Hazelnut

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Scientific Name and Introduction

Corylus avellana L., the filbert or hazelnut, is a member of the birch family (Betulaceae). The edible seed is surrounded by a round to slightly oblong shell that must be separated from a husk during or after harvest. All important world cultivars originated from human selections of wild *C. avellana* in Europe and Turkey. The common name "filbert" originated in England and was originally applied to the long-husked types of *Corylus avellana* to distinguish them from the short-husked types and has since been used in the U.S. to distinguish the cultivated *Corylus avellana* from other native wild species of *Corylus*. The common name "hazelnut" is more commonly applied worldwide for nuts produced by all *Corylus* species.

Whatever the chosen common name, nuts from this genera represent one of the world's major nut crops, second only to almonds (Thompson et al. 1996). Turkey produces most of the world supply (70%), followed by Italy (22%), Spain (5%), and the United States (3%). By far the largest production area in the United States is the Pacific Northwest, with 99% of production in the Willamette Valley of Oregon (Mehlenbacher and Olsen 1997). Market uses for the U.S. crop have been roughly evenly divided between in-shell and kernel markets, but trends are shifting towards kernel markets. The major variety in the U.S. is Barcelona, followed by Davinia, Ennis, and Willamette.

Two wild species, *C. americana* and *C. cornuta*, are found in the United States. *C. americana* has been used in breeding programs for crossing with *C. avellana* in attempts to provide genotypes with sufficient cold hardiness and eastern filbert blight tolerance or resistance to allow production east of the Rocky Mountains with some success.

Quality Characteristics and Criteria

In-shell hazelnuts should be properly sized to meet the stated market type and should be properly filled with at least 50% of the shell cavity occupied by nutmeat. Shells should be free of cracks and noticeable mechanical injury and clean and brightly colored; coloring patterns should be characteristic of the stated variety. The pellicle should be smooth and devoid of husk attachments.

Kernels should meet the stated market type, be free of any misshapen or underdeveloped kernels, and be free of any shell or foreign material and off odor, off flavor, or mold. Water content of kernels should not exceed 6% if shelled or 7% if in-shell, and the total water content of unshelled nuts should not exceed 10 to 12%. Size is specified with grade as a determinant of quality, and minimum sizes are used for specification of classes "Extra" and "Class I" in international trade.

For in-shell markets, larger and particularly rounded types are preferred. Shelled markets accommodate both rounded and oblong types, and size preference depends on the intended end

use. Hazelnut kernel oil content ranges from 57 to over 70%, and total sugars average about 4%; both vary with variety and growing location (Botta et al. 1994). Hazelnuts are highest among tree nuts in α-tocopherol content (366 μg/g oil) and are also a rich source of vitamin B_6 (0.54 to 0.89 mg per 100 g) (Richardson 1997).

Horticultural Maturity Indices

In areas where hazelnuts are mechanically harvested, nuts are usually allowed to naturally drop from trees prior to sweeping from the orchard floor, and harvesting may commence after 90% of the nuts have dropped (Lagerstedt 1979). Kernels are considered mature after oil accumulation is complete and when the nut detaches from the base of the husk (Thompson et al. 1996). In the United States, most nuts are mature during or by the end of August but may be prevented from dropping by an immature, clasping husk. In production areas where hand harvesting from trees is still practiced, or for varieties in which husks fail to open and allow nut drop, nuts are considered mature when they will rattle inside the husk, indicating detachment of the nut from the base of the husk.

Grades, Sizes, and Packaging

U.S. standards exist for hazelnuts in the shell and for importation of in-shell or shelled hazelnuts, and international UN/ECE standards exist for both in-shell and shelled hazelnuts. Grades are primarily determined by size, degree of kernel fill, color, and freedom from defects and foreign material. U.S. No. 1 filberts must contain no more than 20% filberts of a different type (round shaped versus long type); no more than 10% defective nuts, provided that no more than 5% are poorly filled (blanks), no more than 5% are rancid, decayed, moldy or insect injured, and no more than 3% are insect injured; and not more than 15% filberts that fail to meet the specified size and of which no more than 10% are undersized. Furthermore, shells are free from surface moisture and the combined shell and kernel moisture content is not greater than 10%; shells are well formed, unbroken, not discolored, have adhering husk covering not more than 5% of the shell area and are practically free of adhering dirt and other foreign material.

Size is specified in connection with the grade in terms of minimum and maximum diameters which will pass through round openings of a screen and are specified separately for round-type varieties and long-type varieties:

Size	Round-type		Long-type	
	Minimum	Maximum	Minimum	Maximum
	in. (mm)			
Jumbo	56/64 (22.2)	—	47/64 (18.6)	—
Large	49/64 (19.4)	56/64 (22.2)	48/64 (19.0)	44/64 (18.6)
Medium	45/64 (17.9)	49/64 (19.4)	45/64 (17.9)	34/64 (13.5)
Small	—	45/64 (17.9)	—	35/64 (13.9)

All hazelnuts imported into the United States in lot quantities which exceed 115 lb (52.2 kg) net weight must meet minimum grade standards as specified under section 8e of the Agricultural Marketing Agreement Act. In-shell hazelnuts must meet U.S. No. 1 grade and be at least medium size with a tolerance for insect injury of 2% or less. Shelled hazelnuts must be well dried and clean; free from foreign material, mold, rancidity, decay, or insect injury; and free from serious damage caused by serious shriveling or other means. Stated tolerances for shelled hazelnuts include not more than 0.0002% foreign material; not more than 5% of kernels or pieces of kernels which are below grade, including not more than 2% for mold, rancidity, decay, or insect injury; and no more than 1% with rancidity or insect injury.

International grade standards are exercised at the export control stage and are specified for both in-shell and shelled hazelnuts. For in-shell nuts, UN/ECE classifications of Extra, Class I, and Class II exist in which the shell of all nuts must be well formed, intact, sound, and clean and the kernels must be sound, clean, sufficiently developed, and free from mold, visible damage from insects or pests, presence of live or dead insects or pests, rancidity, foreign smell or taste, and blemishes. All hazelnuts must contain less than 12% moisture and kernels not more than 7% moisture, and foreign material may not exceed 0.25% of the total in-shell weight. Sizing and statement of variety, commercial type, or shape is compulsory for Extra and Class I but is optional for Class II. For specified sizes in nuts of all classes, a total tolerance by count of 5% for rounded types and 10% for oblong types for nuts not meeting the specified size is allowed.

Extra hazelnuts must be 16 mm in diameter or more and be of superior quality, must be characteristic of the variety and/or commercial type, and must be practically free from defects with the exception of very slight superficial defects, provided they do not affect general appearance, quality, or keeping quality. They must contain no more than 4% empty nuts on a count basis; not more than 3% of the weight of in-shell nuts may contain shell defects; and not more than 5% of the kernels may be defective, of which not more than 3% may be moldy, rotten, rancid, or damaged by insects.

Class I hazelnuts must be 14 mm or more in diameter and be of good quality, must be characteristic of the variety and/or commercial type, and may contain only slight defects that do not affect the general appearance, quality, or keeping quality. They must contain not more than 6% empty nuts on a count basis; not more than 5% of the weight of in-shell nuts may contain shell defects; and not more than 8% of the kernels may be defective, of which not more than 5% may be moldy, rotten, rancid, or damaged by insects.

Class II hazelnuts may be of any size (if size is specified, tolerances apply) and be of marketable quality; they may contain defects provided that the in-shell nuts retain their essential characteristics as regards general appearance, quality, and keeping quality. They must contain not more than 8% empty nuts on a count basis; not more than 7% of the weight of in-shell nuts may contain shell defects; and not more than 12% of the kernels may be defective, of which not more than 6% may be moldy, rotten, rancid, or damaged by insects. Sizing or screening is used to specify market size in 2 mm increments from 22 mm to 14 mm or less. Sizing for nuts less than 22 mm in diameter must include the maximum and minimum size range, mention the minimum size followed by the words “and over,” or mention the maximum size followed by the

words “and less.” For nuts for final consumers under the classification “screened,” the size “and less” is not allowed.

For hazelnut kernels, UN/ECE classifications of Extra, Class I, and Class II also exist; and requirements are similar to those stated for kernels of in-shell nuts with the addition of provisions for intactness of kernels and a slightly reduced tolerance for kernel moisture content from not more than 7% for in-shell kernels to not more than 6% for shelled kernels. Foreign material may not exceed 0.25% for kernels in any classification. Sizing and statement of variety is also compulsory for Extra and Class I kernels but optional for Class II. For kernels in all classes, a total tolerance of 10% is allowed for kernels other than the specified variety and/or type, and a size tolerance by weight of 5% is allowed for rounded types and 10% for oblong types. To be designated either Extra or Class I, hazelnut kernels must have a minimum diameter of 9 mm, with the exception of hazelnuts of the piccolo type or hazelnuts having a similar designation for which a diameter of 6 to 9 mm is allowed.

Extra hazelnut kernels must be of superior quality, must be characteristic of the variety and/or commercial type, and must be practically free of defects with the exception of very slight superficial defects provided they do not affect the general appearance, quality, or keeping quality. Total tolerances for defects are 5% by weight or 6% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 1% may be rancid, rotten, moldy, have off odor or off flavor, or be damaged by insects or rodents; no more than 2% may be not fully developed, including shrunken and shriveled, stained, and yellowish kernels; and not more than 3% may be mechanically damaged and pieces. Not included in the total tolerance is that not more than 2% may be twin hazelnuts.

Class I hazelnut kernels must be of good quality, must be characteristic of the variety and/or commercial type, and may have slight defects of form and color provided that these do not affect the general appearance, quality, or keeping quality. Total tolerances for defects are 12 to 13% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 1.5% may be rancid, rotten, moldy, have off odor or off flavor, or be damaged by insects or rodents; no more than 4% may be not fully developed, including shrunken and shriveled, stained, and yellowish kernels; and not more than 8% may be mechanically damaged and pieces. Not included in the total tolerance is that not more than 5% may be twin hazelnuts.

Class II hazelnut kernels may be of any size (if size is specified, tolerances apply) and be of marketable quality; they may contain defects provided that kernels retain their essential characteristics as regards general appearance, quality, and keeping quality. Total tolerances for defects are 16 to 18% if the lot is specified as “Old Crop.” Of the total tolerance, no more than 3% may be rancid, rotten, moldy, have off odor or off flavor, or be damaged by insects or rodents; no more than 8% may be not fully developed, including shrunken and shriveled, stained, and yellowish kernels; and not more than 10% may be mechanically damaged and pieces. Not included in the total tolerance is that not more than 8% may be twin hazelnuts.

Hazelnut kernels may be sized or screened, with the size expressed in increments of 2 mm. All sizes are allowed, subject to the minimum designations for Extra and Class I hazelnut kernels.

For kernels for final consumers under the classification “screened,” the size “and less” is not allowed.

Optimum Storage Conditions

Soon after harvest, nuts should be dried to below 10 to 12% moisture, with kernels below 6 to 7% moisture to deter mold growth. In-shell and unroasted kernels may be stored for 24 mo with minimal loss in quality at temperatures up to 10 °C (50 °F). Roasted kernels may only be held for 6 mo prior to development of detectable rancidity stored at 0, 5, or 10 °C (32, 41, or 50 °F). However, reduced temperature may be effective in combination with other protective measures such as vacuum packaging in extending roasted kernel shelf-life to 1 year or more (Ebraheim et al. 1994).

Retail Outlet Display Considerations

Hazelnuts are normally marketed at ambient temperature. Use of vacuum or low-O_2 MAP is recommended to extend shelf-life. In-shell hazelnuts may be marketed in bulk containers. Exposure to moisture and high RH should be avoided.

Chilling Sensitivity

Hazelnuts are not sensitive to chilling and are commonly stored at temperatures at or below freezing for long term storage.

Ethylene Production and Sensitivity

Ethylene may be used as a harvest aide to enhance maturation of husks for earlier harvest (Lagerstedt 1979). During storage hazelnuts produce very low levels of ethylene.

Respiration Rates

Properly dried hazelnuts exhibit very low respiration rates during storage.

Physiological Disorders

Black tips on kernels appears to be associated with nuts having split or weak sutures. It appears to be caused by an oxidation process that occurs on the pellicle only and may or may not be associated with moldy kernels (Thompson et al. 1996).

Twin kernels occur when two kernels develop within one nut shell, and is an undesirable trait because of the small size and irregular shape of affected kernels.

Blank nuts are in-shell hazelnuts devoid of normal kernels. It results from defective embryo sacs, unviable eggs, failure of fertilization, or embryo abortion at varying stages of development. Owing to the alternate bearing cycles for hazelnuts, poorly filled nuts may also result during an overproduction year, and poor kernel fill appears to be a heritable trait (Thompson et al. 1996).

Postharvest Pathology

The most common decay found in hazelnuts is molds, with *Romularia* spp. most prevalent throughout nut development. It is the major pathogen associated with kernel tip mold (Ebraheim et al. 1997, p. 483). Although *Romularia* spp. appear to infect hazelnuts during nut development and may be quiescent prior to maturity and storage, many molds require breakage of the shell to contaminate the nut; thus, intactness of the shell offers some natural defense against mold infestation.

The dominant flora during storage are *Penicillium* and *Aspergillus* spp. *A. flavus,* capable of producing aflatoxin, has been isolated from hazelnuts in storage (Eke and Goktan 1987). Reduction of in-shell moisture content to below 10% and nutmeat moisture content to less than 6% is an effective means of deterring mold growth. Sanitation with chlorine dips may also be effective in reducing the incidence of mold infestation by reducing the amount of innoculum carried into postharvest storage. Because of the high amounts of organic material on the surface of shells, chlorine concentrations should be monitored and replenished as necessary to maintain chlorine at concentrations necessary to kill microorganisms.

Quarantine Issues

To prevent spread of eastern filbert blight *(Anisogramma anomala),* all trees, plants, cuttings, and scions of all species and varieties of the wild and cultivated filbert or hazelnut, *Corylus* spp., may not be transported into Oregon from States and districts of the U.S. east of and including the States of Montana, Wyoming, Colorado, and New Mexico; the entire State of Washington; and all provinces, districts, and territories of Canada east of and including the province of Alberta.

Special Considerations

Hazelnuts marketed in-shell should be sampled periodically to assess nutmeat quality. Although the most common nut causing allergy in children and adults is peanut, hazelnuts may also be an allergenic food additive (Ewan 1996), and the presence of hazelnut in foods must be declared. An ELISA test can be used to detect hazelnut presence in complex food mixtures (Holzhauser and Vieths 1999). Shelling, blanching, or roasting decreases hazelnut shelf-life compared to storage in-shell (Ebraheim et al. 1994). Roasting temperature and duration interact to decrease shelf-life with increasing roasting temperature and duration (Richardson and Ebraheim 1997). Hazelnuts absorb lipophilic compounds that can induce off flavor. Although frozen storage may be used to increase shelf-life, once out of storage hazelnuts should be used as soon as possible due to reduced shelf-life at room temperature.

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