Harvesting, Handling, & Grading

Today, most pecans are harvested mechanically. They are shaken from the trees, gathered, cleaned, and dried almost immediately. As a result, they have a uniformly high quality—generally better than that of hand-harvested nuts that remain on the ground for longer periods of time. In storage they can retain their quality for up to a year or more if temperature and moisture levels are carefully controlled.

This chapter discusses pecan harvesting, drying, and storage. It also provides simple guidelines for growers to use when grading their pecans before marketing them.

Harvesting

Until a few years ago, most pecans were harvested by hand. When labor became scarce and prohibitively expensive, growers rapidly turned to mechanical equipment to harvest, grade, and dry their pecans.

Manual Harvesting

Pecans can still be harvested by hand in home orchards, around scattered trees, and in terrain too rough for harvesting equipment. If no mechanical equipment is used, the nuts drop naturally, and they must be picked up continually. If they remain on the ground and exposed to rain and soil moisture for a week or more, they begin to discolor and spoil.

Mechanical Harvesting

The mechanical systems that have replaced hand harvesting consist of tree shakers, nut sweepers, vacuum harvesters, and trash separators. This equipment is expensive, and you must carefully determine its cost-effectiveness for your orchard.

Equipment

Mechanical harvesting involves three operations:

1. Shaking the tree after the nuts have ripened. Depending on the cultivar, shaking may need to be done once or twice.
2. Sweeping the nuts into windrows and picking them up.
3. Cleaning sticks, clods, leaves, and other trash from the nuts before drying and grading.

Shakers. Tree shakers (Figures 6-1 and 6-2) have jaws that clamp the trunk of a tree and shake the whole tree at one time. They are especially suitable for mature trees that have high branches and large trunks. Shakers have pods or cushions in the jaws that help prevent the jaws from damaging the tree trunk. Trunk damage is a common problem, especially when harvesting early.

Sweepers. Sweepers (Figures 6-3 and 6-4) rake the pecans into windrows for easier harvesting. Some sweep the orchard floor without digging into the soil; others have fingers or flippers that gather nuts from holes and depressions. Sweepers can be mounted on the harvester so that both operations can be done in a single pass.
Harvesters. Mechanical pecan harvesters (Figures 6-5 and 6-6) range from small, walk-behind models that harvest an acre a day to large, self-propelled machines that harvest five or more acres per day. Vacuum-type harvesters use the suction of powerful blowers to pick up nuts, but they also pick up hulls, leaves, and sticks that must be separated from the nuts.

Harvesting Conditions
Mechanical harvesting must be done during dry weather. In wet weather, leaves and trash foul the mechanism and cannot be cleaned from the nuts effectively. For the same reason, cattle should be removed from the orchard well in advance of harvesting to give the mure plenty of time to cake and dry.

The orchard floor does not need to be perfectly flat for mechanical harvesting, but it should be smooth enough for the harvester to pick up the nuts. The ground should be smoothed when the orchard or the grass is planted.

The best orchard floor for a vacuum-type harvester is a short sod covering. If the ground has been cultivated, the harvester will pick up clods and dirt along with the pecans.

Charles B. Ogburn
Auburn University

Drying And Storing Nuts
As soon as pecans fall from the tree, they begin to dry and cure. Initially, this process improves the quality of the nuts until they reach an optimum appearance, aroma, flavor, and texture. But, if the process continues, the seed coat darkens and the oil in the kernel increases in peroxide and free fatty acid levels. These compounds cause the nut to be stale and rancid.

Drying is one of the most important steps in assuring a high quality appearance and flavor in pecans. The moisture content of the pecan kernel should be reduced to about 8 percent as soon as possible after harvest and to 4.5 percent before long-term storage. Moisture content should then be maintained at 4.5 percent throughout storage.

MOISTURE SENSITIVITY
A new pecan is very sensitive to moisture. It should be harvested in dry weather and not allowed to lie on moist ground or be rained on.

More often than for any other reason, nut quality is lost when a nut dries properly and then becomes wet again.

Pecans that are harvested in wet weather and remain wet for several days usually turn dark immediately after being shelled. The kernels absorb tannins from the shells and membranes, and they often have a bitter flavor and mold easily.

One experiment that demonstrated the harmful effects of leaving pecans on moist ground used five varieties of nuts. Initially, the kernel moisture averaged 4.74 percent. The nuts were spread on wet soil in a pecan orchard. They were then picked up at intervals to determine moisture content and percentage of molded nuts. Table 6-1, page 89, shows that the nuts began to absorb moisture immediately and to mold in three days. As many as 87 percent of the Stuart cultivar had molded in ten days.

Drying
As pecans mature on the tree, the moisture level of the sap in the kernels gradually drops from an initial 30 percent to about 8 percent when the nuts normally dehisce (split their shucks). Buyers usually will accept nuts that have an 8 percent moisture level; however, the price may be lowered because of excessive moisture.

While the optimum moisture level for highest quality in stored pecans is 3.5 percent, 4.5 is a safe level for preventing mold growth. The moisture of nut kernels must be reduced to these levels before long-term storage.

Mechanical Systems
Pecans that are shaken mechanically from the trees generally have a higher moisture content than those that drop naturally because they do not have time to dry in the air before they are shaken down. It
Table 6-1. Effect Of Moist Soil On Moisture Content And Molding Of Pecan Kernels.

<table>
<thead>
<tr>
<th>Days On Wet Ground</th>
<th>Moisture Content Percentage</th>
<th>Molded Nuts Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stuart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4.22</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5.42</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>7.16</td>
<td>44</td>
</tr>
<tr>
<td>8</td>
<td>7.04</td>
<td>46</td>
</tr>
<tr>
<td>10</td>
<td>8.35</td>
<td>87</td>
</tr>
<tr>
<td>Schley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.97</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5.70</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6.80</td>
<td>70</td>
</tr>
<tr>
<td>8</td>
<td>7.33</td>
<td>75</td>
</tr>
<tr>
<td>10</td>
<td>8.35</td>
<td>75</td>
</tr>
<tr>
<td>Moneymaker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5.34</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>7.55</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>9.24</td>
<td>35</td>
</tr>
<tr>
<td>8</td>
<td>9.75</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>10.18</td>
<td>65</td>
</tr>
<tr>
<td>President</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4.26</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4.92</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>5.18</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>5.75</td>
<td>20</td>
</tr>
<tr>
<td>10</td>
<td>6.58</td>
<td>45</td>
</tr>
<tr>
<td>Pabst</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>5.85</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5.49</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>6.23</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>5.73</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>6.20</td>
<td>30</td>
</tr>
</tbody>
</table>

This section was adapted with permission from material prepared by E. K. Heaton, A. L. Shewfelt, and L. R. Beauchat, University of Georgia Department of Food Science, and A. E. Badenhop, Horticulturist, Purdue University (deceased).

is necessary to dry the shaken nuts quickly, either naturally or artificially, to reduce the kernel moisture to 8 percent and maintain the quality of the nut.

With a mechanical dryer, you can dry harvested pecans regardless of weather conditions. The drying trailers also provide a place to hold pecans during harvest.

Mechanical drying systems (Figure 6-8) for pecans operate in the same way as those for peanuts and other crops. Pecans are placed in the drying trailer, and warm, dry air is forced up through them. A drying zone is created at the bottom of the trailer where the air enters, and as the pecans dry, this zone moves up through the pecans until it reaches the top and completes the drying process. Pecans above the drying zone still have relatively high moisture levels while those below it are dry enough for safe storage.

Temperature. The optimum dryer temperature is about 95 degrees Fahrenheit. Temperatures above this tend to create off-flavors, darkening of the nutmeat, and a general loss of quality. Lower temperatures can dry pecans effectively although more slowly.

During the drying process, check the drying air temperature regularly. You can do this easily by inserting a pocket-type dial thermometer into a ¼-inch hole in the center of the plenum chamber wall (the air chamber under the pecans) opposite the air entry from the fan. If the thermometer indicates a different temperature than that indicated by the thermostat on the blower, you probably need to recalibrate the thermostat.

Humidity. Dryer humidity varies with weather conditions and the temperature of the forced air, but the relative humidity of the dryer air should remain below 60 percent. Lower relative humidity will decrease drying time.

Air Flow. The air flow in a drying system that is recommended by the Peerless Manufacturing Company of Shellman, Georgia, is approximately 90 cubic feet per minute [cfm] of air per square foot of drying floor while operating against a static pressure head of 1 inch of water. With 8- x 14-foot trailers, the drying area per trailer is 112 square feet. Hence, the total air flow that the fans in this system should be able to deliver is 10,080 cfm.

Dryer Conditions. Table 6-2, page 90, compares drying rates that were determined experimentally for different air temperatures, humidities, and air flow rates. These figures suggest the relative importance of temperature, humidity, and air flow upon drying time.

Figure 6-8. A mechanical drying system.

Temperature, Humidity, And Air Flow

As a general rule, higher temperature, lower humidity, and increased air flow all increase drying speed. However, each of these factors has practical limits, and each must be monitored closely during the drying process to maintain good quality control.
Table 6-2. Effect Of Drying Conditions On Drying Times For In-Shell Pecans.

<table>
<thead>
<tr>
<th>Temperature (degrees F.)</th>
<th>Relative Humidity (percent)</th>
<th>Air Movement (cfm)</th>
<th>Drying Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>9</td>
<td>420</td>
<td>9 hours</td>
</tr>
<tr>
<td>78</td>
<td>39</td>
<td>300</td>
<td>17 hours</td>
</tr>
<tr>
<td>70</td>
<td>50</td>
<td>slight</td>
<td>2-3 weeks</td>
</tr>
<tr>
<td>66</td>
<td>40</td>
<td>640</td>
<td>15 hours</td>
</tr>
<tr>
<td>66</td>
<td>40</td>
<td>slight</td>
<td>2-3 weeks</td>
</tr>
<tr>
<td>50</td>
<td>60</td>
<td>slight</td>
<td>3-4 weeks</td>
</tr>
<tr>
<td>32</td>
<td>60</td>
<td>slight</td>
<td>4-6 weeks</td>
</tr>
</tbody>
</table>

Equipment Requirements And Costs

Mechanical drying systems require drying trailers and dryers. Peerless Manufacturing Company recommends a 2 to 1 ratio of 9 x 12 x 4-foot drying trailers to dryers. For 100 acres of pecans, four drying trailers and two dryers are sufficient.

The cost of this equipment in 1987 was as follows:

Four drying trailers $1,700 each $6,800
Two dryers $1,600 each $3,200

Drying Costs:
$9.00 to $10.00 per ton

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Auburn University
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STORING NUTS

A substantial portion of the pecan crop is placed in warehouses each year and held until removed for marketing in-shell or for shelling. Refrigeration and humidity control in warehouses are necessary to maintain high quality and to prevent mold growth.

The critical factor in storing pecans is maintaining a moisture level high enough to preserve the quality of the nut but low enough to prevent mold from growing. For pecans, this level is about 4.5 percent, and it can be maintained by storing the nuts at 32 to 34 degrees Fahrenheit and 65 percent relative humidity. For storage longer than one year, freezing is recommended.

Table 6-3 indicates the relationship between temperature, relative humidity, and mold growth in two cultivars of stored, in-shell pecans.

Table 6-3. Effects Of Temperature And Humidity On Mold Growth For In-Shell Pecans.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Relative Humidity</th>
<th>Days Before Visible Mold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stuart</td>
</tr>
<tr>
<td>86</td>
<td>80</td>
<td>19</td>
</tr>
<tr>
<td>68</td>
<td>80</td>
<td>35</td>
</tr>
<tr>
<td>50</td>
<td>80</td>
<td>71</td>
</tr>
<tr>
<td>32</td>
<td>80</td>
<td>208</td>
</tr>
</tbody>
</table>

In addition to an equilibrium between the moisture level of the air and the moisture content of the kernel, there is also an equilibrium between the moisture content of the kernel and that of the other parts of the nut. The inner and outer shells of the nut have a higher moisture content than the kernel. Consequently, as the nuts lose moisture during storage, slightly more is lost from the shells than the kernels, and as a result, the shellout percentage of the nut is slightly higher.

At the same time, however, moisture loss is also weight loss, and weight losses during storage have been reported as high as 15 percent. For this reason, pecans being placed into storage need to be carefully monitored for moisture content. Otherwise, serious misunderstandings can occur as the pecans are bought, sold, and stored.

Shelling And Handling Shelled Pecans

The pecan shell protects the nutmeats from bruising, discoloration, insects, and mold. This advantage is somewhat offset by the fact that the shell and middle partition contribute over 50 percent of the weight and volume of the nut. Some warehouses use the protection offered by the shell during storage under refrigeration and shell them just before marketing. However, most use improved methods of packaging and storage to hold shelled pecans in 30-pound, foil-laminated boxes for a year or more without significant loss of quality.

Most pecans are now shelled in a few, large, modern plants that have refrigerated storage for both in-shell and shelled nuts. Shelling pecans has become highly mechanized, and the capacity of a plant is determined by its number of cracking machines. Large plants may operate as many as 80 cracking machines with total capacities of 30 tons of pecans per day and annual outputs of 7 million pounds of nutmeat.
Pecans must undergo a series of steps before marketing. Figure 6-9 is a flowchart that outlines those steps.

![Flowchart]

**CLEANING AND SIZING**

Cleaning and sizing are necessary whether or not the pecans are shelled before storage or not, and they are often done at the orchard. Cleaning removes the pops, shrivels, and trash. Usually, the nuts go immediately into the sizer, which separates them into nine sizes, beginning at smaller than \( \frac{9}{16} \) inch and increasing in \( \frac{9}{16} \)-inch increments from \( \frac{9}{16} \) up to larger than \( \frac{15}{16} \) inch.

The equipment needed for cleaning and sizing includes screens and blowers for removing foreign material and separating the nuts according to size.

**CONDITIONING**

Before pecans are shelled, they are moistened or *conditioned* to prevent the meats from shattering. Conditioning raises the moisture content of the meats to about 8 percent, making them limp and pliable while keeping the shells dry, brittle, and easily shattered.

Several different conditioning methods have been used successfully, including soaking the nuts in cold water with 1,000 ppm chlorine for 24 hours or, in another process, steam and pressure treating them for between 3 to 8 minutes. The soaking processes require a considerable waiting period and produce from 50- to 87-percent yields of halves. The steam processes are faster and produce a higher percentage of halves that also are less susceptible to spoiling. However, excessive heat may darken the meats somewhat and cause them to taste partially cooked.

The Food and Drug Administration now requires that sufficient heat be applied during conditioning to destroy any _E. coli_ bacteria that may be present on the nuts. Consequently, the most common conditioning practice today is to keep the pecans moist for 24 hours and then dip them in near-boiling water for a short time.

**CRACKING, SHELLING, AND SIZING**

Nuts are cracked when force is applied to both ends of the shell. Cracking machines position each nut in front of a plunger which then strikes it. The nuts then drop to a conveyor that carries them to the shellers. The shellers remove the shell fragments, and then the pecan halves and pieces pass over holes of progressively larger diameters. The halves are sorted into eight sizes according to the number per pound as shown in Table 6-4.

**Table 6-4. Sizes Of Pecan Halves.**

<table>
<thead>
<tr>
<th>Size Name</th>
<th>Number Of Halves Per Pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammoth</td>
<td>200-250</td>
</tr>
<tr>
<td>Jr. Mammoth</td>
<td>251-300</td>
</tr>
<tr>
<td>Jumbo</td>
<td>301-350</td>
</tr>
<tr>
<td>Extra Large</td>
<td>351-450</td>
</tr>
<tr>
<td>Large</td>
<td>451-550</td>
</tr>
<tr>
<td>Medium</td>
<td>551-650</td>
</tr>
<tr>
<td>Topper</td>
<td>651-750</td>
</tr>
<tr>
<td>Small Topper</td>
<td>751 &amp; up</td>
</tr>
</tbody>
</table>

Broken or cut nutmeats are also graded into eight sizes—mammoth, extra large, large, medium, small, midget, granules, and meal. Halves and large pieces that are off-colored may be sliced into smaller pieces since the color is less apparent in the smaller grades.

**DRYING NUTMEATS**

From the sizer, the nutmeats pass into the dryer-cooler where the moisture level is reduced again from about 8 percent to 3.5. The meats are dried with warm air in much the same way as are the whole pecans in the orchard. Immediately after drying, the meats must be cooled to prevent quality deterioration.

The most efficient drying temperature is about 100 degrees Fahrenheit. Temperatures below this require longer drying times while those above 120 degrees begin to affect nut quality. At the higher temperatures, the oil in the meats begins to migrate to the meat surface, giving it a greasy appearance, and the meats themselves become dry and slightly tough, tend to become stale more quickly, and acquire a slightly cooked flavor.

The most important factor for controlling the moisture in the meats during storage is the relative humidity of the storage atmosphere. The moisture in the kernels reaches an equilibrium with the moisture in the air. For example, a relative humidity of 58 percent in the air produces an equilibrium moisture content of 3.5 percent in meats stored at 34 to 36 degrees Fahrenheit. As a general rule, storage at 60- to 65-percent relative humidity below 32 degrees Fahrenheit or at 65- to 70-percent relative humidity above 32 degrees Fahrenheit is optimum.
INSPECTING AND GRADING

Inspecting and grading is often handled by someone other than the producer. However, it is important to understand how to grade pecans so that you can estimate the price they will bring. Grading is discussed and illustrated in the following section, Grading Pecans.

STORING NUTMEATS

After moisture in the pecan meats is reduced to 4 percent and controlled, other variables determine the storage life of the pecans. The most important of these is temperature, but others include the size of the pieces, the fat content of the nuts, foreign odors in the warehouse, and pests and diseases.

Temperature. In general, the lower the temperature, the longer the storage life of pecan meats will be. Freezing does not damage pecans since their moisture content is relatively low. Pecan meats kept at 0 degrees Fahrenheit maintain a satisfactory quality for as long as 2 years. Table 6-5 summarizes the storage life of shelled pecans at different temperatures.

<table>
<thead>
<tr>
<th>Temperature (degrees F.)</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>32</td>
<td>12</td>
</tr>
<tr>
<td>0</td>
<td>24</td>
</tr>
</tbody>
</table>

Piece Size. The smaller the pecan pieces, the more surface is exposed and the more the pieces have been bruised during shelling and processing. Both of these cause oil to migrate from the meats, and this oil becomes stale and rancid very quickly. For this reason, pecan pieces and pecan meal are seldom stored for longer than 3 months.

Fat Content. The percentage of fat in pecans varies significantly. Van Deman, for example, has a relatively high fat content (75.9 percent) while Oklahoma's is much lower (68.7 percent). As a rule, the varieties with higher fat percentages retain their quality much better during storage.

Foreign Odors. Pecans absorb gases and odors from the storage atmosphere as easily as they do moisture, and some of these can change the odor, flavor, and stability of the meats. For this reason, pecans should not be stored with apples, other fruits, or petroleum products, in rubber-like packages, or in rooms that tend to be musty. If possible, Freon or brine should be used as a refrigerant rather than ammonia because traces of ammonia can quickly blacken the pecan seed coats.

Foreign odors can be removed from the atmosphere by ventilation, activated carbon, or ozone treatment. Once the odors are in the pecans, however, there is no practical way to remove them.

Pests And Diseases. Pecan meats dried to 4-percent moisture or lower and stored at 45 degrees Fahrenheit or below are practically immune to attack by storage insects and diseases. At higher moisture levels, molds can develop. Of particular concern is the potential hazard of Aspergillus flavus, an organism that produces dangerous toxins called aflatoxins. At temperatures above 55 degrees, pecans become susceptible to insect infestations.

PACKAGING

Since pecans are high in oil content and have oxidizable tannins, volatile flavors, and other biochemically active substances, they are relatively unstable. They must be stored in packages that protect them from air, light, moisture, insects, rodents, foreign flavors, and rough handling.

A large proportion of shelled pecans are packaged in corrugated, greaseproof cardboard cartons.

Consumer packages may also be glass jars, flexible bags of airtight materials, and overwrapped chipboard boxes. Small metal and glass containers are usually vacuum sealed or packed with inert gas. Most pecans are packaged and stored as raw nuts, but some are toasted.

Reducing the air in packages by a vacuum or inert gas substantially extends the storage life of pecans. With raw pecan meats, vacuum packaging and carbon dioxide has extended the storage life from 3 to 10 months at 70 degrees and to more than 30 months at 32 degrees.

Toasted pecans are much less stable than raw ones and become stale much more rapidly. Without vacuum packaging, they have a storage life of about five days. With vacuum packaging in glass jars, their storage life is extended to about 30 days.

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Parts of this section were adapted with permission from material prepared by A. E. Badenhop, Purdue University Department of Horticulture (deceased), and E. K. Heaton, A. L. Shewfelt, and L. R. Beuchat, University of Georgia Department of Food Science.

Grading Pecans

Before marketing pecans, you need to be able to grade them yourself. By knowing ahead of time the quality of the nuts, you will be able to anticipate the price they will bring.

To grade a load of pecans, you must draw accurate samples from the load and then analyze the kernels in the samples correctly. For most producers and buyers, the relatively simple hand test for percentage of edible kernel and percentage of kernel grades is sufficient for grading a load of pecans.
USDA GUIDELINES

The USDA established standards for grading pecans are available in the document, "United States Standards for Grades of Pecans in the Shell (41 F.R. 39303)." The standards are discussed more fully in the "Federated Pecan Growers' Standards for Grades of Pecans in the Shell." These guidelines regulate the way that pecans are marketed to the public, and they apply primarily to processors who buy loads of pecans from producers and then shell, grade, and package the pecans. When boxes of pecans leave the processors, they need to be identified as U.S. No. 1 or U.S. No. 2 pecans.

As a producer, you will probably sell your pecans as field run mixtures of nuts, so it is not very practical to try to identify a load of pecans as No. 1 or No. 2. Although the USDA criteria influence the way that buyers grade pecans, you will usually sell yours according to the simpler hand test to determine the percentage of edible kernel and the percentages of No. 1, No. 2, and No. 3 kernels in the load.

These grades are not the same as the USDA grades even though they are based on similar kernel characteristics. Since this handbook is intended for producers, discussion is limited here to the guidelines for hand tests and refers to the USDA standards only where they apply.

SAMPLING

Samples must represent an entire load of pecans. Take a minimum of 0.1 percent by weight for sampling (1 pound out of 1000). If there are less than five bags, take sample nuts from each bag. Between five and fifty bags, sample at least five bags; with more than fifty, 10 percent of the bags should be sampled.

The ideal way to take samples is to dump the bags into empty containers and take sample nuts from the top, middle, and bottom. If using a probe [Figure 6-10], take nuts from different areas of different bags [Figure 6-11].

DISCOUNTING FOR MOISTURE

Buyers may accept pecans with moisture of 8 percent or even higher, but the price for your load will probably be reduced when moisture is above 6 percent. Generally, for each 1 percent of moisture above 6 percent, the load's salable weight is reduced by 1.2 percent.

Example: for a 1000-pound load with 9-percent moisture,
9 - 6 = 3 percent excess
3 x 1.2 = 3.6 percent reduction in weight
1000 x .036 = 36 pounds discounted
1000 - 36 = 964 pounds net weight

GRADING

You will crack and grade only a portion of the nuts that you draw for sampling, so a sample should contain enough nuts for you to separate into lots for grading at random [Figure 6-12]. You should also be able to take additional lots from the sample in borderline cases. In all, a sample should contain more than twice as many nuts as you need for the lots you crack and grade. The nuts that you do not crack can be put back with the rest of the load.

Thoroughly mix the nuts drawn for the sample by gently pouring the pecans from one container into another six to eight times. You can then separate the pecans to be graded from the sample by either by weight (usually in 1-pound lots) or by count (usually multiples of 100 nuts).

The USDA guidelines are based on lots of 100 nuts, a number that makes calculating percentages of defects relatively easy and that is appropriate for grading pecans that are already shelled. However, buyers are particularly interested in the percentage of edible-kernel content of the pecans based on weight. For this reason, it is easier to grade pecans by weight.

Determining Percentage Of Edible Kernel

Measure out a minimum of three 1-pound lots from the sample and crack the pecans in the lots very carefully either by hand or in mechanical crackers. Pick out the edible kernels and pieces by hand. Weigh the edible kernels in each 1-pound lot; then calculate the percentage of edible kernel for each lot. The average of the three percentages will be considered the average percentage for the load.

If extreme variation occurs between the lots, crack three additional 1-pound lots. Then the average of the edible kernel percentages of all six lots will be the average for the load. The average percentage of edible kernel for the load is called the "guaranteed hand test." It is also commonly referred to as "percent shellout" of a sample.
Figure 6-13, Criteria for grading kernel color in a hand test: a) No. 1 kernels; b) No. 2 kernels; c) No. 3 kernels.

Analyzing The Hand Test

Edible kernels should be further broken down into percentages of No. 1, No. 2, and No. 3 kernels as a part of the hand test. If the percentage of edible kernel with the hand test is 40 percent, for example, it might contain 35-percent No. 1 kernels, 2-percent No. 2 kernels, and 3-percent No. 3 kernels.

The criteria for grading in a hand test are related to USDA standards but are somewhat simpler (Figure 6-13). Kernels are identified as edible or inedible, and the edible kernels are then graded on the basis of a combination of color and development:

No. 1 Kernel—bright colored, full bodied, solid
No. 2 Kernel—bright colored, light weight
No. 3 Kernel—brown colored, either full bodied or light weight

Inedible or rejected kernels are poorly developed (wafers) or have insect damage, embryo rot, adhering fuzzy material, mold, decay, or rancidity (see following discussion). The inedible kernels and pieces should be weighed and reported as a percentage of the load. This percentage does not affect the percentage of edible meats but helps to describe the load to the buyer. For example, a hand test could have an edible meat yield (No. 1, No. 2, or No. 3 kernel) of 40 percent and a rejected meat yield of 4 percent.

Kernel Characteristics And Damage

Kernel color, development, insect damage, internal discoloration, adhering fuzzy material, mold, decay, and rancidity are kernel characteristics that determine whether a kernel will be No. 1, No. 2, No. 3, or inedible (Figure 6-14).
Figure 6-14. Some defects which may result in kernels being rejected: a) white mold; b) adhering fuzz; c) stink bug damage; d) rotten eye; e) rot or rancid kernel; f) light halves.

**Kernel Color.** The skin colors of pecan kernels are light, light brown, medium brown, and dark brown. Specifications by USDA allow a kernel in one color classification to have up to 25 percent of its surface one classification darker than the classification of the kernel (Figures 6-15 and 6-16). Natural markings, such as lines or specks, do not count toward kernel color. When more than 25 percent of a kernel is dark brown or darker, it is rejected.

Figure 6-15. Kernel color ranging from golden (a) to light brown (b) to medium brown (c, d, most of e) to dark brown (upper center of e, f).

**Development.** There are four degrees of kernel development—well developed, fairly well developed, poorly developed, and undeveloped (Figures 6-17, 6-18, 6-19, and 6-20, page 96). Poorly developed and undeveloped kernels (wafer) are rejected.

As pecan kernels are forming, there are some cases where the bottom end of one or both halves will not develop. If the undeveloped skin breaks off evenly or if the kernel is smooth at the bottom end, the kernel is still acceptable (Figure 6-21, page 96).
Figure 6-17. Well developed kernels.

Figure 6-18. Fairly well developed kernels.

Figure 6-19. Poorly developed kernels.

Figure 6-20. Two views of undeveloped kernels.

Figure 6-21. Incompletely developed kernels with smooth bottom end.
Insect Damage. Dark spots on the kernels are commonly called stink bug damage. When evaluating kernels with dark spots, consider both the size and number of the spots. A kernel with one spot on each half, and neither larger than a pencil lead (\(\frac{\text{1}}{8}\text{ inch}\), is acceptable if the spot has not caused the entire kernel to be bitter (Figure 6-22, top row).

The entire kernel is rejected if it has a spot larger than a pencil lead (Figure 6-22, middle row) or more than one spot per half (Figure 6-22, bottom row). If over 0.5 percent of the sample has pencil point spots, the excess above 0.5 percent is rejected.

Internal Discoloration [rotten eye, eye rot, embryo rot]. If green, gray, brown, or black discoloration occurs on the eye of the nut, where the kernel halves join together, or on the back of the center ridge of the kernel (Figure 6-23), the entire kernel is rejected.

Sizing
Pecan size is independent of quality, but it is usually specified with the grade. Size can be determined by count per pound or pecan diameter. Usually, it reflects both count per pound and the percentage weight of the ten smallest nuts per hundred. For all sizes, the ten smallest nuts cannot constitute less than 7 percent of the weight of the hundred nuts in the lot.
To determine count per pound, weigh as closely as possible an even pound of nuts and count them. Weigh a second pound of nuts and average the two counts.

To determine the percentage weight of the ten smallest nuts per hundred, count out a lot of one-hundred nuts at random from the sample and weigh it to the nearest gram or ¼ ounce. Spread the nuts out and carefully select the ten smallest nuts. Carefully weigh these ten nuts to the nearest gram or ⅛ ounce and calculate this as a percentage of the weight of the hundred nuts.

If the ten smallest nuts do not make up 7 percent of the weight of the sample, then the nuts are not uniform enough to be classified as a particular size. If the lot is on the borderline, then size an additional lot of one-hundred nuts.

Table 6-6 shows USDA’s standard size classifications for pecans.

**Table 6-6. USDA Standards For Pecan Size Classifications.**

<table>
<thead>
<tr>
<th>Size</th>
<th>Nuts Per Pound*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oversize</td>
<td>55 or less</td>
</tr>
<tr>
<td>Extra Large</td>
<td>56 to 63</td>
</tr>
<tr>
<td>Large</td>
<td>64 to 77</td>
</tr>
<tr>
<td>Medium</td>
<td>78 to 95</td>
</tr>
<tr>
<td>Small</td>
<td>96 to 120</td>
</tr>
</tbody>
</table>

*In each classification, the smallest ten nuts per hundred must weigh at least 7 percent of the total weight of the sample.

**External Defects Of Pecans**

Some pecans are sold to consumers still in the shell. The hand test does not grade the appearance of in-shell pecans. The USDA has established the standards shown in Table 6-7 for the external appearance of No. 1 and No. 2 pecans.

**Table 6-7. USDA Standards For External Defects Of In-Shell Pecans.**

<table>
<thead>
<tr>
<th>Defect</th>
<th>No. 1</th>
<th>No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Defects</td>
<td>5% total</td>
<td>10% total</td>
</tr>
<tr>
<td>Serious Damage</td>
<td>2% (included in 5%)</td>
<td>3% (included in 10%)</td>
</tr>
<tr>
<td>Foreign Material</td>
<td>0.5% by weight</td>
<td>0.5% by weight</td>
</tr>
<tr>
<td>Color</td>
<td>Fairly uniform</td>
<td>No requirement</td>
</tr>
</tbody>
</table>

The external defects classification in Table 6-7 includes shells that are damaged and shells that are seriously damaged. Damaged shells include adhering shuck material (Figure 6-26), cracks that spread when slight pressure is applied to the shell (Figure 6-27), and broken shells where any part of the shell that is missing is less than ¼ inch in diameter (Figure 6-28). Serious damage includes adhering material that covers more than 20 percent of the shell (Figure 6-29), broken shells where the missing portion of the shell is larger than ¼ inch in diameter (Figure 6-30), and weevil holes in the shell (Figure 6-31).

**Figure 6-28. Damage: hole less than ¼-inch diameter.**

**Figure 6-29. Serious damage: adhering shuck covering more than 20 percent of shell surface.**

**Figure 6-26. Damage: adhering shuck covering 5 to 20 percent of shell surface.**

**Figure 6-30. Serious damage: hole greater than ¼-inch diameter.**

**Figure 6-27. Damage: cracked shell but meat not visible.**
Foreign material includes sticks, hulls, and other trash (Figure 6-32). Pecans are considered "fairly uniform in color" when not more than 5 percent of the shells have sharply contrasting shell color (Figures 6-33, 6-34, and 6-35).

Figure 6-32. Foreign material commonly found in loads of pecans.

Figure 6-33. Shells that are uniform in color.

Figure 6-34. Shells that are fairly uniform in color.

Figure 6-35. Shells that are irregular in color.

Appreciation is expressed to Tom Wellman, Troy Simms Pecan Co., Dothan, Alabama, for assistance in supplying material for photographs in this section.

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