Concealed Damage

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The almond quality problem known as concealed damage (CD) is marked by brown discoloration of the nut meat. This discoloration cannot be detected unless the kernel is cut open. Informal field observations suggested that the problem is found in nuts that are soaked by early autumn rains and/or held for prolonged periods prior to hulling. This project was designed to assess the incidence of CD in relation to on-the-ground holding of wetted almonds. A number of tests were run on almond samples in order to obtain a better understanding of the physiological and biochemical basis of CD.

Four bins of unhulled almonds (totalling approximately 120 cu. ft.) were divided into 2 lots. One lot was spread on a gently-sloping asphalt slab and subjected to an artificial "rain" from an oscillating lawn sprinkler. Total "rainfall" was 1.25 inches. The wet and dry lots of almonds were then halved and 4 small stacks of almonds were established. Two stacks (one wet, one dry) were placed where they would receive full sunlight during the day. A second pair of stacks was placed in the shade. All stacks were covered with clear plastic sheeting and fumigated with Phostoxin at the recommended dose (100 pellets/1000 cu. ft.) in order to control navel orangeworm (NOW). After 3 days the phostoxin level had fallen below the limits of detection and the stacks were uncovered.

Samples were taken from the north (N) and south (S) faces of each stack immediately after fumigation and then at 2 week intervals for 6 weeks. Samples were taken from the center of each stack at 6 weeks. Thermocouples were used to measure temperature at the N and S faces and the center of each stack throughout the course of the experiment.

A number of analyses were performed on samples. Concealed damage (internal browning) was assayed in our laboratory before roasting of the kernels and by DFA of California after a 2 minute roasting in oil. The viability of kernels was tested by determining the percentage of seeds which would germinate after a 30-day stratification period at 36°F. The moisture content of shells and kernels was measured by drying samples to a constant weight. Total sugars and reducing carbohydrates were measured in ethanol extracts of the dried kernels.

In addition to analyses pertinent to CD, samples of intact kernels (no NOW damage) were assayed for aflatoxin by DFA of California. Samples of NOW-damaged almonds taken at the 2-, 4-, and 6-week samplings were combined and tested for aflatoxin.

Temperatures at the S face of stacks in full sunlight reached a maximum of 145-150°F. The greatest temperature range for a single day was 90°. The highest temperature reached in a shaded stack was 110°F with a maximum daily range of 30°.

Moisture content of kernels in dry stacks was never greater than 4%. Moisture content of wetted kernels at the first (post-fumigation) sampling was 24% at the N (cooler) face of stacks and 16-18% at the S face. Moisture content dropped through subsequent samplings (more rapidly at the S faces) so that by the 4-week sampling all kernels, whether from stacks of wetted or dry nuts, had moisture contents of 2-4%.

Prior to roasting, CD occurred only in stacks that had been wetted. No nuts showed CD at the initial sampling. By the 2-week sampling 75% of the kernels taken from the S face of the sun-exposed stack showed internal darkening. Fewer nuts taken from the N face of the exposed stack showed CD. After 6 weeks a small amount of CD was observed in the shaded, wet stack. Analyses of CD after roasting parallel the observations on unroasted nuts. Roasting revealed a small amount (2-10%) of CD in all samples. These observations lead us to conclude that CD results from the wetting and subsequent heating of almond kernels.

Germination tests reveal that wet almonds stored with direct exposure to the sun deteriorate rapidly. None of the kernels in initial samples taken from the S face of the exposed, wet stack was capable of germination. After 2 weeks kernels taken from the N face of the wet, exposed stack were dead. Samples taken from all other locations showed high rates of germination. The data indicate, however, a slow deterioration of the wet nuts held in the shade. This may be the result of the prolific fungal growth in the shaded, damp stack. These losses of seed viability (seen in initial samples) precede observed increases in CD.

Our analyses of the ethanol-soluble sugar constituents of the kernels indicate that those samples which show considerable CD contain greatly elevated (7-10 fold) levels of reducing sugars with, perhaps, a slight decrease in total ethanol-soluble carbohydrate. Sucrose, by far the dominant sugar species in the almond kernel (> 80%) decreased by over 50%, relative to dry almond samples, in nuts taken from the wet, exposed stack at the 2-week sampling. In these samples, glucose, fructose, galactose and inositol were significantly increased.

The physiological cause of CD, a proposal: We propose that the following sequence of events leads to the appearance of CD in almonds. Upon wetting (rehydration) almonds, as for all kinds of seed, become more susceptible to harsh conditions. Exposure to high temperatures damages those kernels, probably by disrupting cell membranes. As a result the kernels are no longer able to germinate. Carbohydrate-metabolizing enzymes and stored food (carbohydrates) reserves are no longer separated with the result that reducing sugar levels rise. These reducing sugars can then react, in heat-catalyzed reactions, with amino acids and other cellular amines to give a brown discoloration.

We must stress that most of this is hypothetical and requires further testing.

Concealed damage--a suggested field solution: Samples of almonds were collected from the S faces of each of the wetted stacks at the time of the post-fumigation sampling. These in-hull almonds were air-dried at 85°F for 3 days. They were then returned to the corresponding dry stacks and held until the completion of the experiment (6 weeks). The kernels taken from the exposed stack and dried were incapable of germination. However, the incidence of CD, either before or after roasting, was no greater than in nuts held dry for the entire experiment.

Therefore, we suggest that CD can be avoided if wetted almonds are rapidly dried, at moderate temperatures, before on-the-ground storage is attempted.

Aflatoxin: Aflatoxin was found in samples of NOW-damaged almonds taken from each of the wetted stacks of almonds. In addition, aflatoxin (369 ppb) was found in the nuts taken at 6 weeks from the center of the heavily fungus-infested wet, shaded stack. It is our opinion that standard sorting procedures would remove these contaminated kernels from the processed product. This point should be tested.

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The "field causes" of concealed damage (internal darkening) in almonds were examined by testing samples taken from stacks of wet or dry in-hull nuts placed either in full sunlight or shade. Significant concealed damage was found only in those almonds which were stored wet in the heat of the sun. Concealed damage was preceded by the death (loss of germinability) of the kernel and was accompanied by an increase in reducing sugar content.

Trials indicate that concealed damage can be avoided if wet nuts are air-dried prior to on-the-ground storage. Seed death does not necessarily lead to concealed damage.