENOATE	0.000	0.583
26.46	129	WILEY# 123998 MW 204 C15H24	0.232	1.511
26.59	131	2-DODECANONE	0.403	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.319	0.362
27.53	139	CAS# 030021-74-0	0.099	0.331
27.75	143	A-MUUROLENE	0.148	0.510
27.90	144	B-SELINENE	2.769	0.886
28.04	145	A-SELINENE	3.204	0.971
28.34	147	METHYL ?-UNDECENOATE	0.241	0.000
29.16	154	D-CADINENE	0.810	2.685
29.39	155	G-CADINENE	0.409	1.493
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.105	1.965
30.73	166	A-MUUROLINE	0.000	0.288
31.15	170	2-TRIDECANONE	0.397	0.512
31.36	171	GERANYL PROPANOATE	0.000	0.088
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.074
32.28	177	trans-GERANIOL	0.000	0.979
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.061	0.346
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.446
36.42	196	MW 210 ME 43,54,82	0.135	0.089
39.11	211	CARYOPHYLLENE OXIDE	0.106	0.066
40.23	221	HUMULENE MONO-EPOXIDE I	0.048	0.131
40.28	223	MW222 ME 43,82	0.232	0.122
41.07	225	HUMULENE MONO-EPOXIDE II	0.250	0.153
41.55	228	HUMULENE MONO-EPOXIDE III	0.063	0.136
41.88	231	MW 222 ME 43,79,80	0.356	0.268
43.88	242	MW 220 ME 43,79,91	0.163	0.000
44.73	246	T-CADINOL	0.077	0.248
46.08	255	T-MUUROLOL ME 95,121,204	0.057	0.119
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.076	0.524
6.42	9	A-PINENE	0.103	0.153
7.46	14	ISOBUTYL ISOBUTYRATE	0.280	0.153
8.10	16	B-PINENE	0.866	0.655
9.11	18	MYRCENE	60.712	45.653
9.77	22	2-METHYL-BUTYL PROPANOATE	0.536	0.335
9.90	23	ISOAMYL ISOBUTYRATE	0.483	0.525
9.96	24	2-METHYL-BUTYL ISOBUTARATE	1.641	1.178
10.28	26	L-LIMONENE	0.268	0.235
10.62	27	B-PHELLANDRENE? C10H15	0.295	0.210
11.59	32	trans-OCIMENE	0.370	0.229
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.075	0.070
12.68	36	METHYL HEPTANOATE	0.244	0.220
12.91	40	ISOAMYL ISOVALERATE	0.187	0.271
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.342	0.310
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.447	0.399
15.98	51	METHYL OCTANOATE	0.721	0.555
16.26	55	NONANAL	0.250	0.467
19.41	73	METHYL NONANOATE	0.165	0.158
19.56	75	2-DECANONE, A-YLANGENE	0.060	0.100
19.93	77	A-COPAENE	0.126	0.242
21.00	83	LINALOOL	0.347	0.259
21.31	88	A-GURJUNENE	0.372	0.374
21.42	89	7-METHYL-2-DECANONE	0.071	0.075
22.56	93	C15H24 CALARENE?	0.082	0.158
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.953	0.855
23.01	96	2-UNDECANONE	0.533	0.648
23.10	97	2-DECANOL	0.180	0.352
23.44	99	8-CARYOPHYLLENE	4.725	8.080
23.84	102	METHYL DEC-4-ENOATE	1.801	1.927
24.03	103	MW168 2-OL? ME 43,81,110,108	0.073	0.108
25.18	114	B-FARNESENE	0.000	0.000
26.10	122	HUMULENE	13.195	20.805
26.16	123	METHYL DEC-4,8-DIENOATE	0.154	0.132
26.46	129	WILEY# 123998 MW 204 C15H24	0.306	0.538
26.59	131	2-DODECANONE	0.064	0.078
27.32	138	A-FARNESENE OR ZINGIBERENE	0.135	0.197
27.53	139	CAS# 030021-74-0	0.084	0.137
27.75	143	A-MUUROLENE	0.127	0.216
27.90	144	B-SELINENE	0.319	0.558
28.04	145	A-SELINENE	0.356	0.612
28.34	147	METHYL ?-UNDECENOATE	0.000	0.000
29.16	154	D-CADINENE	0.655	1.137
29.39	155	G-CADINENE	0.330	0.604
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.081	0.141
30.73	166	A-MUUROLINE	0.059	0.110
31.15	170	2-TRIDECANONE	0.843	1.060
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.741	0.925
32.28	177	trans-GERANIOL	0.703	0.446
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.000	0.108
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.228	0.221
36.42	196	MW 210 ME 43,54,82	0.062	0.082
39.11	211	CARYOPHYLLENE OXIDE	0.094	0.251
40.23	221	HUMULENE MONO-EPOXIDE I	0.000	0.147
40.28	223	MW222 ME 43,82	0.151	0.201
41.07	225	HUMULENE MONO-EPOXIDE II	0.237	0.653
41.55	228	HUMULENE	0.000	0.137

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21220 EROICA	21016 FUGGLE
		MONO-EPOXIDE III		
41.88	231	MW 222 ME 43,79,80	0.666	1.036
43.88	242	MW 220 ME 43,79,91	0.429	0.609
44.73	246	T-CADINOL	0.088	0.170
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.090
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.077
48.69	268	FARNESOL	0.066	0.084
6.42	9	A-PINENE	0.155	0.075
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.221
8.10	16	8-PINENE	0.884	0.712
9.11	18	MYRCENE	61.773	54.039
9.77	22	2-METHYL-BUTYL PROPANOATE	0.237	0.157
9.90	23	ISOAMYL ISOBUTYRATE	0.124	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.549	0.443
10.28	26	L-LIMONENE	0.233	0.186
10.62	27	B-PHELLANDRENE? C10H15	0.264	0.242
11.59	32	trans-OCIMENE	1.577	0.105
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.292	0.426
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.000	0.170
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.271	0.114
15.98	51	METHYL OCTANOATE	0.257	0.088
16.26	55	NONANAL	0.070	0.098
19.41	73	METHYL NONANOATE	0.204	0.097
19.56	75	2-DECANONE, A-YLANGENE	0.161	0.212
19.93	77	A-COPAENE	0.053	0.225
21.00	83	LINALOOL	0.508	0.651
21.31	88	A-GURJUNENE	0.155	0.000
21.42	89	7-METHYL-2-DECANONE	0.214	0.083
22.56	93	C15H24 CALARENE?	0.000	0.157
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.325	0.272
23.01	96	2-UNDECANONE	0.820	0.406
23.10	97	2-DECANOL	0.000	0.348
23.44	99	8-CARYOPHYLLENE	12.756	7.628
23.84	102	METHYL DEC-4-ENOATE	0.875	0.409
24.03	103	MW168 2-OL? ME 43,81,110,108	0.167	0.122
25.18	114	B-FARNESENE	0.000	4.870
26.10	122	HUMULENE	0.355	20.059
26.16	123	METHYL DEC-4,8-DIENOATE	0.419	0.147
26.46	129	WILEY# 123998 MW 204 C15H24	0.104	0.528
26.59	131	2-DODECANONE	0.344	0.073
27.32	138	A-FARNESENE OR ZINGIBERENE	0.000	0.543
27.53	139	CAS# 030021-74-0	0.000	0.090
27.75	143	A-MUUROLENE	0.060	0.173
27.90	144	B-SELINENE	2.268	0.177
28.04	145	A-SELINENE	2.562	0.186
28.34	147	METHYL ?-UNDECENOATE	0.000	0.424
29.16	154	D-CADINENE	0.293	1.092
29.39	155	G-CADINENE	0.167	0.573
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.000	0.147
30.73	166	A-MUUROLINE	0.000	0.117
31.15	170	2-TRIDECANONE	0.606	0.397

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21102 GALENA	21014 HALLERTAU
31.36	171	GERANYL PROPANOATE	0.091	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.949	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.077	0.080
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.228	0.064
36.42	196	MW 210 ME 43,54,82	0.437	0.080
39.11	211	CARYOPHYLLENE OXIDE	0.156	0.126
40.23	221	HUMULENE MONO-EPOXIDE I	0.164	0.000
40.28	223	MW222 ME 43,82	0.878	0.087
41.07	225	HUMULENE MONO-EPOXIDE II	0.000	0.279
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.088
41.88	231	MW 222 ME 43,79,80	1.761	0.435
43.88	242	MW 220 ME 43,79,91	0.461	0.235
44.73	246	T-CADINOL	0.055	0.125
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.070
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.326	0.134
6.42	9	A-PINENE	0.109	0.064
7.46	14	ISOBUTYL ISOBUTYRATE	0.479	0.151
8.10	16	8-PINENE	0.027	0.653
9.11	18	MYRCENE	55.179	53.508
9.77	22	2-METHYL-BUTYL PROPANOATE	1.009	0.184
9.90	23	ISOAMYL ISOBUTYRATE	0.554	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	5.004	0.278
10.28	26	L-LIMONENE	0.218	0.158
10.62	27	B-PHELLANDRENE? C10H15	0.239	0.204
11.59	32	trans-OCIMENE	2.260	0.144
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.151	0.000
12.68	36	METHYL HEPTANOATE	0.427	0.647
12.91	40	ISOAMYL ISOVALERATE	0.169	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.152	0.264
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.930	0.150
15.98	51	METHYL OCTANOATE	0.878	0.203
16.26	55	NONANAL	0.079	0.095
19.41	73	METHYL NONANOATE	0.436	0.138
19.56	75	2-DECANONE, A-YLANGENE	0.071	0.258
19.93	77	A-COPAENE	0.111	0.214
21.00	83	LINALOOL	0.206	0.939
21.31	88	A-GURJUNENE	0.577	0.044
21.42	89	7-METHYL-2-DECANONE	0.009	0.086
22.56	93	C15H24 CALARENE?	0.053	0.120
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	1.317	0.000
23.01	96	2-UNDECANONE	0.386	0.696
23.10	97	2-DECANOL	0.131	0.337
23.44	99	8-CARYOPHYLLENE	4.602	7.238
23.84	102	METHYL DEC-4-ENOATE	2.237	0.660
24.03	103	MW168 2-OL? ME 43,81,110,108	0.042	0.157
25.18	114	B-FARNESENE	0.000	0.000
26.10	122	HUMULENE	10.599	24.799
26.16	123	METHYL DEC-4,8-DIENOATE	0.180	0.000
26.46	129	WILEY# 123998 MW 204	0.281	0.670

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21135 HERSBRUCK	21097 HULLERER BITTERER
		C15H24		
26.59	131	2-DODECANONE	0.076	0.132
27.32	138	A-FARNESENE OR ZINGIBERENE	0.000	0.227
27.53	139	CAS# 030021-74-0	0.054	0.113
27.75	143	A-MUUROLENE	0.101	0.214
27.90	144	B-SELINENE	0.465	0.190
28.04	145	A-SELINENE	0.544	0.207
28.34	147	METHYL ?-UNDECENOATE	0.000	0.069
29.16	154	D-CADINENE	0.586	1.250
29.39	155	G-CADINENE	0.300	0.653
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.142	0.151
30.73	166	A-MUUROLINE	0.064	0.136
31.15	170	2-TRIDECANONE	1.561	0.421
31.36	171	GERANYL PROPANOATE	0.119	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.219	0.000
32.28	177	trans-GERANIOL	0.000	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.000	0.102
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	1.725	0.071
36.42	196	MW 210 ME 43,54,82	0.186	0.125
39.11	211	CARYOPHYLLENE OXIDE	0.064	0.111
40.23	221	HUMULENE MONO-EPOXIDE I	0.000	0.099
40.28	223	MW222 ME 43,82	0.237	0.239
41.07	225	HUMULENE MONO-EPOXIDE II	0.134	0.357
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.100
41.88	231	MW 222 ME 43,79,80	0.579	0.638
43.88	242	MW 220 ME 43,79,91	0.263	0.263
44.73	246	T-CADINOL	0.059	0.125
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.075
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.000	0.064
6.42	9	A-PINENE	0.000	0.087
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.088
8.10	16	8-PINENE	0.527	0.737
9.11	18	MYRCENE	44.828	52.818
9.77	22	2-METHYL-BUTYL PROPANOATE	0.000	0.415
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.168
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.066	0.844
10.28	26	L-LIMONENE	0.147	0.207
10.62	27	B-PHELLANDRENE? C10H15	0.145	0.212
11.59	32	trans-OCIMENE	0.000	0.092
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.079
12.68	36	METHYL HEPTANOATE	0.418	0.231
12.91	40	ISOAMYL ISOVALERATE	0.000	0.075
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.289	0.000
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.171	0.408
15.98	51	METHYL OCTANOATE	0.134	0.110
16.26	55	NONANAL	0.226	0.084
19.41	73	METHYL NONANOATE	0.090	0.088
19.56	75	2-DECANONE, A-YLANGENE	0.334	0.251
19.93	77	A-COPAENE	0.259	0.617
21.00	83	LINALOOL	0.805	0.503

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21457 LIBERTY	21113 LUBELSKA
21.31	88	A-GURJUNENE	0.077	0.169
21.42	89	7-METHYL-2-DECANONE	0.214	0.121
22.56	93	C15H24 CALARENE?	0.190	0.300
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.000	0.000
23.01	96	2-UNDECANONE	0.921	0.387
23.10	97	2-DECANOL	0.531	0.602
23.44	99	8-CARYOPHYLLENE	5.573	4.386
23.84	102	METHYL DEC-4-ENOATE	0.551	0.772
24.03	103	MW168 2-OL? ME 43,81,110,108	0.210	0.122
25.18	114	B-FARNESENE	0.324	0.093
26.10	122	HUMULENE	29.352	8.090
26.16	123	METHYL DEC-4,8-DIENOATE	0.132	0.352
26.46	129	WILEY# 123998 MW 204 C15H24	0.735	1.994
26.59	131	2-DODECANONE	0.203	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.326	0.273
27.53	139	CAS# 030021-74-0	0.103	0.352
27.75	143	A-MUUROLENE	0.248	0.574
27.90	144	B-SELINENE	0.306	2.221
28.04	145	A-SELINENE	0.335	2.426
28.34	147	METHYL ?-UNDECENOATE	0.191	0.399
29.16	154	D-CADINENE	1.330	2.714
29.39	155	G-CADINENE	0.746	1.516
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.141	3.993
30.73	166	A-MUUROLINE	0.146	0.364
31.15	170	2-TRIDECANONE	0.580	0.241
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.000	0.134
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.229	0.205
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.340
36.42	196	MW 210 ME 43,54,82	0.147	0.179
39.11	211	CARYOPHYLLENE OXIDE	0.331	0.082
40.23	221	HUMULENE MONO-EPOXIDE I	0.145	0.137
40.28	223	MW222 ME 43,82	0.260	0.000
41.07	225	HUMULENE MONO-EPOXIDE II	0.962	0.194
41.55	228	HUMULENE MONO-EPOXIDE III	0.159	0.074
41.88	231	MW 222 ME 43,79,80	0.752	0.531
43.88	242	MW 220 ME 43,79,91	0.489	0.195
44.73	246	T-CADINOL	0.177	0.336
46.08	255	T-MUUROLOL ME 95,121,204	0.114	0.132
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.161	0.166
6.42	9	A-PINENE	0.043	0.047
7.46	14	ISOBUTYL ISOBUTYRATE	0.068	0.000
8.10	16	8-PINENE	0.504	0.421
9.11	18	MYRCENE	41.506	29.558
9.77	22	2-METHYL-BUTYL PROPANOATE	0.117	0.000
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.197	0.176
10.28	26	L-LIMONENE	0.124	0.145
10.62	27	B-PHELLANDRENE? C10H15	0.149	0.099

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21114 NADWIS-LANSKA	21073 NORTH-ERN BREWER
11.59	32	trans-OCIMENE	0.066	0.000
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.293	0.259
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.128	0.081
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.083	0.148
15.98	51	METHYL OCTANOATE	0.189	0.100
16.26	55	NONANAL	0.091	0.193
19.41	73	METHYL NONANOATE	0.092	0.183
19.56	75	2-DECANONE, A-YLANGENE	0.240	0.268
19.93	77	A-COPAENE	0.304	0.268
21.00	83	LINALOOL	0.814	0.254
21.31	88	A-GURJUNENE	0.043	0.106
21.42	89	7-METHYL-2-DECANONE	0.098	0.198
22.56	93	C15H24 CALARENE?	0.172	0.179
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.000	0.947
23.01	96	2-UNDECANONE	0.737	0.690
23.10	97	2-DECANOL	0.442	0.443
23.44	99	8-CARYOPHYLLENE	9.651	6.953
23.84	102	METHYL DEC-4-ENOATE	0.663	1.089
24.03	103	MW168 2-OL? ME 43,81,110,108	0.140	0.207
25.18	114	B-FARNESENE	0.080	17.712
26.10	122	HUMULENE	32.402	21.404
26.16	123	METHYL DEC-4,8-DIENOATE	0.075	0.451
26.46	129	WILEY# 123998 MW 204 C15H24	0.387	0.796
26.59	131	2-DODECANONE	0.105	0.167
27.32	138	A-FARNESENE OR ZINGIBERENE	0.509	0.316
27.53	139	CAS# 030021-74-0	0.181	0.157
27.75	143	A-MUUROLENE	0.289	0.282
27.90	144	B-SELINENE	0.325	1.492
28.04	145	A-SELINENE	0.358	1.546
28.34	147	METHYL ?-UNDECENOATE	0.310	0.242
29.16	154	D-CADINENE	1.508	1.438
29.39	155	G-CADINENE	0.887	0.811
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.213	0.237
30.73	166	A-MUUROLINE	0.103	0.159
31.15	170	2-TRIDECANONE	0.458	0.738
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.070
32.28	177	trans-GERANIOL	0.099	0.257
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.193	0.196
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.057	0.203
36.42	196	MW 210 ME 43,54,82	0.115	0.199
39.11	211	CARYOPHYLLENE OXIDE	0.205	0.550
40.23	221	HUMULENE MONO-EPOXIDE I	0.103	0.298
40.28	223	MW222 ME 43,82	0.308	0.261
41.07	225	HUMULENE MONO-EPOXIDE II	0.599	1.612
41.55	228	HUMULENE MONO-EPOXIDE III	0.144	0.000
41.88	231	MW 222 ME 43,79,80	0.568	1.358
43.88	242	MW 220 ME 43,79,91	0.342	0.439
44.73	246	T-CADINOL	0.179	0.247
46.08	255	T-MUUROLOL ME 95,121,204	0.128	0.131
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.094
48.69	268	FARNESOL	0.340	0.339

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21114 NADWIS-LANSKA	21073 NORTH-ERN BREWER
6.42	9	A-PINENE	0.066	0.125
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.174
8.10	16	B-PINENE	0.649	0.862
9.11	18	MYRCENE	44.179	55.587
9.77	22	2-METHYL-BUTYL PROPANOATE	0.000	0.183
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.108
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.000	0.428
10.28	26	L-LIMONENE	0.169	0.248
10.62	27	B-PHELLANDRENE? C10H15	0.149	0.265
11.59	32	trans-OCIMENE	0.000	0.488
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.391	0.706
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.206	0.251
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.178	0.150
15.98	51	METHYL OCTANOATE	0.113	0.199
16.26	55	NONANAL	0.141	0.077
19.41	73	METHYL NONANOATE	0.155	0.166
19.56	75	2-DECANONE, A-YLANGENE	0.260	0.177
19.93	77	A-COPAENE	0.160	0.284
21.00	83	LINALOOL	0.390	0.344
21.31	88	A-GURJUNENE	0.073	0.000
21.42	89	7-METHYL-2-DECANONE	0.116	0.049
22.56	93	C15H24 CALARENE?	0.113	0.154
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.854	0.000
23.01	96	2-UNDECANONE	0.592	0.292
23.10	97	2-DECANOL	0.284	0.307
23.44	99	8-CARYOPHYLLENE	5.415	9.217
23.84	102	METHYL DEC-4-ENOATE	0.939	0.565
24.03	103	MW168 2-OL? ME 43,81,110,108	0.211	0.077
25.18	114	B-FARNESENE	17.417	0.000
26.10	122	HUMULENE	18.740	21.642
26.16	123	METHYL DEC-4,8-DIENOATE	0.368	0.389
26.46	129	WILEY# 123998 MW 204 C15H24	0.461	0.619
26.59	131	2-DODECANONE	0.127	0.084
27.32	138	A-FARNESENE OR ZINGIBERENE	0.264	0.179
27.53	139	CAS# 030021-74-0	0.053	0.112
27.75	143	A-MUUROLENE	0.143	0.217
27.90	144	B-SELINENE	0.217	0.182
28.04	145	A-SELINENE	0.161	0.210
28.34	147	METHYL ?-UNDECENOATE	0.206	0.000
29.16	154	D-CADINENE	0.766	1.301
29.39	155	G-CADINENE	0.431	0.650
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.121	0.129
30.73	166	A-MUUROLINE	0.085	0.124
31.15	170	2-TRIDECANONE	0.417	0.337
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.200	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.131	0.110
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.146	0.068
36.42	196	MW 210 ME 43,54,82	0.127	0.082

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21044 NORTHDOWN	21197 NUGGET
39.11	211	CARYOPHYLLENE OXIDE	0.284	0.122
40.23	221	HUMULENE MONO-EPOXIDE I	0.156	0.065
40.28	223	MW222 ME 43,82	0.127	0.109
41.07	225	HUMULENE MONO-EPOXIDE II	0.855	0.250
41.55	228	HUMULENE MONO-EPOXIDE III	0.112	0.090
41.88	231	MW 222 ME 43,79,80	0.755	0.295
43.88	242	MW 220 ME 43,79,91	0.210	0.169
44.73	246	T-CADINOL	0.113	0.119
46.08	255	T-MUUROLOL ME 95,121,204	0.045	0.057
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.187	0.230
6.42	9	A-PINENE	0.066	0.095
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.244
8.10	16	8-PINENE	0.639	0.671
9.11	18	MYRCENE	42.280	60.676
9.77	22	2-METHYL-BUTYL PROPANOATE	0.106	0.559
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.550
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.173	1.307
10.28	26	L-LIMONENE	0.173	0.203
10.62	27	B-PHELLANDRENE? C10H15	0.199	0.244
11.59	32	trans-OCIMENE	0.104	0.571
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.063
12.68	36	METHYL HEPTANOATE	0.337	0.615
12.91	40	ISOAMYL ISOVALERATE	0.000	0.124
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.127	0.201
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.098	0.257
15.98	51	METHYL OCTANOATE	0.165	0.470
16.26	55	NONANAL	0.000	0.052
19.41	73	METHYL NONANOATE	0.122	0.326
19.56	75	2-DECANONE, A-YLANGENE	0.000	0.052
19.93	77	A-COPAENE	0.321	0.167
21.00	83	LINALOOL	0.559	0.904
21.31	88	A-GURJUNENE	0.000	0.113
21.42	89	7-METHYL-2-DECANONE	0.000	0.000
22.56	93	C15H24 CALARENE?	0.228	0.069
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.000	0.298
23.01	96	2-UNDECANONE	0.181	0.363
23.10	97	2-DECANOL	0.474	0.230
23.44	99	8-CARYOPHYLLENE	12.260	6.289
23.84	102	METHYL DEC-4-ENOATE ?-UNDECENOATE	0.798	1.366
24.03	103	MW168 2-OL? ME 43,81,110,108	0.000	0.054
25.18	114	B-FARNESENE	0.746	0.000
26.10	122	HUMULENE	31.313	15.386
26.16	123	METHYL DEC-4,8-DIENOATE	0.000	0.128
26.46	129	WILEY# 123998 MW 204 C15H24	0.198	0.359
26.59	131	2-DODECANONE	0.800	0.077
27.32	138	A-FARNESENE OR ZINGIBERENE	0.210	0.321
27.53	139	CAS# 030021-74-0	0.153	0.086
27.75	143	A-MUUROLENE	0.300	0.237
27.90	144	B-SELINENE	0.291	0.560
28.04	145	A-SELINENE	0.324	0.647
28.34	147	METHYL ?-UNDECENOATE	0.000	0.164
29.16	154	D-CADINENE	1.517	0.760
29.39	155	G-CADINENE	0.815	0.399
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.146	0.102
30.73	166	A-MUUROLINE	0.163	0.075
31.15	170	2-TRIDECANONE	0.149	0.500
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.077
32.28	177	trans-GERANIOL	0.000	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.199	0.000
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.119
36.42	196	MW 210 ME 43,54,82	0.000	0.112
39.11	211	CARYOPHYLLENE OXIDE	0.410	0.051
40.23	221	HUMULENE MONO-EPOXIDE I	0.089	0.000
40.28	223	MW222 ME 43,82	0.067	0.328
41.07	225	HUMULENE MONO-EPOXIDE II	0.801	0.113
41.55	228	HUMULENE MONO-EPOXIDE III	0.153	0.000
41.88	231	MW 222 ME 43,79,80	0.168	0.643
43.88	242	MW 220 ME 43,79,91	0.101	0.206
44.73	246	T-CADINOL	0.138	0.062
46.08	255	T-MUUROLOL ME 95,121,204	0.086	0.000
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.154	0.071

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21223 OLYMPIC	21227 PERLE
6.42	9	A-PINENE	0.127	0.077
7.46	14	ISOBUTYL ISOBUTYRATE	0.116	0.193
8.10	16	8-PINENE	1.037	0.618
9.11	18	MYRCENE	61.466	41.489
9.77	22	2-METHYL-BUTYL PROPANOATE	0.470	0.120
9.90	23	ISOAMYL ISOBUTYRATE	0.121	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	1.424	0.308
10.28	26	L-LIMONENE	0.247	0.177
10.62	27	B-PHELLANDRENE? C10H15	0.269	0.199
11.59	32	trans-OCIMENE	0.040	0.591
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.549	0.000
12.68	36	METHYL HEPTANOATE	0.136	0.425
12.91	40	ISOAMYL ISOVALERATE	0.476	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.051	0.111
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.216	0.061
15.98	51	METHYL OCTANOATE	0.066	0.053
16.26	55	NONANAL	0.053	0.096
19.41	73	METHYL NONANOATE	0.040	0.047
19.56	75	2-DECANONE, A-YLANGENE	0.056	0.256
19.93	77	A-COPAENE	0.201	0.350
21.00	83	LINALOOL	0.316	0.242
21.31	88	A-GURJUNENE	0.096	0.000
21.42	89	7-METHYL-2-DECANONE	0.000	0.047
22.56	93	C15H24 CALARENE?	0.093	0.224
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.055	0.000
23.01	96	2-UNDECANONE	0.000	0.319
23.10	97	2-DECANOL	0.238	0.487
23.44	99	8-CARYOPHYLLENE	8.722	12.480
23.84	102	METHYL DEC-4-ENOATE	0.743	0.150

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	60052 PRIDE OF RINGWOOD	21077 SAAZ
24.03	103	MW168 2-OL? ME 43,81,110,108	0.000	0.096
25.18	114	B-FARNESENE	0.000	0.162
26.10	122	HUMULENE	13.614	31.397
26.16	123	METHYL DEC-4,8-DIENOATE	0.408	0.175
26.46	129	WILEY# 123998 MW 204 C15H24	0.518	0.845
26.59	131	2-DODECANONE	0.000	0.110
27.32	138	A-FARNESENE OR ZINGIBERENE	0.177	0.296
27.53	139	CAS# 030021-74-0	0.116	0.183
27.75	143	A-MUUROLENE	0.248	0.315
27.90	144	B-SELINENE	0.738	0.276
28.04	145	A-SELINENE	0.764	0.320
28.34	147	METHYL ?-UNDECENOATE	0.000	0.000
29.16	154	D-CADINENE	0.979	1.770
29.39	155	G-CADINENE	0.547	0.862
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.116	0.190
30.73	166	A-MUUROLINE	0.107	0.177
31.15	170	2-TRIDECANONE	0.300	0.273
31.36	171	GERANYL PROPANOATE	0.105	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.065	0.000
32.28	177	trans-GERANIOL	1.055	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.084	0.123
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.063	0.000
36.42	196	MW 210 ME 43,54,82	0.000	0.077
39.11	211	CARYOPHYLLENE OXIDE	0.166	0.152
40.23	221	HUMULENE MONO-EPOXIDE I	0.059	0.072
40.28	223	MW222 ME 43,82	0.113	0.100
41.07	225	HUMULENE MONO-EPOXIDE II	0.224	0.366
41.55	228	HUMULENE MONO-EPOXIDE III	0.076	0.136
41.88	231	MW 222 ME 43,79,80	0.253	0.389
43.88	242	MW 220 ME 43,79,91	0.139	0.276
44.73	246	T-CADINOL	0.097	0.186
46.08	255	T-MUUROLOL ME 95,121,204	0.057	0.115
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.127	0.192
6.42	9	A-PINENE	0.089	0.049
7.46	14	ISOBUTYL ISOBUTYRATE	0.043	0.000
8.10	16	8-PINENE	0.690	0.486
9.11	18	MYRCENE	46.727	34.050
9.77	22	2-METHYL-BUTYL PROPANOATE	0.121	0.000
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.220	0.000
10.28	26	L-LIMONENE	0.197	0.166
10.62	27	B-PHELLANDRENE? C10H15	0.156	0.081
11.59	32	trans-OCIMENE	0.000	0.000
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.334	0.626
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.180	0.258
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.319	0.340

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21186 SPALTER	21173 STRISSLESPALT
15.98	51	METHYL OCTANOATE	0.473	0.225
16.26	55	NONANAL	0.116	0.308
19.41	73	METHYL NONANOATE	0.250	0.380
19.56	75	2-DECANONE, A-YLANGENE	0.147	0.501
19.93	77	A-COPAENE	0.241	0.191
21.00	83	LINALOOL	0.317	0.337
21.31	88	A-GURJUNENE	0.230	0.173
21.42	89	7-METHYL-2-DECANONE	0.125	0.222
22.56	93	C15H24 CALARENE?	0.133	0.113
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.326	1.043
23.01	96	2-UNDECANONE	0.690	1.394
23.10	97	2-DECANOL	0.226	0.299
23.44	99	8-CARYOPHYLLENE	8.708	5.010
23.84	102	METHYL DEC-4-ENOATE	1.808	1.769
24.03	103	MW168 2-OL? ME 43,81,110,108	0.230	0.417
25.18	114	B-FARNESENE	0.000	18.900
26.10	122	HUMULENE	1.946	18.111
26.16	123	METHYL DEC-4,8-DIENOATE	0.571	0.259
26.46	129	WILEY# 123998 MW 204 C15H24	0.680	0.531
26.59	131	2-DODECANONE	0.053	0.264
27.32	138	A-FARNESENE OR ZINGIBERENE	1.932	0.255
27.53	139	CAS# 030021-74-0	0.000	0.134
27.75	143	A-MUUROLENE	0.000	0.189
27.90	144	B-SELINENE	9.372	0.255
28.04	145	A-SELINENE	10.128	0.178
28.34	147	METHYL ?-UNDECENOATE	1.329	0.104
29.16	154	D-CADINENE	1.124	0.829
29.39	155	G-CADINENE	0.650	0.519
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.137	0.181
30.73	166	A-MUUROLINE	0.133	0.099
31.15	170	2-TRIDECANONE	0.551	0.957
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.104	0.081
32.28	177	trans-GERANIOL	0.217	0.080
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.146	0.167
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.182	0.424
36.42	196	MW 210 ME 43,54,82	0.079	0.272
39.11	211	CARYOPHYLLENE OXIDE	0.337	0.476
40.23	221	HUMULENE MONO-EPOXIDE I	0.076	0.329
40.28	223	MW222 ME 43,82	0.175	0.294
41.07	225	HUMULENE MONO-EPOXIDE II	0.106	1.530
41.55	228	HUMULENE MONO-EPOXIDE III	0.082	0.155
41.88	231	MW 222 ME 43,79,80	0.852	1.789
43.88	242	MW 220 ME 43,79,91	0.231	0.487
44.73	246	T-CADINOL	0.140	0.174
46.08	255	T-MUUROLOL ME 95,121,204	0.067	0.099
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.083
48.69	268	FARNESOL	0.169	0.160
6.42	9	A-PINENE	0.091	0.062
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.202
8.10	16	8-PINENE	0.861	0.634
9.11	18	MYRCENE	60.356	43.977
9.77	22	2-METHYL-BUTYL	0.000	0.257

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

		PROPANOATE		
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.112
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.000	0.736
10.28	26	L-LIMONENE	0.225	0.175
10.62	27	B-PHELLANDRENE? C10H15	0.234	0.139
11.59	32	trans-OCIMENE	0.055	0.082
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.658	0.326
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.238	0.323
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.230	0.000
15.98	51	METHYL OCTANOATE	0.168	0.103
16.26	55	NONANAL	0.166	0.255
19.41	73	METHYL NONANOATE	0.341	0.119
19.56	75	2-DECANONE, A-YLANGENE	0.313	0.216
19.93	77	A-COPAENE	0.090	0.293
21.00	83	LINALOOL	0.557	0.649
21.31	88	A-GURJUNENE	0.127	0.000
21.42	89	7-METHYL-2-DECANONE	0.144	0.133
22.56	93	C15H24 CALARENE?	0.055	0.243
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.691	0.000
23.01	96	2-UNDECANONE	0.612	0.385
23.10	97	2-DECANOL	0.179	0.509
23.44	99	8-CARYOPHYLLENE	2.481	10.500
23.84	102	METHYL DEC-4-ENOATE	1.180	0.570
24.03	103	MW168 2-OL? ME 43,81,110,108	0.211	0.091
25.18	114	B-FARNESENE	14.019	0.000
26.10	122	HUMULENE	9.083	29.252
26.16	123	METHYL DEC-4,8-DIENOATE	0.313	0.147
26.46	129	WILEY# 123998 MW 204 C15H24	0.243	0.872
26.59	131	2-DODECANONE	0.174	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.179	0.131
27.53	139	CAS# 030021-74-0	0.000	0.088
27.75	143	A-MUUROLENE	0.137	0.233
27.90	144	B-SELINENE	0.130	0.237
28.04	145	A-SELINENE	0.069	0.281
28.34	147	METHYL ?-UNDECENOATE	0.118	0.082
29.16	154	D-CADINENE	0.398	1.364
29.39	155	G-CADINENE	0.226	0.824
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.119	0.210
30.73	166	A-MUUROLINE	0.000	0.196
31.15	170	2-TRIDECANONE	0.479	0.255
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.063	0.000
32.28	177	trans-GERANIOL	0.193	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.073	0.205
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.233	0.000
36.42	196	MW 210 ME 43,54,82	0.155	0.172
39.11	211	CARYOPHYLLENE OXIDE	0.139	0.540
40.23	221	HUMULENE MONO-EPOXIDE I	0.106	0.152
40.28	223	MW222 ME 43,82	0.137	0.150
41.07	225	HUMULENE MONO-EPOXIDE II	0.425	1.140
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.000
41.88	231	MW 222 ME 43,79,80	0.854	0.609
43.88	242	MW 220 ME 43,79,91	0.186	0.141
44.73	246	T-CADINOL	0.064	0.144
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.092
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.093	0.191

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

GC/FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/MASS SPECTROSCOPY	21049 STYRIAN	21112 TARGET
6.42	9	A-PINENE	0.089	0.119
7.46	14	ISOBUTYL ISOBUTYRATE	0.328	0.406
8.10	16	8-PINENE	0.795	0.865
9.11	18	MYRCENE	56.296	58.164
9.77	22	2-METHYL-BUTYL PROPANOATE	0.171	0.482
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.461
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.753	1.408
10.28	26	L-LIMONENE	0.207	0.228
10.62	27	B-PHELLANDRENE? C10H15	0.229	0.226
11.59	32	trans-OCIMENE	0.057	0.366
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.054
12.68	36	METHYL HEPTANOATE	0.270	0.602
12.91	40	ISOAMYL ISOVALERATE	0.000	0.118
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.305	0.427
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.000	0.589
15.98	51	METHYL OCTANOATE	0.000	0.446
16.26	55	NONANAL	0.141	0.107
19.41	73	METHYL NONANOATE	0.070	0.689
19.56	75	2-DECANONE, A-YLANGENE	0.216	0.821
19.93	77	A-COPAENE	0.198	0.336
21.00	83	LINALOOL	0.751	0.891
21.31	88	A-GURJUNENE	0.000	0.000
21.42	89	7-METHYL-2-DECANONE	0.094	0.401
22.56	93	C15H24 CALARENE?	0.166	0.000
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.266	0.519
23.01	96	2-UNDECANONE	0.301	1.502
23.10	97	2-DECANOL	0.366	0.282
23.44	99	8-CARYOPHYLLENE	7.269	4.952
23.84	102	METHYL DEC-4-ENOATE	0.196	1.912
24.03	103	MW168 2-OL? ME 43,81,110,108	0.096	0.214
25.18	114	B-FARNESENE	4.187	0.000
26.10	122	HUMULENE	20.607	10.291
26.16	123	METHYL DEC-4,8-DIENOATE	0.106	0.221
26.46	129	WILEY# 123998 MW 204 C15H24	0.527	1.123
26.59	131	2-DODECANONE	0.000	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.000	0.233
27.53	139	CAS# 030021-74-0	0.000	0.165
27.75	143	A-MUUROLENE	0.211	0.215
27.90	144	B-SELINENE	0.152	0.329
28.04	145	A-SELINENE	0.184	0.404
28.34	147	METHYL ?-UNDECENOATE	0.269	0.000
29.16	154	D-CADINENE	0.013	1.215
29.39	155	G-CADINENE	0.536	0.653
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.000	0.798
30.73	166	A-MUUROLINE	0.167	0.198
31.15	170	2-TRIDECANONE	0.228	0.974
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.114

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

32.28	177	trans-GERANIOL	0.000	0.000
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.112	0.118
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.000	0.388
36.42	196	MW 210 ME 43,54,82	0.000	0.460
39.11	211	CARYOPHYLLENE OXIDE	0.265	0.095
40.23	221	HUMULENE MONO-EPOXIDE I	0.000	0.536
40.28	223	MW222 ME 43,82	0.000	0.000
41.07	225	HUMULENE MONO-EPOXIDE II	0.569	0.210
41.55	228	HUMULENE MONO-EPOXIDE III	0.000	0.000
41.88	231	MW 222 ME 43,79,80	0.394	1.253
43.88	242	MW 220 ME 43,79,91	0.119	0.266
44.73	246	T-CADINOL	0.119	0.114
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.000
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.000	0.000

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21015 TETTNANG	21041 WILLAMETTE
6.42	9	A-PINENE	0.080	0.078
7.46	14	ISOBUTYL ISOBUTYRATE	0.000	0.217
8.10	16	8-PINENE	0.753	0.741
9.11	18	MYRCENE	50.137	55.492
9.77	22	2-METHYL-BUTYL PROPANOATE	0.000	0.234
9.90	23	ISOAMYL ISOBUTYRATE	0.000	0.000
9.96	24	2-METHYL-BUTYL ISOBUTARATE	0.000	0.507
10.28	26	L-LIMONENE	0.205	0.191
10.62	27	B-PHELLANDRENE? C10H15	0.147	0.251
11.59	32	trans-OCIMENE	0.000	0.114
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.000	0.000
12.68	36	METHYL HEPTANOATE	0.509	0.532
12.91	40	ISOAMYL ISOVALERATE	0.000	0.000
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.230	0.224
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.260	0.120
15.98	51	METHYL OCTANOATE	0.172	0.087
16.26	55	NONANAL	0.233	0.073
19.41	73	METHYL NONANOATE	0.228	0.078
19.56	75	2-DECANONE, A-YLANGENE	0.290	0.097
19.93	77	A-COPAENE	0.129	0.190
21.00	83	LINALOOL	0.441	0.661
21.31	88	A-GURJUNENE	0.125	0.000
21.42	89	7-METHYL-2-DECANONE	0.199	0.000
22.56	93	C15H24 CALARENE?	0.085	0.141
22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.873	0.380
23.01	96	2-UNDECANONE	0.759	0.131
23.10	97	2-DECANOL	0.257	0.313
23.44	99	8-CARYOPHYLLENE	3.697	6.934
23.84	102	METHYL DEC-4-ENOATE	1.220	0.288
24.03	103	MW168 2-OL? ME 43,81,110,108	0.255	0.041
25.18	114	B-FARNESENE	16.938	7.097
26.10	122	HUMULENE	13.277	18.815
26.16	123	METHYL DEC-4,8-DIENOATE	0.338	0.196
26.46	129	WILEY# 123998 MW 204 C15H24	0.321	0.472
26.59	131	2-DODECANONE	0.169	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.194	0.599
27.53	139	CAS# 030021-74-0	0.000	0.106
27.75	143	A-MUUROLENE	0.121	0.170
27.90	144	B-SELINENE	0.166	0.245
28.04	145	A-SELINENE	0.099	0.238
28.34	147	METHYL ?-UNDECENOATE	0.177	0.407
29.16	154	D-CADINENE	0.532	0.970
29.39	155	G-CADINENE	0.317	0.493
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.114	0.107
30.73	166	A-MUUROLINE	0.059	0.099
31.15	170	2-TRIDECANONE	0.574	0.142
31.36	171	GERANYL PROPANOATE	0.000	0.000
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.157	0.050
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.131	0.071
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.192	0.000
36.42	196	MW 210 ME 43,54,82	0.163	0.000
39.11	211	CARYOPHYLLENE OXIDE	0.282	0.097
40.23	221	HUMULENE MONO-EPOXIDE I	0.180	0.000
40.28	223	MW222 ME 43,82	0.161	0.000
41.07	225	HUMULENE MONO-EPOXIDE II	0.901	0.200
41.55	228	HUMULENE MONO-EPOXIDE III	0.089	0.071
41.88	231	MW 222 ME 43,79,80	1.033	0.118
43.88	242	MW 220 ME 43,79,91	0.235	0.000
44.73	246	T-CADINOL	0.098	0.104
46.08	255	T-MUUROLOL ME 95,121,204	0.000	0.061
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.000
48.69	268	FARNESOL	0.131	0.457

GC/ FID RT.	CMPD. #	TENTATIVE IDENTIFICATION BY GC/ MASS SPECTROSCOPY	21498 YEOMAN	9/17 COLUMBUS
6.42	9	A-PINENE	0.121	0.125
7.46	14	ISOBUTYL ISOBUTYRATE	0.455	0.066
8.10	16	8-PINENE	0.829	0.745
9.11	18	MYRCENE	51.427	42.267
9.77	22	2-METHYL-BUTYL PROPANOATE	0.659	0.370
9.90	23	ISOAMYL ISOBUTYRATE	0.522	0.184
9.96	24	2-METHYL-BUTYL ISOBUTARATE	1.946	0.800
10.28	26	L-LIMONENE	0.237	0.236
10.62	27	B-PHELLANDRENE? C10H15	0.260	0.177
11.59	32	trans-OCIMENE	0.159	0.168
12.45	35	2-METHYL-BUTYL 2-METHYL-BUTYRATE	0.180	0.090
12.68	36	METHYL HEPTANOATE	0.349	0.000
12.91	40	ISOAMYL ISOVALERATE	0.274	0.106
14.31	43	METHYL 4-METHYL-HEXA-2-ENOATE	0.139	0.000
14.39	45	METHYL 6-METHYL-HEPTANOATE	0.119	0.153
15.98	51	METHYL OCTANOATE	0.209	0.000
16.26	55	NONANAL	0.059	0.000
19.41	73	METHYL NONANOATE	0.070	0.000
19.56	75	2-DECANONE, A-YLANGENE	0.133	
19.93	77	A-COPAENE	0.252	0.764
21.00	83	LINALOOL	0.379	0.417
21.31	88	A-GURJUNENE	0.000	
21.42	89	7-METHYL-2-DECANONE	0.000	0.000
22.56	93	C15H24 CALARENE?	0.123	0.252

APPENDIX 1-continued

Detailed GLC analysis of assorted hop varieties.
Analytical Conditions: see Kenny (1990), supra.
OIL AREA PERCENTS OF COMMERCIAL HOPS

22.72	95	A-BERGAMOTENE, METHYL DECANOATE	0.000	0.000
23.01	96	2-UNDECANONE	0.361	0.068
23.10	97	2-DECANOL	0.268	
23.44	99	8-CARYOPHYLLENE	6.954	10.236
23.84	102	METHYL DEC-4-ENOATE	0.692	0.457
24.03	103	MW168 2-OL? ME 43,81,110,108	0.115	0.000
25.18	114	B-FARNESENE	0.000	0.000
26.10	122	HUMULENE	10.146	17.370
26.16	123	METHYL DEC-4,8-DIENOATE	0.553	
26.46	129	WILEY# 123998 MW 204 C15H24	0.439	1.992
26.59	131	2-DODECANONE	0.045	0.000
27.32	138	A-FARNESENE OR ZINGIBERENE	0.223	0.508
27.53	139	CAS# 030021-74-0	0.117	0.464
27.75	143	A-MUUROLENE	0.209	0.733
27.90	144	B-SELINENE	2.829	1.230
28.04	145	A-SELINENE	3.352	1.291
28.34	147	METHYL ?-UNDECENOATE	0.075	0.000
29.16	154	D-CADINENE	1.028	3.412
29.39	155	G-CADINENE	0.484	2.048
30.34	164	CAS# 016728-99-7 OR G-SELINENE	0.134	2.809
30.73	166	A-MUUROLINE	0.095	0.366
31.15	170	2-TRIDECANONE	0.313	0.000
31.36	171	GERANYL PROPANOATE	0.000	0.753
31.46	172	MW 212 METHYL ?-DODECENOATE	0.000	0.000
32.28	177	trans-GERANIOL	0.363	0.180
32.54	179	CAS# 000483-77-2 (CALAMENENE ?)	0.069	0.381
34.38	187	METHYL 3,6-DODECDIENOATE ME 79	0.061	0.000
36.42	196	MW 210 ME 43,54,82	0.048	0.135
39.11	211	CARYOPHYLLENE OXIDE	0.061	0.235
40.23	221	HUMULENE MONO-EPOXIDE I	0.059	0.109
40.28	223	MW222 ME 43,82	0.078	
41.07	225	HUMULENE MONO-EPOXIDE II	0.161	0.358
41.55	228	HUMULENE MONO-EPOXIDE III	0.073	0.167
41.88	231	MW 222 ME 43,79,80	0.365	0.847
43.88	242	MW 220 ME 43,79,91	0.000	0.455
44.73	246	T-CADINOL	0.101	0.232
46.08	255	T-MUUROLOL ME 95,121,204	0.062	0.111
47.50	262	MW 220 ME 41,67,109 DIEPOXIDE?	0.000	0.112
48.69	268	FARNESOL	0.148	

APPENDIX 2

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

Identification	Group	COLUMBUS 92-12-8-2	Area % GALENA 92-12-8-3
Apha-Pinene		0.125	0.184
Beta-Pinene	1	0.943	0.883
Myrcene	1	51.571	66.560
Methyl butyl Isobutyrate		0.838	3.575
Limonene	4	0.288	0.350
Linalool	3	0.470	0.294
Caryophyllene	1	6.297	3.097
Farnesene?	1	0.275	0.112
Humulene	1	11.049	5.764

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

Muurolene	4	0.768	0.309
Selinene	4	1.472	0.341
Geranyl Acetate	3	0.016	0.048
delta Cadinene	4	1.834	0.292
Gamma Cadinene	4	1.095	0.143
Geranyl Isobutyrate	3	1.716	0.296
Undecanone-2		1.348	0.059
Geraniol	3	0.048	0.060
Limonen-10-ol		0.155	0.021
Caryophyllene oxide	2	0.259	0.014
Humulene epoxide I	2	0.430	0.033
Humulene epoxide II	2	1.450	0.068
Caryolan-i-ol	2	0.120	0.006
Humulene epoxide III	2	0.025	0.013
Humulol	2	0.185	0.011
beta Eudesmol?			
alpha Eudesmol?			
Humulenol II	2	0.103	
Humulene diepoxide?	2		
Major Hydrocarbons (1)		70.135	76.216
Oxidation Products (2)		2.572	0.145
Floral-Estery (3)		2.250	0.698
Citrus Piney (4)		5.457	1.435
Total Accounted For		80.414	78.494
Humulene/Caryophyllene		1.753	1.861

Identification	Group	CHINOOK 92-12-9-1	NUGGET 92-12-9-2
Apha-Pinene		0.047	0.081
Beta-Pinene	1	0.435	0.667
Myrcene	1	28.469	51.972
Methyl butyl Isobutyrate		1.410	1.274
Limonene	4	0.136	0.183
Linalool	3	0.369	1.022
Caryophyllene	1	9.516	8.597
Farnesene?	1	0.353	0.162
Humulene	1	21.157	19.029
Muurolene	4	1.517	0.921
Selinene	4	1.385	0.818
Geranyl Acetate	3	0.210	0.044
delta Cadinene	4	4.215	0.926
Gamma Cadinene	4	2.686	0.445
Geranyl Isobutyrate	3	3.323	0.076
Undecanone-2		0.675	0.453
Geraniol	3	0.155	0.079
Limonen-10-ol		0.049	0.037
Caryophyllene oxide	2	0.076	0.032
Humulene epoxide I	2	0.326	0.220
Humulene epoxide II	2	0.663	0.328
Caryolan-i-ol	2	0.088	0.015
Humulene epoxide III	2	0.033	
Humulol	2	0.379	0.040
beta Eudesmol?		0.248	
alpha Eudesmol?		0.205	
Humulenol II	2	0.112	0.022
Humulene diepoxide?	2	0.316	
Major Hydrocarbons (1)		59.924	80.427
Oxidation Products (2)		1.993	0.657
Floral-Estery (3)		4.057	1.221
Citrus Piney (4)		9.939	3.293
Total Accounted For		75.913	85.598
Humulene/Caryophyllene		2.223	2.213

Area Percent Report
Sample Name: 92-12-8-2

Pk #	Ret Time	Area	Area %	Identification
1	7.030	3884	0.031	
2	7.854	1456	0.011	
3	8.010	1580	0.012	
4	9.053	8364	0.066	
5	9.260	10821	0.086	
6	9.358	15718	0.125	Alpha-Pinene
7	9.800	4213	0.033	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

8	10.297	2957	0.023	
9	10.543	9679	0.077	
10	11.097	967	0.007	
11	11.242	118386	0.943	Beta-Pinene
12	11.904	1183	0.009	
13	12.476	6468547	51.571	Myrcene
14	12.685	4762	0.038	
15	12.746	3884	0.031	
16	13.064	52106	0.415	
17	13.204	48568	0.387	
18	13.274	105192	0.838	Methyl butyl Isobutyrate
19	13.586	36238	0.288	Limonene
20	13.797	3396	0.027	
21	13.938	26704	0.212	
22	14.149	4588	0.036	
23	14.333	8748	0.069	
24	14.520	1416	0.011	
25	14.602	16543	0.131	
26	14.879	17328	0.138	
27	15.087	7345	0.058	
28	15.212	931	0.007	
29	15.420	743	0.005	
30	15.506	3693	0.029	
31	15.722	3398	0.027	
32	15.801	10636	0.084	
33	16.009	5267	0.042	
34	16.069	2526	0.020	
35	16.244	25684	0.204	
36	16.624	3088	0.024	
37	16.793	10279	0.081	
38	16.915	3626	0.028	
39	17.427	1969	0.015	
40	17.673	67587	0.538	
41	18.248	2557	0.020	
42	18.354	1000	0.008	
43	18.423	691	0.005	
44	18.953	7042	0.056	
45	19.178	7410	0.059	
46	19.291	6033	0.048	
47	19.466	10779	0.085	
48	19.777	7142	0.056	
49	19.956	4956	0.039	
50	20.134	23743	0.189	
51	20.364	804	0.006	
52	20.742	2092	0.016	
53	20.877	5423	0.043	
54	20.984	1676	0.013	
55	21.043	923	0.007	
56	21.229	29717	0.236	
57	21.448	1539	0.012	
58	21.532	7494	0.059	
59	21.843	8179	0.065	
60	22.211	1838	0.014	
61	22.295	6856	0.054	
62	22.441	19924	0.158	
63	22.568	2933	0.023	
64	22.750	66342	0.528	
65	22.922	5479	0.043	
66	23.076	2236	0.017	
67	23.224	1919	0.015	
68	23.360	6240	0.049	
69	23.682	59058	0.470	Linalool
70	23.938	25935	0.206	
71	24.171	19672	0.156	
72	24.285	1535	0.012	
73	24.432	6320	0.050	
74	24.542	1797	0.014	
75	24.816	10688	0.085	
76	25.028	9189	0.073	
77	25.276	29524	0.235	
78	25.457	3016	0.024	
79	25.597	16721	0.133	
80	25.737	4624	0.036	
81	25.858	45802	0.365	
82	26.177	789857	6.297	Caryophyllene
83	26.267	147160	1.173	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

84	26.483	11876	0.094	
85	26.654	2115	0.016	
86	26.951	19239	0.153	
87	27.128	7807	0.062	
88	27.262	34560	0.275	Farnesene?
89	27.452	5485	0.043	
90	27.650	12130	0.096	
91	27.741	32092	0.255	
92	28.029	22059	0.175	
93	28.286	1385879	11.049	Humulene
94	28.518	174316	1.389	
95	28.816	1217	0.009	
96	29.099	46594	0.371	
97	29.289	65255	0.520	
98	29.452	50235	0.400	
99	29.663	101538	0.809	
100	29.743	96334	0.768	Muurolene
101	29.922	184741	1.472	Selinene
102	30.066	2003	0.016	Geranyl Acetate
103	30.168	16997	0.135	
104	30.380	230089	1.834	delta Cadinene
105	30.604	137367	1.095	Gamma Cadiene
106	30.702	18692	0.149	
107	30.952	9850	0.078	
108	31.085	4796	0.038	
109	31.312	215300	1.716	Geranyl Isobutyrate
110	31.411	169139	1.348	Undecanone-2
111	31.517	26715	0.213	
112	31.630	77466	0.617	
113	31.737	5913	0.047	
114	31.821	6115	0.048	Geraniol
115	32.106	9621	0.076	
116	32.224	20686	0.164	
117	32.501	13220	0.105	
118	32.620	30790	0.245	
119	33.031	7712	0.061	
120	33.254	2445	0.019	
121	33.462	7790	0.062	
122	33.722	28110	0.224	
123	33.960	4270	0.034	
124	34.081	2094	0.016	
125	34.192	4256	0.033	
126	34.312	4289	0.034	
127	34.372	5764	0.046	
128	34.483	5031	0.040	
129	34.565	5092	0.040	
131	34.901	34301	0.273	
132	35.009	13488	0.107	
133	35.126	5975	0.047	
134	35.299	1614	0.012	
135	35.487	11667	0.093	
136	35.854	17035	0.135	Limonen-10-ol
137	36.161	2233	0.017	
138	36.312	32546	0.259	Caryophyllene oxide
139	36.476	1067	0.008	
140	36.577	2462	0.019	
141	36.935	6949	0.055	
142	37.071	1073	0.008	
143	37.206	13125	0.104	
144	37.370	2081	0.016	
145	37.555	7101	0.056	
146	37.672	54047	0.430	Humulene epoxide I
147	38.006	8150	0.065	
148	38.127	3162	0.025	
149	38.444	2423	0.019	
150	38.688	30971	0.246	
151	38.915	181869	1.450	Humulene epoxide II
152	39.075	15063	0.120	Caryolan-1-ol
153	39.222	3225	0.025	Humulene epoxide III
154	39.501	7444	0.059	
155	39.809	1283	0.010	
156	39.935	1171	0.009	
157	40.158	5912	0.047	
158	40.396	1243	0.009	
159	40.677	52277	0.416	
160	40.871	8343	0.066	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

161	41.254	6706	0.053	
162	41.404	23253	0.185	Humulol
163	41.759	4806	0.038	
164	41.946	30832	0.245	
165	42.077	2776	0.022	
166	42.236	2521	0.020	
167	42.537	2687	0.021	
168	42.964	11140	0.088	
169	43.065	7509	0.059	
170	43.258	23800	0.189	
171	43.848	4438	0.035	
172	44.637	12985	0.103	Humulenol II
173	45.039	5691	0.045	
174	45.892	3866	0.030	
175	46.597	1815	0.014	
176	47.014	2417	0.019	
177	50.412	1109	0.008	

= 1.25428E + 007

Area Percent Report
Sample Name: 92-12-8-3

Pk #	Ret Time	Area	Area %	Identification
1	7.034	2371	0.022	
2	7.855	753	0.007	
3	7.988	864	0.008	
4	8.623	706	0.066	
5	9.056	1684	0.016	
6	9.262	2429	0.023	
7	9.359	19367	0.184	alpha Pinene
8	9.801	6546	0.062	
9	10.096	924	0.008	
10	10.318	10977	0.104	
11	10.547	49458	0.469	
12	10.920	660	0.006	
13	11.098	1561	0.014	
14	11.242	93039	0.883	beta Pinene
15	11.733	1061	0.010	
16	11.901	3162	0.030	
17	12.090	1322	0.012	
18	12.484	6985773	66.360	Myrcene
19	12.692	7230	0.068	
20	12.750	5559	0.052	
21	13.073	155982	1.481	
22	13.217	83592	0.794	
23	13.301	376416	3.575	Methylbutyl Isobutyrate
24	13.593	36853	0.350	Limoene
25	13.810	1808	0.017	
26	13.942	30257	0.287	
27	14.151	2083	0.019	
28	14.317	15305	0.145	
29	14.529	2092	0.019	
30	14.609	73712	0.700	
31	14.896	239176	2.272	
32	15.091	5970	0.056	
33	15.333	699	0.006	
34	15.508	2556	0.024	
35	15.713	3795	0.036	
36	15.804	17078	0.162	
37	16.011	59153	0.561	
38	16.246	26755	0.254	
39	16.818	12944	0.123	
40	17.427	1728	0.016	
41	17.682	151069	1.435	
42	18.253	1689	0.016	
43	18.730	932	0.008	
44	18.953	1326	0.012	
45	19.192	122003	1.159	
46	19.329	5927	0.056	
47	19.481	11385	0.108	
48	19.791	7946	0.075	
49	19.952	1333	0.012	
50	20.134	5804	0.055	
51	20.727	9706	0.092	
52	20.879	21447	0.203	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

53	21.054	2750	0.026	
54	21.227	17557	0.166	
55	21.769	2599	0.024	
56	22.298	42843	0.407	
57	22.437	4686	0.044	
58	22.494	4842	0.046	
59	22.739	15483	0.147	
60	22.234	720	0.006	
61	23.358	6212	0.059	
62	23.681	30996	0.294	Linalool
63	23.937	41114	0.390	
64	24.168	9021	0.085	
65	24.789	2293	0.021	
66	25.025	2599	0.024	
67	25.343	82950	0.788	
68	25.449	1561	0.014	
69	25.596	28078	0.266	
70	25.830	3277	0.031	
71	26.073	326058	3.097	Caryophyllene
72	26.267	160273	1.522	
73	26.482	8286	0.078	
74	26.695	887	0.008	
75	26.833	1478	0.014	
76	26.923	20836	0.197	
77	27.019	1307	0.012	
78	27.112	1737	0.016	
79	27.223	11802	0.112	Farnesene?
80	27.440	2763	0.026	
81	27.709	6688	0.063	
82	28.023	24366	0.231	
83	28.227	606830	5.764	Humulene
84	28.353	4325	0.041	
85	28.485	24982	0.237	
86	28.582	4950	0.047	
87	28.782	837	0.008	
88	29.082	8038	0.076	
89	29.251	9309	0.088	
90	29.429	7845	0.074	
91	29.642	32547	0.309	Muurolene
92	29.716	35968	0.341	Selinene
93	29.883	5145	0.048	Geranyl Acetate
94	30.139	3103	0.029	
95	30.328	30746	0.292	delta Cadinene
96	30.562	15061	0.143	gamma Cadinene
97	30.780	1170	0.011	
98	31.068	2479	0.023	
99	31.144	7554	0.071	
100	31.383	31189	0.296	Geranyl Isobutyrate
101	31.504	6271	0.059	Undecanone-2
102	31.610	3590	0.034	
103	31.720	6384	0.060	Geraniol
104	32.097	2303	0.021	
105	32.222	1438	0.013	
106	32.489	10866	0.103	
107	32.608	3493	0.033	
108	33.028	780	0.007	
109	33.719	42378	0.402	
110	33.949	697	0.006	
111	34.181	786	0.007	
112	34.478	1455	0.013	
113	34.754	699	0.006	
114	34.891	1927	0.018	
115	35.004	1561	0.014	
116	35.121	616	0.005	
117	35.487	19190	0.182	
118	35.892	2261	0.021	Limonen-10-ol
119	36.302	1551	0.014	Caryophyllene oxide
120	37.203	2536	0.024	
121	37.660	3554	0.033	Humulene epoxide I
122	38.680	5605	0.053	
123	38.888	7257	0.068	Humulene epoxide II
124	39.082	690	0.006	Caryolan-1-ol
125	40.154	1386	0.013	Humulene epoxide III
126	40.669	3261	0.031	
127	40.872	1801	0.017	
128	41.248	3412	0.032	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

129	41.399	1245	0.011	Humulol
130	41.937	4179	0.039	
131	43.258	1708	0.016	

Total area = 1.0527E + 007

Area Percent Report
Sample Name: 92-12-9-1

Pk #	Ret Time	Area	Area %	Identification
1	7.028	3603	0.029	
2	7.848	1142	0.009	
3	8.004	772	0.006	
4	9.048	3120	0.025	
5	9.253	7251	0.060	
6	9.351	5689	0.047	alpha Pinene
7	9.794	4017	0.033	
8	10.302	1522	0.012	
9	10.538	14530	0.120	
10	11.090	761	0.006	
11	11.231	52365	0.435	beta Pinene
12	11.886	700	0.005	
13	12.412	3424969	28.463	Myrcene
14	12.648	2525	0.021	
15	12.725	2971	0.024	
16	13.048	23622	0.196	
17	13.193	43283	0.359	
18	13.268	169688	1.410	Methylbutyl Isobutyrate
19	13.576	16461	0.136	Limonene
20	13.794	2031	0.016	
21	13.929	18137	0.150	
22	14.311	4573	0.038	
23	14.595	10186	0.084	
24	14.873	11403	0.094	
25	15.080	12395	0.103	
26	15.413	700	0.005	
27	15.501	899	0.007	
28	15.700	2332	0.019	
29	15.796	15536	0.129	
30	16.002	9137	0.075	
31	16.243	38778	0.322	
32	16.787	5760	0.047	
33	16.906	1286	0.010	
34	17.425	608	0.005	
35	17.676	114830	0.954	
36	18.247	625	0.005	
37	18.947	1621	0.013	
38	19.175	28172	0.234	
39	19.294	3311	0.027	
40	19.463	9984	0.083	
41	19.771	2700	0.022	
42	19.947	1731	0.014	
43	20.130	4426	0.036	
44	20.732	2604	0.021	
45	20.874	10809	0.089	
46	21.044	2047	0.017	
47	21.230	61271	0.509	
48	21.533	14424	0.119	
49	21.780	1521	0.012	
50	21.843	956	0.007	
51	22.211	2063	0.017	
52	22.293	15179	0.126	
53	22.443	32264	0.268	
54	22.570	3366	0.028	
55	22.756	106737	0.887	
56	23.080	5302	0.044	
57	23.356	6309	0.052	
58	23.680	44440	0.369	Linalool
59	23.941	75567	0.628	
60	24.170	15675	0.130	
61	24.434	2150	0.017	
62	24.524	1616	0.013	
63	24.806	7293	0.060	
64	25.028	2541	0.021	
65	25.278	37278	0.309	
66	25.346	31734	0.263	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

67	25.605	32557	0.270	
68	25.881	90397	0.751	
69	26.140	1145130	9.516	Caryophyllene
70	26.269	176130	1.463	
71	26.486	9543	0.079	
72	26.835	1812	0.015	
73	26.988	22481	0.186	
74	27.140	17473	0.145	
75	27.353	42477	0.353	Farnesene?
76	27.473	5304	0.044	
77	27.783	61915	0.514	
78	28.035	24287	0.201	
79	28.343	2545867	21.157	Humulene
80	28.547	315497	2.622	
81	28.832	2334	0.019	
82	28.945	5985	0.049	
83	29.120	75042	0.623	
84	29.300	116317	0.966	
85	29.469	97160	0.807	
86	29.682	182550	1.517	Muurolene
87	29.764	166698	1.385	Selinene
88	29.967	25357	0.210	Geranyl Acetate
89	30.169	7062	0.058	
90	30.417	507237	4.215	delta Cadiene
91	30.630	323297	2.686	gamma Cadiene
92	30.879	5404	0.044	
93	31.069	10371	0.086	
94	31.155	5319	0.044	
95	31.332	399851	3.323	Geranyl Isoburyrate
96	31.467	81272	0.675	Undecanone-2
97	31.617	7782	0.064	
98	31.730	18703	0.155	Geraniol
99	31.890	7540	0.062	
100	32.109	8984	0.074	
101	32.223	86628	0.719	
102	32.436	9265	0.077	
103	32.491	6647	0.055	
104	32.620	30270	0.251	
105	33.035	3306	0.027	
106	33.230	743	0.006	
107	33.464	4214	0.035	
108	33.728	87090	0.723	
109	33.951	2444	0.020	
110	34.183	3253	0.027	
111	34.370	4703	0.039	
112	34.480	4897	0.040	
113	34.758	3342	0.027	
114	34.896	11595	0.096	
115	35.007	14221	0.118	
116	35.299	1278	0.010	
117	35.489	39880	0.331	
118	35.873	5944	0.049	Limonen-10-ol
119	35.982	1196	0.009	
120	36.163	3016	0.025	
121	36.310	9199	0.076	Caryophyllene oxide
122	36.564	1474	0.012	
123	36.871	5580	0.046	
124	37.205	13593	0.113	
125	37.365	21562	0.179	
126	37.551	3095	0.025	
127	37.669	39322	0.326	Humulene epoxide I
128	37.863	1467	0.012	
129	38.004	7647	0.063	
130	38.124	2074	0.017	
131	38.438	1793	0.014	
132	38.685	50800	0.422	
133	38.900	79889	0.663	Humulene epoxide II
134	39.082	10671	0.088	Caryolan-1-ol
135	39.209	4042	0.033	Humulene epoxide III
136	39.500	2852	0.023	
137	39.716	694	0.005	
138	39.789	600	0.005	
139	40.149	3072	0.025	
140	40.465	1310	0.010	
141	40.672	16151	0.134	
142	40.874	13029	0.108	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

143	41.250	10136	0.084	
144	41.406	45643	0.379	Humulol
145	41.758	11528	0.095	
146	41.846	13183	0.109	
147	41.945	25814	0.214	
148	42.073	9818	0.081	
149	42.534	5222	0.043	
150	42.964	29878	0.248	beta Eudesmol?
151	43.065	24765	0.205	alpha Eudesmol?
152	43.255	33781	0.280	
153	43.565	1828	0.015	
154	43.846	10003	0.083	
155	44.289	5485	0.045	
156	44.370	3097	0.025	
157	44.633	13527	0.112	Humulenol II
158	45.042	12525	0.104	
159	45.700	38097	0.316	Humulene diepoxide?
160	45.885	3830	0.031	
161	46.615	2140	0.017	
162	47.030	2967	0.024	
163	48.254	4136	0.034	
164	48.524	1729	0.014	
165	52.198	1275	0.010	

Total area = 1.20327E + 007

Area Percent Report
Sample Name: 92-12-9-2

Pk #	Ret Time	Area	Area %	Identification
1	7.034	1627	0.013	
2	7.850	1222	0.010	
3	9.051	1362	0.011	
4	9.259	2214	0.018	
5	9.355	9693	0.081	alpha Pinene
6	9.796	3741	0.031	
7	10.309	1970	0.016	
8	10.542	19685	0.166	
9	11.093	943	0.008	
10	11.236	79174	0.667	beta Pinene
11	11.895	2296	0.019	
12	12.468	6160576	51.972	Myrcene
13	12.679	3749	0.031	
14	12.741	4270	0.036	
15	13.058	44822	0.378	
16	13.201	59258	0.499	
17	13.275	151104	1.274	Methylbutyl Isobutyrate
18	13.582	21713	0.183	Limonene
19	13.800	1814	0.015	
20	13.934	28562	0.241	
21	14.144	933	0.007	
22	14.311	6730	0.056	
23	14.519	2088	0.017	
24	14.609	6243	0.052	
25	14.875	55333	0.466	
26	15.083	3970	0.033	
27	15.326	1045	0.008	
28	15.416	636	0.005	
29	15.503	2028	0.017	
30	15.702	2642	0.022	
31	15.798	10210	0.086	
32	16.005	54321	0.458	
33	16.241	21435	0.180	
34	16.809	7970	0.067	
35	17.438	1939	0.016	
36	17.655	61020	0.514	
37	17.783	1252	0.010	
38	18.248	665	0.005	
39	18.948	1086	0.009	
40	19.179	60530	0.510	
41	19.314	1798	0.015	
42	19.462	8464	0.071	
43	19.546	4332	0.036	
44	19.785	6451	0.054	
45	19.949	1390	0.011	
46	20.130	4840	0.040	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

47	20.722	11806	0.099	
48	20.873	1283	0.010	
49	20.945	2757	0.023	
50	21.226	4405	0.037	
51	21.524	2418	0.020	
52	21.776	2520	0.021	
53	22.199	1123	0.009	
54	22.294	37518	0.316	
55	22.438	12669	0.106	
56	22.558	1478	0.012	
57	22.743	43371	0.365	
58	23.076	1222	0.010	
59	23.236	1059	0.008	
60	23.355	8797	0.074	
61	23.681	121220	1.022	Linalool
62	23.935	17913	0.151	
63	24.167	9930	0.083	
64	24.417	1477	0.012	
65	24.798	946	0.008	
66	24.923	911	0.007	
67	25.023	2303	0.019	
68	25.347	50189	0.423	
69	25.462	730	0.006	
70	25.605	63484	0.535	
71	25.731	14566	0.122	
72	25.863	19067	0.160	
73	26.129	1019106	8.597	Caryophyllene
74	26.267	172193	1.452	
75	26.484	13509	0.114	
76	26.649	3488	0.029	
77	26.830	1518	0.012	
78	26.973	2085	0.017	
79	37.057	3159	0.026	
80	27.127	4597	0.038	
81	27.284	19285	0.162	Farnesene?
82	27.452	4597	0.038	
83	27.558	1014	0.008	
84	27.766	17735	0.149	
85	28.030	20185	0.170	
86	28.324	2255638	19.029	Humulene
87	28.509	62699	0.529	
88	28.575	78837	0.665	
89	28.933	16176	0.136	
90	29.101	26411	0.222	
91	29.319	43633	0.368	
92	29.442	23012	0.194	
93	29.658	109275	0.921	Muurolene
94	29.741	97039	0.818	Selinene
95	29.881	5248	0.044	Geranyl Acetate
96	30.142	4602	0.038	
97	30.351	109776	0.926	delta Cadinene
98	30.580	52832	0.445	gamma Cadinene
99	30.771	1506	0.012	
100	30.851	1737	0.014	
101	31.082	5775	0.048	
102	31.205	11532	0.097	
103	31.330	9041	0.076	Geranyl isobutyrate
104	31.511	53799	0.453	Undecanone-2
105	31.717	9415	0.079	Geraniol
106	31.814	3048	0.025	
107	32.085	5681	0.047	
108	32.219	5853	0.049	
109	32.492	1416	0.011	
110	32.608	7265	0.061	
111	33.033	906	0.007	
112	33.253	722	0.006	
113	33.712	10903	0.092	
114	33.945	1308	0.011	
115	34.071	2438	0.020	
116	34.181	1069	0.009	
117	34.368	5360	0.045	
118	34.474	674	0.005	
119	34.889	9616	0.081	
120	35.001	4520	0.038	
121	35.481	8543	0.072	
122	35.853	4382	0.037	Limonen 10-ol

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

123	35.976	1266	0.010	
124	36.154	1163	0.009	
125	36.296	3788	0.032	Caryophyllene oxide
126	36.909	1692	0.014	
127	37.183	9203	0.077	
128	37.358	1754	0.014	
129	37.660	26083	0.220	Humulene epoxide I
130	37.996	2405	0.020	
131	38.673	14395	0.121	
132	38.889	38989	0.328	Humulene epoxide II
133	39.079	1867	0.015	Caryolan-1 ol
134	39.922	885	0.007	
135	40.138	1296	0.010	
136	40.666	11481	0.096	
137	40.870	4099	0.034	
138	41.245	7744	0.065	
139	41.397	4776	0.040	Humulol
140	41.934	9925	0.083	
141	43.059	2394	0.020	

APPENDIX 2-continued

Detailed GLC analyses of Columbus and other U.S. high alpha hops.

142	43.254	5249	0.044	
143	43.842	1927	0.016	
144	44.637	2619	0.022	Humulenol II

= 1.18535E + 007

Reference:	Code	Variety
	92-12-8-2	Columbus
	92-12-8-3	Galena
	92-12-9-1	Chinook
	92-12-9-2	Nugget

Analytical Conditions: See, Nickerson and van Engel, "Hop Aroma Component Profile and the Aroma Unit," Journal American Society of Brewing Chemists, 50(3), 77-82(1992).

What is claimed is:

1. A new and distinct variety of hop plant named Columbus, substantially as shown and described.

* * * * *

Figure 1

Figure 2

Figure 3

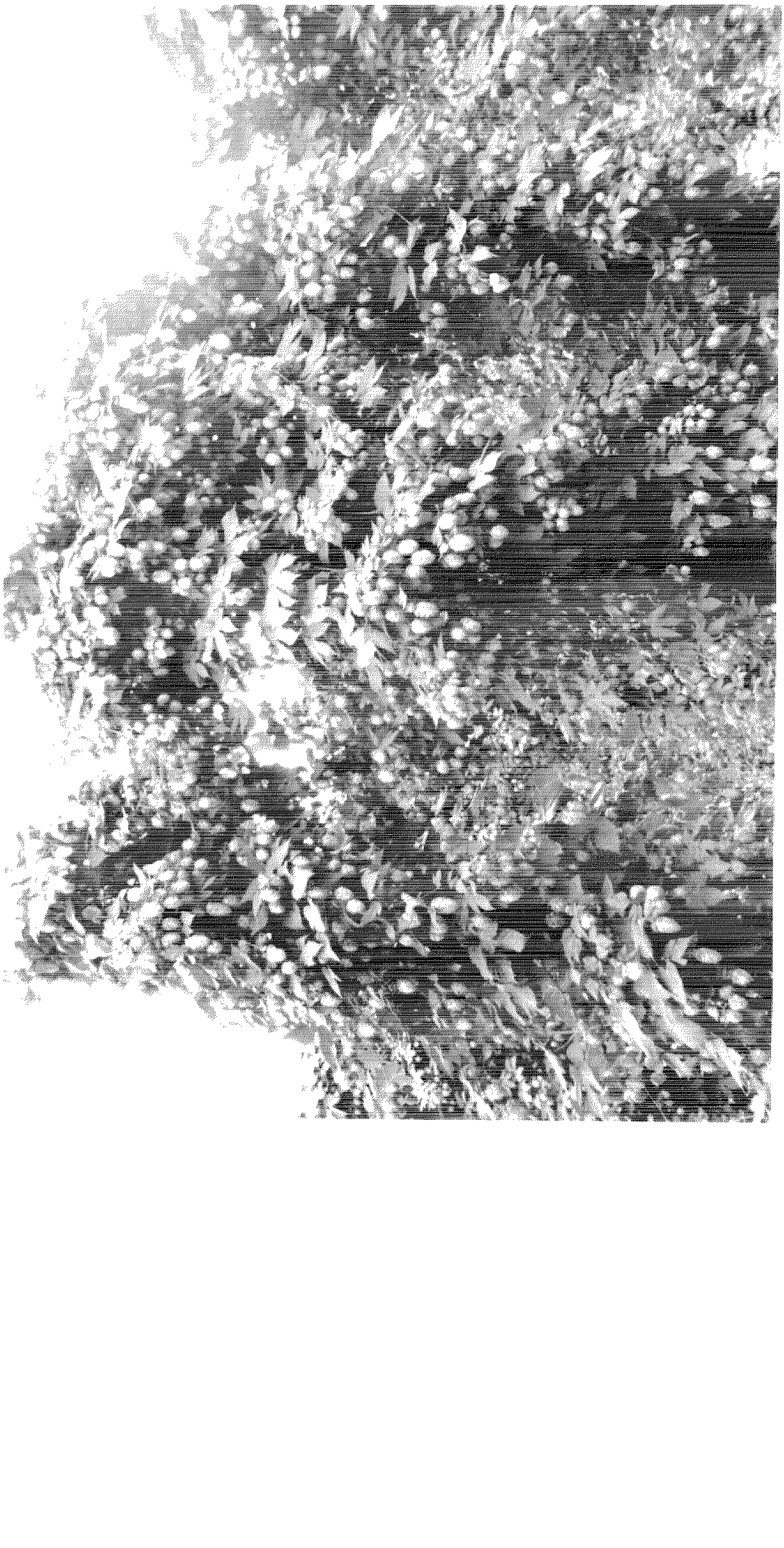

Figure 4

Figure 5