

Hazelnuts in Ontario – Growing, Harvesting and Food Safety

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INTRODUCTION

This Factsheet describes how to grow hazelnuts in Ontario as a commercial business. Topics cover the basics of selecting the appropriate climatic region and ideal soil type for hazelnuts, preparing a field for planting, planting the hazelnut trees and managing the orchard once it is established. Various methods of harvest are discussed, followed by proper handling, processing and storage requirements of the hazelnut crop. A section on food safety links the importance of developing on-farm protocol for Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) to ensure the food that farmers produce is safe for consumption and of high quality, from the field to the consumer.

ORCHARD ESTABLISHMENT

Site Selection

Climatic Requirements

To maximize the annual cropping potential of hazelnut orchards and minimize the risk of winter freezing injury or spring frost injury, plant hazelnut orchards close to large bodies of water, such as the Great Lakes or regions of the province that are known to support other fruit orchard industries. Many hazelnut varieties that are new to Ontario require further testing to fully determine the tolerance of each crop and pollinizer variety to local winter and spring climates.

The most cold-hardy hazelnut varieties will be killed by -40°C temperatures, so avoid planting hazelnuts in any area of the province where -40°C occurs at least once every 15 years (Figure 1). European hazelnut varieties, such as those originating from Europe or from the Oregon State University hazelnut breeding program, are most sensitive to winter cold and frost injury, and have climatic requirements similar to peaches and other tender fruit. European varieties

are better suited to the most climatically moderated regions of the province, such as the Niagara peninsula or along the north shore of Lake Erie.

Hazelnut hybrids, which are crosses between European and native hazelnuts, such as varieties developed previously in New York or at Rutgers University, are less sensitive to winter conditions but still benefit from moderated winters. Colder regions that typically support commercial apple or pear orchard industries, and warmer regions of tender fruit industries would be suitable for hybrid hazelnuts.

Hazelnut orchards located too far from orchard regions would be more likely to sustain winter injury, spring frost injury and reduced annual cropping. Stressed or injured hazelnut orchards are also more susceptible to infection by disease and attack by insect pests.

Soil Type

Hazelnuts will grow best in well-drained, deep, fertile, moist loam to sandy loam soil with good aeration and a soil pH of 6 to 7. Avoid soils with a pH below 5. Sample the soil of the planting site to determine soil pH, fertility and the variability of soil across the field.

Hazelnuts will also grow fairly well on heavier soils such as clay-loam, as long as drainage is adequate and roots can develop and remain in a healthy condition to good depths. Moist clay soil, however, may not support heavy orchard equipment adequately during orchard maintenance and harvesting activities, even where permanent ground cover is established. During harvest, the heavy sweep-brush harvesters require an absolutely flat, drained soil surface to pick up ripened hazelnuts effectively.

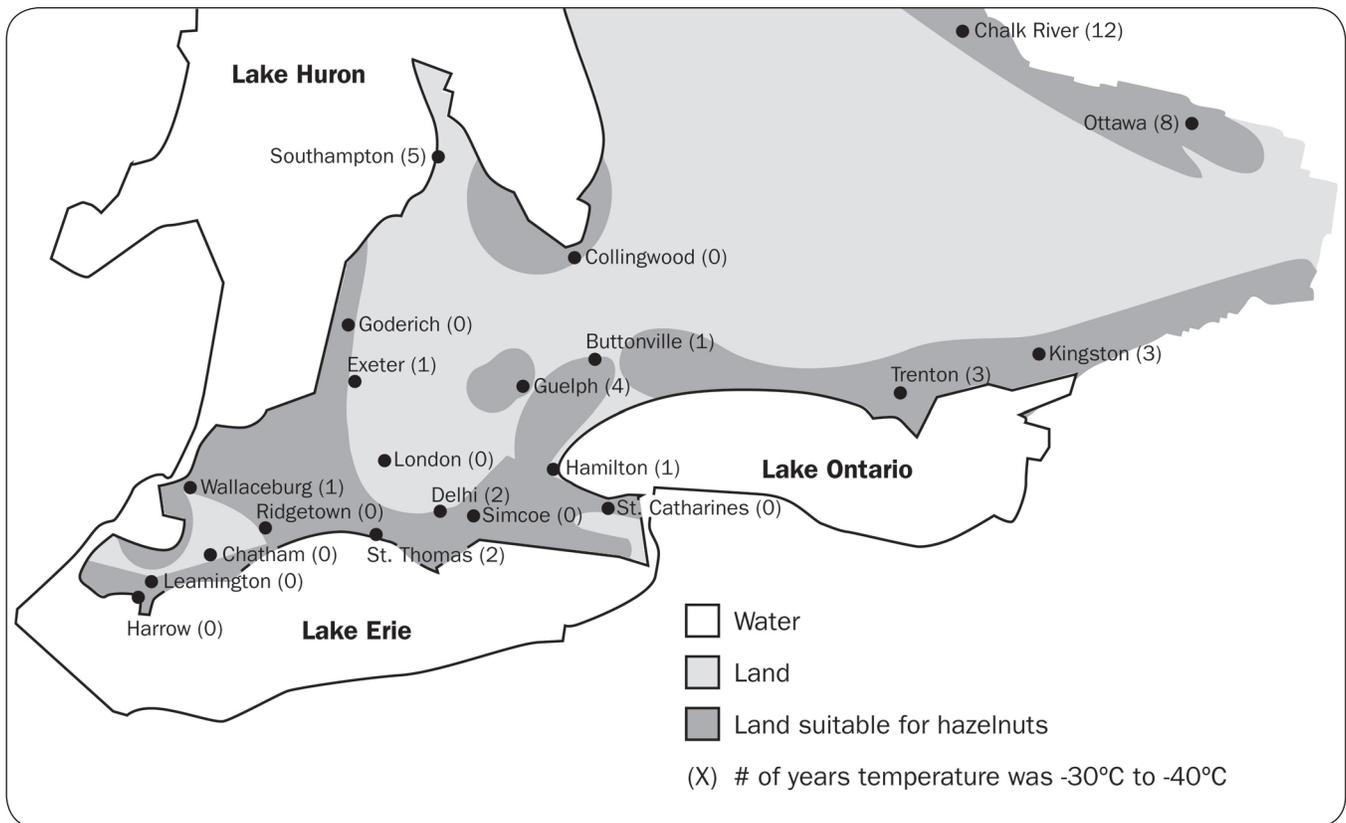


Figure 1. Growing regions for hazelnuts: Soil suitable for hazelnut production and number of years with temperatures of -30°C and lower (1990–2010) in Southern Ontario.

Soil Drainage

Hazelnuts are fairly shallow-rooted, and the majority of the root system will develop in the upper 1–1.5 m of soil, where drainage is adequate. Hazelnut root systems that are not adequately aerated in flooded soils will die below the water level. This can reduce tree health and cropping potential significantly. If the roots are too severely damaged, the trees can either die or take many years to recover, since the trees must re-grow damaged roots to restore normal cropping potential.

Hazelnut orchards located on deep sand or gravel-sand soil on high ground may not need tile drainage installed before the orchard is planted. However, where natural drainage of soil moisture is not adequate, tile drainage will allow the trees to grow and survive better.

To provide adequate drainage of orchards, space perforated tiles 30–40 ft between parallel drains in sandy to sand-loam soil, and 25–30 ft between tiles on heavier soil. Locate tiles approximately 1–1.5 m deep, which maintains the water table at or below

this depth. Tile drainage at this spacing will drain excess soil water from the orchard quickly and prevent flooding injury to hazelnut root systems.

Irrigation

During the first three or four years after planting, young hazelnut trees are very susceptible to drought and will benefit from trickle irrigation to ensure they receive sufficient water during the first growing seasons.

Established hazelnut trees will tolerate relatively dry soils, as the roots can penetrate down into moist soil layers. While bearing hazelnut trees tolerate dry soils, growers in Ontario have noted a larger percentage of empty nut shells following extended periods of dry weather during late spring and summer, significantly reducing crop yield.

Trickle irrigation, using clean water, can help offset the effects of dry weather. Consult with irrigation companies for advice on how to set up irrigation systems for hazelnut orchards.

Use trickle irrigation and good weed management while the young trees are growing to help the young hazelnut root systems and branches develop quickly to produce significant nut yields as soon as possible.

Slope of the Orchard

Avoid planting orchards in low areas of land, which can create a micro-climate that favours frost injury. Higher areas of land that have a gentle slope and a cleared lower area beyond the orchard boundary will have improved air drainage, preventing frost pockets from forming in spring. Where air cannot drain, spring frosts can be a recurring problem. Frost pockets can damage sensitive flowers and new vegetative growth. Growers in Niagara orchards have used wind-generating machines successfully to prevent frost injury in hazelnuts during moderate to heavy spring frost conditions.

Wind Protection

Because hazelnuts are wind-pollinated, they require some air movement to transfer pollen. However, the canopy and developing crop are sensitive to damage by strong winds. Hazelnut plantings, like all horticultural crops, benefit with shelter from damaging winds. Hazelnut orchards also benefit from wind protection that can damage exposed male catkin flowers during cold dry winter months.

Plant windbreaks around the perimeter of new orchards at the same time as, or before, planting hazelnuts. To protect the trees from wind and still allow adequate air drainage, orchard producers will often thin, but not entirely remove, lower branches from conifer windbreak trees up to 1.2–1.8 m above the soil. Thinning lower branches allows the air to move through the windbreak canopy more effectively, to disperse frost pockets that may otherwise be a problem along dense windbreaks.

A single or double row of conifers, such as white or Norway spruce, will provide adequate wind protection. Incorporate three to five different species of conifers in the windbreak to ensure diversity and provide for a healthier windbreak. Eastern white cedar is a good windbreak species to include, however, when used alone, it can become too dense, limiting air movement through the canopy. Colorado blue spruce and Austrian pine are tolerant to the desiccating effect of drifting road salt spray along highways and can help provide wind protection.

Proximity to Forested Areas

Although natural forested areas promote a healthy environment and can help shelter nearby crops from wind damage, hazelnut orchards are often affected by insect pests and diseases commonly found in southern Ontario forests. For example, wood-boring insects can girdle young hazelnut trees, and weevils can attack nuts in bearing orchards near harvest, as well as attack oaks and hickory trees.

Wild native hazelnuts, commonly found growing along forest edges, can harbour most insect pests and diseases of hazelnut orchards. Eastern filbert blight is a serious disease of many hazelnut varieties that can survive on and spread from wild hazelnuts. Ornamental corkscrew hazelnuts can also harbour Eastern filbert blight disease.

Where new hazelnut orchards grow close to forested areas, monitor the health of the orchard and crop weekly, during the entire growing season. Learn to identify the symptoms of diseases and insect pests of hazelnuts and develop an effective pest management program.

Bird species such as crows, blue jays and wild turkeys can consume considerable quantities of hazelnuts that are near ripe. Squirrels, white-tail deer and raccoons can also consume hazelnuts. Forested areas are sanctuaries for wildlife. Manage damage by wildlife more intensely once adjacent hazelnut orchards are producing an annual crop.

Whether wild hazelnuts help pollinize hazelnut orchards has yet to be verified.

Mapping Out the Area

Working from a map of the production area and nearby land features is essential for proper planning of the hazelnut orchard. There are many things to consider before planting the orchard. In addition to the outline of the producing field, include crops growing in adjacent fields, the locations of neighbouring private residences or public buildings that could be affected by noise, dust or spray drift, as well as the location of underlying tile drains, outlets and direction of water flow. Detail topography, soil characteristics and areas of concern.

Ensure that natural water courses and riparian areas are protected; use buffer zones, if necessary, when applying pest control products and other agricultural inputs.

Site Preparation the Year Before Planting

Prepare the soil for hazelnuts starting the year before the trees are planted. Break hardpan soils, which may be located up to 45 cm under the soil, with an appropriate subsoil blade passing in two directions, to ensure that excess water can drain through the subsoil. Disk and cultivate the soil surface 15–20 cm deep to loosen the soil, allowing rain water to penetrate and the root zone to be aerated.

If the soil pH is too acidic for hazelnuts (below pH 6.0), apply lime and till it into the soil. Soil tests can determine whether lime application is necessary and how much lime to add per acre to achieve a soil pH that is more suitable for hazelnuts.

Soils often lack organic matter and hence a healthy soil structure. To improve soil health, plant a cover crop the year prior to planting. A green-manure cover crop can be planted and grown for a full year, then tilled under the following spring.

Another option is to establish a permanent ground cover the year before planting hazelnuts. Once the permanent ground cover is established, mark out the tree rows and till up a 1.2–1.5-m wide strip the following spring for each tree row.

Perform weed control in the fall prior to planting, to mark the tree rows and kill ground cover so the area can be tilled more effectively. This reduces the preparatory work before tree planting the following spring and ensures a weed-free soil for several weeks after the trees are planted. Consult your OMAFRA specialist about suitable herbicides for this purpose. Consult OMAFRA Publication 75, *Guide to Weed Control*, for preplant site preparation prior to any crop.

Orchard Layout and Planting Design

Plant tree rows parallel to existing fence lines, or in the most convenient direction of travel for orchard equipment.

Hazelnuts must cross-pollinate with other compatible hazelnut varieties. Producers of European hazelnuts can follow existing guidelines on pollinizer compatibility, so that crop yield is maximized. In orchards in Oregon, approximately 15% of the trees are pollinizer trees, interspersed throughout the main blocks of crop variety.



Figure 2. A new hazelnut orchard with herbicide weed management and ground cover established.

Plant hazelnuts in large blocks that consist primarily of the main crop variety plus sufficient numbers of pollinizer varieties (Figure 2). Pollinizer varieties must provide adequate amounts of compatible pollen at the appropriate time when female flowers are open and receptive to pollen.

Large blocks consisting of one main crop variety plus pollinizers will enable a majority of the hazelnut crop to mature and drop to the ground at the same time throughout the block. Even nut ripening and simultaneous nut drop allows a mechanized harvester to collect the crop in one or two passes, minimizing the cost of harvesting the crop. Fallen hazelnuts will start to mould or become rancid and rot if they sit on the ground for more than a few days.

At present, it may be best to plant diverse seedling hazelnuts as pollinizers with the main crop variety to ensure that sufficient compatible pollen is transferred, for example, plant every third row within a variety block with seedling pollinizer trees.

The spacing of rows and distance between trees will depend on the varieties chosen. European varieties grow larger than hybrid hazelnuts. European varieties can be planted at 6–7 m between rows and 4 m between trees. Smaller hybrid trees can be planted closer, at 5 m between rows and 3 m between trees.

Nursery Stock

Order hazelnut trees well in advance, from a reputable nursery, to ensure that the trees can be planted at the right time and coordinated with other fieldwork. Contact the nursery or nurseries at least 2 years ahead of planting to determine whether they have the appropriate hazelnut crop and pollinizer varieties, and to know if trees will be available in sufficient quantities. For large orders, it would be wise to place the order with the nursery 2 years in advance since it requires a full year for nurseries to root cloned varieties or produce seedlings to a point where they are ready to ship to growers. Nurseries often have orders from many growers and need to plan for their own production objectives.

Nursery trees should arrive at the farm in good condition with a large mass of healthy moist roots that have not been allowed to dry out. Stems should be thick with lots of healthy dormant buds along the length. There should be no sign of disease on the roots or stem, such as spore-forming structures of Eastern filbert blight disease on the stem surface.

The nursery stock should arrive at the farm just before planting. If the trees arrive early or planting is delayed, keep the trees in a dormant state in a cold storage facility until they can be planted.

Planting the Orchard

Plant hazelnut trees in early spring, from early April, while the young trees are still dormant. This allows the roots to settle in the soil and be ready to grow when the buds break and the vegetative shoots begin to elongate. New shoot growth is proportional to root growth and will indicate whether the unseen roots are growing well in the soil.

Trees planted after budbreak will be stressed, as the roots will be unable to take up enough water to supply expanding leaves. This is why trees often die or are severely stunted during the first year.

In larger orchards, trees can be planted with a tractor-mounted tree planter blade; in smaller orchards, they can be planted by hand with a tree planting spade. Tractor-mounted augers can be used to make planting holes but they tend to hard-pack the soil on the sides and bottom of the holes. This can reduce water drainage or impede root growth through the packed soil layer. To prevent this, growers sometimes weld one or two small metal

slabs to the outer edge of the auger, which cut through packed soil surfaces as the holes are dug.

Care After Planting

If the soil is dry or only partially moist at planting time, water each tree immediately with 12–19 L of water per tree. Usually, the trees do not need fertilizing in the first year. However, where the soil lacks fertility, apply a dilute starter fertilizer right after planting. Also, use a hand hoe to keep a weed-free area, 1 m in diameter, around the young trees, since new trees can be easily damaged by herbicides.

To help control weeds, place a ring of organic mulch around each tree, a few days after they have been planted to prevent the soil from drying out and provide a better environment for roots to grow. Organic mulch will keep the soil moist and will attract earthworm activity in the soil to help incorporate organic matter and improve soil aeration and water percolation to the roots.

Keep mulch clear of the tree trunks to prevent mice from chewing the bark and girdling trunks during winter. Place the mulch in a layer, 7.5–10 cm thick, in a 1–2 m diameter circle around the trunk.

ORCHARD MANAGEMENT

Pruning

Hazelnut trees usually do not require pruning until the second year. Adjust the pruning strategy according to the type of hazelnuts being grown. Prune hazelnuts in late winter and early spring before dormant buds begin to grow. Pruning during late fall may result in tree injury, where fresh large cuts can dry back to main scaffold branches before the cuts heal during the following spring.

European hazelnuts will naturally grow as a multi-stemmed tree. In Italy and Turkey, hazelnuts are grown with 3–5 main trunks, while in Oregon, the same hazelnut varieties are grown with a single trunk and eventually take on a large form similar to an old-fashioned apple tree. A single trunk makes mechanized maintenance and harvesting operations easier. Growers in Ontario may train for one main trunk or multi-stemmed trunks. By the third year, the main trunks should be formed and be free of branches 1–1.5 m above the ground, and the main scaffold limbs developed above this height.

Once main scaffold limbs have grown, prune them each year to remove diseased, dead or old branches to encourage new fruiting branches to grow at the top of the trees.

Remove all prunings from the orchard before the trees begin to grow in spring to prevent spread of disease. Burn or chip prunings and compost them at a location distant from the orchard.

Remove suckers growing from the ground around the trunk or from the lower trunk each year. Prune suckers by hand or kill them with a registered contact herbicide, which will kill the suckers but will not harm the tree above. Consult OMAFRA Publication 75, *Guide to Weed Control*, an OMAFRA specialist or the OMAFRA website to determine which herbicides to use and how to apply them.

Hazelnut nuts form on the new season's growth, so much of the crop will grow at the outer canopy of the trees. Do not prune young trees excessively, to avoid removing too much fruiting wood. Once trees have attained a mature size, a pruning plan may consist of pruning a quarter of an orchard every year over a 4-year period (or a third every 3 years) to sustain hazelnut orchards with adequate new fruiting wood.

Hybrid hazelnuts require a different pruning and training strategy than European varieties. These hybrids are smaller and are multi-stemmed and shrubby. Prune them each year to remove the oldest branches from each bush and allow new branches to grow up from the ground to maintain annual cropping.

Nutrient Management

Nutrient management or fertilizer recommendations for Ontario hazelnuts are still to be determined. Growers must monitor the visual health of the orchard each season. Soil samples and leaf tissue analysis can help the growers decide what fertilizers to apply. Nutrient management strategies developed for commercial hazelnuts in British Columbia and Oregon can provide useful information to help develop a nutrient management program for Ontario.



Figure 3. Hazelnuts maturing inside the husk.

Orchard Floor Management

A flat orchard floor is essential to allow equipment to harvest the nuts. This can be maintained weed free under the canopy of hazelnut trees during establishment and during the cropping years, either through shallow tillage or with herbicides. In bearing orchards, a sod ground cover will provide organic matter to improve soil health. Grass mixtures, such as Kentucky blue grass, perennial rye grass and fescue, with a small percentage of white clover, can provide a healthy ground cover that will out-compete weeds. Mow ground covers regularly to expose mice and voles to predators and to maintain the flat surface needed to harvest the nuts. Roll or scrape the orchard floor as needed to maintain a flat surface. Flail mowing also helps maintain a flat surface.

Post-Harvest Field Management

After harvest is completed, brush or flail mow the orchard to clear or pulverize any remaining nuts, twigs and branches that can attract mice and voles into the orchard. Keep the ground cover fairly short until late fall to discourage mice and voles from inhabiting the orchard during winter.

HARVESTING

Before harvest and just prior to nut drop, flail or mow the orchard floor low to the ground so that the ripe, fallen nuts can be easily harvested. Roll the orchard floor firmly to make it flatter and smoother, allowing the sweeper brushes on the harvester to sweep the hazelnuts off the ground efficiently as it passes.

Harvest hazelnuts after they are fully mature and have dropped to the ground (Figure 3). Most growers wait for the nuts to fall, rather than shake

them from the tree. First, the nuts are swept into rows, then picked up and separated from the debris. The nuts are then moved to a processing plant where they are cleaned, cured (dehydrated) and stored. In Ontario, the harvest usually begins in early September and lasts up to 6 weeks.

The harvest equipment used depends on the age and size of the orchard. In young and small orchards, collect the nuts by hand or with small hand tools or vacuum pick-up equipment and nets. In larger orchards, use specialized ground-sweeping collection equipment to harvest the nuts mechanically.

Service and inspect all equipment and machinery used for harvesting, storage and transportation of hazelnuts before the start of harvest to prevent contamination and to avoid potential working hazards.

In the first step of harvest, a self-propelled windrowing machine using air blast or mechanical fingers sweeps the hazelnuts to a centred narrow windrow. A pick-up machine — the same type used to harvest pecans, almonds and walnuts — then retrieves the nuts from the ground. As hazelnuts are smaller in size than the other nuts, cleaning screens, air flow, clearance in conveyors and augers must be changed to the correct size for hazelnuts. A harvesting machine separates nuts from the leaves, twigs, soil, etc. and conveys them to boxes or bulk trucks for delivery to the processing plants. Some growers use tractor-pulled harvesters, where a rotating drum with rubber fingers flips nuts into a bin as it sweeps the ground. The nuts are deposited into a basket mounted on the harvester.

Depending on the weather conditions, mechanically harvested hazelnuts can contain 5%–25% foreign material. Stationary cleaners at the processing plants remove this material.

FOOD SAFETY

Prevention, reduction or elimination of potential biological, chemical and physical food safety hazards must be a priority during hazelnut production and processing. Health risks associated with hazelnuts include *Salmonella*, which usually originates from animal wastes and aflatoxins caused by fungal contaminants. All activities during the production and processing of hazelnuts should include proactive steps to mitigate these and other potential risks.



Figure 4. Hazelnuts ready for fresh market or value-added products.

Hazelnuts and other tree nuts contain allergenic proteins. All equipment and facilities that are used to harvest, contain, process and store hazelnuts must be dedicated to “nut only” purposes and must be kept physically separated from all other non-nut farm produce, such as fruit and vegetable commodities.

Good Agricultural Practices

Food safety begins in the orchard with implementation of Good Agricultural Practices (GAPs). GAPs may include selection of the orchard site (e.g., on uncontaminated land and far from polluting industrial sites) or adjacent land uses (e.g., away from intense livestock operations where manure may find its way into the orchard). If irrigation water is used, it must not be polluted with animal wastes. As much as possible, exclude wild animals from the hazelnut orchard. Carefully control and monitor human activities such as sanitizing equipment, applying pesticides, herbicides and fungicides, and handling and transporting hazelnuts.

Good Manufacturing Practices

Operational controls that reduce or prevent contamination by people and their activities are also essential to a safe food-processing environment. These controls include personnel practices, receiving, handling and storage, packaging, shipping, cleaning and sanitizing, preventative maintenance, calibration, pest control, waste management and other human activities within the processing facility. Prevention, reduction or elimination of potential biological, chemical and

physical food safety hazards must be a priority during hazelnut processing (Figure 4). Collectively, they are commonly called Good Manufacturing Practices (GMPs), Prerequisite Programs (PRPs) or Best Management Practices (BMPs).

Food safety hazard management begins with the design and construction of the hazelnut processing facility.

Ensure that the facilities are designed and built to discourage pests and external contaminants from entering or staying in the buildings. Internal building surfaces must be cleanable. Design equipment that can be cleaned and sanitized easily, constructed of materials that are compatible with both product and cleaning methods, and installed so it can be cleaned and maintained. Design the flow of the nuts and their byproducts through the plant to ensure that everything — people, ingredients, packaging materials, product, air and waste material — moves within the facility in a way that does not allow contaminants to cross-contaminate any food products. Physically or operationally separate incompatible activities that have the potential to cross-contaminate.

The Grocery Manufacturers Association in the U.S. has developed two food safety resources for nut processors — *Industry Handbook for Safe Processing of Nuts* and *Control of Salmonella in Low Moisture Foods* (see Resources).

Additional detailed food safety information may be obtained from OMAFRA food safety staff by e-mailing foodinspection@ontario.ca.

POST HARVEST OPERATIONS

Post harvest operations are separated into three groups: those that clean and dehydrate the nuts before they are stored, long-term storage, and the operations to shell and package the nuts to be shipped to market or secondary manufacturers. These operations may take place on-farm or at a central processing facility.

Various municipal, provincial and federal regulations must be met, as the post harvest operations require facilities and water, and the end product has to meet existing food safety and quality regulations (*Food Safety and Quality Act, 2001*, Ontario Regulation 119/11). Consult with OMAFRA food safety specialists.

Building and Water Regulations

All buildings must conform to municipal building regulations, and all equipment must meet the required safety standards. Consult your municipal Planning Department and the Ontario Ministry of Labour before you design your processing plant.

Processing facilities that use large quantities of water need permission to extract and dispose of that water. In areas of Ontario that are designated water hazard areas, new facilities that extract more than 50,000 L per day are prohibited or will require a permit to take water. Consult your local office of the Ontario Ministry of Environment to find out which local water regulations apply.

Hazelnut processing facilities should also be designed to reduce food safety hazards. For more information on this, consult the Good Manufacturing Practices section of this Factsheet or consult with OMAFRA food safety specialists.

Cleaning and Drying

Harvested nuts are transported and unloaded at the primary processing facility where they are de-husked, cleaned, washed, sanitized and dried. At each stage, the nuts become progressively cleaner, so the processes after washing should be physically separated to prevent cross-contamination.

Nuts that do not fall free from the husk must be removed from the husk. This can be done by hand on the inspection belts or with a brush or scrubber placed in front of the cleaner on the processing line.

The cleaner removes trash and deposits the nuts on a conveyer, where they are inspected and any remaining debris is removed. Storage bins with grated bottoms help remove debris. These types of bins allow air to circulate between the nuts, which helps with drying if the nuts were collected wet.

The nuts are then washed and sanitized. This procedure can be a batch process or continuous flow system placed in the processing line after they are inspected. A batch system is ideal for small growers. Sanitize the nuts in a bleach or peroxide bath to reduce surface contamination. Some processors bleach nuts with sulphur dioxide, to enhance their appearance.

Finally, the nuts are dried to 5%–8% moisture content to prevent the nuts from becoming rancid or mouldy. The harvested nuts should be dried within 24 hours after harvest. Optimal drying temperatures are 32.2°C–38°C. At this temperature, it takes 2–3 days to reduce the moisture level to the required 5%–8% so they can be stored and kept dry.

Nuts are usually dried in permanent bulk dryers or portable bin-type dryers. The amount of heat necessary to dry hazelnuts to the required temperature is relatively small; there is no need to purchase expensive equipment. For a small farm operation, a homemade box dryer would work. Many inexpensive, fairly efficient dryers have been made by remodelling a modern tobacco kiln, a grain dryer or an old building already on the farm. If the crop is small, dry hazelnuts by spreading them out in a thin layer in a dehumidified room.

During the drying process, the internal colour gradually changes from white to cream, starting from the outside. Kernels containing 5%–8% moisture snap if bitten when they are cold. Meters can precisely measure the moisture content.

As soon as the nuts are dried to an in-shell moisture content of 5%–8%, or a shelled moisture content of 3.5%–4.5%, grade, fumigate and seal them in plastic-lined, airtight boxes, bags or bins and move them into long-term storage. The plastic liners will stabilize the moisture content, prevent the absorption of flavours and odours from other products, and protect the kernels from oxidative rancidity and self-heating.

Storage

The long-term storage facility will be the largest part of the primary processing facility. This is where the nuts will be held until they are shelled or shipped to other manufacturers. One tonne of unshelled nuts will occupy 3–4 m³ of storage.

Since this storage is the interface between the field cleaning operations and the clean shelling and packaging operations, design and implement ways to minimize cross-contamination. Store hazelnuts in a cool, dry place, below 10°C, with 60%–65% relative humidity.

Keep the nuts away from light such as ultraviolet light, which causes the kernels to become rancid

faster and to heat up. This leads to unpleasant off-tastes and odours, which reduce the shelf life and value significantly. They also reduce oil yield and change the composition of the oil. More free fatty acids are produced, which makes it more difficult to decolour and blanch the kernels.

The nuts can be stored for longer periods at cooler temperatures. The storage life depends largely upon the temperature. Hazelnuts stored at room temperature can turn rancid within a few weeks. From 0°C–1.7°C, with 60%–65% relative humidity, hazelnuts will keep for up to 2 years. The storage facilities must be clean and dry, well ventilated and be able to keep the relative humidity below 65%. They must also be protected from rain and kept free of insects, rodents and birds.

Carefully control water activity during storage. It is a measure of the energy status of the water in a system and varies with moisture level and temperature. The aflatoxin-producing *Aspergillus flavus* fungus species cannot grow or produce aflatoxin at water activity less than 0.7, relative humidity below 70% and temperature less than 10°C.¹

Since hazelnuts have a very low water content, they can be frozen in the shell or as kernels. When stored at -3.9°C to -2.8°C, with 60%–65% relative humidity, hazelnuts may be kept in bulk for up to 4 years.

Researchers are investigating the use of Controlled Atmosphere Storage to provide superior long-term storage of hazelnuts. A low oxygen concentration (2%) will prevent oxidation of fats and oils to prevent rancidity, minimize respiration of nuts and prevent infestation by all storage pests. High carbon dioxide (20%) will reduce hazelnut respiration to maintain quality and prevent storage pests. The remaining atmosphere is nitrogen gas. Low humidity and refrigerated temperatures will maintain nuts in a dehydrated condition to prevent mould.

Cracking, Sizing and Packaging

Once the nuts are removed from storage, they can be either packed and immediately shipped, or the kernels can be removed from the shells and then packed and shipped. Shell nuts or process kernels immediately before they are sold, because the kernels degrade faster once they are removed from the shells.

Table 1. U.S. standard grades for minimum and maximum nut diameter

Size classification	Maximum size (mm)	Minimum size (mm)
Round type varieties		
Jumbo	No maximum	22.2
Large	22.2	19.4
Medium	19.4	19.0
Small	19.0	No minimum
Long type varieties		
Jumbo	No maximum	18.6
Large	18.6	17.5
Medium	17.5	13.5
Small	13.5	No minimum

To reduce the amount of broken kernels, size the nuts before they go into the sheller, which removes the kernels from the shells. The sheller is usually composed of three crackers, with 25-cm adjustable diamond rollers. These can be adjusted to lightly crack the nut shells so that fewer kernels are damaged. The winnower separates nut meat from shell fragments after cracking.

Once the kernels are separated from the shells, sort them by size and grade, and inspect them visually to remove kernels with defects and broken kernels.

After the final inspection, pack and ship the kernels. The packaging varies according to the specifications of the buyer. This can vary from small packages for immediate retail sales, large boxes for loose retail sales to large 1-tonne bags for further manufacturing.

In North America, the standard ‘U.S. No. 1’ grade consists of hazelnuts in the shell:

- at least medium size (19.0–19.4 mm)
- less than 20% of a different type (round nuts versus long oval nuts) (Table 1)
- less than 10% defective nuts, provided that less than 5% are poorly filled or blanks and not more than 5% of rancid, decayed, mouldy or insect injured, including not more than 3% with insect damage
- less than 15% of nuts off size, with less than 10% undersized

U.S. No. 1 grade shelled hazelnut includes:

- not more than 0.0002% of foreign materials
- not more than 5% kernels below grade, including not more than 2% mouldy, rancid, decayed or insect damaged

Note: It is possible that a Canadian grade may be established in the future if the Ontario hazelnut industry expands sufficiently. The Oregon hazelnut industry has its own grade standards for hazelnut in shell and kernels, which can be found at http://oregonhazelnuts.org/grades_and_standards.php.

Shipping

Hazelnuts can be shipped in ventilated shipping containers providing that water content, packaging and transport conditions (temperature, relative humidity and protection from insect or any other contamination) of nuts comply with federal and provincial regulations. Protect the cargo against solar radiation to prevent nuts from becoming rancid or self-heating. In damp weather, protect the cargo from moisture, since it may lead to mould, spoilage and self-heating as a result of respiratory activity.

To ensure safe transport, secure the bags in such a way that they cannot slip or shift during transport. Pay attention to the packing pattern of the bags to allow proper cargo ventilation and reduce stack pressure.

Nuts marketed in import or interprovincial trade are regulated by the Fresh Fruit and Vegetables Regulations under the *Canada Agricultural Products Act*. In-shell nuts packaged, labelled, transported, advertised or sold by non-federally registered establishments in Ontario are regulated by Ontario Regulation 119/11 under the *Food Safety and Quality Act*. Consult with OMAFRA Food Inspection Branch staff.

ENDNOTE

- ¹ Beuchat, L.R. (1978). Relationship of water activity to moisture content in tree nuts. *Journal of Food Science*, 43: 754–755.

RESOURCES

The websites listed here may reference pest control products that are not registered in Ontario. For a listing of pest control products registered on hazelnuts in Ontario, see OMAFRA Publication 360, *Guide to Fruit Production*, or an OMAFRA specialist.

www.ontario.ca/crops

In the Horticulture section, see Agroforestry.

www.songonline.ca

www.songonline.ca/ecsong

www.oregonhazelnuts.org/index.php

www.nutfruit.org

www.hazelnutcouncil.org/about/council.cfm

www.nuthealth.org

www.hazelnut.com

www.canadianchestnutcouncil.org

www.wfghazelnuts.com

www.nutgrowing.org

Grocery Manufacturers Association

Industry Handbook for Safe Processing of Nuts

([www.gmaonline.org/downloads/technical-guidance-and-tools/](http://www.gmaonline.org/downloads/technical-guidance-and-tools/Industry_Handbook_for_Safe_Processing_of_Nuts_1st_Edition_22Feb10.pdf)

[Industry_Handbook_for_Safe_Processing_of_Nuts_1st_Edition_22Feb10.pdf](http://www.gmaonline.org/downloads/technical-guidance-and-tools/Industry_Handbook_for_Safe_Processing_of_Nuts_1st_Edition_22Feb10.pdf))

Control of Salmonella in Low Moisture Foods

([www.gmaonline.org/downloads/technical-guidance-and-tools/](http://www.gmaonline.org/downloads/technical-guidance-and-tools/SalmonellaControlGuidance.pdf)

[SalmonellaControlGuidance.pdf](http://www.gmaonline.org/downloads/technical-guidance-and-tools/SalmonellaControlGuidance.pdf)).

OSU Eastern Filbert Blight Help Page: www.oregonstate.edu/dept/botany/epp/EFB/index.htm

OMAFRA Factsheets:

12-007 *Hazelnuts in Ontario – Biology and Potential Varieties*

12-009 *Hazelnuts in Ontario – Pests*

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