california almonds
Almond Board of California

Technical Bulletin:

Stockpiling for Extended Storage of Inhull Almonds

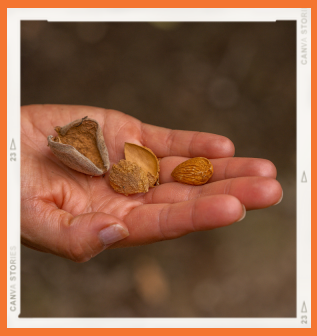
Stockpiling at both the farm and huller/sheller is a common and essential practice that allows the almond industry to process large volumes of inhull almonds harvested in a short period. When stockpiling is properly managed, it can be a practical step for extended storage of excess volume, but poor handling leads to product loss due to mold growth or aflatoxin contamination, quality degradation and infestation. The key to successful stockpile management is to control moisture content and insects, which requires commitment and close coordination among growers and hullers/shellers. The growers need to deliver well-dried nuts, while the hullers/shellers must effectively manage the stockpiles to prevent insect activities and to protect the dried nuts from condensation, rainfall, and water runoff.

Critical Moisture Levels for Almond Harvest and Stockpiling

Moisture levels in harvested nuts impact kernel stability and safety, and should be managed by measurement, timing of the pick up from the farm, and stockpiling logistics at the huller/sheller. How moisture affects the quality and safety of almonds is determined by the available or free water, referred to as the water activity (or relative humidity, rH, if multiplied by 100%). At the same water activity, different components of the harvested nuts can have different moisture contents. The following tables show various levels of moisture found in almond kernels, inhull nuts or hulls that have the same water activity or wetness condition. Testing the moisture content of either the kernels, inhulls or hulls is an important tool for assessing dryness.

- An average moisture content of 6%, 9%, or 12% for kernels, inhull nuts, or hulls, respectively, is recommended for stable long-term stockpile storage.

Kernels	Inhull Nuts	Hulls
Less than 6%	Less than 9%	Less than 12%



- An average moisture content range of 6-9%, 9-13%, or 12-17% for kernels, inhull nuts, or hulls, respectively, is marginal. Extended storage for nuts within this range will lead to quality deterioration or development of concealed damage, a quality change only revealed by discoloration at roasting or blanching. The higher the moisture content, the faster the deterioration. At this range, only short-term temporary storage is advised, and inhull nuts need to be processed promptly to allow the kernels to be dried.

Kernels	Inhull Nuts	Hulls
6-9%	9-13%	12-17%

- An **average** moisture content of greater than 9%, 13%, or 17% for kernels, inhulls, or hulls, respectively, will result in substantial damage if the nuts are not promptly dried. Nuts at this moisture level, are not suitable for stockpiling.

Kernels	Inhull Nuts	Hulls
Less than 6%	Less than 9%	Less than 12%

- A moisture content of 11%, 17%, or 22% for kernels, inhull nuts, or hulls, respectively, **even among small portion of nuts** in a dried lot is dangerous. At this moisture level aflatoxin-producing molds will grow rapidly and aflatoxin contamination will occur. Due to little or no air circulation in a stockpile, any high-moisture nuts will create a wet spot or pocket that can promote mold growth. A lot with even a small quantity of nuts at this moisture level shouldn't be picked up and delivered for stockpiling and needs to be dried promptly in the orchards or a mechanical dryer.

Kernels	Inhull Nuts	Hulls
Greater than 11%	Greater than 17%	Greater than 22%

Impact Factors for Uniform Drying in the Orchards

The almond industry uses an average moisture of kernels, inhulls or hulls nuts from an orchard lot or truckload to decide timing of pick up from the orchard and stockpiling strategy. The number of samples and representation of the dried nuts from various locations or drying situations are crucial to obtaining a reliable moisture reading. The following factors should be taken into consideration as representative samples are collected and tested.

- Unevenly matured nuts at shaking time will have large variation in moisture content. Growers often use stages of hull splitting from A to F to decide timing of tree shaking. Quite often there may be many nuts still in early hull split stages such as C, D, or E at the tree shaking time. The moisture difference between E or F and C or D can be greater than 20%.
- Uneven orchard canopy leads to less uniform nut drying on the orchard floor.
- Hedgerow planting leads to more dense shade in the edge tree rows, which increases drying time.
- The orchards on hilly ground often contributes to variation in drying across different elevations, with much wetter nuts from lower ground.
- More conventional tree spacing leads to more varied light/temperature patterns across the orchard floor, resulting in uneven drying.
- The nuts under tree rows will dry slower than those in windrows or open areas. The exposed temperature under tree rows at the midday can be up to 50F° cooler than in windrows. The moisture levels of the nuts dried under tree rows are more than 2% wetter compared to the nuts dried in windows.
- The moisture levels of the nuts from the tops of windrows are more than 2% drier than the nuts from the middle or bottom.
- East/west oriented rows dry slower or less uniform than north/south rows.
- Any orchard producing above 3,500 kernel pounds per acre likely requires increased drying time.

Growers Delivery of Well-Dried Nuts

Preparation for Harvest

- Follow Integrated Pest Management Guidelines to minimize pest activities or invasion during hull split and nut maturation.
- Remove weeds, debris, loose dirt, etc. to clean orchard ground for harvesting.
- Check nut maturity on percentage of hull split stage E and F, and select shaking time when all the nuts on most of the trees in an orchard are beyond hull split stage E, with the most beyond stage F.
- Check weather forecast and make sure not to shake trees if rainfall is predicted in less than 5 days.
- Try to keep matured nuts on the trees to dry as long as possible, as the nuts dry better on the trees than on the ground; however, try to avoid second or third flight of navel orangeworm, if possible.

Drying Almonds in Orchards

- Shake well-matured nuts onto ground and let the nuts air-dry where fallen.
- Blow nuts from under the tree rows into open areas but do not make windrows to allow better drying among spread nuts especially for East/West oriented tree rows or wet or lower ground areas.
- Make windrows after 5 to 7 days of spread drying when hulls of most nuts turn brown, to allow further drying and moisture equilibration.
- Using a conditioner to remove debris, branches, etc. at windrow making will speed up the drying process.

Delivering Dried Almonds

- Sample nuts for moisture assessment in a systematic way across orchard before beginning harvest operation.
- Pick up the wettest nuts from the middle or bottom of the windrows to assess drying progress, especially from wet or lower zones or areas of more dense trees or shadow.
- The hull snap test is a practical tool to evaluate drying condition of the nuts. If most hull samples make a snap sound, then the moisture level of the nuts is suitable and nuts are about ready for pickup.
- When the average moisture content of 5 to 10 subsamples is below the stable or safe levels, schedule with hullers/shellers for delivery of trailers.
- Try to pick up the dried nuts in the afternoon, if possible, especially when the moisture of the nuts is near the marginal range; pickup later in the day allows trapped moisture from the night or morning dew to vaporize.
- Deliver the dried nuts to a huller/sheller or dedicated stockpiling site as soon as a trailer is filled up.

Dealing with Adverse Situations

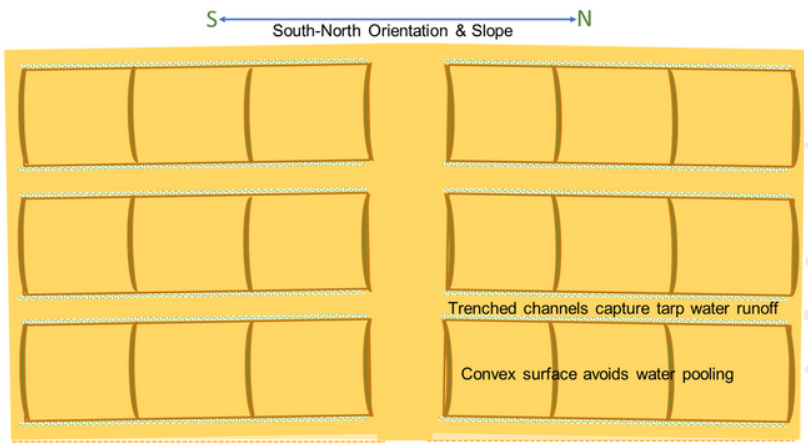
- Inform and coordinate with huller/sheller for urgent or unusual harvest and delivery when moistures are still at marginal levels, but rainfall is expected the next day.
- Do not sweep or pick up for stockpiling when the moistures of any nuts are beyond the dangerous level or the average moisture of the orchard lot is in the red zone, unless nuts will undergo prompt drying.
- After unexpected rainfall events, wait till the ground is dried and solid before entering into the orchard to do any corrections.
- If weather conditions or ambient temperatures are good for quick drying, growers may blow the nuts away from the tree rows to open areas for continual drying or turn or condition the nuts in windrows to speed up the drying if rain fell on the windrows.
- If weather conditions do not support quick drying (e.g., for late varieties), growers may look into mechanical drying options.
- Inform huller/sheller and handlers of any lots with rainfall or wet exposure.

Effective Hullers/Shellers Management of Stockpiles

Hullers/shellers play a very important role in stockpiling. To ensure the safety and quality of almonds during extended stockpiling storage, hullers/shellers must properly prepare stockpiling sites, and have well-designed and executed protocols for receiving, stockpile making and managing, handling adverse conditions, etc.

Preparation for Stockpiling

- Select sites with a firm surface, without ditches, and clean out any debris.
- Divide the site into various zones of north/south orientation for individual stockpiles with the site leveled to slope downward either north or southward overall
- In each zone, level the surface into a series of convex shapes to prevent potential water piling in the middle of each stockpile.
- Make trenches or drainage channels along both sides of each zone to capture rainfall runoffs from the stockpile tarp.



- Place or introduce sufficient amounts of fumigants following label instructions, and seal the surrounding tarp onto the ground with soils or socks of sand.

- Smooth tops of stockpiles

- Use White on Black Tarps

Receiving Dried Almonds

- Work closely with growers to assessing moisture levels and variations of almond nuts in orchards.
- Schedule trailer pickup when an average moisture of the nuts across an orchard or lot is below the safe level.
- Take several samples from various locations of each truckload to make a composite sample for moisture verification.
- For the truckloads without pre-pickup moisture testing, the composite sample may be divided into 3 subsamples for moisture testing.
- Select or pick up some wet nuts with wet hull appearance spotted from a truckload to measure moisture.
- Select stockpiling strategy based on verified moisture levels from the two sets of samples.

Making Stockpiles

- Try to further separate debris and dust from the field-runs at trailer offloading.
- Place well-dried nuts with an average moisture content of <6% in those prepared north/south oriented zones to form stockpiles with a long trapezoid shape.
- Smooth or even the tops of stockpiles to eliminate and reduce the number of valleys.
- Cover the stockpile with white-on-black tarp or similar type of reusable thick tarp. White tarps may be an alternative, while clear tarps trap heat, causing large temperature fluctuations and condensation, should be avoided.

Monitoring and Managing Stockpiles

- Keep records of nut moisture contents of the truckloads making up each stockpile.
- Track the inventory of all stockpiles with moisture levels, locations, identified concerns, etc. to decide processing priorities.
- Check insect activities to verify fumigation efficacy one week after initial fumigation.
- Uncover tarp for quick aeration if any condensation is observed from the initial stockpiling.
- Re-cover stockpile and seal the tarp.
- Check for evidence of condensation and pest activities periodically, once weekly or biweekly. Some commercially available sensor technologies could be useful tools for routine monitoring of insect activities and humidity (condensation) inside a stockpile.
- Refumigate the stockpile if there is evidence of infestation.
- For a stockpile of well-dried nuts with the right tarp, condensation shouldn't be a concern. However, if condensation or high humidity (>58% rH, equivalent to a kernel moisture level of >6%) spots or zones are noticed, a quick aeration should be done.

- Maintain stockpiling areas to prevent contamination from trash, sanitary facilities, dust and other potential sources of contamination. .

Handling Unusual Situations

- For received lots or truckloads with an average moisture content in the marginal range, schedule processing of the nuts right away or make a small or low stockpile for temporary storage if a prompt process is not feasible, then unwrap the tarp to aerate in the daytime and cover with tarp at nighttime till the next soonest available processing schedule.
- For any lots or truckloads with an average moisture content below the safe level, but with a high percentage of nuts with moisture contents above a dangerous level, treat the same as a marginal moisture content range. Frequent aeration may help with rapid moisture equilibration to reduce the high moisture content of wet or green nuts down to a safe level.
- For any lots or truckloads with an average moisture content above the marginal level, do not stockpile; instead, reject or arrange prompt mechanical drying (forced or heated air).
- After any rainfall events, unwrap tarps for quick aeration of the nuts and check for evidence of leaked water from tarp or run-in water from the ground.
- Segregate the portions of nuts exposed to water for prompt drying to prevent fermentation that may lead to a fire hazard

Proper Stockpiling can be a Longer-Term Storage Solution for Inhull Almonds

Minimizing the risk of aflatoxins, insect damage and quality deterioration during stockpiling is imperative. Stockpiling properly dried almonds, by using the right tarp coverage and well-implemented moisture and pest monitoring and control protocols, can be a solution for extended storage of inhull almonds. If no additional moisture and/or pests are introduced during the stockpiling, the quality of almond kernels from the inhull nuts can remain stable for a long time.

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