Characteristics of California Almonds

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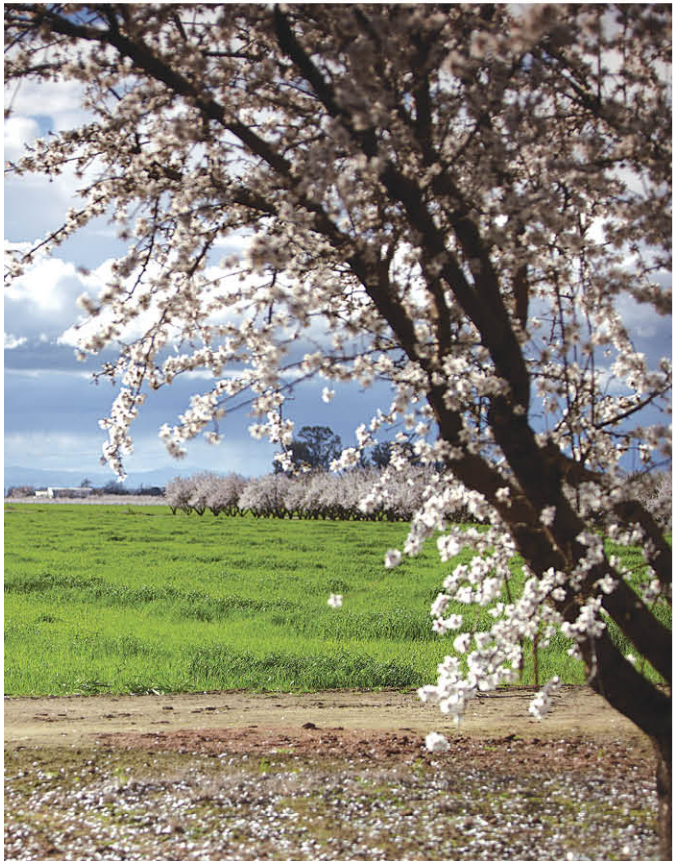
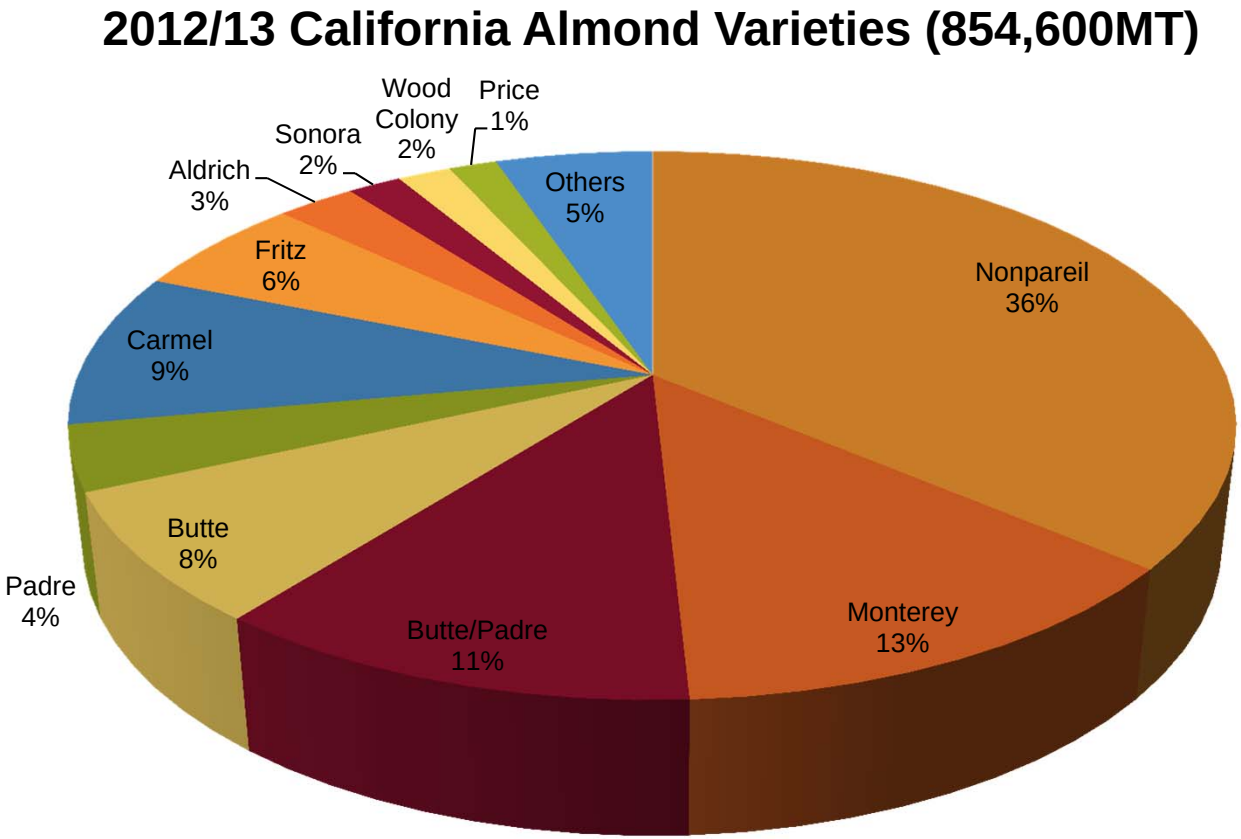
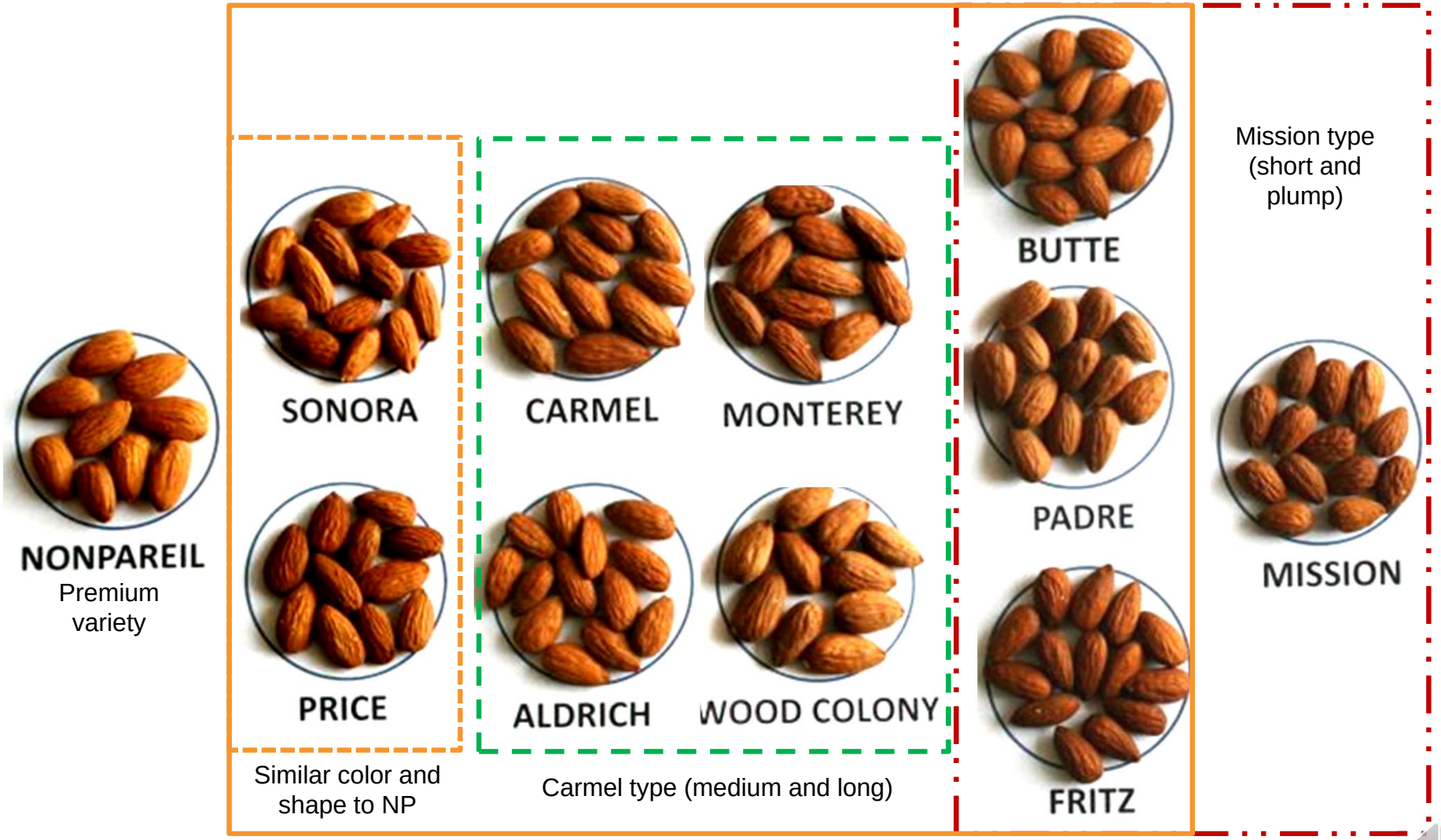


Varieties and Forms

Major Varieties of California Almonds



Marketing Classification of Major California Almond Varieties



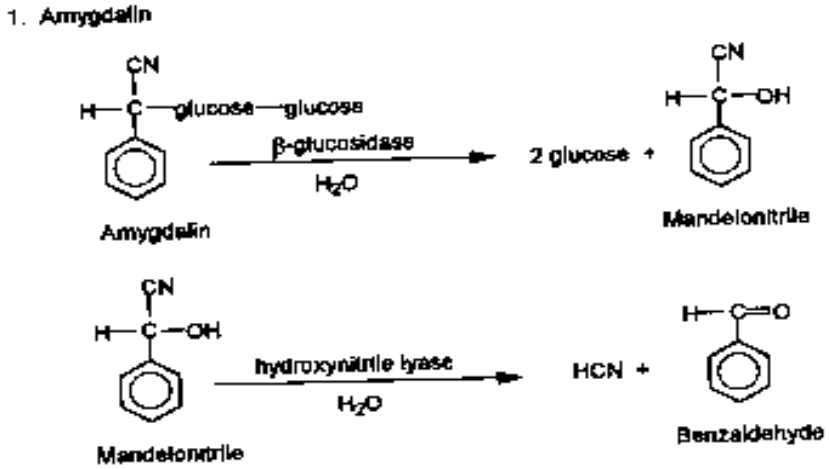
Versatile Forms of California Almonds

Flavor Characteristics

Mystery of Almond Flavor

Almond essence or sweet aromatics ??? ⟷ **Benzaldeyde**

Hydrogen Cyanide



Microbial and Enzymatic Activities

H_2O hydroxynitrile lyase

Mandelonitrile

H_2O β-glucosidase

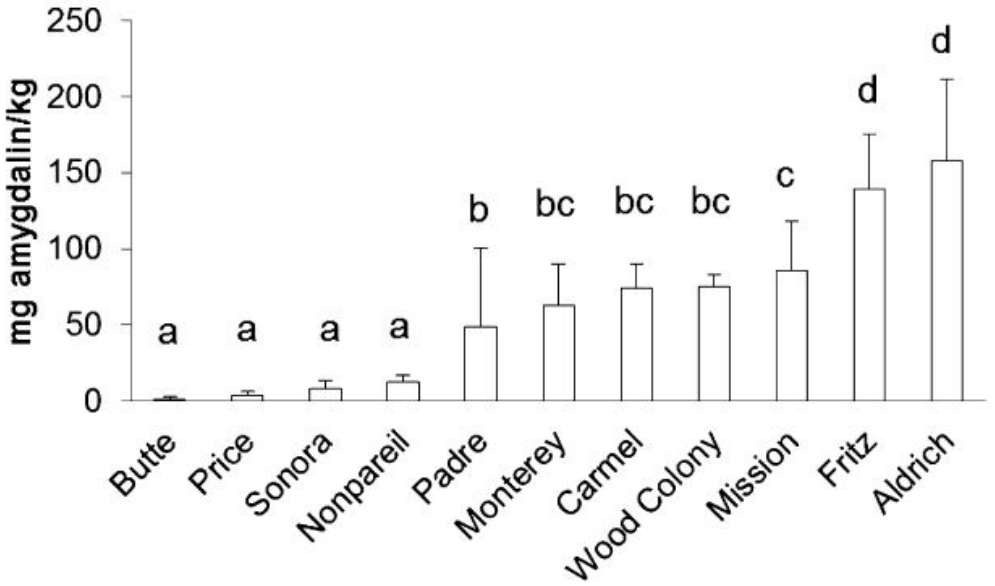
Amygdalin (Vit B_{17})

California Almonds Is Not Only About Benzaldehyde (Amygdalin)

California varieties:
63 ± 58mg/kg
(0.9—215mg/kg)

Semi-bitter varieties:
992 ± 513mg/kg
(524—1773mg/kg)

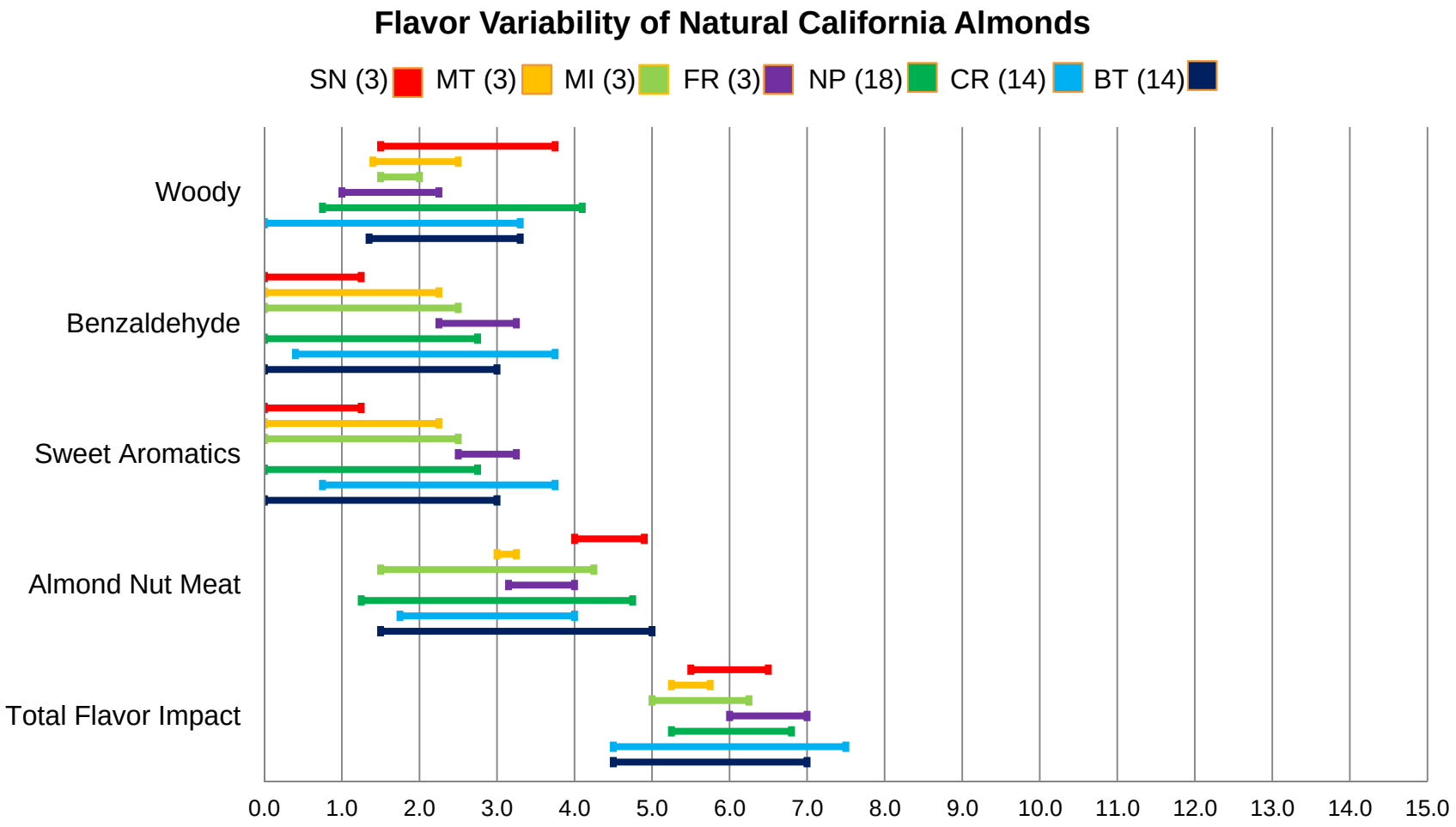
Bitter varieties:
40060 ± 7855mg/kg
(33007—53990mg/kg)
or
(3.3-5.4%)



- The same letters are not significantly different at $p<0.001$.
- The same variety often shows significant difference between growing regions.

Lee et al., 2013, J. Agr. & Food Chem.

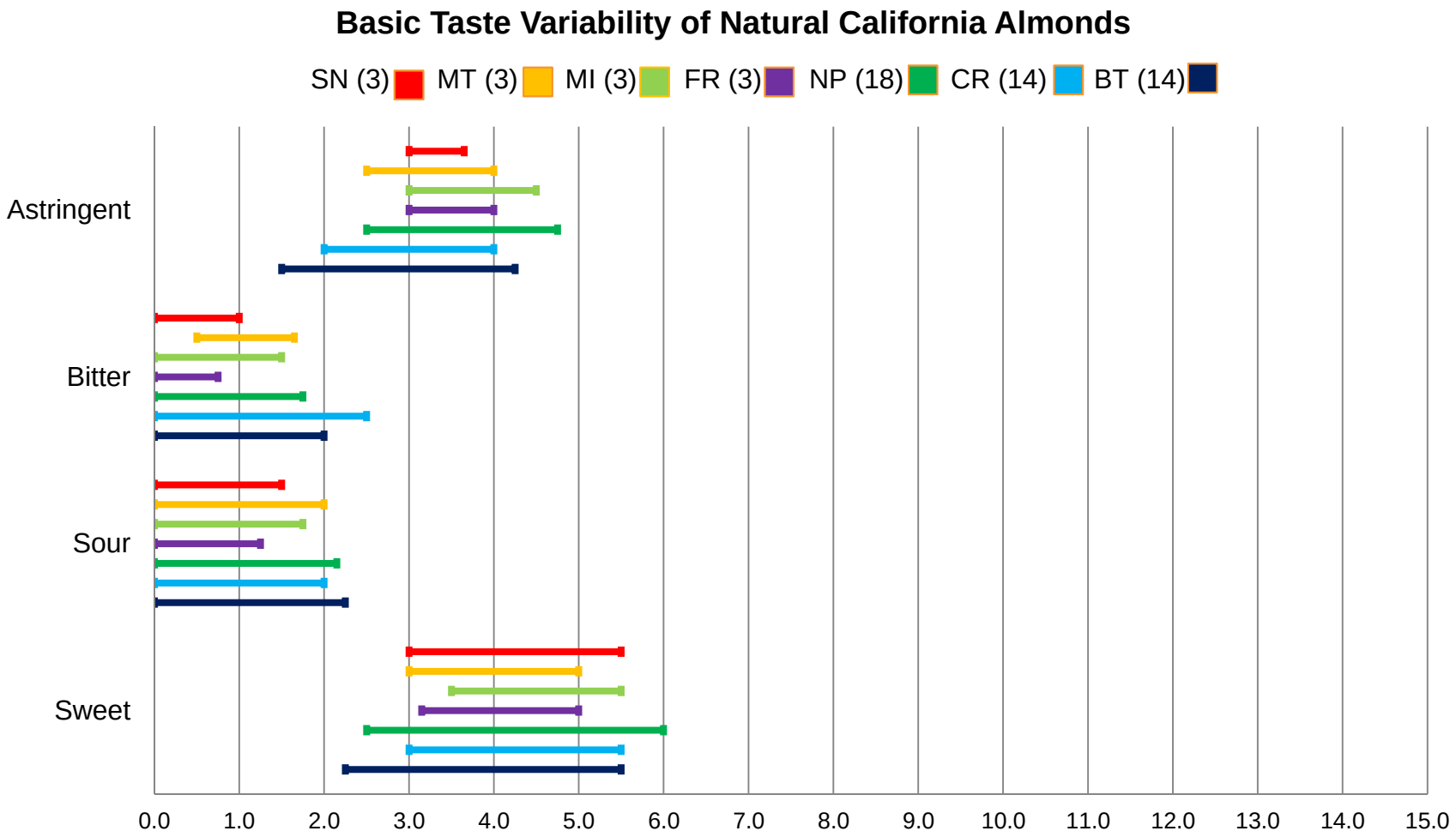
Is One Variety Offering Stronger Flavor Than Others?



SN=Sonora, MT=Monterey, MI=Mission, FR=Fritz, NP=Nonpareil, CR=Carmel, BT=Butte

ABC/Sensory Spectrum 2009, unpublished data

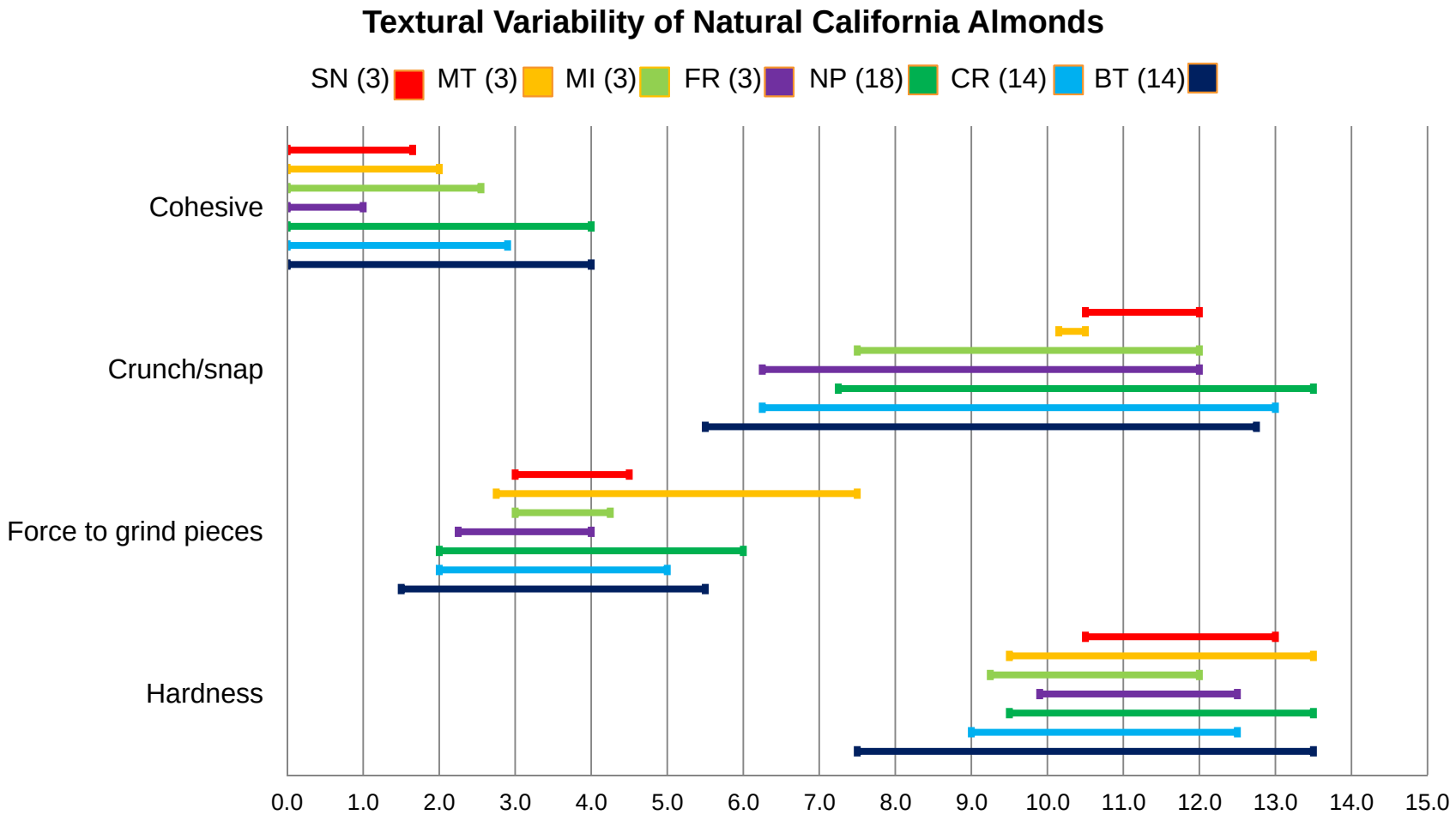
Does One Variety Taste Better Than Others?



SN=Sonora, MT=Monterey, MI=Mission, FR=Fritz, NP=Nonpareil, CR=Carmel, BT=Butte

ABC/Sensory Spectrum 2009, unpublished data

Is One Variety Crunchier Than Others?



SN=Sonora, MT=Monterey, MI=Mission, FR=Fritz, NP=Nonpareil, CR=Carmel, BT=Butte

ABC/Sensory Spectrum 2009, unpublished data

Volatiles Identified in Raw and Roasted Almonds (58)

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Table1. Volatiles identified in raw and freshly roasted almonds

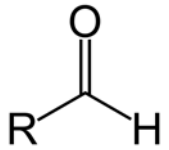
Four groups of identified compounds(**58**)

Aldehydes and ketones (19)	**Pyrazines (7)**	**Alcohols (23)**
Butanal	2-Methylpyrazine	2-Butanol
Butanal, 2-methyl-	2,5-Dimethylpyrazine	3-Pentanol
Butanal, 3-methyl-	2,6-Dimethylpyrazine	2-Pentanol
2,3-Butanedione	2-Ethylpyrazine	1-Butanol, 3-methyl-
Pentanal	2,3-Dimethylpyrazine	Prenol
Hexanal	2-Ethyl-6-methylpyrazine	Ethylhexanol
Heptanal	Trimethylpyrazine	Benzyl Alcohol
2-Heptanone		Isobutyl alcohol
2-Hexenal	**Additional compounds (9)**	Allyl alcohol
2-Methyl-3-ketotetrahydrofuran	à-Pinene	1-Butanol
Octanal	Disulfide, dimethyl	Isopentyl alcohol
2-Heptenal, (Z)-	Limonene	1-Pentanol
Nonanal	2-Amylfuran	Acetoin
2-Octenal, (E)-	Pyrrole	Acetol
Benzeneacetaldehyde	Butyrolactone	1-Hexanol
Furfural	r-Caprolactone	1-Chloro-2-propanol
Decanal	Hexanoic acid	2-Chloro-1-propanol
Benzaldehyde	2-Acetylpyrrole	Heptanol
		Ethyl thioethanol
		1-Octanol
		Propylene Glycol
		Furfuryl alcohol
		Phenylethyl Alcohol

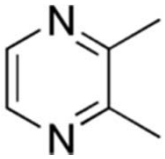
Mitchell et al, UC Davis, 2013, manuscript accepted by JFAC

Three Major Groups of Almond Volatiles

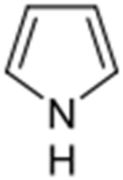
- Aldehydes (19): From lipids
  - floral, fruity, grassy, nutty, toasted, coffee-like

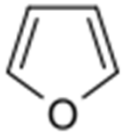


- Pyrazines (7)
  - Flavors of roasted nuts, chocolate, and brown meats, nutty, earthy



- Alcohols (23)
  - Largest group
  - floral, fruity, or fermented flavors
- Additional Compounds (9)
  - Pyrroles, furans, fatty acids, etc.





Mitchell et al, UC Davis, 2013, manuscript accepted by JFAC

Volatiles in Almonds

- Numerous volatiles associated with oxidation were found only in stored almonds and increased with time

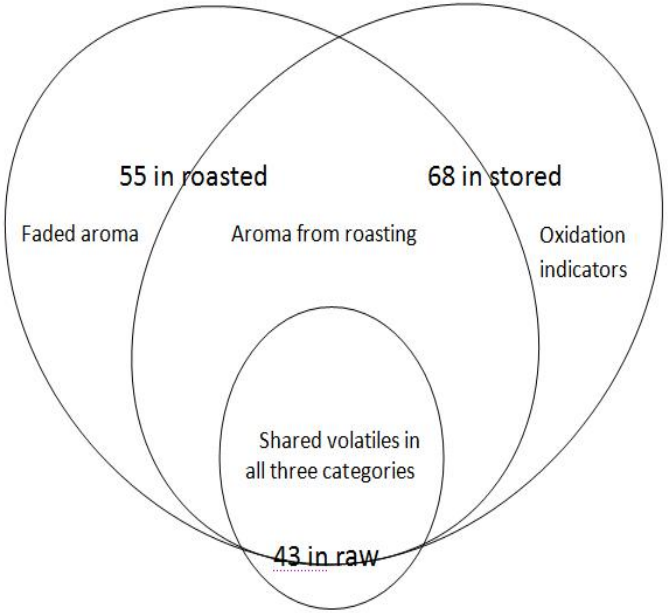


Table 1. Volatiles found only in stored almonds*

Group name	Name of the compounds	Detected time (weeks)
Oxiranes	Pentyl-oxirane	12
	Hexyl-oxirane	20
Ketones	2-Octanone	10
	2-Nonanone	12
	2-Decanone	16
Aldehyde	[Z]-2-Heptenal	16
	[Z]-2-Nonenal	12
	2,4-Nonadienal	8
	[E]-2-Decenal	16
	2-Undecenal	16
Alcohols	Nonanol	16
	1-Octen-3-ol	16
Acids	Acetic acid	12
	Pentanoic acid	16
	Heptanoic acid	12
	Octanoic acid	12
	Nonanoic acid	12
	Hexanoic acid, ethenylester	12

* Almonds were roasted at 138°C for 33min and stored at 35°C with light. Detected time was the time the volatile can be identified thereafter.

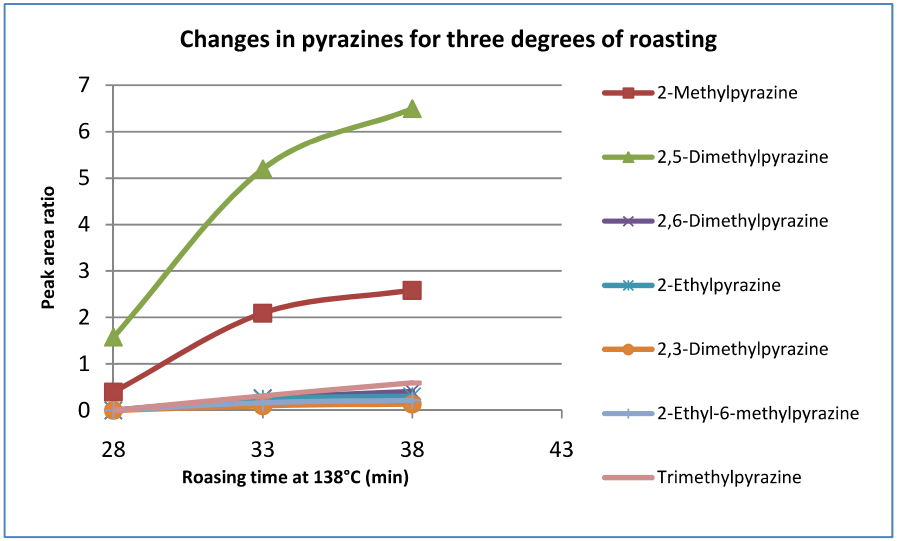
Mitchell et al, UC Davis, 2013, manuscript accepted by JFAC

Flavor Volatiles Increase as Function of Degree of Roasting

Table 3. Changes in pyrazines after roasting

Name of compounds	Raw	Roasted*
2-Methylpyrazine	0.00	1.69
2,5-Dimethylpyrazine	1.08	4.42
2,6-Dimethylpyrazine	0.00	0.23
2-Ethylpyrazine	0.00	0.19
2,3-Dimethylpyrazine	0.00	0.08
2-Ethyl-6-methylpyrazine	0.00	0.13
Trimethylpyrazine	0.00	0.30

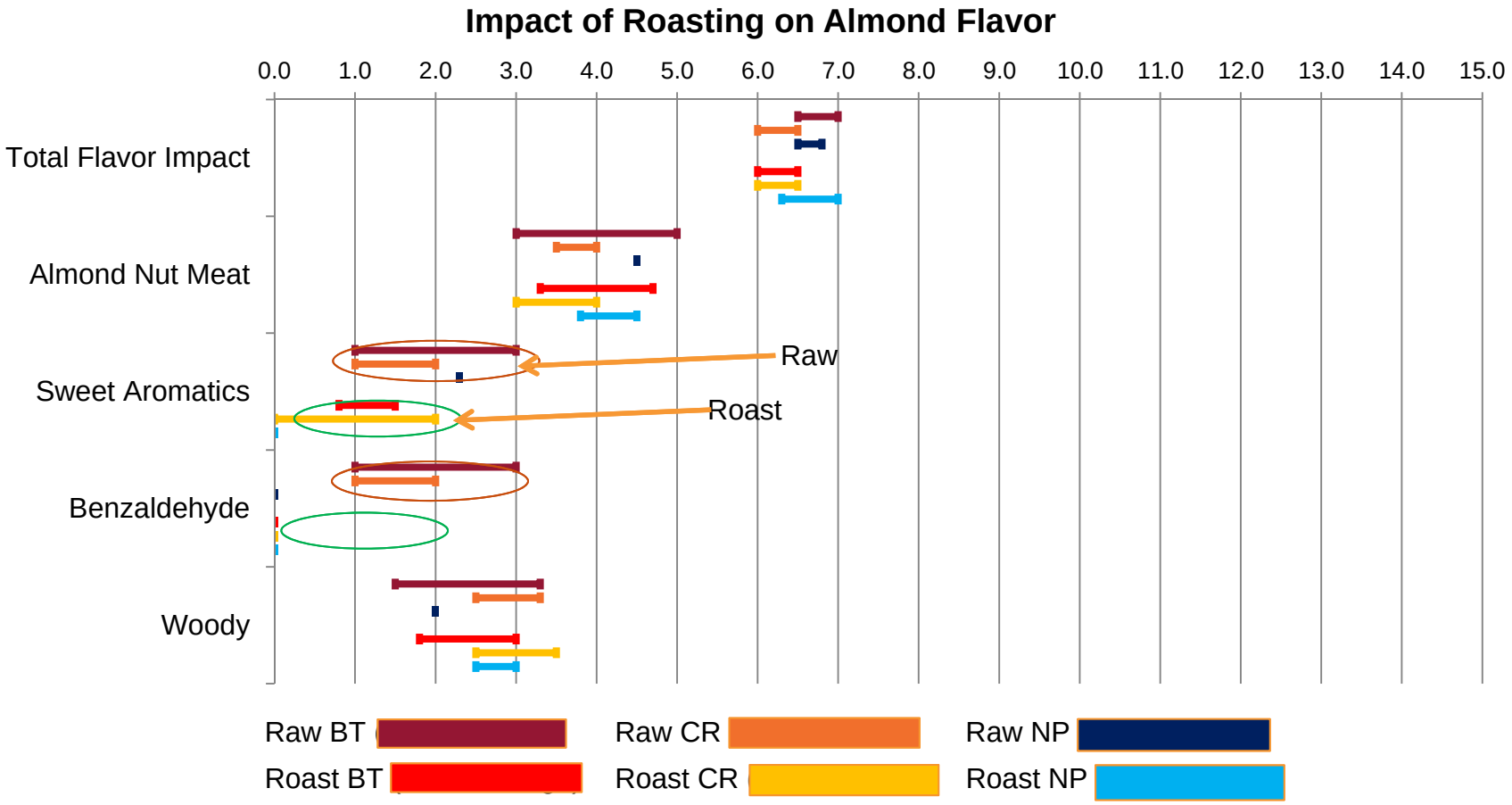
*The average area ratio of three roasted samples



- Pyrazines were generated during roasting.
- The longer the roasting time was the more pyrazines were generated.
  However, the formation speed started leveling off after 33 min of roasting at 138°C.
  That is, longer time had less impact than higher temp. on the formation of pyrazines.

Mitchell 2012, UC Davis, unpublished data

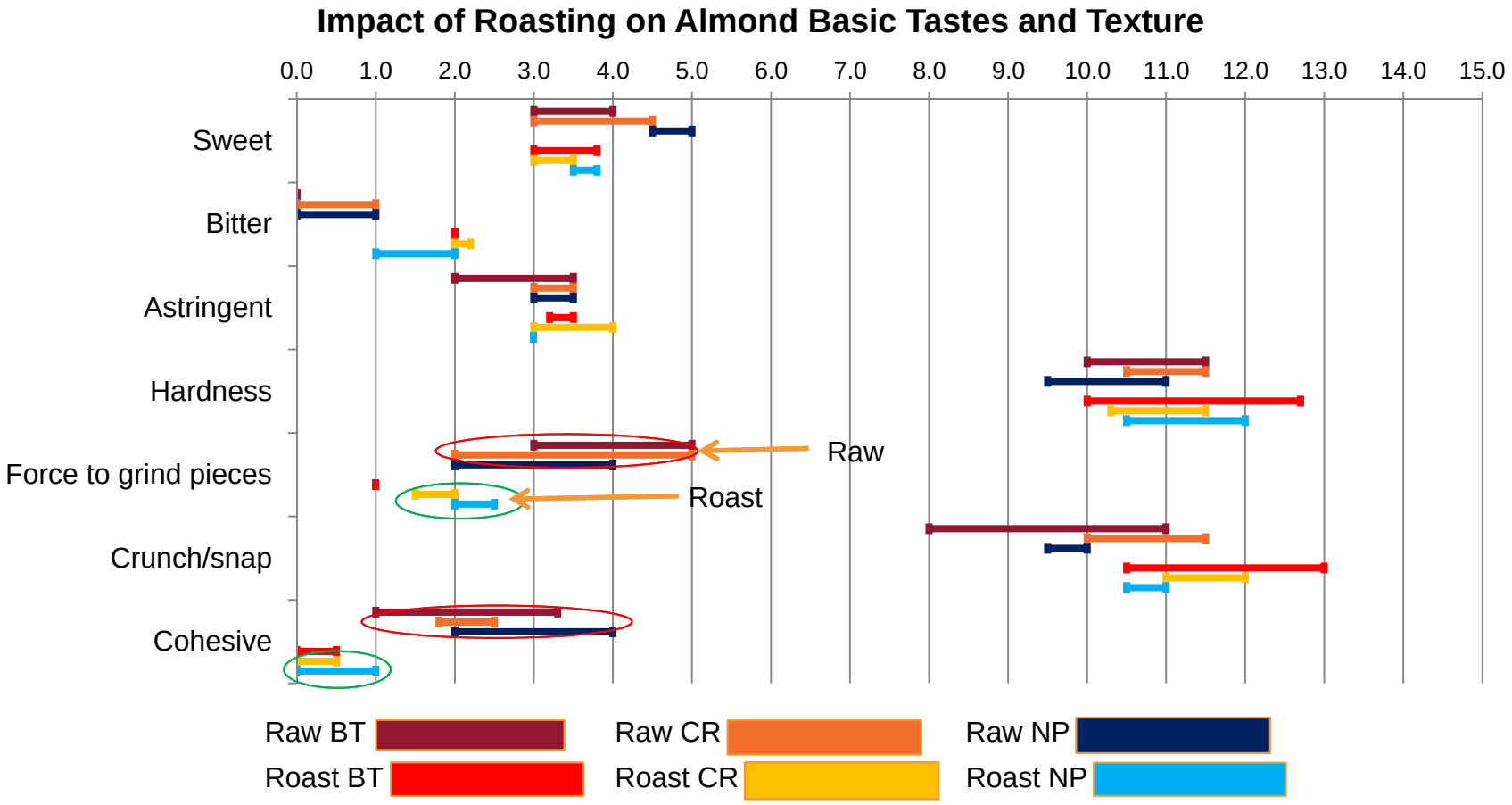
Impact of Roasting on Almond Flavor



BT=Butte, CR=Carmel, NP=Nonpareil

ABC/Sensory Spectrum 2009, unpublished data

Impact of Roasting on Almond Basic Tastes and Texture



BT=Butte, CR=Carmel, NP=Nonpareil

ABC/Sensory Spectrum 2009, unpublished data

Shelf Life and Quality Preservation

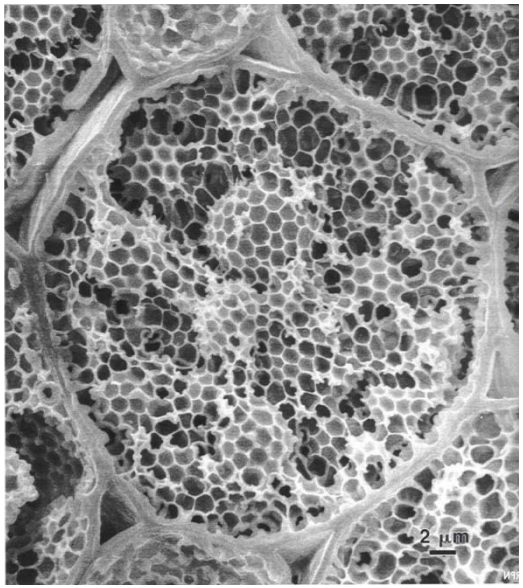
Physical Structure of California Almonds

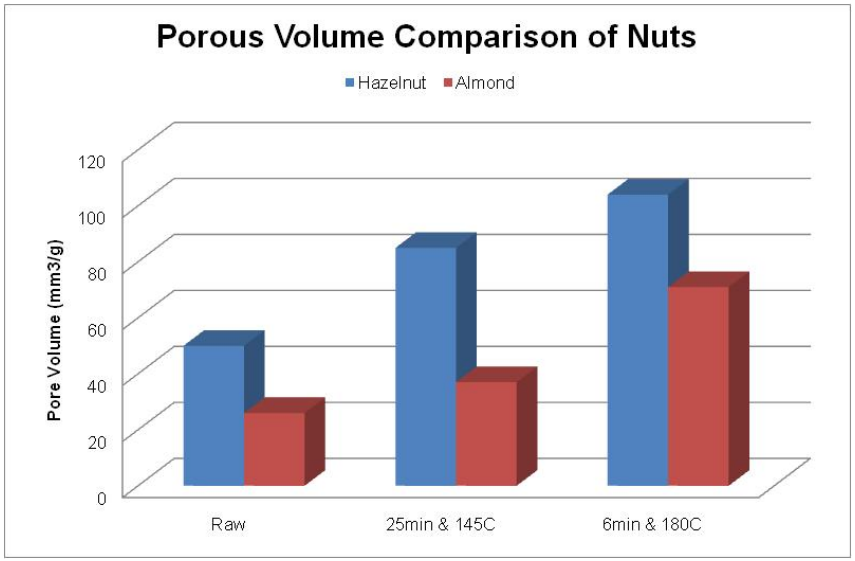
Low water content: < 6% (no bacteria and mold growth)

Tight cellular structure: less porous

Right fatty acid profile: high in mono-unsaturated and low in poly-unsaturated (S:M:P = 8:66:26)

High natural antioxidant content: vitamin E in flesh and flavonoids in skins





Adapted from Perren presentation to ABC 2007

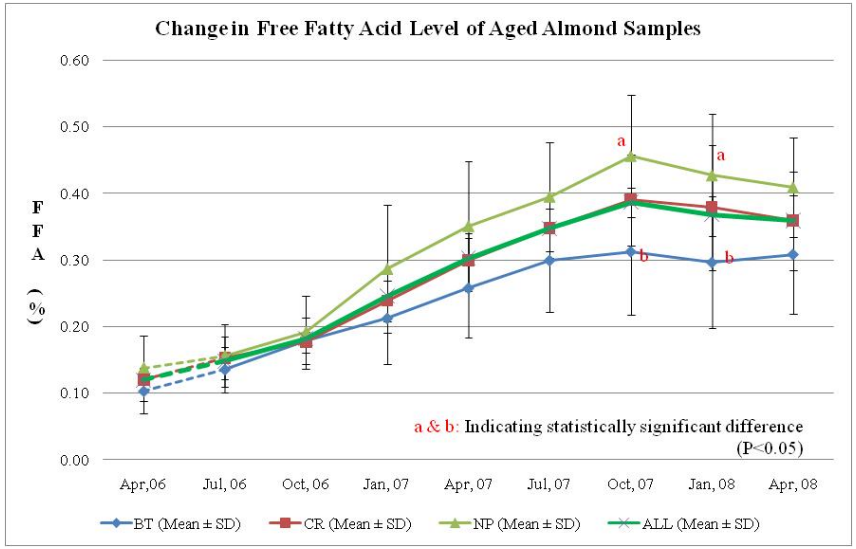
Packaged Raw Almonds May Have 2 Years Shelf Stability at California Ambient Warehouse Conditions

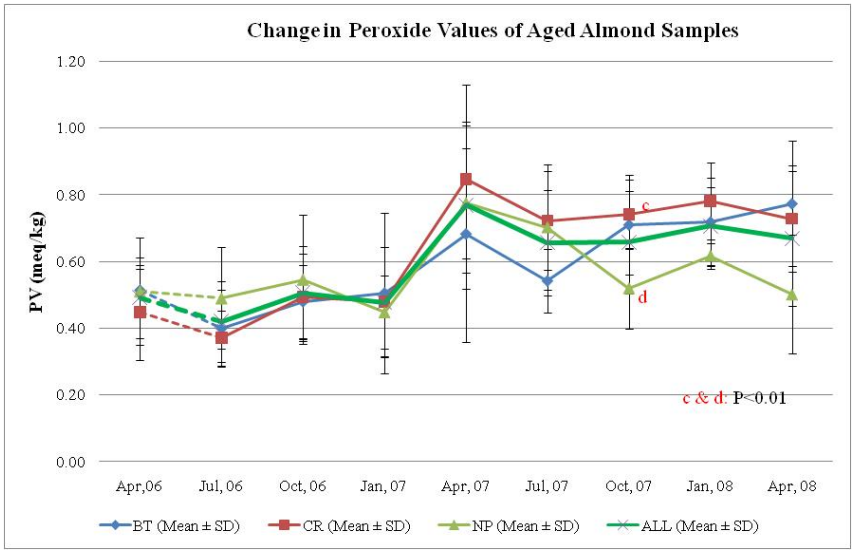
Chemical parameters commonly used in industry:

- <1.5% FFA (Free Fatty Acids)
- <5.0 meq/kg PV (Peroxide Value)

After 2 years storage the FFA and PV levels of natural whole almonds (Nonpareil, Carmel, Butte) were below industry specifications

- Storage at California ambient conditions and with retail packaging



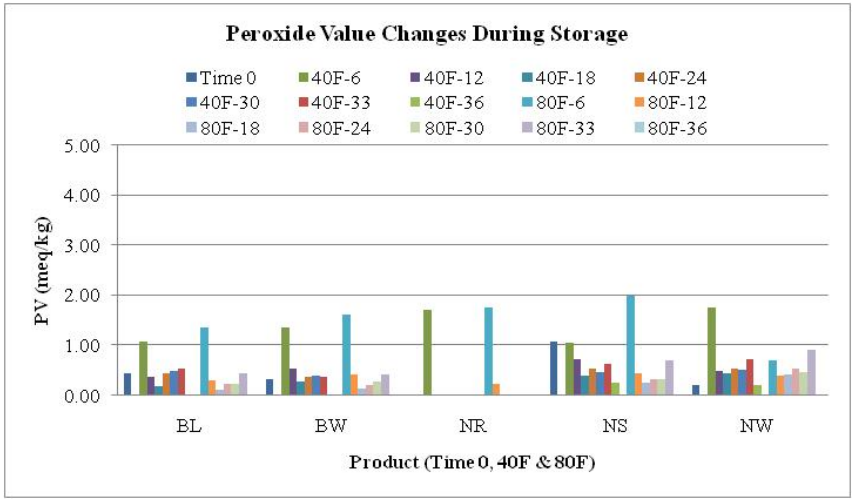


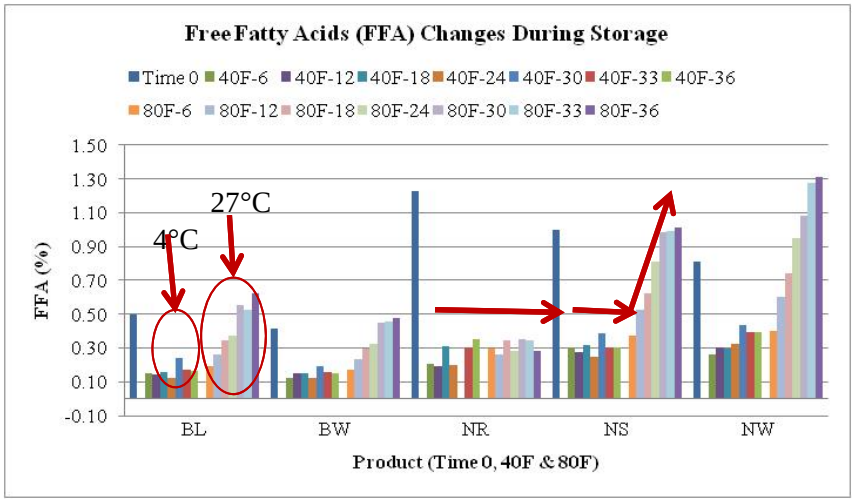
ABC 2009, unpublished data

Properly Packaged Almond Forms May Have up to 3 Years Shelf Life at Ambient Temperature

Five forms (BL, blanched sliced; BW, blanched whole; NR, natural roasted whole; NL, natural sliced; NW, natural whole) passed U.S. military shelf life requirements

- Vacuum packed in aluminum pouches
- Shelf stable through 36 months at 27°C
  - Stable PV (Peroxide Value), moisture content, tocopherols, and fatty acid profile
  - FFA (Free Fatty Acids) increased over time but stayed below industry specification

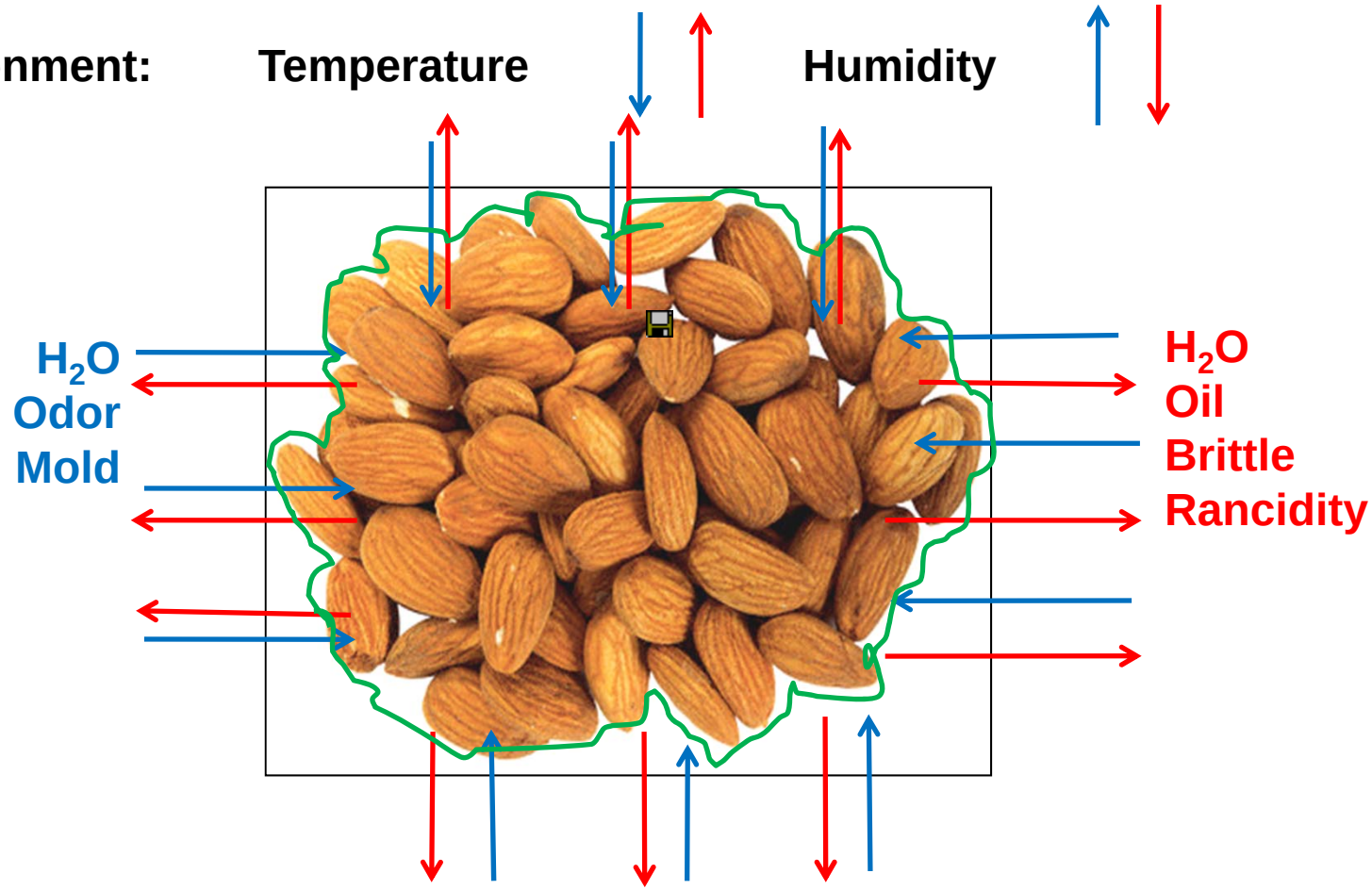




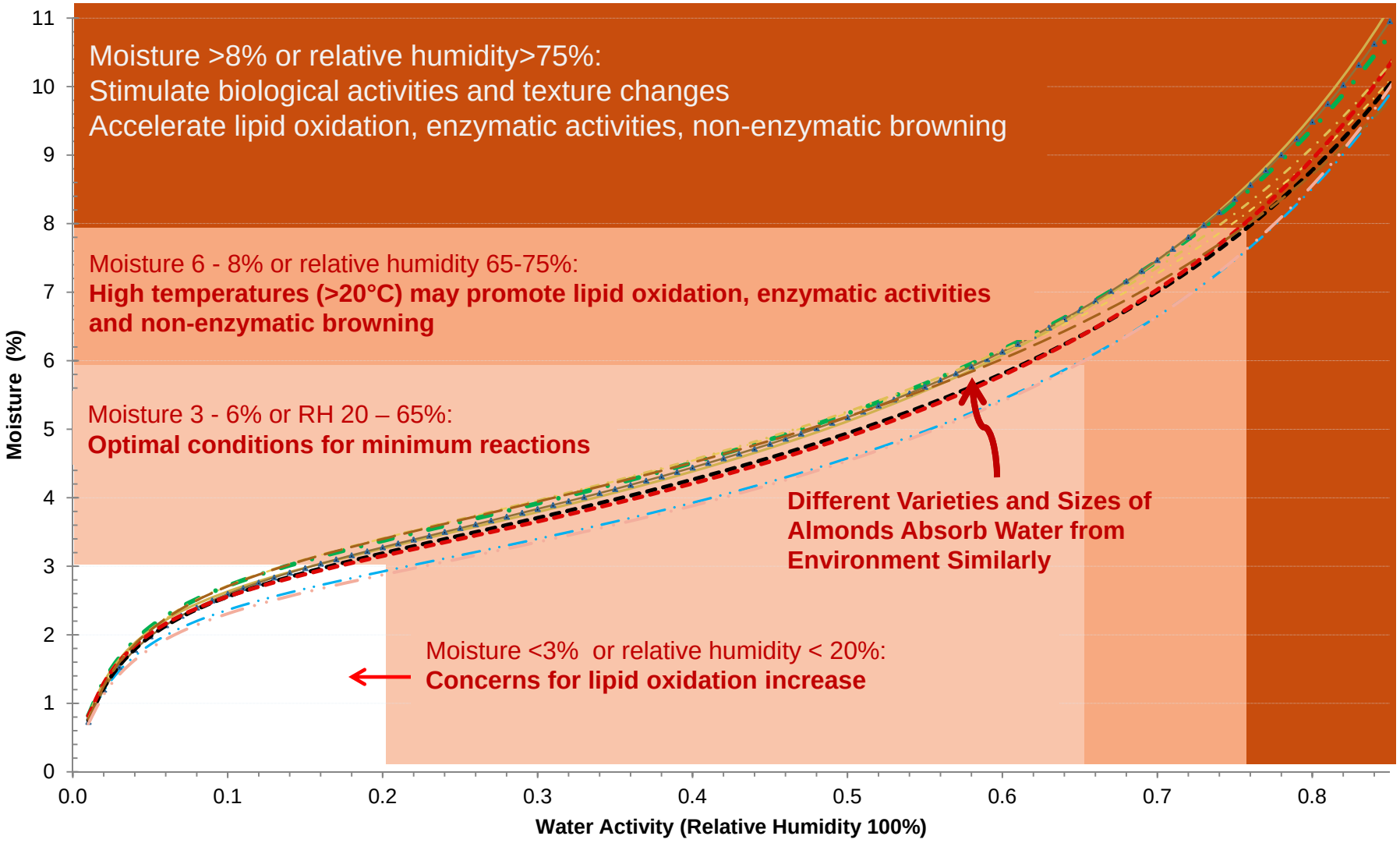
ABC 2008, unpublished data

Almond Interactions with Environment

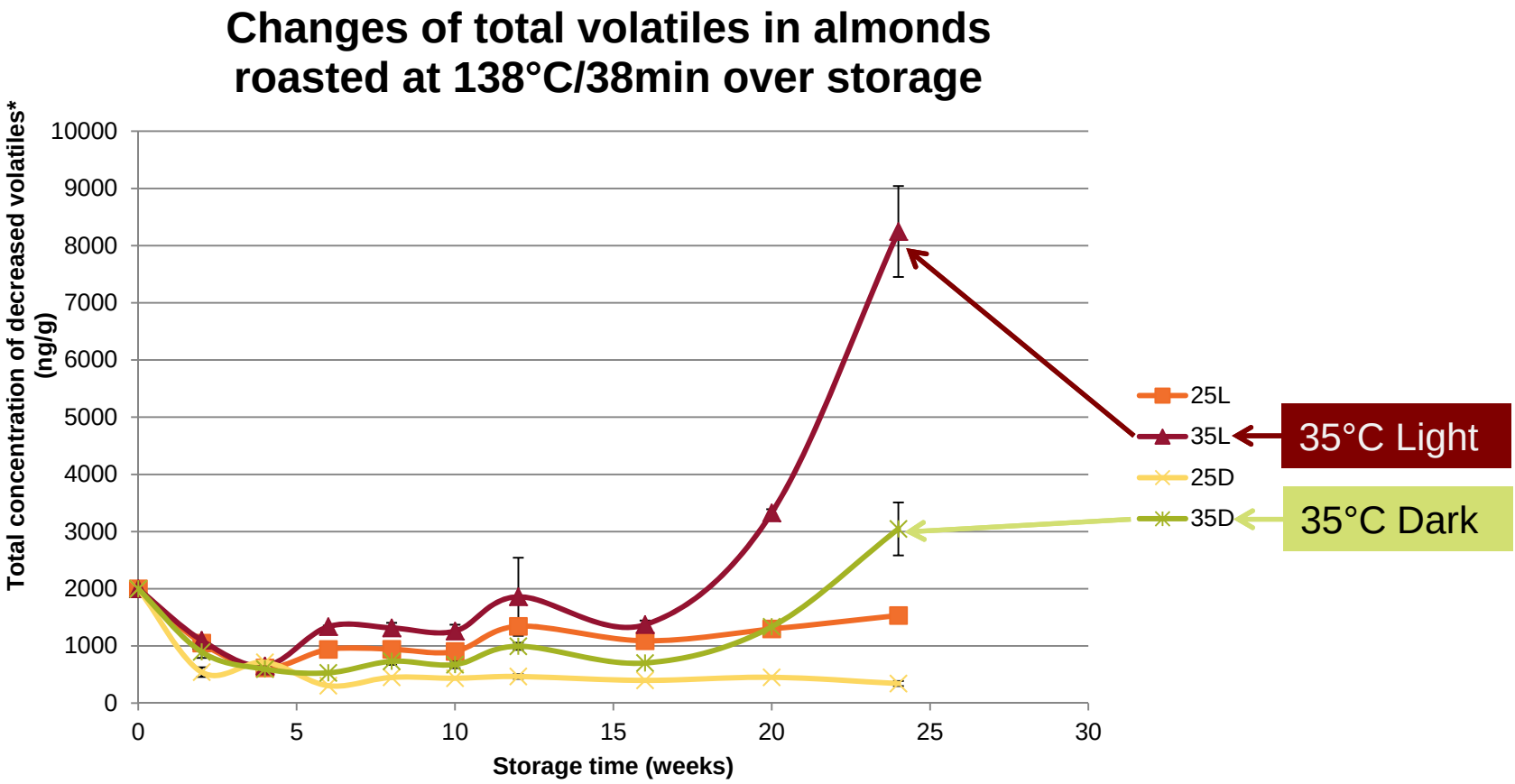
Temperature, humidity, packaging, processing conditions affect quality (oil migration, water migration, flavor fading, etc.)



Impact of Environmental Humidity on Quality



Temperature and Light Accelerate Development of Off-odor Volatiles



Mitchell 2012, UC Davis, unpublished data

Almond Handling Tips

- Pay attention to temperature and humidity in warehouse and during transit
  - Cool and dry conditions (<10°C and <65% relative humidity) may be optimal
  - Other temperature and controlled humidity combinations may also be suitable
- Choose proper packaging materials
- Avoid or reduce oxygen and light exposure
- Process or roast almonds with caution to maintain long shelf stability