

A photograph of an almond orchard. The ground is covered with rows of dark, mulched soil. In the foreground, there are several long, narrow stockpiles of almond hulls and shells, arranged in a line that recedes into the distance. The trees are lush green, and the lighting suggests a bright, sunny day.

# STOCKPILE MANAGEMENT BEST PRACTICES



## AFLATOXINS AND ALMONDS

Aflatoxins are naturally occurring chemicals produced by certain molds. They are a health concern because of their potential to cause cancer. Because of this health risk, maximum allowable levels of aflatoxin contamination in foods have been set by certain countries around the world — including countries that are some of the largest markets for California Almonds.

Aflatoxin contamination begins in the orchard environment. The molds that produce aflatoxins are common in nature. Regarding almonds, these molds may live in the soil, may develop in mummy nuts (nuts that have been damaged by infestations of navel orangeworm or other pests and remain on the tree after harvest), and may be transferred from nut to nut in the form of mold spores carried by these pests.

When almonds that have been shipped to these countries are tested in the lab for aflatoxins and are found to have levels above the allowable limits, the consignment will have to be reconditioned or rejected, at significant cost to both the grower and the handler.

## AFLATOXIN SAMPLING PLAN

Because controlling aflatoxins is important to the almond industry, the Almond Board of California created the Voluntary Aflatoxin Sampling Plan (VASP). The VASP program proactively monitors aflatoxin levels in California Almonds before they are exported to ensure they meet standards set by the European Union.

Almond Board of California-funded research has found that certain conditions in stockpiled almonds increase the risk, growth and spread of *Aspergillus* spp., the fungal molds that produce aflatoxins.<sup>1</sup>

As is the case with most molds, the most significant factor in the growth of *Aspergillus* is moisture content. When in-hull almonds are stockpiled, moisture in the almonds combined with hot weather can create a breeding ground for the *Aspergillus* molds to grow and produce aflatoxins. By monitoring and adjusting the amount of moisture in stockpiled almonds, it is possible to limit the amount of moisture that builds up in stockpiles, thereby preventing the growth of *Aspergillus* mold.



*The California Almond industry prides itself on providing safe, high-quality almonds to a worldwide market.*

<sup>1</sup>Lampinen, Bruce. Almond stockpile monitoring for aflatoxin potential. 2008–2009 Final Research Report, Almond Board of California.

# ALMOND STOCKPILING BEST PRACTICES

Additional research funded by the Almond Board of California has resulted in the following best practices for stockpile management to prevent aflatoxins and minimize the formation of concealed damage,<sup>2</sup> a condition in which off-flavors and off-colors are revealed after roasting.

## HARVEST MOISTURE LEVELS

The first step to effectively manage *Aspergillus* growth and concealed damage is to ensure moisture content of the almonds does not exceed allowable levels. To accurately determine moisture levels of almonds, it is important to take a good sample of nuts before sweeping.

Taking samples across the orchard floor and along the tree row provides a complete sample of the almonds. Keep in mind that there is variability between drying on the orchard floor and in windrows. Sampling should take this variability into account.

Take samples of the “worst case” almonds — those on the north side of the canopy next to the tree trunk, where moisture tends to range about 2% higher than other areas of the orchard. Within the windrow, moisture tends to accumulate on the bottom layers of almonds, so be sure to choose those to sample. Once an accurate sample has been taken, determine what the overall moisture level is of the almonds. Before stockpiling, moisture content for almonds should be:

- Below 6% for the in-shell kernel;
- Less than 9% for the total fruit (in-hull almond); and
- Less than 12% moisture content for hulls.

As a practical guideline, do not stockpile if either the hull moisture content exceeds 12% or the kernel moisture content exceeds 6%.



*When sampling from windrows, be sure to include nuts in the bottom layers of the windrow, where moisture tends to accumulate.*



*When sampling for moisture, be sure to include samples taken from the north side of the canopy next to the tree trunk.*

## RAIN AT HARVEST

Rain during harvest can complicate moisture control efforts, and since rain can increase the risk of both mold growth and concealed damage, it's important to adjust harvest accordingly.

If rain is in the forecast:

- Don't shake. Nuts dry faster on the tree than on the orchard floor, so leave the almonds on the trees during rain.
- If you've already shaken, but the nuts are still too wet to pick up, blow them away from tree trunks. Don't windrow.
- If nuts have been windrowed, condition them through a drop chute.
- Remove leaves and other trash to help nuts dry faster.
- Condition the crop both before and after a rain to promote the most rapid drying; note that a greater benefit is seen with conditioning after rain.

Maintaining optimum moisture levels before stockpiling is critical to limiting mold growth and concealed damage. If moisture or relative humidity levels are too high to stockpile, move the nuts to a dry area, or machine-dry.

## CREATING STOCKPILES

When choosing where to stockpile almonds on the farm, look for an area where you can have a raised or sloped bottom. This encourages any moisture to drain away from the stockpile, further limiting mold growth.

The shape and positioning of stockpiles can also be used to control moisture and mold growth. Stockpiles should have an even, flat top. This helps minimize areas where condensation can build up on the underside of the tarp, with the resulting moisture affecting the nuts.

Also, position the long side of the stockpile on the north-south axis. Condensation and mold growth are usually worse on the north end of the pile when the long side is oriented on the east-west axis.



*Stockpiles should be built with an even, flat top to prevent valleys where moisture can collect.*

# MANAGING STOCKPILE MOISTURE

Covering a stockpile with a tarp is necessary, but it can increase the humidity within the stockpile, causing an increase in moisture and an increase in the risk of mold growth and concealed damage. When choosing a tarp, keep in mind:

- A white-on-black tarp is the best choice to minimize temperature fluctuations, which lead to condensation and eventual mold growth.
- Clear tarps allow the greatest temperature fluctuations, but can be used on dry, in-hull almonds that are well below the moisture threshold.
- White tarps fall between white-on-black and clear tarps in terms of temperature fluctuations.

Controlling the relative humidity (rH) in a stockpile is critical to food safety. If you find that moisture levels are too high in a stockpile, open up the tarps in the daytime to allow moisture to escape, and close them at night, when relative humidity tends to increase. Also, pay close attention to the outside of the piles, where large changes in temperature and condensation can increase moisture levels.

To best calculate the moisture content of a stockpile based on the rH, use the accompanying chart. An rH of greater than 65% within the pile is the maximum for almond storage. In the chart, green-shaded areas indicate moisture contents that are suitable for stockpiling. Yellow areas are borderline, and red areas indicate moisture contents that are too wet for stockpiling.

The California Almond industry prides itself on providing safe, high-quality almonds to a worldwide market. Making sure that stockpiles are managed to prevent mold-inducing moisture will help maintain almond quality and safety. Your commitment to food safety plays a critical role in keeping California Almonds as the Nut of Choice by consumers worldwide.

## WATER CONTENT

Relative Humidity	Water Activity	Kernels + Hulls	Hulls	Kernels
30	.30	3.80	4.43	2.73
31	.31	3.89	4.59	2.79
32	.32	4.00	4.76	2.85
33	.33	4.11	4.94	2.92
34	.34	4.22	5.12	2.99
35	.35	4.34	5.31	3.06
36	.36	4.47	5.50	3.14
37	.37	4.61	5.71	3.22
38	.38	4.75	5.92	3.31
39	.39	4.89	6.13	3.40
40	.40	5.05	6.36	3.50
41	.41	5.20	6.59	3.60
42	.42	5.37	6.83	3.71
43	.43	5.54	7.07	3.82
44	.44	5.72	7.32	3.98
45	.45	5.90	7.58	4.06
46	.46	6.09	7.85	4.18
47	.47	6.29	8.12	4.31
48	.48	6.49	8.40	4.45
49	.49	6.70	8.69	4.59
50	.50	6.92	8.98	4.73
51	.51	7.14	9.28	4.88
52	.52	7.37	9.59	5.03
53	.53	7.60	9.90	5.19
54	.54	7.84	10.22	5.35
55	.55	8.09	10.55	5.51
56	.56	8.34	10.89	5.69
57	.57	8.60	11.23	5.86
58	.58	8.87	11.58	6.04
59	.59	9.14	11.94	6.23
60	.60	9.42	12.30	6.42
61	.61	9.70	12.67	6.61
62	.62	9.99	13.05	6.81
63	.63	10.29	13.43	7.01
64	.64	10.59	13.82	7.22
65	.65	10.90	14.22	7.43
66	.66	11.22	14.62	7.65
67	.67	11.54	15.04	7.87
68	.68	11.87	15.45	8.10
69	.69	12.20	15.88	8.33
70	.70	12.55	16.31	8.56
71	.71	12.89	16.75	8.80
72	.72	13.25	17.20	9.05
73	.73	13.61	17.65	9.30
74	.74	13.97	18.11	9.55
75	.75	14.34	18.58	9.81
76	.76	14.72	19.06	10.07
77	.77	15.11	19.54	10.34
78	.78	15.50	20.03	10.61
79	.79	15.89	20.52	10.89
80	.80	16.30	21.02	11.17
81	.81	16.71	21.53	11.45
82	.82	17.12	22.05	11.75
83	.83	17.55	22.57	12.04
84	.84	17.97	23.10	12.34
85	.85	18.41	23.64	12.64
86	.86	18.85	24.18	12.95
87	.87	19.30	24.74	13.27
88	.88	19.75	25.29	13.59
89	.89	20.21	25.86	13.91
90	.90	20.68	26.43	14.24
91	.91	21.15	27.01	14.57
92	.92	21.63	27.60	14.90
93	.93	22.11	28.19	15.25
94	.94	22.60	28.79	15.59
95	.95	23.10	29.39	15.94
96	.96	23.60	30.01	16.30
97	.97	24.11	30.63	16.66
98	.98	24.63	31.26	17.02
99	.99	25.15	31.89	17.39
100	1.00	25.68	32.53	17.76

## CONCEALED DAMAGE

Another consequence of moisture at harvest is concealed damage, which can significantly impact quality and reduce grower returns in years with late harvests and/or early rains. Concealed damage is apparent only after roasting, when the kernel interiors turn darker than undamaged nuts, and flavor can be bitter. In extreme cases, kernel internal color and flavor are altered before roasting. Prolonged moisture at elevated temperatures (above field temperatures) and even at ambient temperatures can create this condition.

Current Almond Board-funded research seeks a better understanding of the field conditions that contribute to concealed damage as well as mold, and management practices in the field that can reduce these risks.

If untimely rain at harvest is anticipated, this new information can help determine when growers should take action to prevent mold development and concealed damage, particularly with more vulnerable late-harvest varieties or under other scenarios for delayed crop maturity.

Among other factors, the research is establishing a threshold for the specific kernel moisture content, temperature, and the various time and field management scenarios that will lead to the appearance of concealed damage, and refine guidelines for when action should be taken under different field, handling, temperature and moisture scenarios.

**FOR MORE INFORMATION ON STOCKPILE MANAGEMENT  
CONTACT [STAFF@ALMONDBOARD.COM](mailto:STAFF@ALMONDBOARD.COM) OR  
VISIT [ALMONDS.COM/OUTLOOK](http://ALMONDS.COM/OUTLOOK)**



*Under certain conditions, in-hull almonds that are stockpiled can develop fungal molds that produce aflatoxins.*



*Concealed damage is apparent only after roasting (right), when the kernel turns darker than undamaged nuts (left).*



*An uneven surface on a stockpile is conducive to mold growth.*



Almond Board of California  
1150 9th St., Suite 1500  
Modesto, CA 95354 USA  
Almonds.com  
T: 209.549.8262

©2014 Almond Board of California

