

## Long-term storage study of raw and blanched almonds

Xiangyang Lin & others, College of Bioscience and Biotechnology, Fuzhou University, China  
Paul Chen, Yun Li & Roger Ruan, University of Minnesota, USA

### EXECUTIVE SUMMARY

Temperature, relative humidity (RH), and packaging influenced the moisture content of almonds and had a subsequent impact on shelf life quality. Whole almonds packed in cartons without liners must be protected from conditions of both high temperature and high RH even during short-term (<30 days) storage—storage under controlled conditions at 21.1°C (~70°F) and 45% RH is recommended. Whole almonds and almond forms packed in sealed polyethylene bags can better withstand varying ambient conditions (4-35°C [40–95°F], 60–90% RH) during long-term storage and maintain good quality shelf life based on typical parameters (e.g., mold count, moisture, peroxide value, free fatty acids). The chemical and microbiological parameters of all samples (in cartons/no liners & PE bags) remained stable during storage at 4°C (40°F) and 45% RH for up to 22 months.

Free fatty acid levels were affected by both humidity and temperature during storage, while peroxide values were only affected by temperature. Whole kernels with brown skins were largely protected from lipid oxidation, but free fatty acids increased slowly over time at high-humidity storage. Without barrier packaging the kernels rapidly absorbed moisture from a high humidity environment. Blanching partially deactivates enzymatic activities but may trigger lipid oxidation. Blanched forms showed smaller increases in free fatty acids and greater increases in peroxide value over storage time than brown skin almonds.

### BACKGROUND

Maintaining almond quality during long-term storage at ambient conditions is challenging in emerging export markets, such as China, which can have widely varying temperatures and relative humidities depending on the season and region. This study evaluated the shelf life quality of almonds—raw kernels, blanched kernels, and blanched sliced—stored for at least 18 months at ambient and controlled (including abusive) conditions. The study also compared the effects of storing whole raw almonds in unlined cartons or sealed polyethylene (PE) bags. (The PE film used provides a reasonable barrier to moisture but not a good oxygen barrier.) Samples were analyzed monthly for various chemical and microbiological parameters. Samples and storage conditions are listed in Tables 1 and 2.

Table 1. Almond samples

Variety	Form	Treatment	Packaging
Nonpareil	whole	raw	500 g, PE bag*
Nonpareil	whole	raw	5 lb, unlined carton
California	whole	blanched	500 g, PE bag
California	sliced	blanched	500 g, PE bag

\* PE film thickness: 180 µm.

Table 2. Storage conditions

Temperature °C (°F)	RH (%)
4 (40)	45, 75, 95
21 (70)	45, 70, 95
38 (100)	35, 65, 85
Ambient summer 21-35 (~70–95)	70–90
Ambient winter 4-16 (~40–60)	60–80

## MAJOR FINDINGS

**Mold growth:** Visible mold growth was found when kernel moisture content increased to  $\geq 8\%$ .

*For almonds packed in unlined cartons:*

- Whole kernels were very susceptible to mold spoilage when stored at high temp/high RH conditions
  - At 21.1°C (70°F) and 37.8°C (100°F) at high RH (85 and 95% RH), kernels had visible mold growth in about 10 days and spoiled after 20 days of storage
  - At 4.4°C (40°F) and high RH (85 and 95% RH), kernels had no visible mold growth until 10 months of storage



At 20 days (21.1°C/70°F, 95% RH)



At 7 months (4.4°C/40°F, 95% RH)

*For almonds packed in sealed PE bags:*

- At 21.1°C (70°F) and high RH (95% RH), all samples in bags had visible mold growth at 11 months
- At 37.8°C (100°F) and high RH (85% RH), whole kernels in bags had visible mold at 10 months; blanched samples in bags were discarded at 9 months due to unacceptable browning

**Moisture:** The moisture content of all samples was  $\sim 5\%$  at the start of storage (in China).

*For all samples during storage at 21.1°C (70°F) and 37.8°C (100°F):*

- Moisture gains occurred at  $\geq 70\%$  RH (to above 6% moisture)
- Moisture losses occurred at 35 and 45% RH (to below 4% moisture)

*For whole kernels in unlined cartons:*

- Highest moisture gains occurred during storage at high RH ( $\geq 75\%$ )
- Moisture gains/losses were greater in storage (including ambient) than for whole kernels in sealed bags
- Moisture content ranged from 3 to 14% during storage, depending on conditions

*For blanched kernels and slices (in sealed bags):*

- Changes in moisture content were similar to those for whole kernels in sealed bags

**Lipid stability:** Peroxide value (PV) and free fatty acids (FFA) were monitored.

*For whole kernels (in unlined cartons and sealed bags):*

- PV  $< 2$  meq/kg during 18 months of storage at all storage conditions
- $< 1.5\%$  FFA throughout storage life at ambient and other conditions, except at extreme conditions (37.8°C [100°F] and 85% RH, in bags; 37.8°C [100°F] and  $\geq 65\%$  RH, in cartons)

*For blanched kernels and slices (in sealed bags):*

- PV  $< 5$  meq/kg throughout storage at 4.4°C (40°F) at all RH (45–95%)
- PV increased ( $\geq 6$  meq/kg) by 5 months storage at 37.8°C [100°F] at all RH (35–95%)
- PV  $\leq 5$  meq/kg for  $\sim 12$  months at ambient conditions
- $< 1\%$  FFA throughout storage life at all conditions, including ambient

## OUTCOMES AND FUTURE PLANS

1. *Publications:* The lipid deterioration data has been published (Lin, X. & others. 2012. *California almond shelf life: lipid deterioration during storage*. Journal of Food Science 77(6): C583–C593).
2. *Follow up research:* Research group in China began a formal shelf life study in November 2012 on raw and lightly salted roasted Nonpareil kernels in two different packages and stored under various conditions.