Sorting for Aflatoxin: The Needle in the Haystack
Session Speakers

Tim Birmingham, ABC
Brendan O’Donnell, TOMRA Sorting Solutions
Jared Morse, MPA Solutions
TOMRA: SORTING FOR AFLATOXIN
OVERVIEW:

• WHO IS TOMRA?
• WHAT IS AFLATOXIN?
• CONTROLLING CONTAMINATION
• GLOBAL LIMITS AND TESTING
• REJECTED SHIPMENTS
• CASE STUDY: ADVANCED AFLATOXIN DETECTION WITH TOMRA DETOX ™
Publicly listed on Oslo Stock Exchange (OSEBX: TOM)

4000+
EMPLOYEES
GLOBALLY

8.6
BILLION NOK
REVENUES IN 2018

TOMRA
SORTING SOLUTIONS

FOOD
RECYCLING
MINING

TOMRA
COLLECTION SOLUTIONS

REVERSE VENDING
MATERIAL RECOVERY
INSTALLED BASE WORLDWIDE

**REVERSE VENDING**

<table>
<thead>
<tr>
<th>Region</th>
<th>~Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic</td>
<td>15,100</td>
</tr>
<tr>
<td>Germany</td>
<td>30,000</td>
</tr>
<tr>
<td>Other Europe</td>
<td>14,600</td>
</tr>
<tr>
<td>North America</td>
<td>16,000</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>7,400</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>83,100</td>
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**RECYCLING**

<table>
<thead>
<tr>
<th>Region</th>
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<tbody>
<tr>
<td>EMEA</td>
<td>4,250</td>
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<tr>
<td>Americas</td>
<td>865</td>
</tr>
<tr>
<td>Asia</td>
<td>820</td>
</tr>
<tr>
<td>Other</td>
<td>25</td>
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**MINING**

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<td>Europe</td>
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<tr>
<td>US / Canada</td>
<td>41</td>
</tr>
<tr>
<td>Australia</td>
<td>12</td>
</tr>
<tr>
<td>South Africa</td>
<td>37</td>
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<tr>
<td>Other</td>
<td>35</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>153</td>
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</table>

**FOOD BULK**

<table>
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<tr>
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<th>~Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMEA</td>
<td>2,250</td>
</tr>
<tr>
<td>Americas</td>
<td>2,950</td>
</tr>
<tr>
<td>Asia</td>
<td>675</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>6,875</td>
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</tbody>
</table>

**FOOD LANE**

<table>
<thead>
<tr>
<th>Region</th>
<th>~Units</th>
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</thead>
<tbody>
<tr>
<td>EMEA</td>
<td>790</td>
</tr>
<tr>
<td>Americas</td>
<td>1,705</td>
</tr>
<tr>
<td>APAC</td>
<td>840</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>3,335</td>
</tr>
</tbody>
</table>

Food Lane includes Compac and BBC
WHAT IS AFLATOXIN?
WHAT IS AFLATOXIN

Aflatoxin

A type of naturally occurring toxin created by fungal mold continually challenging growers and processors.
TYPES OF AFLATOXIN

B1 / B2 named for blue fluorescence
G1, G2, Y named for the green and yellow fluorescence

Four types of Aflatoxin on splits under UV Blacklight: AFB1, AFB2, AFG1, & AFG2
AFLATOXIN IN BRAZIL NUTS
GLOBAL REGULATORY LIMITS AND TESTING PROCEDURES
EVERY COUNTRY HAS THEIR OWN LIMITS

Maximum Aflatoxin Levels (PPB) for Top Importers
(by % of California Almond Exports)

Between EU and Japan alone, nearly 40% of California’s almond exports must be less than 10 ppb

USA LIMIT: 20 PPB
EVERY COUNTRY TESTS DIFFERENTLY

- Different quantities sampled
- Different sample locations
- Different number of samples
- Test samples separately vs. blend samples

The bottom line:
- No uniform globally agreed sampling and testing method creates uncertainty

Japan Aflatoxin Testing Protocol

NOTE: Korea has initiated mandatory import testing due to Japanese violations
REJECTED SHIPMENTS
THE PAIN OF REJECTION

- Ocean Freight x2
- Cleaning Cost
- Re-Packaging Cost
- TIME
- Brand Reputation
THE PAIN OF REJECTION

- Ocean Freight x2: ($6,000-$10,000)
- Cleaning Cost: ($5,000-$10,000)
- Re-Packaging Cost: ($4,000-$5,000)
- TIME: ($5,000-$20,000)
- Brand Reputation:
- TOTAL: ($20,000-$45,000)
- NOT accounting for damage to reputation
THE PAIN OF REJECTION

• What if it’s a domestic rejection?

Kenya: Govt. agency recalls Jetlak Food's Nuteez peanut butter after it tests positive for cancer-linked aflatoxin; company comments
Author: Business Daily (Kenya), Published on: 4 February 2019

Cargill Expands Previously Announced Voluntary Recall of Select Southern States® Feed Due to High/Excessive/or Elevated Aflatoxin Levels

• TOTAL: $130,000- $1,000,000
• Likely a legal battle as well- who is responsible?
CONTROLLING CONTAMINATION
CONTROLLING CONTAMINATION

Proper Irrigation:
Stressed trees more susceptible to fungal growth

Control Insect Damage:
Exposed meats promote fungal growth

Get the Mummies!

Clean, Dry, Cool Storage

TOMRA DETOX ™ SORTING
CASE STUDY

- Prominent California almond packer had a load rejected from Japan for Aflatoxin
  - (This was very clean J-Spec product with less than 1% Insect Damage)

- Full 20’ load, 36,000 lbs. run through TOMRA DETOX™ equipment

- ABC involved as a non-biased third party monitoring testing and sampling

- Method:
  - 3 samples from incoming product (6 tests total)
  - 3 Samples post TOMRA DETOX™ sorting (6 Tests Total)
  - 3 samples from TOMRA DETOX™ sorter reject stream (6 tests total)
EQUIPMENT USED

TOMRA Nimbus 640 with double Laser in DETOX™ Configuration
CASE STUDY

First samples tested: Incoming product after rejection

<table>
<thead>
<tr>
<th>Subsample</th>
<th>Total Aflatoxin</th>
<th>Aflatoxin B1</th>
<th>Aflatoxin B2</th>
<th>Aflatoxin G1</th>
<th>Aflatoxin G2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsample 1</td>
<td>&lt; 0.4 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Subsample 2</td>
<td>&lt; 0.4 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
<td>&lt; 0.1 ppb</td>
</tr>
</tbody>
</table>

All incoming samples tested min. levels for aflatoxin

This is after the load was rejected from Japan...
CASE STUDY

Second samples tested: Output, clean product after TOMRA Detox™ Sorter

<table>
<thead>
<tr>
<th>Total Aflatoxin Subsample 1</th>
<th>&lt; 0.4 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin B1 Subsample 1</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2 Subsample 1</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1 Subsample 1</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2 Subsample 1</td>
<td>&lt; 0.1 ppb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Aflatoxin Subsample 2</th>
<th>&lt; 0.4 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin B1 Subsample 2</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2 Subsample 2</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1 Subsample 2</td>
<td>&lt; 0.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2 Subsample 2</td>
<td>&lt; 0.1 ppb</td>
</tr>
</tbody>
</table>

All outgoing samples tested min. levels for aflatoxin

This is after the load was run through TOMRA DETOX™
CASE STUDY

Third samples tested: Rejected product from TOMRA Detox™

<table>
<thead>
<tr>
<th>Total Aflatoxin</th>
<th>Subsample 1</th>
<th>114 ppb</th>
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</thead>
<tbody>
<tr>
<td>Aflatoxin B1</td>
<td>Subsample 1</td>
<td>88.4 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2</td>
<td>Subsample 1</td>
<td>12.0 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1</td>
<td>Subsample 1</td>
<td>9.7 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2</td>
<td>Subsample 1</td>
<td>3.8 ppb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Aflatoxin</th>
<th>Subsample 2</th>
<th>27.9 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin B1</td>
<td>Subsample 2</td>
<td>19.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2</td>
<td>Subsample 2</td>
<td>2.0 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1</td>
<td>Subsample 2</td>
<td>5.9 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2</td>
<td>Subsample 2</td>
<td>0.9 ppb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Aflatoxin</th>
<th>Subsample 1</th>
<th>49.9 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin B1</td>
<td>Subsample 1</td>
<td>26.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2</td>
<td>Subsample 1</td>
<td>3.1 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1</td>
<td>Subsample 1</td>
<td>17.8 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2</td>
<td>Subsample 1</td>
<td>2.9 ppb</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Aflatoxin</th>
<th>Subsample 2</th>
<th>84.8 ppb</th>
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</thead>
<tbody>
<tr>
<td>Aflatoxin B1</td>
<td>Subsample 2</td>
<td>47.2 ppb</td>
</tr>
<tr>
<td>Aflatoxin B2</td>
<td>Subsample 2</td>
<td>10.9 ppb</td>
</tr>
<tr>
<td>Aflatoxin G1</td>
<td>Subsample 2</td>
<td>21.8 ppb</td>
</tr>
<tr>
<td>Aflatoxin G2</td>
<td>Subsample 2</td>
<td>4.9 ppb</td>
</tr>
</tbody>
</table>

All reject samples tested very high in aflatoxin
Average **54.38 ppb B1** and **85.68 ppb total**

*** Important to note***
The total reject from 36,000 lbs. was 54 lbs. **(0.15%)**
SUMMARY

When it comes to total cost, damage to your brand reputation, damage to the industry reputation, we must use every tool at our disposal!

• Orchard Management
  • Winter Sanitation, proper irrigation, pest control program
• Storage Management / Stockpile Management
• Sorting for Serious Damage (correlation vs. causation)
• TOMRA Detox™ Sorting (final safeguard)
WE ARE LOCAL - CALIFORNIA BASED SERVICE AND SALES SUPPORT

Northern California (San Joaquin North)
Bob MacKie
Bob.Mackie@tomra.com
(916) 388-3918

Central/Southern California (Stanislaus South)
John Duwe
John.Duwe@tomra.com
(916) 365-6722

www.tomra.com
THANK YOU

PLEASE VISIT US AT BOOTH 335
Almond Sorting - Aflatoxins

Industry challenges and our approach to providing solutions to the food industry
Optimum Sorting – who are we?
Experience

• Our leadership team has over 200 years experience in food sorting – our only focus is sorting!
Focus on research and development

- We invest more than 15% of the total sales revenues back into R&D
- Our team of 15+ R&D employees work continuously on improvements and the next generation of sorters
- Partnerships with local universities and institutions to help speed up development
Aflatoxin in Almonds

• Number of *Aspergillus* (Fungi) species present in the environment

• *Aspergillus flavus and Aspergillus parasiticus* are two species commonly found in almond orchards
  – Given right conditions, and a host, they can grow and produce a chemical compound known as aflatoxin
  – Aflatoxin is a secondary metabolite

• Aflatoxin is a potent carcinogen

• Widely regulated given its prevalence in various crops grown around the world
  – EU is particular vigilant when in regards to aflatoxin

• Aflatoxin is measured in parts per billion
  – PPB equivalent to:
    • 1 drop in an Olympic size pool
    • A pinch of salt to a 10 ton bag of potato chips
So why is the focus on aflatoxin so important

- The outlook for industry growth is very good but the risk to the manufacturers are also growing
Almond Process Flow

- Example of the current process flow with a final pass for reducing aflatoxins
How companies currently control aflatoxin

While we cannot see the aflatoxin it can be associated and reduced by targeting other defects:

- Molds and decay
- Insect damage
- Shrivel

However – Aflatoxins are still present on nuts that look good to the human eye. Other sorters removing visible damage (molds and insect damage) will not see all of the defects and the manufacturer will remain vulnerable to failing an aflatoxin test.
What if we could see the invisible

- It is known that some residues from aflatoxin fluoresce.
- Using a UV laser light source, we can stimulate fluorescence.
- Our laser technology is extremely sensitive and can pick up the slightest amount of fluorescence.
- So it does not detect the aflatoxin itself, but the fluorescing “by product.”
- By removing all the fluorescing kernels, we reduce the amount of Aflatoxin drastically.
- This can be done with almost no false rejects and at high throughput on our VENTUS 1800.
- The good almonds are “invisible” to the technology.
AflaSort is an option on our VENTUS platform (600 – 900 – 1200 – 1800) with capacities of up to 25,000 lb/hr.

It sorts based on Biological Characteristics.

Defects to be detected are invisible to the human eye, but are believed to be carcinogenic.

Examples:
- Aflatoxin on peanuts, tree nuts, dried fruits, spices, cereals, figs, …
- Ochratoxin on coffee
- Detection

- A picture of a damaged nut.
- A picture of the same nut under Blacklight
- A picture as seen by the VENTUS AflaSort
- This picture shows the fluorescence of the infected nut as seen by the VENTUS
- Due to the high resolution of the VENTUS, this small sized defect shows up as many pixels....
- Count the pixels!!!! Better than 0,3mm resolution

More than 30 pixels!
AflaSort – Detection
Detection
- Test results on Aflatoxin

- The test was performed on a “normal” batch of products
- We received this print-out from a customer who analyzed samples in his own lab after sorting on the Ventus
- Our laser technology is extremely sensitive and can pick up the slightest amount of fluorescence
- The product was sorted and accept was collected (first 5 samples on the sheet) : significant reduction below required levels
- The reject was resorted and split again into “rerun accept” and “reject”
- Even the rerun accept was clean
- The Reject has high concentration

<table>
<thead>
<tr>
<th>ACCEPT</th>
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<tbody>
<tr>
<td>TEST 3</td>
<td>ACCEPT</td>
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<td></td>
<td></td>
<td>SAMPLE 2</td>
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<tr>
<td>TEST 5</td>
<td>ACCEPT</td>
<td>SAMPLE 1</td>
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<tr>
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<td></td>
<td>SAMPLE 2</td>
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<td>TEST 6</td>
<td>ACCEPT</td>
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<td>ACCEPT</td>
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<td>TEST 9</td>
<td>ACCEPT</td>
<td>SAMPLE 1</td>
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<td>TEST 4</td>
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<tr>
<td>TEST 8</td>
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<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
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<tr>
<td>TEST</td>
<td>RECOVERY REJECT</td>
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<tr>
<td></td>
<td></td>
<td>SAMPLE 2</td>
</tr>
<tr>
<td>TEST</td>
<td>REJECT</td>
<td>SAMPLE 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAMPLE 2</td>
</tr>
<tr>
<td>TEST</td>
<td>REJECT</td>
<td>SAMPLE 1</td>
</tr>
<tr>
<td></td>
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<tr>
<td>TEST</td>
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<td>SAMPLE 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SAMPLE 2</td>
</tr>
</tbody>
</table>
Challenges to the manufacturers

While “new technologies” have been introduced to detect the presence of aflatoxins, the industry still has many challenges to overcome.

- Now that you have a solution to help reduce your chances of a positive test, how and where do you implement the solution?
- Validation: how can the operator ensure the sorter is working properly before production is started
- Verification once the line is operational, how can the operator be sure that it is still working
- Preventing good product loss (we don’t want you to lose thousands of pounds of almonds just to find 40 lb of infected)
What the future brings

We have come a long way in helping increase the safety of our food supply and the future is looking promising.

We will only achieve our goals by working together with industry partners like the attendees at this conference including:

- Food manufacturers
- Technology and sensor based companies
- Labs
- The Almond Board and other industry boards

We need to work to set global standards on testing so that manufacturers have a clear path to reducing their risks.

Sorters are unique machines that have the ability to see and calculate every single object that go through their sensors. We need to work with the manufacturers to collect and utilize any necessary data so that we can take actionable steps to resolving the issues that they are facing.
We welcome industry partners to join in our efforts
Please visit MPA Solutions at booth #105 to learn more

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Sorting for Aflatoxin: The Needle in the Haystack
Upcoming Sessions at 10:45 a.m.

• Almond Food Safety: Past, Present and Future (Room 1)
• Europe: Playing a Pivotal Role in Almonds’ Future (Room 2)
• Alternatives for Managing Replant Pests and Problematic Weeds (Room 3)
Visit the Exhibit Halls and Participate in the Passport Game

- 3P Partners #2206
- ABC Booth #526
- AC Horn #421
- Ag Spray Equipment #2203
- Bayer CropScience #127
- Best Drayage #2112
- Bird Gard, LLC #1812
- Borrell USA #327
- Cablevey Conveyors #217
- Central Life Sciences #917
- JAX, Inc. #413
- JKB Energy #635
- K•Coe Isom #707
- Lincoln Agribusiness Services #733
- Napasol #2205
- NETZSCH Premier Technologies #218
- Satake #521
- Suterra, LLC #1638
- TOMRA Sorting Solutions #335
- Trécé, Inc #516
- Valent U.S.A. #621
- Westbridge Agricultural Products #1534
- Wilkey Industries #320
- Yara North America #627

The first 500 attendees to turn in a completed passport card to the ABC booth (#526) will receive a hat and will be entered to win one of seven amazing prizes!
Lunch: Pushing Your Personal Limits
Featuring John Stenderup

Doors open at 12:15 p.m. in Building C
You must have already purchased a ticket to attend luncheon

Sponsored by:

[Image of Farm Credit]
Food Truck Village

Food Truck Village is located next to Building D

Open on Tuesday and Wednesday from 11:00 a.m. – 2:30 p.m.

Cash and credit cards are accepted
Almond Food Truck

Wednesday, December 12

- 9 am to Noon
- Donation-Only (all proceeds to benefit California FFA)
- Outside the Registration Tent

California FFA

California FFA members will be on-site selling CalAg License Plates

Valent U.S.A. is proud to partner with the California FFA Foundation and support the CalAgPlate program.
Shuttle Service will be provided by The Almond Conference from the downtown hotels to Cal Expo daily.

- Downtown Pickup Location: Hyatt Sacramento Front Drive
- Cal Expo Pickup and Drop-Off Location: Blue Gate

Shuttle Schedule:

- **Tuesday, Dec. 10**
  - 6:45 a.m. – 6:30 p.m.
- **Wednesday, Dec. 11**
  - 6:45 a.m. – 6:30 p.m.
- **Thursday, Dec. 12**
  - 6:45 a.m. – 1:30 p.m.
2019 Research Update

Pick up a copy at the ABC booth #526
Join the Conversation!

Use #AlmondConf to share highlights from The Almond Conference
Dedicated Trade Show Time
4:30 p.m. – 6:00 p.m.
Social Reception Sponsored by:
Join Tonight’s Social Reception

Come and Sample: ALMOND BROWN ALE

Stop by:
The Almond Board Lounge in Building D.

Sample:
Almond brown ale during the Tuesday and Wednesday receptions.

This almond beverage is the result of a special project from Dominique Camou and Lucas Schmidt in collaboration with Temblor Brewing Company.

Industry members and attendees are welcome to stop by and have a taste.

When:
Tuesday and Wednesday evening reception from 4:30-6:00 p.m.

4:30 p.m. – 6:00 p.m. - Pavilion + Building D
10 YEARS OF PROGRESS
JOIN THE JOURNEY

It’s all there at SustainableAlmondGrowing.org
Thank you!