Cumin

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Delicate, slender and rather pretty, *Cumin cyminum* L. is an annual herb of the parsley family, *Umbelliferae*. Growing up to a height of 20-60 cm, this herb has tapered roots, erect stalk, very finely divided green leaves and white or rose colored small flowers.[1,2] Pale green to golden-brown in color, the dried cumin fruit (seed) is about 5-6 mm long,[2,3] uniformly elliptical, deeply furrowed and resembles caraway;[4,5] each of the two carpels is loaded with a seed.

Cumin cultivation extends from North Africa across Asia Minor to North India.[3] The herb also thrives in the Soviet Union, China and Latin America. India and Iran are the 'preferred origin' of the seed.[3]

India is the largest producer of cumin seed in the world,[4,6] with Gujarat accounting for about 60%.[6,7] China and Turkey are also significant sources of cumin; and a limited quantity originates from Egypt.[4] Cumin-1, a single plant selection developed from germplasm material, is the best variety which gives good resistance against diseases like wilt and alternaria blight and yields 700 kg/h of seeds, oblong in shape and ash-brown in color.[7] The annual quantity harvested averages 45,000-50,000 t.[8] Not more than 4% of the seeds raised in India are exported, though 10-15% could be spared without eroding the country's requirements.[6] Total consumption of this spice outside of India is ca 15,000 t.

Cumin is a distinctive and powerful spice, a key flavoring factor in curry powder and a staple of chili powder.[3,4] Either whole or ground, it makes an excellent seasoning in meats, sauces, salad dressings, marinades, stews, pickles and specialty cheeses, potatoes, lentils, cabbages and dried beans of all kinds.[3,5]

Effects of cryogenic and ambient grinding on color and volatiles of cumin seed have been investigated.[9] Cryogenically ground sample is significantly lighter in color than the ambient ground counterpart, and retains more of the volatiles of the natural spice.

FCC[10] vaguely defines cumin oil as the one obtained by steam distillation from the plant *Cuminum cyminum* L. Specifically, the commercial oil is derived from dried seed of fresh harvest, whole, crushed or finely comminuted immediately prior to distillation;[2,11-14] the yield ranges from 2.5% to 6%.[4,5,11,12]

Hydrodiffusion technology has been applied for the recovery of cumin oil from Polish seeds in a yield of 5%;[15a] 12 h hydrodistillation affords an average yield of 3.47%.[15b]

Liquid CO_2 extraction of cumin seeds at 20°C and 55-58 bar for 2 h yields 3.5% of volatile oil as against 3% by 4 h steam distillation.[16]

Table I. Distillation of Cumin Seed

Grinding mm	Distillation time, h.	Yield of oil, %	Steam Consumption/kg
1.2	10	0.41	758
3.5	19	2.16	283
5.5	23	2.93	268
Whole	32	3.08	328

Let us look closely into the intricacies in the conventional steam distillation of cumin oil.

Comprehensive studies[17-23] of the distillation of cumin reported on the influence of a) the fatty oil on the direction of distillation; b) degree of grinding of the fruit on distillation; and c) distillation rate and steam pressure of the process, the yield and quality of essential oil.

It has been found that the rate of distillation of a) the isolated essential oil, b) a mixture of essential fatty oils in their natural ratio 1:4,[23] and c) whole fruits, is in the ratio 1:3:16.[18] Therefore, the tissue structure of the fruits play a vital role in distillation. Residing in the endosperm of the fruits, the fatty oil is segregated from the essential oil by the seed cover and the endocarp of the fruit. Hence, hydrodiffusion of the essential oil through the fruit cover is the crucial factor that controls the duration of the distillation.

From the Bulgarian work, we have assembled in the distillation data (Table I). One can see that compared to whole fruits, the distillation time of coarsely ground fruits, 5.5 mm, is less by 31%; yield decreased only by 3.5% and the steam consumption dropped from 328 to 268 kg. With ground fruits, the distillation time is shorter, but the yield is lower.

GC analysis of essential oil obtained during distillation of ground fruits showed that hydrocarbons dominate the earlier and oxygenated compounds (cuminaldehyde) the latter fractions; a reversal of this compositional feature prevailed in the fractions from whole fruits. Direct contact of steam with the essential oil in the ground fruits caused the components to distill with respect to their volatility—in the beginning, the volatile hydrocarbons and later the high boiling oxygenated compounds (cuminaldehyde). In case of the whole fruits, more water soluble oxygenated compounds (cuminaldehyde) passed easily through the fruit cover. Specific gravity and optical rotation of the separated

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oil increased with coarseness of the substrate but refractive index, acid number and aldehyde content decreased. This is attributed to the higher evaporation of the hydrocarbons of the essential oil during the grinding of the fruits.

As in the case of fruits of other umbellifers, the fatty oil in cumin[18] complicates the recovery of the essential oil. Part of the fatty oil is volatile and forms emulsion. Another factor to be reckoned with is the partial solubility of essential oil in water. Further, the cohobated (water) oils are marked by the presence of 68-77% aldehyde. For these reasons, it is necessary to recycle the distillation water.[2,12]

Perhaps the most dramatic finding is the influence of the steam pressure and the distillation rate on the duration and steam consumption of the process. High quality oil is obtained when whole cumin fruits are distilled at 4 atm steam pressure and 6.15% distillation rate. It is advantageous to stop the distillation at 90-95% yield since the terminal oil is poorer in aldehyde concentration.

Freshly distilled cumin oil is initially colorless, later turning yellow to brown, not infrequently with a greenish tint,[12,13] and is sensitive to light, air, moisture, alkali and metals.[12] The spice is characterized by a peculiar distinctive aroma,[2] crossed with "some green/grassy notes" and "strong musty/earthy flavor,"[5] warm, slightly bitter, and to a degree disagreeable.[2] The essential oil reveals a strong powerful impact somewhat disagreeable,[10] crisply described as "bug-like."[13]

During distillation, decomposition of minute amounts of the proteins in the endosperm of the fruits imparts a peculiar putrified note, reminiscent of sulphides and amines, to freshly distilled cumin oil, which is not encountered in "treated" and "doctored up" oils.[12] The heavy, diffusive, spicy herbacious, fatty green, distinctly curry-like and bitter, its pungent odor is marked by nutty warmth in the background[24-26] and softness which is difficult to copy and distinguishes the natural from the synthetic oil.[12] In minute quantities (<0.5%), the oil can impart a lift to perfume and flavor compositions with exceptional diffusive power of greenish topnotes.[24]

The physicochemical properties of cumin oil display a wide range:[2,10,11,13,23,26-34]

Specific gravity: between 0.8945 and 0.9560 (0.9050 and 0.9250)

Optical rotation: between 1°30' and +8° (+3 and +8°)

Refractive index: between 1.4910 and 1.5150 (1.5010 and 1.506 at 20°C)

Aldehyde (as cumin aldehyde): between 16-65%.[13,26,27]

EOA[27] and FCC[10] pinpoint the requirements as 45-52%.

Cumin oil is not a significant item of commerce; the world production is about 8 t.[35] The oil is distilled in Spain, Egypt, Morocco, Algeria, France, USSR and India.[25,26]

Investigations spanning roughly a century report that cumin oil contains the following:[14,28-33,36-44]

α-pinene
β-pinene
cis- and trans-sabinene
δ-3-carene
myrcene
limonene
α- and β-phellandrene
α-, β- and γ-terpinene
terpinolene
p-cymene
α-*p*-dimethyl styrene
linalool
farnesol
α-terpineol
terpinen-4-ol
piperitol
cis- and trans-sabinene hydrate
cuminyl alcohol
p-menth-3-en-7-al
perillaldehyde
phellandral
myrental
cumin aldehyde
anisaldehyde
3-*p*-menthene-7-al
1,3-*p*-menthadien-7-al
1,4-*p*-menthadien-7-al
cryptone
trans-dihydrocarvone
cuminic acid
linalyl acetate
α-terpenyl acetate
bornyl acetate
methyl cinnamate
benzyl cinnamate
1,8-cineol
terpinolene oxide
caryophyllene oxide
dillapiole
daucene
α-copaene
β-elemene
β-caryophyllene
β-farnesene
β-bisabolene

Monoterpene hydrocarbons comprise about 53%, sesquiterpenes about 3% and oxygenated compounds about 43% of the oil.[26]

Most flexible and ingenious routes to regulate and step up cumin aldehyde and the quality of the oil are by blending of appropriate fractions isolated by steam fractionation during distillations or other grades of oil, or by vacuum distillation to remove certain undesirable fractions. In this manner, industry produces oil with different compositional features, agreeable organoleptic profiles and desired analyses.

Thus technically all parameters are coordinated to boost the concentration of cumin aldehyde which is regarded as the key determinant in the assessment of the quality of cumin oil.

Synthetic cumin aldehyde is the most troublesome adulterant. Guenther is of the view that adulteration with synthetic cumin aldehyde cannot be detected analytically except that the addition of an excess of this aldehyde would affect the angular rotation of the oil.[2] Provatoroff[24] discloses that "the comparison of the smelling strip with cumin oil and with the 50% cumin aldehyde solution, the latter diluted to correspond with the percentage of aldehyde present in the cumin oil, rapidly reveals the significant difference between the two and this will also be reflected in the composition."

According to Varo and Heinz,[41] the major natural aldehydes in fresh cumin may be 1,4-*p*-menthadiene-7-al and most of the other aldehydes may be artifacts except myrental and phellandral. Freshly ground cumin contains high concentration of the 1,4-*p*-menthadien-7-al, comparatively low level of cumin aldehyde and negligible amount of 1,3-*p*-menthadien-7-al and 3-*p*-menthen-7-al. The 1,4-*p*-menthadien-7-al disappears when the fresh spice is subjected to high temperature. Development of 3-*p*-menthen-7-al on heating cumin seed is responsible for the characteristic odor associated with curry powder.

These changes are due to the disproportionation of 1,4-*p*-menthadiene-7-al and gives oxidation cumin aldehyde.[41]

Structurally, 1,4-*p*-menthadien-7-al is derived from γ-terpinene by replacement of a C_7-hydrogen with -CHO group. The reactions of the 1,4-dienal are parallel to that of γ-terpinene, viz., hydrogen transfer leading to *p*-3-menthene and *p*-cymene, isomerization to α-terpinene and oxidation of *p*-cymene. Whereas γ-terpinene aromatizes easily to *p*-cymene, the other two conversions are triggered by catalysts. To the best of our knowledge, thermal disproportionation or conjugation of this *p*-menthadiene is not known.

Basically, it seems that the principal constitutents to the odor impact of the oil are the aldehydes—particularly 3-*p*-menthen-7-al, 1,4- and 1,3-*p*-menthadien-7-al and cumin aldehyde—the minor constituents playing a subtle role.[38] 3-*p*-Menthen-7-al might be a major contributor and its odor is sweaty-rancid. The other three aldehydes are green spicy and nutty in odor and do not differ significantly from one another; the 1,3- and 1,4-isomers have similar odor profiles.[32] A conclusion can, therefore, be drawn that the four aldehydes represent only two odor types. Perhaps it may be possible to determine "the freshness of cumin seed oil by the relative proportion of the four aldehydes responsible for the odor."[28]

Recent investigation[33] on the antifungal potential of cumin oil shows that it causes a highly significant decrease in both mycelial growth and aflatoxin production at 0.2 mg/mL and completely inhibits their production at higher levels. Though practical guidelines are lacking, chances are that the oil may serve as mould inhibitor or deterant in the deterioration of stored food by aflatoxin fungi.

Extraction of oleoresin from cumin seed, 40-45 mesh, with different solvents—methylene dichloride, ethylene dichloride, acetone, hexane and ethanol—by cold percolation and Soxhlation has been reported.[46] Except with hexane, the other solvents yield "heterogenous and dark brownish-green products" with "strong characteristic flavor." Hexane yields a greenish homogeneous isolate with comparatively less flavor and ethanol yields a pasty material. Cumin seeds roasted at 125°C produce oleoresins with better flavor than unroasted seeds.

Of brownish or yellowish green color,[22] cumin oleoresin has volatile oil concentration of 50-70ml/100g. Federal specification EE-S-00645C (Amy-GL) requires 60 ml of volatile oil at 5% dispersion rate. Standardized cumin oleoresins with 63-70% w/w oil,[47] Superresin cumin, 20% Superresin encapsulated in food starch, 50% Superresin + 50% dextrin with spice equivalent of 5, 25 and 60 respectively,[48] water soluble and oil dispersible encapsulated cumin oil and oleoresin of 6-fold flavour strength[5] are also available. Neither EOA nor FCC record the physicochemical properties of cumin oleoresin.

Though we do not have recent data, consumption of cumin oleoresin is of the order of 10-12 t per annum.[3]

Cumin absolute has an intense, exciting, intricate fragrance profile reminiscent of the crushed spice with a "richer, true-to-nature cumin seed character" than the diffusive volatile oil. When flavor and perfumery compositions require a "green spicy" touch, traces of the absolute are indispensable.

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