Sensory Characteristics and Consumer Acceptance of Mechanically Harvested California Black Ripe Olives


April 2, 2012
Overview and goal of the project

• Table olives produced in the US are hand-picked, a labor intensive and expensive practice.
• Mechanical harvesting is particularly challenging with table olives. The **limiting factors** are:
  1) fruit damage that affects the final quality (our focus);
  2) effective fruit removal technology; and
  3) developing an economically viable harvester and defining its operating parameters.
• The goal of this project was to develop economically feasible mechanical harvesting for California black ripe ‘Manzanillo’ table olives, the most widely used cultivar in California.
Specific aims of the study

• For commercial use of mechanical harvesting technology, the final processed fruit quality needs to be guaranteed first.

• Sensory evaluation was carried out with trained panels and consumers to understand:
  1) the sensory characteristics of table olives harvested and processed in different ways
  2) their relation to consumer preferences
An update on the findings and accomplishments from our collaboration team (years 2007-2011)

• Up to date...
  ❖ Fruit damage has largely been eliminated.
  ❖ Both canopy contact and trunk shaking technologies have been demonstrated to be effective fruit removal technologies.
  ❖ The trunk shakers can be used in high-density orchards. The canopy harvester can be used in the new high-density orchards and in existing orchards if trees are pruned into hedgerows.
  ❖ However, in practice, both harvesting technologies are limited by tree canopy shape and by their respective platforms. Canopy contact and trunk shaking technologies must be improved through engineering, tested on effective platforms and evaluated on properly trained trees.
Canopy contact shaking head harvester, Central Valley, California 2007
Trunk shaking harvester, Central Valley, California
Each row was randomly assigned to either “hand harvest” or “machine harvest”

Half were treated at “Processor A” and the other half at “Processor B”

Half were processed “fresh” and half after being held in storage tanks (“stored”)

8 differently treated olives/row

*Olives from different rows (#1-6) which went through the same treatment were pooled together

*yr 08-09 and yr 10-11: canopy contact harvester; 6 field replications
*yr 09-10: trunk shaker; 4 field replications.

“Commercial olives” from each Processor

2 commercial olives

*The olives were standard products to be compared against experimental ones
<table>
<thead>
<tr>
<th>Sample abbreviation</th>
<th>Processor</th>
<th>Commercial</th>
<th>Harvesting method</th>
<th>Processing method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_Comm</td>
<td>A</td>
<td>Commercial</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A_Hand_F</td>
<td>-</td>
<td>-</td>
<td>Hand</td>
<td>Fresh olives</td>
</tr>
<tr>
<td>A_Hand_S</td>
<td>-</td>
<td>-</td>
<td></td>
<td>Stored olives</td>
</tr>
<tr>
<td>A_Mech_F</td>
<td>-</td>
<td>Machine*</td>
<td></td>
<td>Fresh olives</td>
</tr>
<tr>
<td>A_Mech_S</td>
<td>-</td>
<td></td>
<td></td>
<td>Stored olives</td>
</tr>
<tr>
<td>B_Comm</td>
<td>B</td>
<td>Commercial</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>B_Hand_F</td>
<td>-</td>
<td>-</td>
<td>Hand</td>
<td>Fresh olives</td>
</tr>
<tr>
<td>B_Hand_S</td>
<td>-</td>
<td>-</td>
<td></td>
<td>Stored olives</td>
</tr>
<tr>
<td>B_Mech_F</td>
<td>-</td>
<td>Machine*</td>
<td></td>
<td>Fresh olives</td>
</tr>
<tr>
<td>B_Mech_S</td>
<td>-</td>
<td></td>
<td></td>
<td>Stored olives</td>
</tr>
</tbody>
</table>

*yr 08-09 and yr 10-11: canopy contact harvester
yr 09-10: trunk shaker
Methods: Descriptive Analysis

- **Panel**: 8 trained panelists for each year (from the University of California, Davis)
- **Training sessions**
  - Developed descriptors (30-35 descriptors, depending on the year)
  - Selected references
  - Concept alignment
Qualitative Reference samples

‘Earthy’ = Soil + olives

‘Ocean-like’ = Green seaweed + anchovy + olives
 Trying the qualitative reference for “earthy/soil-like” in order to understand the concept of it in the black olives.

Then trying the sample olives to detect the “earthy/soil-like” characteristic in the sample.
# Methods: Descriptive Analysis

## Table 2. Descriptors for olives (yr 08-09, canopy contact harvester)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Reference</th>
<th>Attribute</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smell (Aroma)</td>
<td></td>
<td>Taste/Flavor</td>
<td></td>
</tr>
<tr>
<td>Painty</td>
<td>Correction fluid</td>
<td>Sweetness</td>
<td>Sucrose solution</td>
</tr>
<tr>
<td>Briny</td>
<td>Black olive brine</td>
<td>Saltiness</td>
<td>NaCl solution</td>
</tr>
<tr>
<td>Ocean-like</td>
<td>Green seaweed + anchovy*</td>
<td>Umami</td>
<td>MSG + brine</td>
</tr>
<tr>
<td>Fermented</td>
<td>Sauerkraut</td>
<td>Bitterness</td>
<td>Caffeine solution</td>
</tr>
<tr>
<td>Canny</td>
<td>Keys, cans</td>
<td>Roasted</td>
<td>Roasted sunflower seeds</td>
</tr>
<tr>
<td>Earthy</td>
<td>Potting soil*</td>
<td>Buttery</td>
<td>Melted butter + brine*</td>
</tr>
<tr>
<td>Sautéed Mushroom</td>
<td>Sautéed Mushroom*</td>
<td>Ripeness</td>
<td>Unripe ---- Ripe</td>
</tr>
<tr>
<td>Dried Fruit</td>
<td>Dried Prune</td>
<td>Firmness</td>
<td></td>
</tr>
<tr>
<td>Floral</td>
<td>Chrysanthemum tea</td>
<td>Juicy / Moist release</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>Small ---- Large</td>
<td>Crumbly / Crunchy</td>
<td></td>
</tr>
<tr>
<td>Oval</td>
<td>Round ---- Oval</td>
<td>Fibrous</td>
<td></td>
</tr>
<tr>
<td>Surface roughness</td>
<td>Smooth ---- Rough</td>
<td>Mouth coating</td>
<td></td>
</tr>
<tr>
<td>Glossy</td>
<td>Dull ---- Glossy</td>
<td>Briny after-taste</td>
<td></td>
</tr>
<tr>
<td>Skin brownness</td>
<td>Black ---- Brown</td>
<td>Lasting flavor</td>
<td></td>
</tr>
<tr>
<td>Flesh Brownness</td>
<td>Black ---- Brown</td>
<td>Astringent</td>
<td></td>
</tr>
<tr>
<td>Flesh greenness</td>
<td>Black ---- Green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>* Mixed with olives</td>
</tr>
</tbody>
</table>
Methods: Descriptive Analysis

- **Individual Evaluation**
  - Rated intensities of sensory attributes for each sample in triplicate
  - Randomized order of presentation
  - Line scale
  - Serving: 3 olives/sample (i.e. 2 whole + 1 olive sliced in half) @ room temp.
  - Proper cleansers were provided
Methods: Consumer test

- **Consumer criteria**
  - Age over 18 years
  - American
  - Black olives users and likers
- **N=104~109 (depending on the year)**
- **Tasting Questions:**
  - Overall liking
  - Appearance liking
  - Flavor (Taste & Smell) liking
  - Texture liking
- **Exit survey**
  - Socio-economics & demographics
  - Usage
Methods: Consumer test

- **Tasting Procedure**
  - 9-point hedonic scale
  - Serving: 2 whole olives/ sample @ room temperature
  - Randomized order of presentation
  - Proper cleansers were provided
Results

First, the **canopy contact head harvesters**.
The biggest difference was seen between processing methods - fresh processed vs. others (commercial & stored), primarily along PC 1.

A processor difference was observed as the next biggest factor, primarily along PC 2 (37.7%).
Descriptive analysis results (yr. 08-09 using canopy contact harvester) (cont’d)

- Texture & Flavor: Crumbly, Fermented Ocean-like, Sautéed mushroom
  - BComm
  - BMechS
  - AHandS

- Appearance: Brightness of flesh Brightness of skin (brown)
  - AComm

- Texture & Flavor: Firmness, Fibrous, Dried Fruit, Bitterness
  - BMechF
  - BHandF

- Flavor, After-taste, Mouthfeel: Salty, Umami, Buttery, Flavor lasting, Briny aftertaste, Juicy, Mouth-coating
  - AHandF
  - AMechF

Fig. 1 – Sensory map of 10 olives (yr. 08-09 using canopy harvester)

- The difference between harvesting methods was minimal!
The main difference among products was observed between processing method (fresh processed vs. non-fresh [i.e. stored and commercial]), as shown by PC1 (54.3%).

Fig. 2 – Sensory map of 10 olives (yr. 10-11 using canopy contact harvester)
There was little difference between harvesting methods (Hand vs. Machine).
Descriptive Analysis Results using canopy contact harvester (yrs 08-09 and 10-11)

• The biggest difference was seen between processing methods - fresh processed vs. others (commercial & stored).
• The difference between harvesting methods was minimal!
Overall degree of liking: **On average** (yr. 08-09 using canopy contact harvester)

**Fig. 3** – Mean (N=100) overall liking scores (right); and partitioning of sources of variations for overall liking scores (left) (yr. 08-09 using canopy harvester)

- On average, “fresh” processed black olives were **liked the MOST**; and the “commercial” products were **liked the LEAST**.
- The two significant (P<0.05) factors that had driven the differences in the liking scores were 1) commercial vs. non-commercial products and 2) processing methods (fresh vs. stored)
- **Harvesting method** was **NOT a significant source of variation** and there was no difference in liking between hand- and machine-harvested products.
Overall degree of liking: On average (yr. 10-11 using canopy contact harvester)

- On average, "fresh" processed black olives were **liked the MOST**.
- There was a significant (P<0.05) difference in consumer acceptance between processing method (fresh vs. stored).
- There was **NO significant difference** between **mechanically- and hand-harvested** olives.
Flavor liking had the highest correlation with overall degree of liking and appearance liking was the least correlated.
Overall degree of liking: Preference Mapping *(yr. 08-09 using canopy contact harvester)*

Fig. 6 - Internal preference map of 100 individual consumers based on overall degree for liking for 10 olives (yr. 08-09 using canopy harvester) *Each vector (on the left graph) represents individual consumers*

- The 100 consumers were **homogeneous** in their liking for black olive.
- The **majority** preferred “fresh” processed black olives; whereas the “commercial” products were liked the least.
- **Harvesting method** was **NOT** a significant source differentiating one’s liking.
Overall degree of liking: Preference Mapping (yr. 10-11 using canopy contact harvester)

Fig. 7 - Internal preference map of 109 individual consumers based on overall degree for liking for 10 olives (yr. 10-11 using canopy harvester) and indication of group information *Each point (on the left graph) represents an individual consumer

Three consumer segments which differ in preference for olives were identified:
• Cluster 1 (n=14) : Hard to generalize a trend based on this map.
• Cluster 2 (n=57, majority): Fresh-processed olives
• Cluster 3 (n=38): Commercial ones and fresh-processed olives from processor B
Consumer test Results using **canopy contact harvester** (yr 08-09 and 10-11)

- The majority of American consumers liked olives that were **fresh processed**.
- There was no significant difference in overall acceptability between **harvesting methods** (Hand vs. Machine).
- Flavor liking had the highest correlation with overall degree of liking and appearance liking was the least correlated.
Results

And now to the Trunk shaking harvester.
The biggest difference was seen between commercial vs. others, primarily along PC 1.

The next largest difference was observed between “Hand harvested x Fresh processed” vs. “Store processed in processor A”, primarily along PC 2.

The difference between harvesting methods was not large, but it was significant as can be seen in the left quadrant.
Overall degree of liking: On average (yr. 09-10 using trunk shaker)

- On average, “fresh” processed black olives were **liked the MOST**; the “Machine harvested, then processed after storage from processor A” product was **liked the LEAST**.
- The significant (P<0.05) factors that drove differences in liking were 1) Processing method (fresh vs. stored), 2) Processor (A vs. B), 3) Harvesting method (Machine vs. Hand) and 4) interaction of Harvesting method by Processing method.

**Fig. 9 – Mean (N=109) overall liking scores (right); and partitioning of sources of variations for overall liking scores (left) (yr. 09-10 using trunk shaker)**
Harvesting method was not the largest factor, but there was a noticeable decrease in overall liking of Machine harvested olives compared to Hand harvested ones. This effect was mainly due to the “Store processed in Processor A” samples. Other treatments showed some decrease, but not a significant one.

• **Harvesting method** was not the largest factor, but there was a noticeable decrease in overall liking of Machine harvested olives compared to Hand harvested ones. This effect was mainly due to the “Store processed in Processor A” samples. Other treatments showed some decrease, but not a significant one.

• This finding can be attributed to the over-ripe nature of the fruit harvested that year.
Yr. 09-10

<table>
<thead>
<tr>
<th></th>
<th>Flavor liking</th>
<th>Appearance liking</th>
<th>Texture liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall liking</td>
<td><strong>0.990</strong></td>
<td>0.916</td>
<td><strong>0.900</strong></td>
</tr>
</tbody>
</table>

Values in bold are significantly different from 0 with a significance level alpha=0.05

Fig.10 – Pearson’s correlation coefficients of liking for specific attributes to overall liking (top); and Means for hedonic ratings of the 10 olive samples for overall degree of liking and liking for appearance, flavor and texture (bottom)

- Flavor liking had the highest correlation with overall degree of liking and appearance liking was the least correlated.
- For this particular year, appearance and texture likings were also found to be highly correlated to overall liking.
The 109 consumers were *homogeneous* in their liking for black olive.

The *majority* preferred “fresh” processed black olives; whereas the olives that were “Machine harvested, then store-processed” were liked the least.

*Harvesting method and Processing method interaction* was found to *significant* in influencing one’s liking.

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**Fig. 11 - Internal preference map of 109 individual consumers based on overall degree for liking for 10 olives (yr. 08-09 using canopy harvester)*** Each vector (on the left graph) represents individual consumers

- Few consumers in this area
- Most of the consumers are in this area

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Overall degree of liking: **Preference Mapping**
(yr. 09-10 using trunk shaker)
Descriptive analysis and Consumer test Results for the **Trunk shaking harvester** (yr 09-10)

- In contrast to the canopy contact head harvester, there were some noticeable differences between hand- and mechanically-harvested olives both in sensory qualities and consumer acceptance.
- The trunk shaking technology for over-ripe fruits may need further refinement before its application is satisfactory.
- However, we were again able to confirm that fresh-processed olives have strong potential in the Californian olive market.
- This year’s study also confirmed that flavor liking had the highest correlation with overall degree of liking.
Identification of drivers of likes/dislikes for Californian consumers
Overall liking was highly related to flavor liking; and some extent to texture liking; however, appearance liking was not a significant source in this regression model.

- **Drivers of flavor likes:** Sweet, Buttery, Roasted, Saltiness, Umami, Ripeness, Briny after-taste, Lasting flavor
- **Drivers of flavor dislikes:** Dried fruit, Fermented
Overall liking was highly related to flavor, appearance, and texture liking.

- **Drivers of flavor likes:** Buttery, Sautéed Mushroom
- **Drivers of flavor dislikes:** Fermented fruit, Metallic, Green/Grassy, Earthy
- **Texture:** Balance of firmness, crunchiness, fibrousness & Juicy (firmer preferred)
- **Driver of appearance dislike:** Surface roughness

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**Fig. 13 - PLS-Regression of the consumer hedonic ratings onto the sensory attributes from the descriptive analysis (yr. 09-10; trunk shaker)**
Drivers of liking: yr. 10-11 using canopy contact harvester

Three clusters had different drivers of likes of dislikes
- Cluster 1 (N=14): Not well defined in this regression model
- Cluster 2 (N=57): Likes - Buttery, Sweet, Umami, Ocean-like, Sugary, Sautéed mushroom, Floral; Dislikes - Fermented, Green/grassy, Bitter, Earthy/musty, Rancid, Metallic, Briny/Salty
- Cluster 3 (N=38): Disliked firm, chewy, crunchy textures
A shift in consumer perceptions and preferences was observed. Particularly in the last year, consumer preferences did shift toward a more specific direction. This could be due to their increased familiarity with imported olives.

In general, Buttery can be considered an important characteristic that drives consumer preferences; whereas Fermented fruit can be regarded as a characteristic that drives consumers to dislike the product.
Conclusions

• No significant difference in the sensory profiles nor in consumer acceptance of hand- and mechanically-harvested olives using the canopy-contact mechanical harvester.

• Canopy contact head mechanical harvesting can provide a cheaper alternative to traditional hand harvesting of black ripe table olives.
Conclusions

• The trunk shaking technology for over-ripe fruit may need further refinement before its application yields satisfactory quality.

• Our research showed strong potential for fresh-processed olives on the California olive market.

• In general, **Buttery** has been identified to be an important characteristics that drives consumer preference; whereas **Fermented fruit** was found to be an important characteristic that drives consumers to dislike a product.
Acknowledgements

• US Department of Agriculture
• California Olive Committee
• Bell Carter
• Musco Family Olives
• Descriptive analysis panelists
• Consumers

Thank you for your attention!