# *Risks presented in Almonds*

## Aflatoxins

Aflatoxins are a group of ~ 20 toxins produced by the fungi *Aspergillus flavus*, *Aspergillus parasiticus* and *Aspergillus nomius*. The most relevant toxins present in dried fruits and nuts are B1, B2, G1 and G2. The difference between them apart of the chemical structure is the level of toxicity they present.

*Aspergillus flavus, parasiticus,* and *nomious* are the fungi that can be found on almonds.

Contamination of almonds with mould spores can start since the fruit is on the tree, when the hull splits and exposes the in-shell kernel leaving it susceptible to the insect attacks. Fungi spores will reach the nuts on the trees by air or by being carried by pests such as Navel orangeworm or others. Growth and proliferation of the mould and contamination with aflatoxins can continue during the stockpiling and handling stages. Kernels that present insect damaged are more susceptible to aflatoxin contamination than intact kernels.

Good storage conditions would prevent the fungi from colonizing internal nut tissue.

Temperature and relative humidity are among the most important factors for preventing the development of *Aspergillus spp.* and aflatoxins production, if the kernel has moisture $\geq 7\%$ and temperature between 15-37°C it is ideal for aflatoxin production.

## Infestation / Insects at the orchard

In the orchard there are several pests that can attack the almond tree. However, not all of them will reflect their damage on the almond kernel. The insects whose presence will be reflected on the almond kernels are:

1. Navel Orangeworm (*Amyelois transitella*):

Female moths lay eggs on mummy nuts both on the tree, and on new crop nuts after the hull starts splitting. They also lay eggs on nuts that have been damaged by peach twig borer (see insect #4). Once the eggs hatch the larvae will bore into the nutmeat. Later, instar larvaes will consume most of the nut. Signs of infestation with Navel orangeworm (NOW) are the presence of frass and webbing on the kernels produced by the larvaes.

The varieties that are mostly likely to be infested with NOW either have a longer hull-splitting period or have a softer shell.

The risk of NOW is not only the damage by feeding on the kernels but also the increased possibility of contamination with *Aspergillus spp.* and consequent aflatoxin.

2. Leaffooted Plant Bugs (*Leptoglossus zonatus, Leptoglossus clypealis, Leptoglossus occidentalis*):

This insect migrates into orchards in March or April after over-wintered in the adult stage. The damage is caused when the worms feed on the nuts before the shell hardens. Depending on the stage of the nut, this can cause the nut to be aborted. It can also cause the nut to gum internally, resulting in a bump or gumming on the shell. Black spots on the kernel, wrinkles or malformed nuts could be a consequence of the leaffooted bug feeding after the shell has hardened.

3. Stink Bugs (*Chlorochroa uhleri, Acrosternum hilare, Thyanta pallidovirens*):

Stink bugs can cause damage to the nut as they insert a needlelike mouth through the hull and kernel. The damage caused will be determined by the phase of development of the kernel. If it is in an early stage the kernel become wrinkled and misshapen. If it is in a later stage where it has already hardened, a black spot will appear at the puncture site.

4. Peach Twig Borer (*Anarsia lineatella*):
The female moths lay eggs on the fruit, leaves and twigs. The summer larvae generation will enter the fruit near the stem end and directly feed from immature nuts causing shallow channels and surface grooves. The varieties with softer shells are more susceptible to infestation from these insects.

5. Box elder Bug (*Leptocoris trivittatus*):
The damage to the nutmeat will occur before the shell hardens as the bug cannot pierce the shell. The evidence of a box elder bug attack on almonds will be a brown spot on a depressed surface of the kernel. This will be produced when the bug feeds from the mature kernel.

6. Carpophilus beetles (*Carpophilus spp.*):
This beetle used to be mainly a fruit stone pest but it has recently migrated to almond trees. Ripening and rotten fruits (and mummies) would be emanating volatiles that attract the insects. In comparison with other insects this beetle doesn't discriminate between almond varieties. Instead of feeding from the surface, when able to infest, *Carpophilus spp.* penetrate into the kernel and lay there for some time. *Carphophilus species* have several generations per year with females laying more than 1000 eggs and can hibernate at different stages of their life-span (larvae, pupae, adult).

Good hygienic conditions in the orchard (removal of mummies), and during stockpiling and handling, as well as fumigation are crucial in avoiding post-harvest contamination.
It has to be considered that infestation can not only occur while the almonds are in the orchards but also during transportation and storage if proper conditions are not maintained. Despite fumigation processes being carried out for each shipment, they are still susceptible to infestation since the almonds are a rich source of nutrients for insects and other pests. Almonds are packed in cardboard boxes without liners. Therefore, the possibility for infestation can increase.
It is important to have a good inspection procedure in place upon reception of the product. Good hygienic conditions and pest control programme at the warehouses also play an important role in keeping up the quality of the almond kernels.

## Microbiological contamination

As was described in the *Harvesting and Processing* section, almonds are dried while in the orchard. As they come in contact with the soil, the air, insects and, potentially birds, they will be contaminated with all kind of microorganisms. Some of these microoganisms can simply cause spoilage, however, others can cause pathogens. For instance: **Salmonella** is nowadays of great concern. It inhabits the intestines of birds, animals, and humans. Also, it can be found in open waters, waste piles, soil, etc. The conditions allowing for *Salmonella spp.* to grow and multiply are extensive, and therefore, it can survive all along the chain. There are several guidelines that can be followed in order to prevent and control the spread of the bacteria starting from the orchard and through packing. These include orchard history and floor management, water sources and quality, soil nutrition, wildlife and bird management, workers hygiene, fumigation, etc. **Pasteurization** is now a practice used in the USA to control microbiological load, specifically since almonds have been the cause of salmonella outbreaks.
There are 4 main techniques that are used to pasteurize the almonds:

- **Roasting (dry or oil) and Blanching**: these techniques will modify the physical characteristics of the almonds.

- **Propylene oxide:** This has been banned in the EU as the toxicological data shows that it can cause skin, eye and respiratory tract irritation.

- **Steam vacuum:** to avoid changing the quality of the product, during this process, precise doses of steam are injected into a vacuum chamber. The heat from the steam only works on the skin of the kernel preserving the properties of the almonds.

## Admixture risks

Gum Contamination / Gummosis:

Gummosis is the formation of gum on the surface of the tree as a consequence of the exudation of the sap. The condition can be caused by stress to the tree, a wound (mechanical or by insect), or bacterial attack. The gum can be clear or yellow-brown coloured. Clear gum is likely caused by stress. Yellow-brown coloured gum could be due to a canker caused by a fungus or bacteria. It is possible for gum to appear on the finished product if small pieces of solidified gum pass through the foreign body controls.

## Other risks

Phomopsis Fruit Rot and Branch Dieback (Phomopsis amygdali):

This fungus attacks the trees causing damage to the fruit and to the tree. The hulls will appear grey/brown, discoloured and shrivelled. They often have clear gum secretions and shrivelled kernels.

Gumming kernels:

Kernels also can be contaminated with clear gum. It is not completely concluded if it is a physiological disease or caused by infestation. The clear, hardened gum (that comes from the hull) will cover a sunken area on the wide end of a shrivelled kernel.

It is possible that this is associated with the Leaf footed Plant Bug attack but a darkened spot (characteristic of the plant bug) was not seen in 80-85% of cases.

Concealed damage: This is a result of high temperatures and humidity applied to wet almonds. When the moisture level of the almonds is high (>10%), the germination process can start. However, this will stop when temperatures goes over 54°C. The amount of sugars and lipids in the nuts increases and a Maillard reaction will occur as a consequence of the high temperature causing browning in the centre of the nut.

## Foreign bodies:

Shells: once the shell has separated from the kernel using hard shell crackers and shear rolls, some pieces of shell can continue through the process. Although there is a risk of pieces of shell continuing along the process, aspirators, gravity separator, laser sorters and visual inspection will help to remove this from the finished product.

Others: Almonds coming in contact with the orchard floor are subject to physical contamination – foreign materials that can cause illness or injury, such as stones, glass and metal in food products. These can be removed at the processing site by laser sorters, x-ray machines, metal detector and visual inspection.

## Rancidity:

Rancidity can be defined as an unpleasant taste and smell of foods containing fats or oils. This occurs when the oils present in the almonds suffer oxidation (oxygen attack triglycerides) or hydrolysis (addition of water) releasing components as peroxides, hydrocarbons, aldehydes, ketones, and free fatty acids. These reactions are triggered by heat, light, metals, enzymes or oxygen.

The most commonly measured compounds to indicate Lipid oxidation and Hydrolysis are peroxides and free fatty acids respectively. Peroxide value will give an indication of early oxidation as it will decline as the oxidation progresses. The industrial standard for Peroxide Value in almonds is <5 meq/kg and Free Fatty Acids is <1.5 %.

The control of temperature, moisture and oxygen are then essential to prevent quality deterioration and rancidity. Ideal storage conditions for almonds are 10ºC and Relative Humidity of 65%. Higher temperature values can increase the oxidative reaction on lipids as well as the exposure to oxygen. High Relative Humidity will produce adsorption of moisture by the almonds, activating lipases enzymes.

References:


- Australian Almond Board, http://www.australianalmonds.com.au/industry
- Californian Almond Board, http://www.almonds.com/
- D&S Ranches, http://www.california-almonds.com/Articles.asp?ID=258
- University of California, Integrated Pest Management Program http://www.ipm.ucdavis.edu/index.html