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FOOD SAFETY & QUALITY ROUNDUP

Moderator: Brian Dunning (Shoei Foods)
Speakers: Tim Birmingham (ABC), Guangwei Huang (ABC)

california almonds
Almond Board of California

2021 Almond Food Safety & Quality Highlights

01. Pasteurization– Efficacy for Insect Disinfestation

02. Amygdalin & HCN

03. Aflatoxin

04. Smoke Taint

05. Almond Shelf Life

Pasteurization Efficacy for Insect Disinfestation (Indian Meal Moth & Red Flour Beetle

Dr. Sandipa Gautam – UC Riverside / Kearney Ag Research Center
Michele Brasil – Olam International (Almond Leadership Program)

Study Looked at Efficacy of Four Processes against Different Life Stages of IMM and RFB

Insect Life Stages:

- Eggs
- Larvae
- Pupae
- Adults

Processes Evaluated:

- Steam under vacuum (H2O Express) - Batch Process
- Propylene Oxide (PPO) – Batch Process
- Steam/moist heat under atmospheric Conditions (JBT) – Continuous Process
- Phosphine Fumigation – Batch Process

Project Design



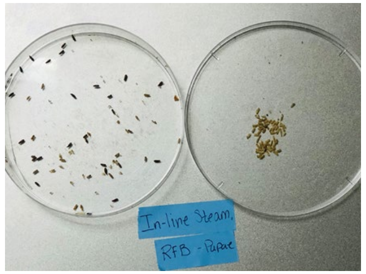
Propagated Life stages – Eggs, Larvae, Adults

Infested Almonds

Placed in mesh bags

Buried in 50 Lb boxes for batch processes or placed on conveyor belt for continuous process

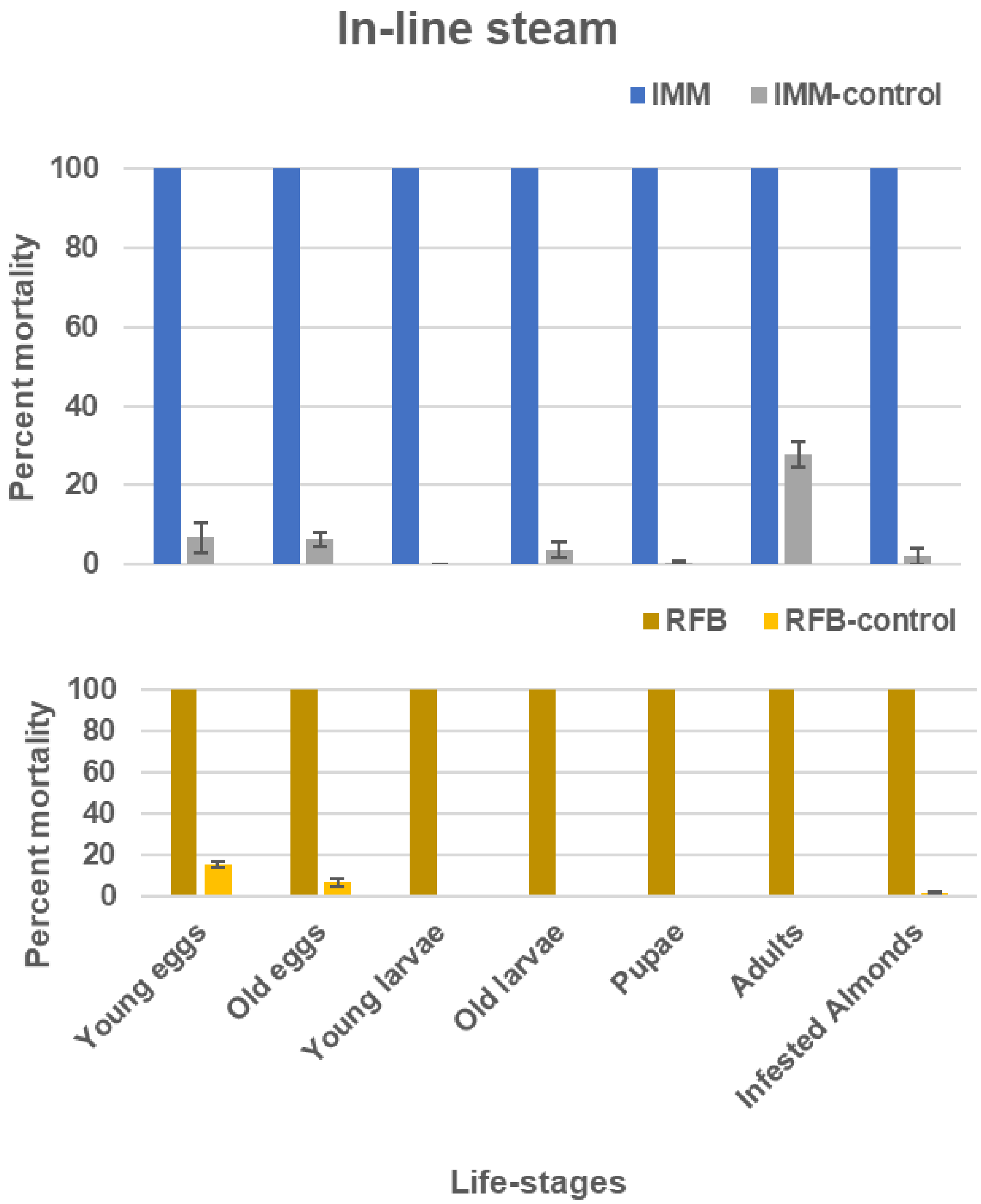
Subject to treatment



Incubation / Analyzed for Mortality

Results Example

In-Line Steam



Summary Results: Pasteurization Efficacy for Insect Disinfestation

- All four treatments (Steam under vacuum, in-line steam/moist heat, PPO and Phosphine effectively controlled all life stages of IMM and RFB
- Any infestation of pasteurized product is most likely due to post process re-infestation
- Appropriate steps should be taken to minimize reinfestation

Amygdalin and HCN

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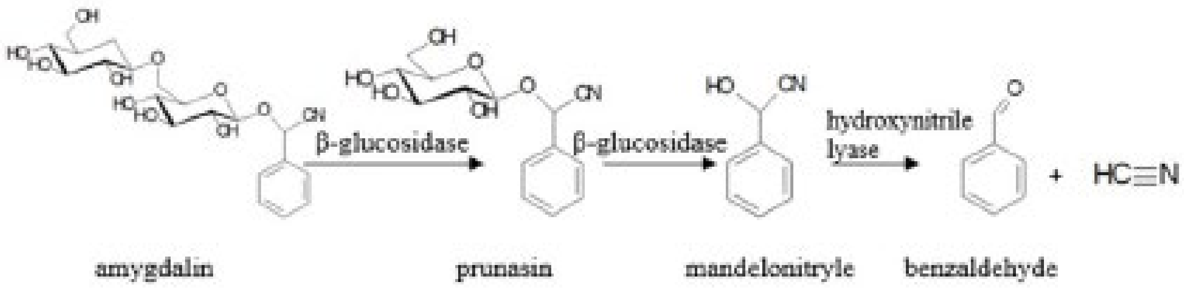
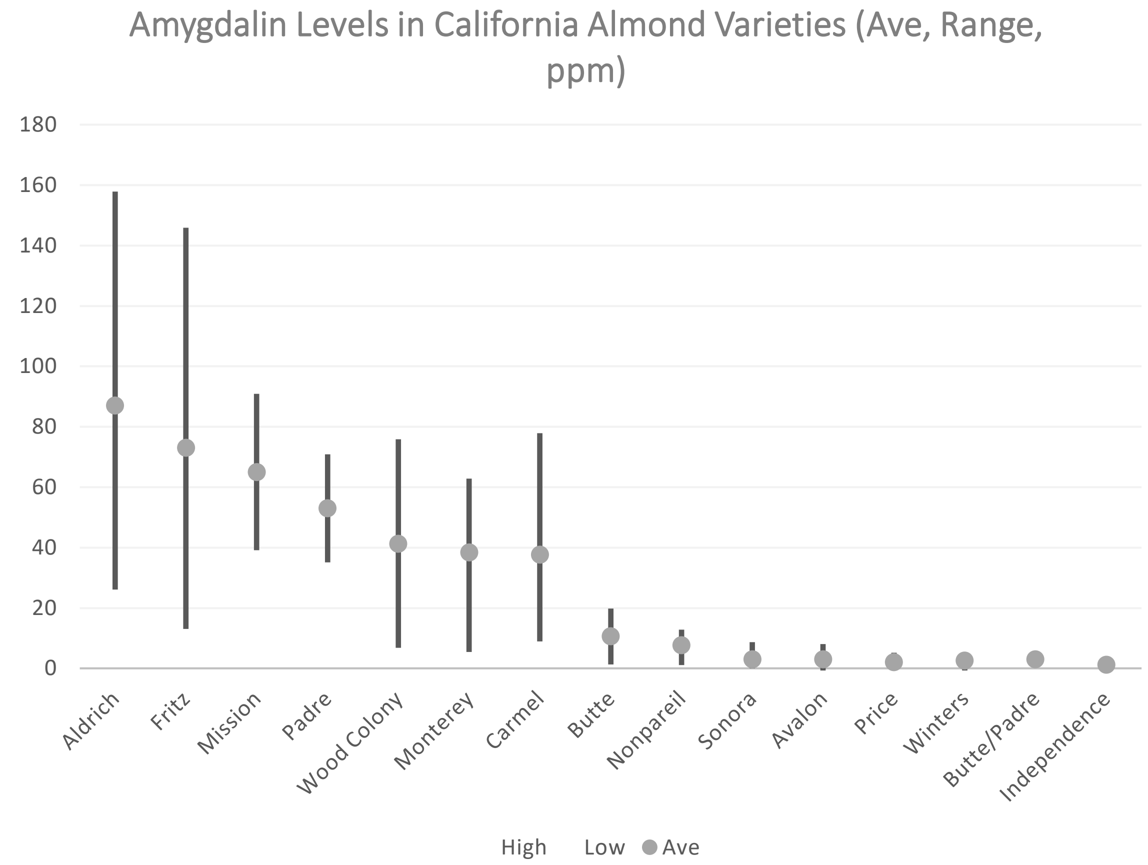
HCN Concerns for California Almonds?

EU Food Safety initially proposed a limit of 20ppm in almonds - now changed to 35ppm

- Amygdalin vs. benzaldehyde vs. hydrogen cyanide (HCN)
- ABC funded projects on amygdalin for 4 years
- 1 part of amygdalin will release 0.06 part of HCN
- No HCN analyses done on CA almonds prior to 2021



Amygdalin Levels in California Almond Varieties

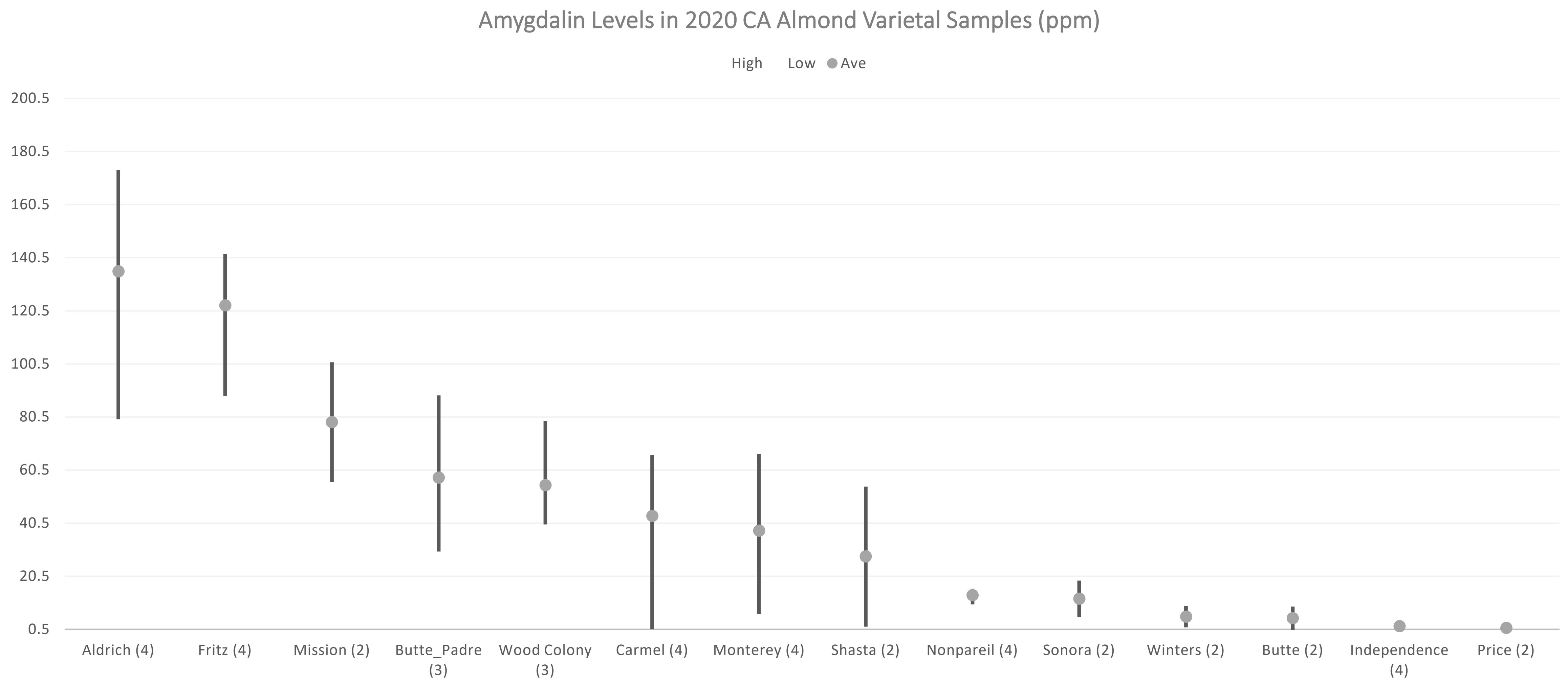


* Extracted from 3 published papers

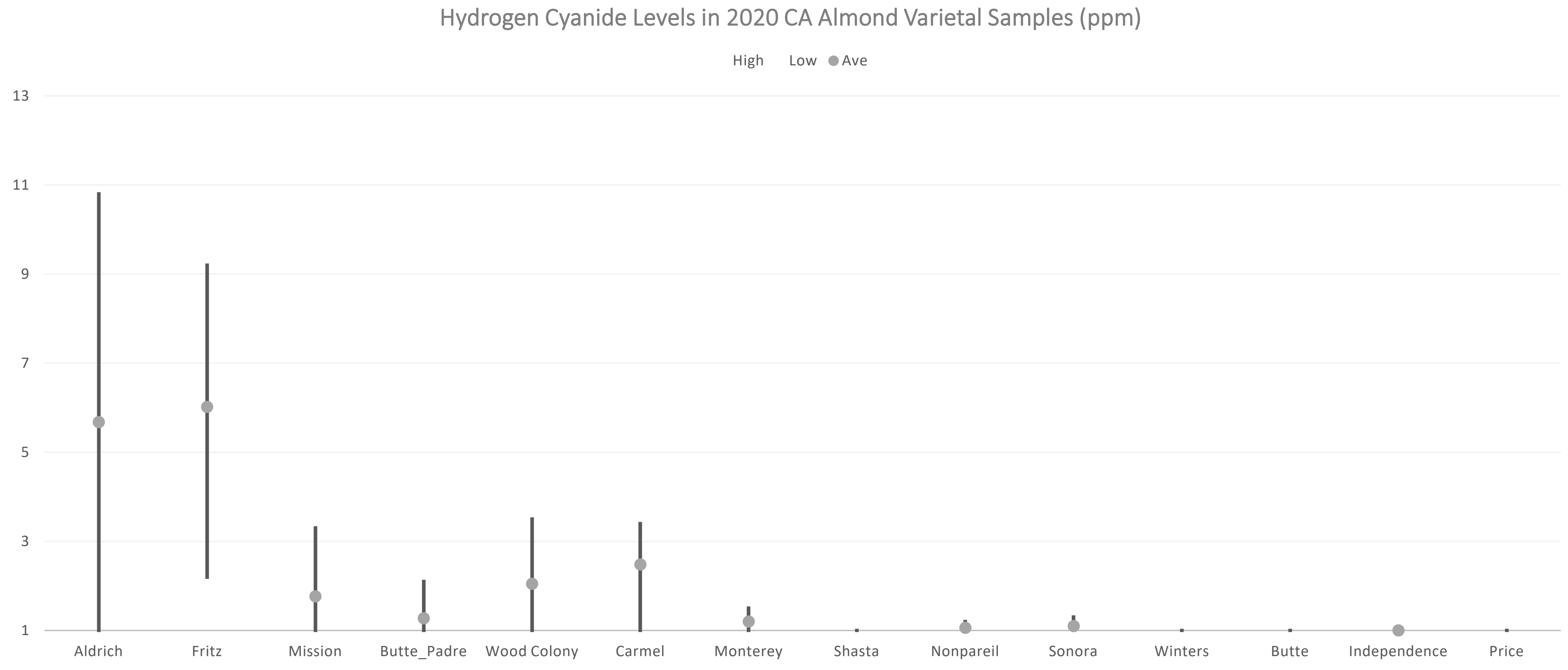
- The reported levels: 0.1 to 215 ppm from 4 crop seasons, with large season variations observed:
  - Crop 2010: 0.8 – 215ppm
  - Crop 2014: 1.6 – 76ppm
  - Crop 2015: 0.7 – 100ppm (unpublished)
  - Crop 2016: 0.1 – 27ppm
- Varietal variation in 3 ranges with Aldrich & Fritz over 100ppm
- Regional variations also noticed

Sources: Lee et al. (2013) J. Agric, Food Chem. 61: 7754-7759; Luo et al. (2018), Acta Hortic. 1219: 1-8; King et al. (2019), J. Agric. Food Chem. 67: 3229-3241.

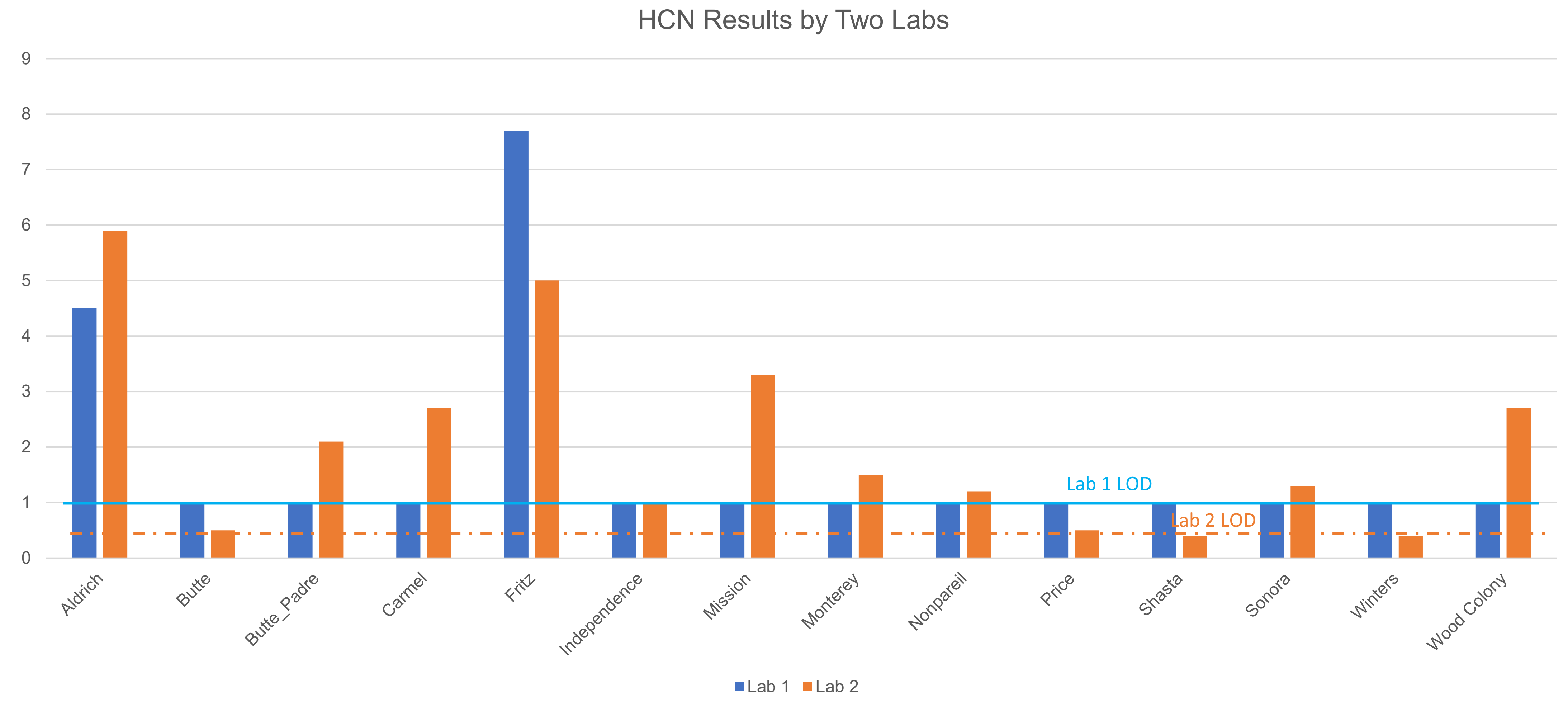
Amygdalin in California Almonds (May & July, 2021)



HCN in California Almonds (May & July, 2021)



Variability of HCN Measurement (Labs, Methods)



EURL Considers CEN16160 as the Preferred Method

Method	Lab 1	Lab 2	CEN 16160
Sample Cryo-Grinding	X	X	?
β-glucosidase hydrolysis	X	X	Extraction/ hydrolysis
HCN Extraction	Distillation	?	Steam Distillation
HCN Measurement	Headspace/GC	Titration	Derivatization /HPLC
Limit of Quantification (ppm)	1.0	1.0	2.0
ISO 17025 Accreditation	X	X	

Aflatoxin

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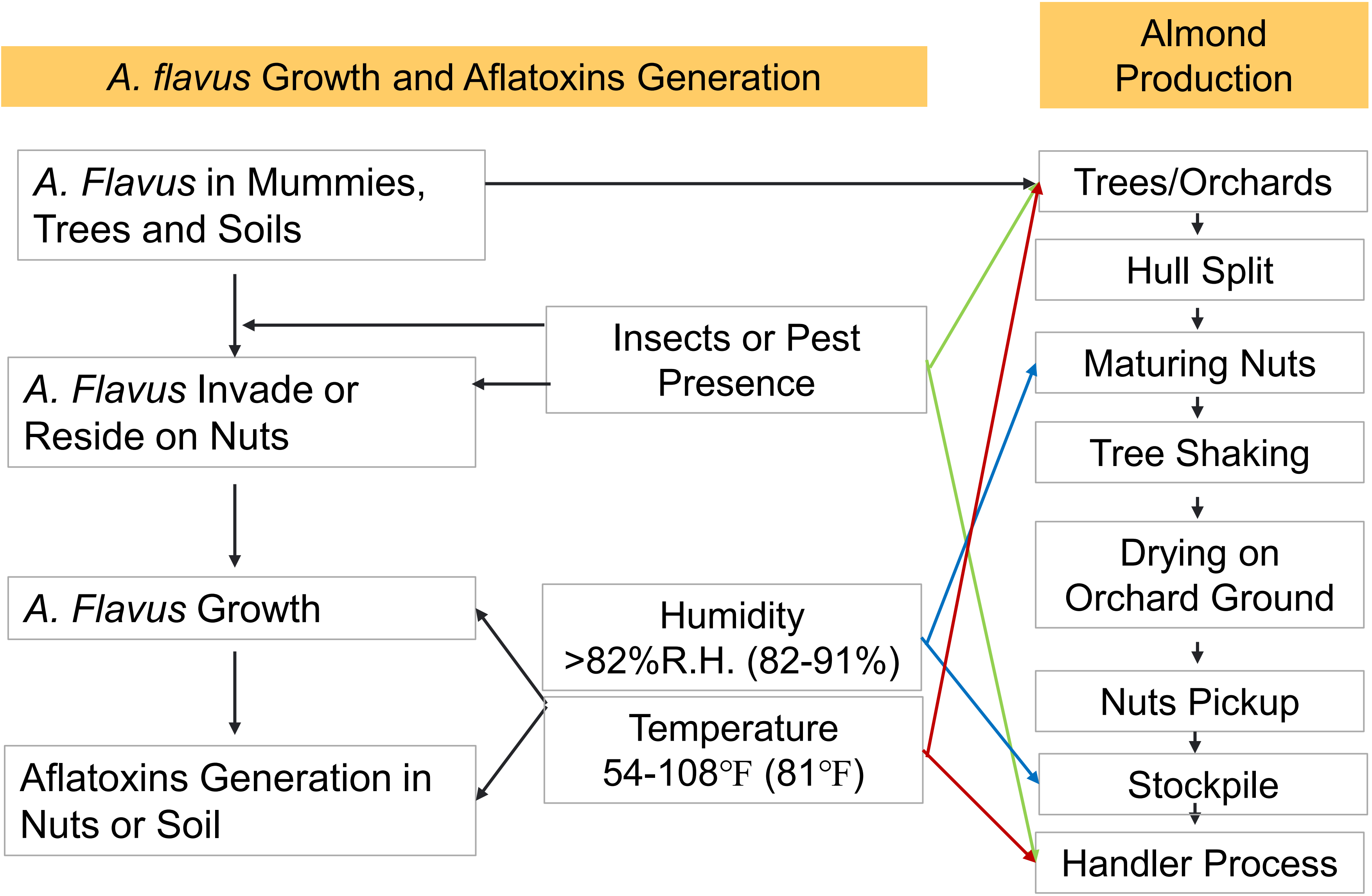
Aflatoxin Approach

- Sources of Aflatoxin Contamination
- Aflatoxin Mitigation
  - Pre-Harvest
  - Stockpiling
  - Post-Harvest
  - Reconditioning
- Regulatory

Aflatoxin Risk Associated With Almond Production and Processing



Majority of aflatoxin contamination of almonds can be attributed to insect-damaged nuts

Palumbo et al., 2014. *Spread of* Aspergillus flavus *by navel orangeworm (*Amyelois transitella*) on almond. Plant Disease 98:1194-1199*

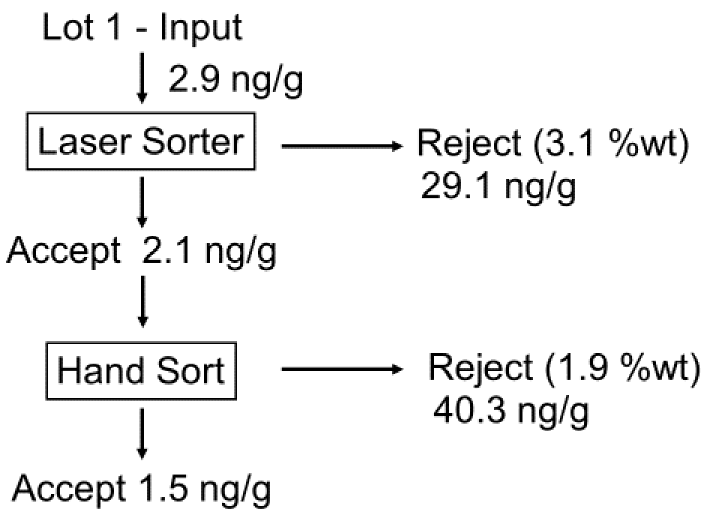
Grade Category	Weight (%)	Aflatoxin (%)
High Quality	83.7	3.2
Mechanical Damage (Chip/Scratch)	7.4	7.9
Insect Damage	7.2	76.3
Other defects (i.e.. Gummy/Shrivel)	1.5	11.8
Mold	0.2	0.8
Total	100.0	100.0

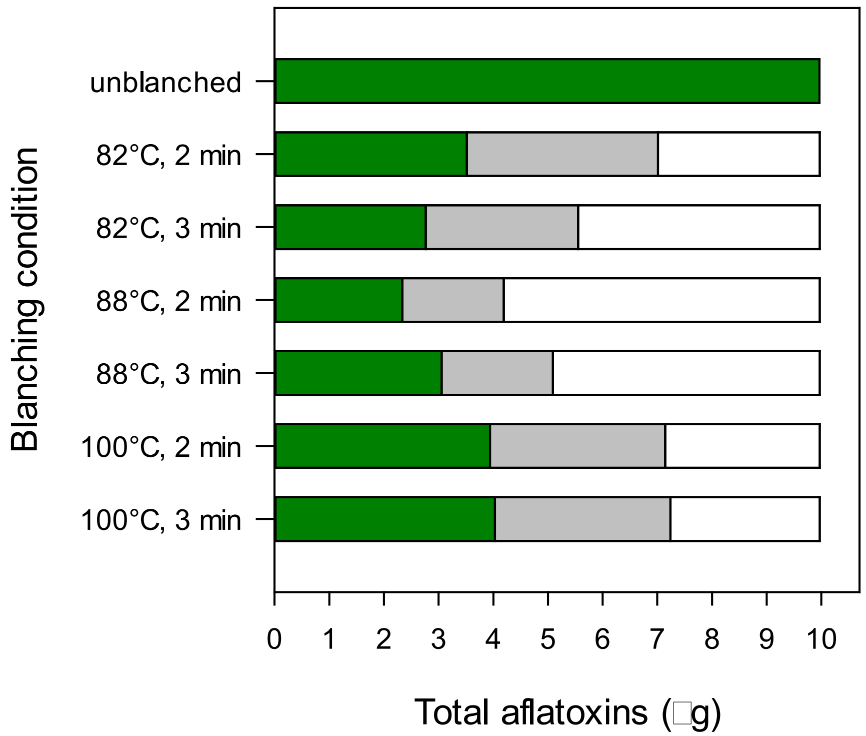
Whitaker et al., 2010. Correlation between aflatoxin contamination and various USDA grade categories of shelled almonds. J. AOAC Int. 93(3):943-947

Sorting and Blanching Can Reduce Aflatoxin Level

Sorting to remove damaged product; **Blanching** to reduce aflatoxin levels of contaminated product

Example of Sorting Efficacy:
Commercial Almond Lot (44,000 pounds)





Mahoney et al., 2020. Effect of blanching on aflatoxin contamination and cross-contamination of almonds. J. Food Prot. 83:2187-2192

Short to medium-term storage is unlikely to result in aflatoxin accumulation

Minimum a_w required for growth of *A. flavus*: >0.80 a_w (Gibson et al.)

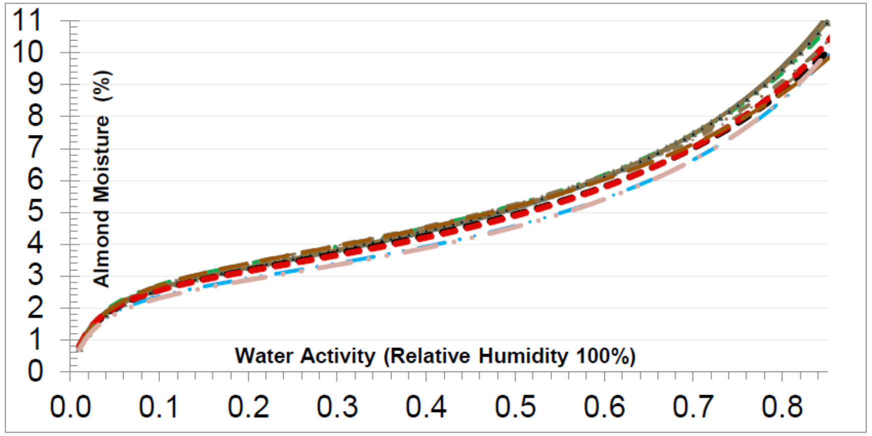
Minimum a_w required for aflatoxin production by *A. flavus*: >0.90 a_w (Gallo et al.)

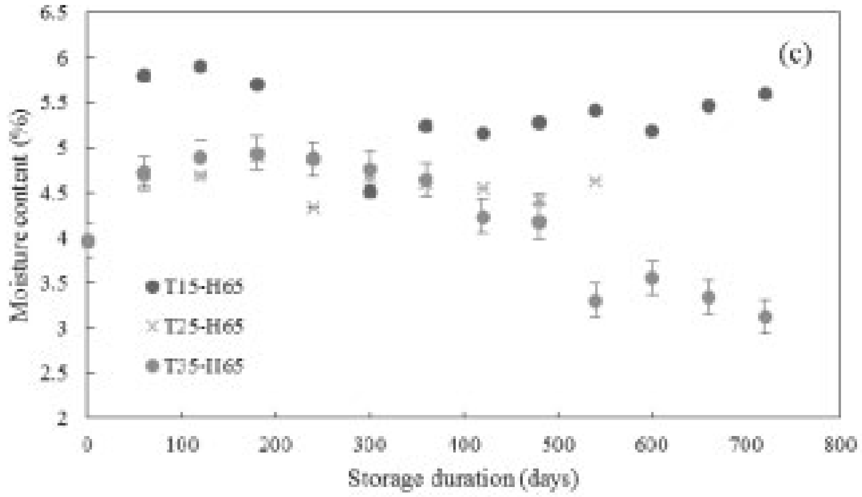
Gibson et al., 1994. Predicting fungal growth: the effect of water activity on Aspergillus flavus *and related species. Int J. Food Microbiol. 23:419-431.*

Gallo et al. 2016. Effect of temperature and water activity on gene expression and aflatoxin biosynthesis in Aspergillus flavus *on almond medium. Int. J Food Microbiol. 217:162-169*

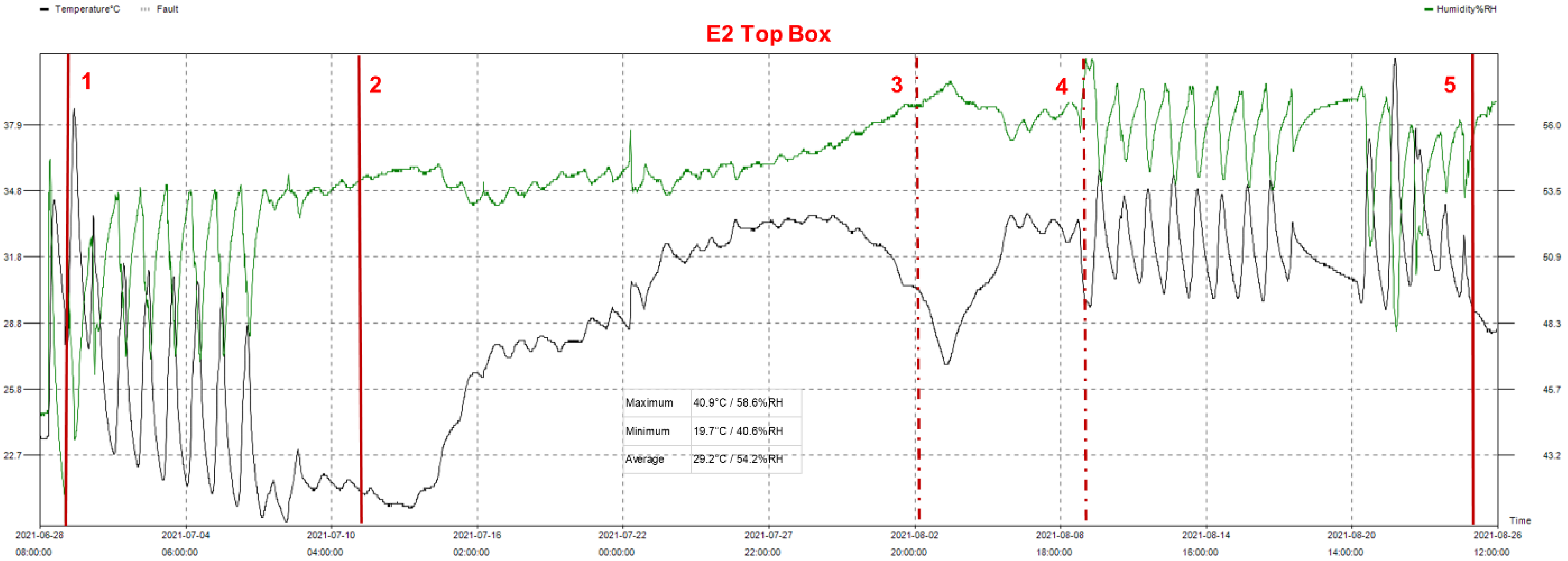
Wu et al., 2019. California almond shelf life: Changes in moisture content and textural quality during storage. Transactions of the ASABE. 62, 661-671

Almond Moisture Isotherm Curve; Dr. Ted Labuza, University of Minnesota (Unpublished Data)



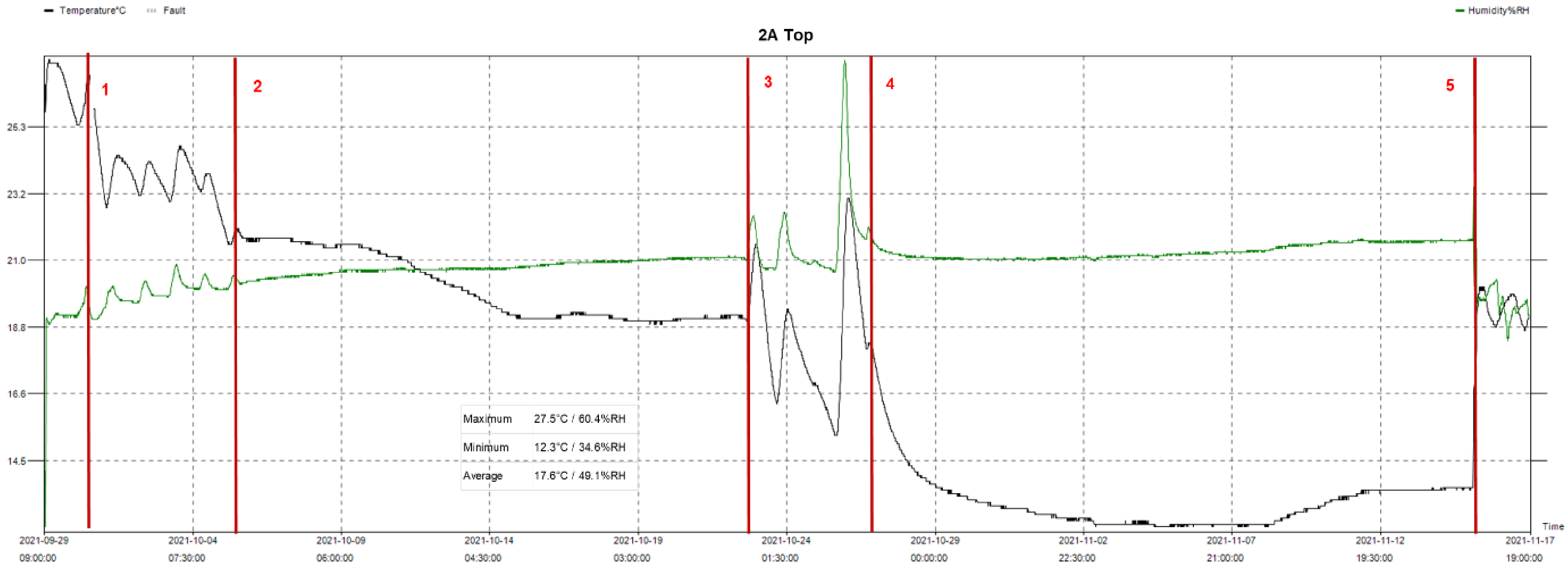


Conditions during transit from CA to Italy (July 2021 Shipment) do not support generation of aflatoxin



1. Loaded into a container; 2. Container loaded to a vessel; 3. Arrived into an Italian port (est.); 4. Off-loaded from the vessel; 5. Arrived at customer warehouse

Conditions during transit from CA to Japan (October 2021 Shipment) do not support generation of aflatoxin



1. Departed from handler; 2. Container loaded to a vessel; 3. Arrived at Tokyo port (est.); 4. Moved into customer warehouse 5. Dataloggers retrieved out of pallets

Growth of *A. Flavus* and Generation of Aflatoxins Driven by Humidity and Temperature

- No aflatoxigenic mold growth and toxin generation
  - At marginal temperatures (10℃/ 50℉ and 43°C/ 109℉) regardless of a_w
  - At a_w of 0.82, regardless of temperature
- Toxins were detected in the range of 0.86-0.99 a_w
  - Optimal a_w of 0.98 and optimal temperature in the range of 25-30°C (77-86℉)

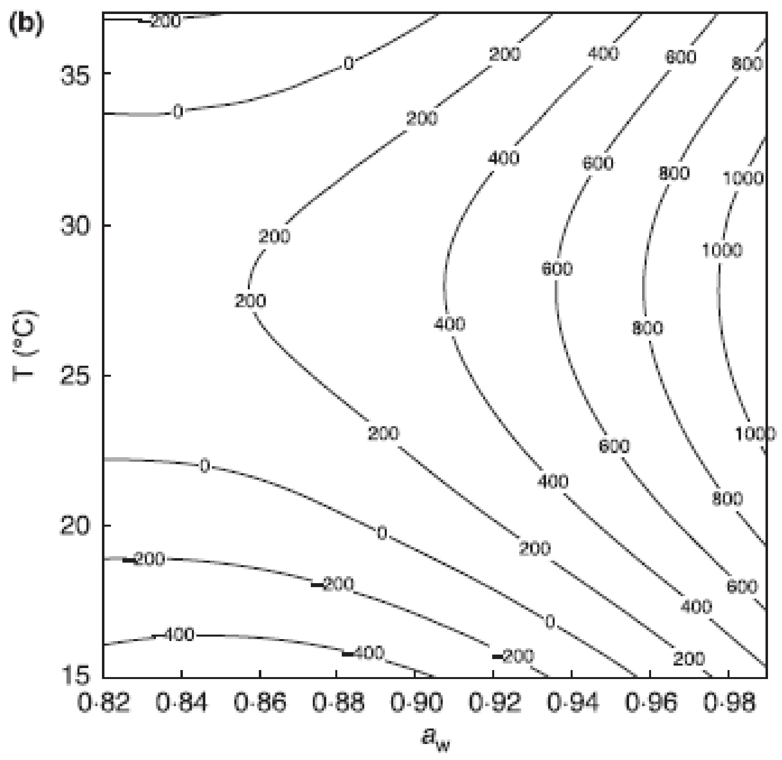


Figure 6 Contour plots showing the effects of a_w and temperature on aflatoxin production by *Aspergillus flavus* (a) DISF15 and (b) DISF10.

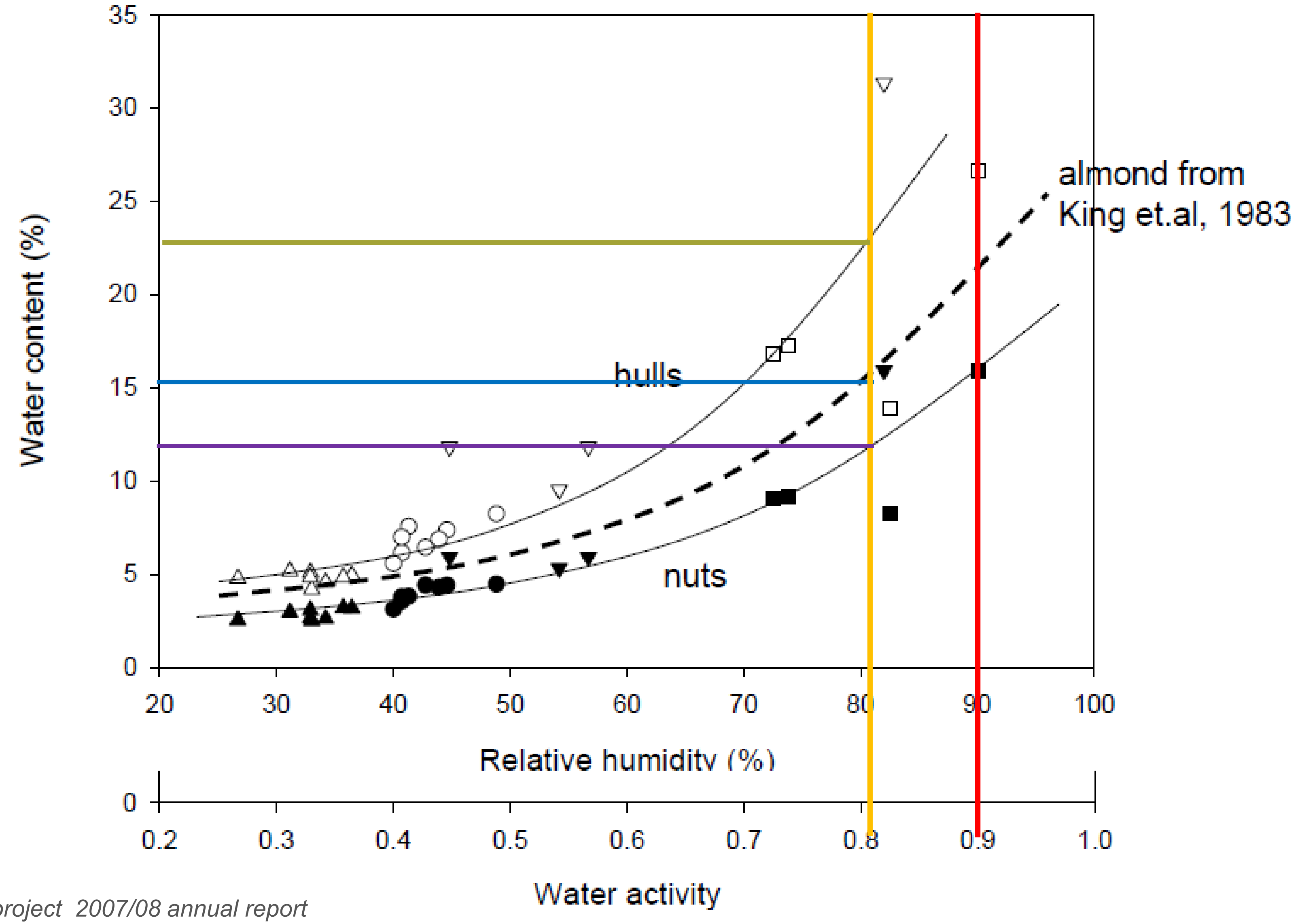
Mousa W., et al., J. Applied Microbiology 111, 1262-1274

Risky Moisture Ranges for *A. flavus* Growth and Aflatoxin Generation

23% hull's MC for AFLT concern

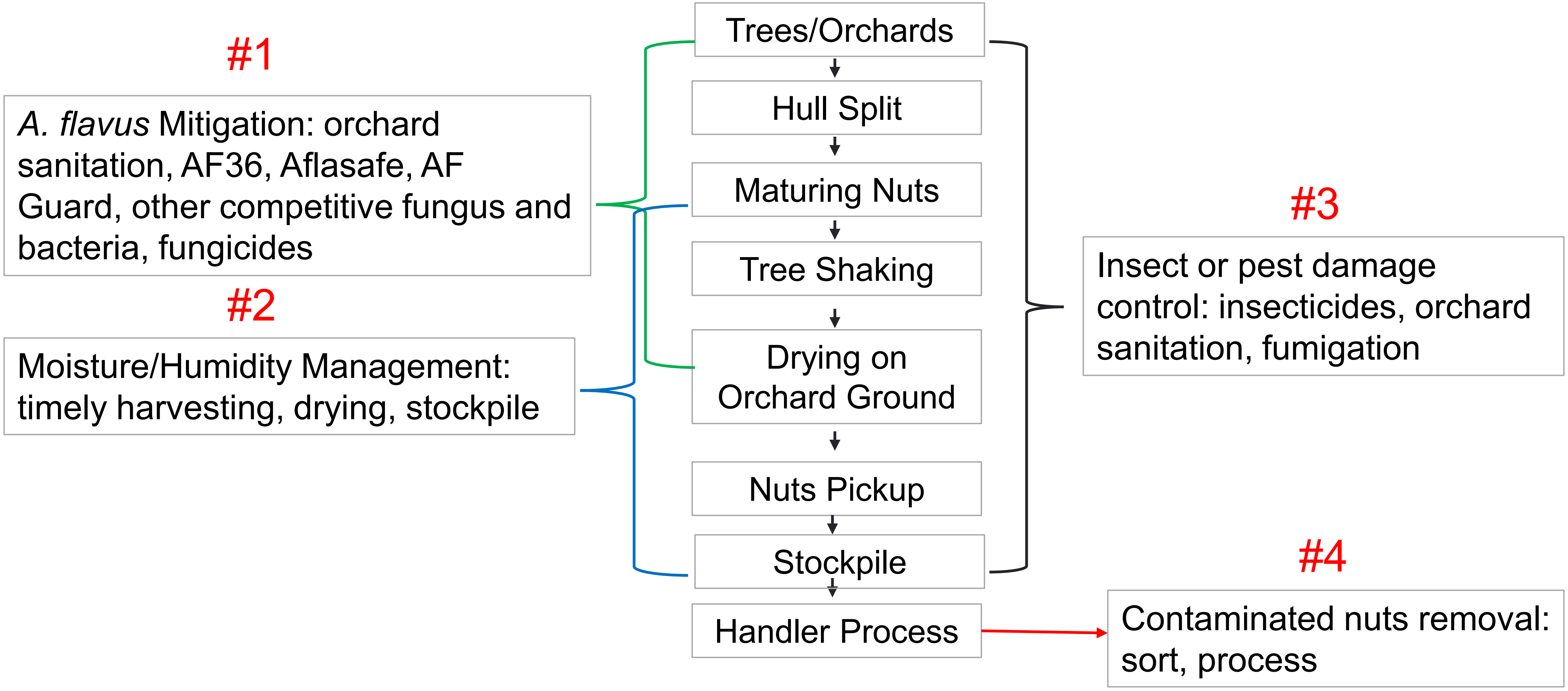
15% inhull kernel MC for AFLT concern

12% inshell kernel MC for AFLT concern



Taken from Lampinen B. et al. stockpile project 2007/08 annual report

Wholistic Strategies to Mitigate Aflatoxin Risk



Smoke Taint

Alyson Mitchell (UC Davis) &
Stanislau Bogusz (U. of São Paulo, Brazil)

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Smoke Taint

- Crops are increasingly exposed to smoke from wildfires
- Exposure to smoke can result in grapes and wines with undesirable sensory characters, commonly described as smoky, burnt, ashy and/or medicinal
- Collectively this is termed “smoke taint”
- To date, there is little information available on how smoke exposure impacts the quality and sensory characteristics of other crops important to California
- However, both deposition of smoke related compounds (e.g. PAHs) and volatile organic compounds related to smoke are considered problematic

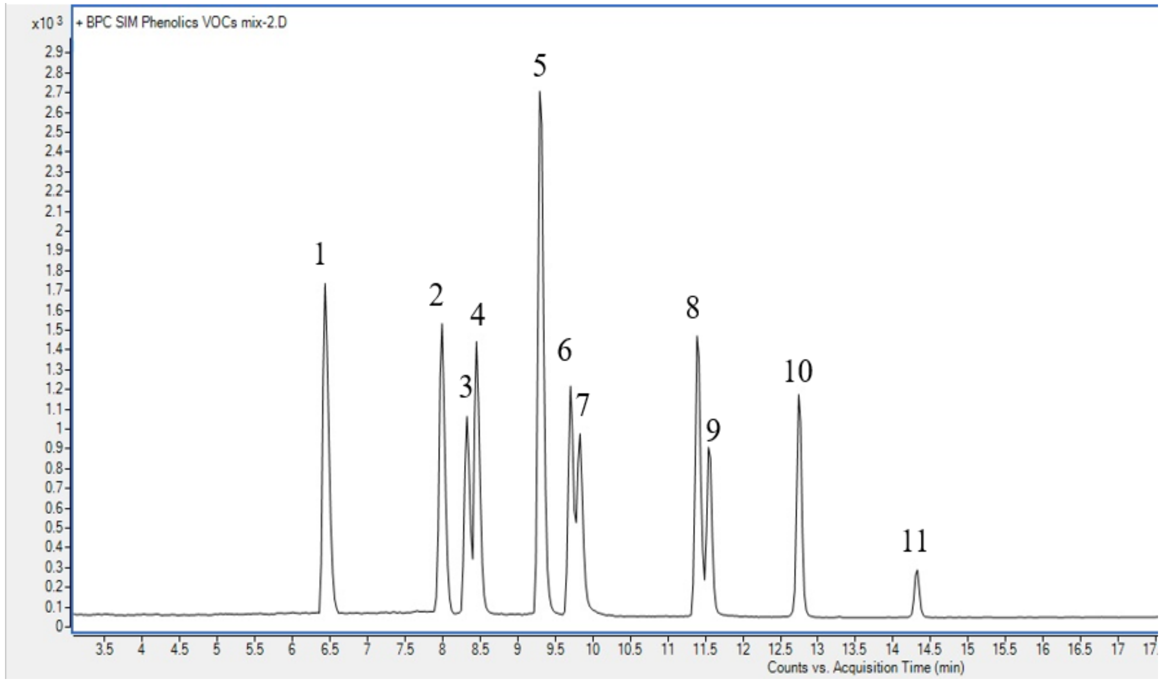
Inhull Almond Sampling

- Almond samples (1 lb) of the Nonpareil (soft shell), Monterey (semi-hard shell), and Butte (hard shell), variety were obtained from stockpiles at North State Hulling
- All the samples were exposed to smoke close to the area where the samples were collected
  - The amount of smoke exposure time may have varied
  - The distance from the fires may have varied
- Control samples were obtained from the laboratory of Prof. Zhongli Pan
- Samples analyzed by Dr. Mitchell's Lab





GC-MS/SIM Chromatogram of almond spiked with 11 compounds related to Smoke Taint



Peak Order	Cmpd Name	Retention Time (min approx.)	SIM ion (m/z)
1	guaiacol	6.5	109, 124
2	creosol	8	123, 138
3	phenol	8.35	94, 95
4	o-cresol	8.5	107, 108
5	4-ethylguaiacol	9.35	137, 152
6	p-cresol	9.75	107, 108
7	m-cresol	9.8	107, 108
8	4-ethylphenol	11.4	107, 122
9	eugenol	11.55	149, 164
10	syringol	12.75	139, 154
11	4-methylsyringol	14.35	153, 154

Figure 5 – Chromatogram GC-MS/SIM obtained by HS-SPME-GC-MS/SIM, showing the separation of the smoke taint standards. 1 = guaiacol, 2 = creosol, 3 = phenol, 4 = o-cresol, 5 = 4-ethylguaiacol, 6 = p-cresol, 7 = m-cresol, 8 = 4-ethylphenol, 9 = eugenol, 10 = syringol, 11 = 4-methylsyringol.

Results

- No smoke taint compounds in any of the samples (hull, shell, kernel)
- No smoke taint compounds concentrated in kernels and should not be a quality issue
- Possible reasons for not found in hulls and shells:
  - Proximity to fires
  - Exposure time
  - Positioning in the stockpiles
  - Sample size used in the headspace vials (1 gm)
    - Although other volatiles were apparent in this sample size

Shelf Life

Ron Pegg et al. (The University of Georgia)

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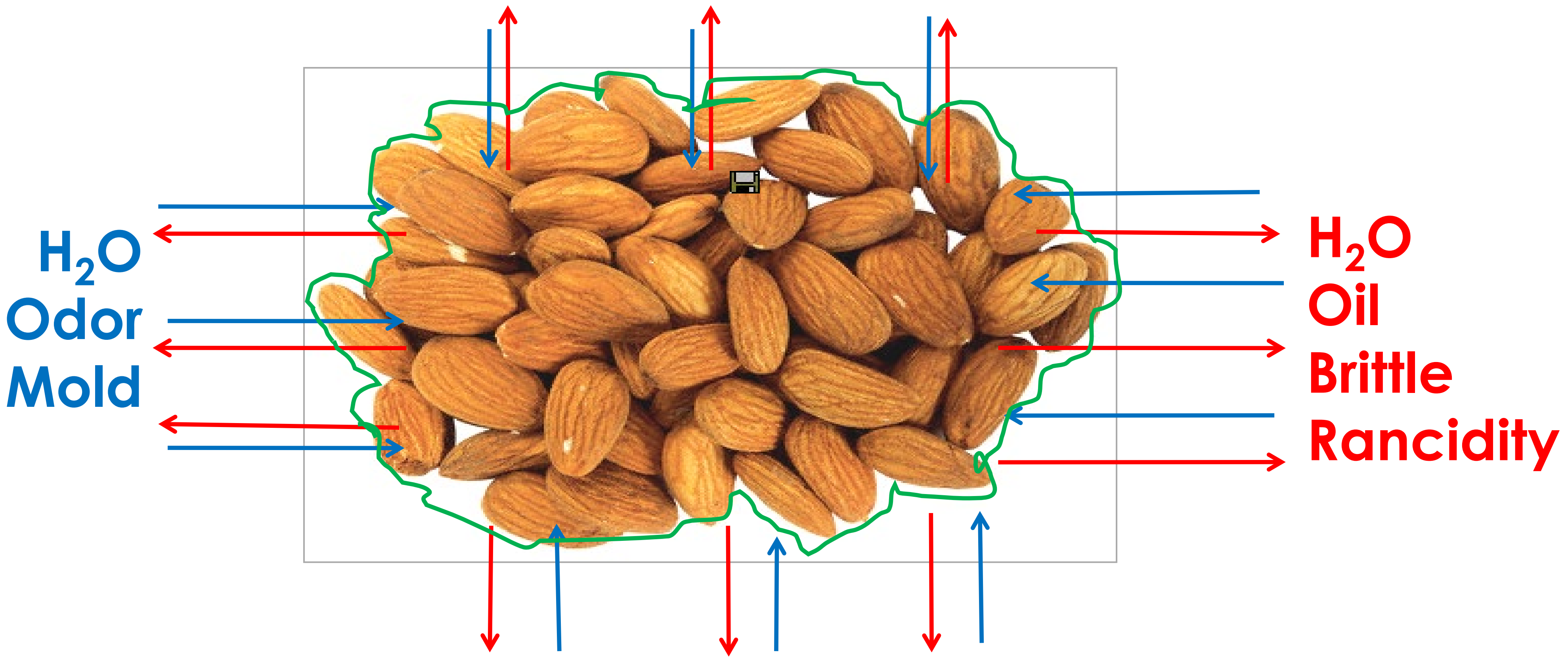
Almond Properties Changes with Environmental Conditions

Temperature, humidity, packaging, processing conditions affect quality (oil migration, water migration, flavor fading, etc.)

Environment: Temperature ↓ ↑ Humidity ↑ ↓



TWO YEAR SHELF LIFE STUDY OF RAW AND ROASTED NONPAREIL ALMONDS

Temp: 40, 59, 77, 95°F
RH: 50 & 65%

Temp: 40, 59, 77, 95°F

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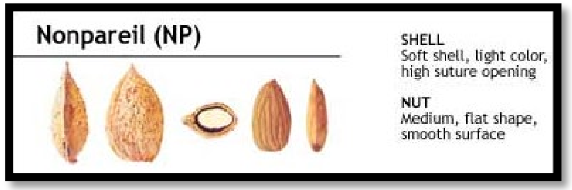
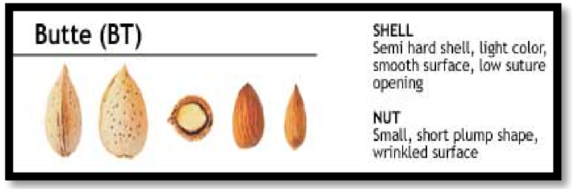
TWO YEAR SHELF LIFE STUDY OF RAW INSHELL AND SHELLED NONPAREIL AND BUTTE ALMONDS

Control (10℃/65%), 15℃/55%, 15℃/70%, 25℃/55%, 25℃/70%,
Reference (4℃/No RH Control), CA ambient, GA ambient





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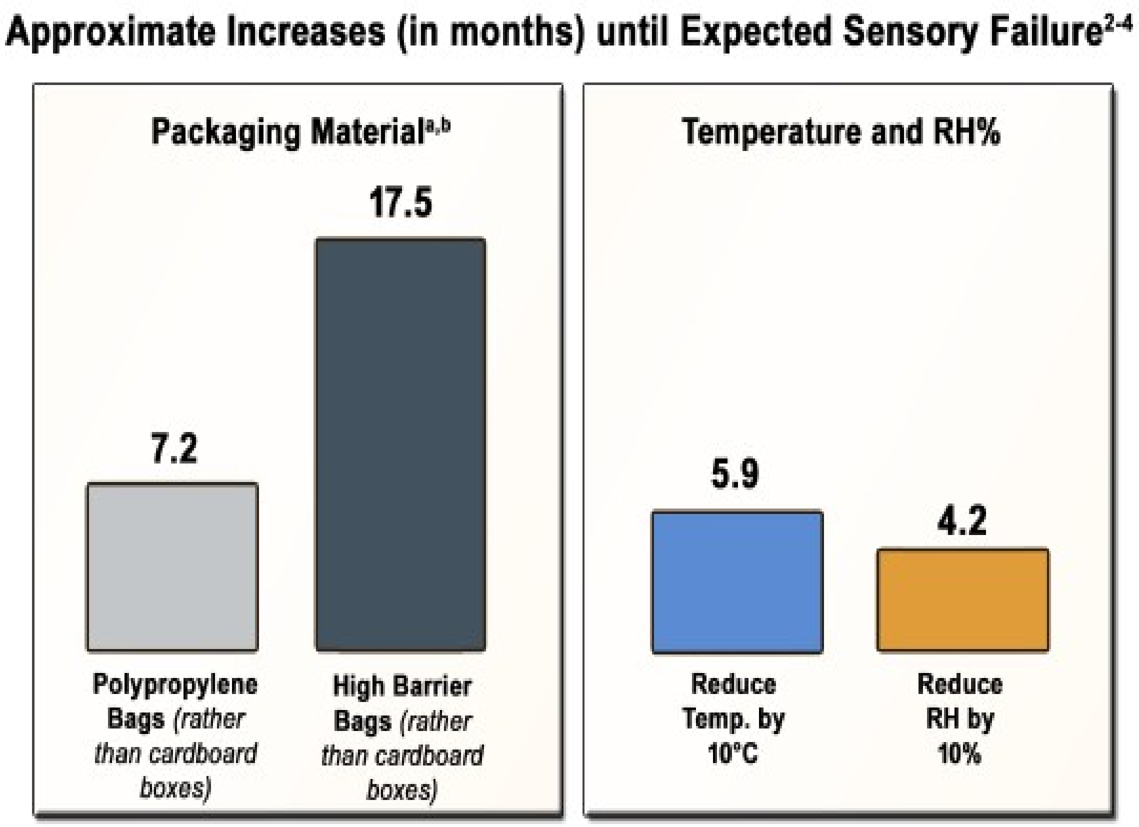
Lowering Storage Temperature and Relative Humidity, Packages or Inshell Extend Shelf Life



Sensory failure = Rejection by 25% or more panelists

Months until sensory failure = 49 − .59(°C) − .42(RH%)

Inshell – Shelled >> 4-8 months

Nonpareil > Butte (Shelled)
Nonpareil ≈ Butte (Inshell)

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Parrish D. et al. Intl. J. Food Sci. & Technology, 2019; Pegg, R. et al. unpublished 2021


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