# Evaluation of Mandatory Testing California Olive Oil 2017/18 Season

Submitted to the

Olive Oil Commission of California

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**Evaluation of Mandatory Testing, California Olive Oil, 2017/18 Season**

## SUMMARY

The Olive Oil Commission of California (OOCC) contracted with the UC Davis Olive Center to analyze and report on 2017/18 data produced under the mandatory sampling and testing requirements of California olive oil standards. The standards require the OOCC to take five samples for testing from each Handler, and require Handlers to separately sample and test every lot.

Of 187 samples collected (78 samples by the OOCC and 109 samples by 13 Handlers), 161 samples (86 percent) were from lots that were designated as Extra Virgin grade prior to testing, 12 samples (6 percent) were designated as a lower grade, and 14 samples (7 percent) were unidentified by grade. Sixty-four of the 78 OOCC samples (82 percent) were from the same lots tested by the Handlers.

All samples were analyzed based on the quality tests specified in the standards, and 47 of the 78 OOCC samples were also analyzed for the purity tests specified in the standards.

Test results showed that all 161 samples that were designated by Handlers as Extra Virgin grade prior to testing were confirmed by Handler testing to be Extra Virgin grade. OOCC testing found that three of these samples (two percent) were Virgin grade.

Eleven of the 12 samples designated as below Extra Virgin grade prior to testing were confirmed by Handler testing to be either Virgin or Crude grade. One sample designated as Virgin grade by the Handler was deemed Extra Virgin grade by Handler testing and Virgin grade by OOCC testing. Thirteen of the 14 samples with unidentified grade met Extra Virgin grade while one sample was Crude by OOCC testing.

In total, 173 of 187 samples (93 percent) met California standards for Extra Virgin grade: 70 of 78 OOCC samples and 103 of 109 Handler samples. Ten Handlers did not conduct all of the required tests for 43 samples, so it is unknown whether complete data would have shown a different passage rate. Five of 64 samples (8 percent) that were from the same lots tested by both the Handlers and OOCC were not in agreement.

Test results also showed that 45 of 47 OOCC samples (96 percent) were within purity parameters of California standards. One Koroneiki sample did not meet the standards for Apparent β-sitosterol and total sterols and one Sevillano sample exceeded the limit for heptadecenoic acid (C17:1).

In the future the OOCC may wish to consider:

- adopting a policy to ensure that complete Handler data, including blend composition and all tests, are received by the commission by the commission's deadline;
- adopting a policy on how to address "second extraction" oil;
- requiring Handlers to specify organoleptic defect(s) in the Handler data-submission form and to use laboratories and sensory panels that have been accredited by the International Olive Council (IOC) or American Oil Chemists' Society (AOCS);
- requiring accredited sensory panels to report grades based on California grades;
- requiring the third-party agency to verify and report the OOCC ID with Handler's lot number, Handler's designated-grade prior to testing, harvest location and variety (or the percentages of varieties in blends);
- requiring accredited sensory panels to report grades based on California grades;
- standardize IDs that can be used to differentiate the samples without revealing the identities of the Handlers.

## INTRODUCTION

The Olive Oil Commission of California contracted with the UC Davis Olive Center to analyze the testing results for oils produced during the 2017/18 season. The oils were sampled and tested pursuant to California olive oil standards[1] which require annual sampling and testing of olive oil produced in California.

The standards require the OOCC to conduct sampling and testing under the direction of the California Department of Food and Agriculture (CDFA) or by an approved independent third party. The sampling party must take five samples at random from each Handler[2] following the sampling procedures and protocols of the International Organization for Standardization (ISO)[3] and Appendix A[4] in the California olive oil standards, and send the samples to an accredited laboratory for analysis. In addition, the standards require each Handler to sample, test, and grade all lots by a certified laboratory chosen by the Handler, including the Handler's own laboratory if certified, following an official testing method described in the California olive oil standards. Grading is based on the quality standards summarized in Table 1 and described in the Appendix.

**Table 1. Quality tests and standards for California olive oil grades**

| *Test* | Extra Virgin | Virgin | Crude |
|---|---|---|---|
| *Free Fatty Acidity (FFA) %m/m expressed as oleic acid* | ≤0.5 | ≤1.0 | >1.0 |
| *Peroxide Value (PV) meq. $O_2$/kg oil* | ≤15.0 | ≤20.0 | >20.0 |
| *$K_{232}$ Ultraviolet Absorbance (UV) $K^{1\%}_{1cm}$* | ≤2.40 | ≤2.60 | >2.60 |
| *$K_{270}$ Ultraviolet Absorbance (UV) $K^{1\%}_{1cm}$* | ≤0.22 | ≤0.25 | >0.25 |
| *ΔK Ultraviolet Absorbance (UV) $K^{1\%}_{1cm}$* | ≤/0.01/ | ≤/0.01/ | ≤/0.01/ |
| *Moisture and Volatile Matter %* | ≤0.2 | ≤0.2 | ≤0.3 |
| *Insoluble Impurities %m/m* | ≤0.1 | ≤0.1 | ≤0.2 |
| *Pyropheophytin a (PPP) %* | ≤17 | N/A | N/A |
| *1,2–Diacylglycerols (DAGs) %* | ≥35 | N/A | N/A |
| *Organoleptic Median of Defects (MeD)* | 0 | >0.0 | ≤2.5 |
| *Organoleptic Median of Fruity (MeF)* | >0.0 | >2.5 | N/A |

## SAMPLE INFORMATION

A total of 187 samples were tested for the 2017/18 season: 78 samples (42 percent) were collected by the OOCC and 109 (58 percent) were collected by 13 Handlers. The OOCC samples were collected by CDFA officials from Handler lots in January and February 2018 and sent to the Eurofins Central Analytical Laboratories (New Orleans, Louisiana) for chemistry tests and the California Olive Oil Council (COOC) for

[1] See California Department of Food and Agriculture, "2017-2018 Grade and Labeling Standards for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil", effective September 1, 2017 and continuing through June 30, 2018 unless amended or terminated.
[2] "Handler" is defined by Section 5.13 of the California standards as "a person who engages, in this state, in the operation of marketing olive oil that he or she has produced, or purchased or acquired from an olive producer, or that he or she is marketing on behalf of an olive producer, whether as an owner, agent, employee, broker, or otherwise."
[3] ISO 5555:2001- International Standard, Animal and Vegetable Fats and Oils-Sampling.
[4] Appendix A: Sampling, Testing and Grading Methodology for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.

organoleptic analysis, respectively. Samples that were found to be outside the organoleptic standard for Extra Virgin grade were sent to the Australian Oils Research Laboratory (Wagga Wagga, New South Wales, Australia) for retesting.

Based on matching lot numbers, we were able to confirm that 64 of 78 OOCC samples (82 percent) were from the same lots tested by the Handler. Handler sampling dates ranged from October 31, 2017 to February 14, 2018, with all 13 Handlers providing sampling date information but two Handlers not providing harvest date information. Each Handler sent samples to a certified laboratory and sensory panel of their choice.

Variety and variety percentage were provided for 102 of 109 Handler samples (94 percent) and 69 of 78 OOCC samples (88 percent, based on matching lot numbers) and is summarized in Table 2. Overall, 133 of 187 samples (71 percent) were single-variety, 38 samples (20 percent) were blends and 16 samples (9 percent) were unspecified or vaguely defined.

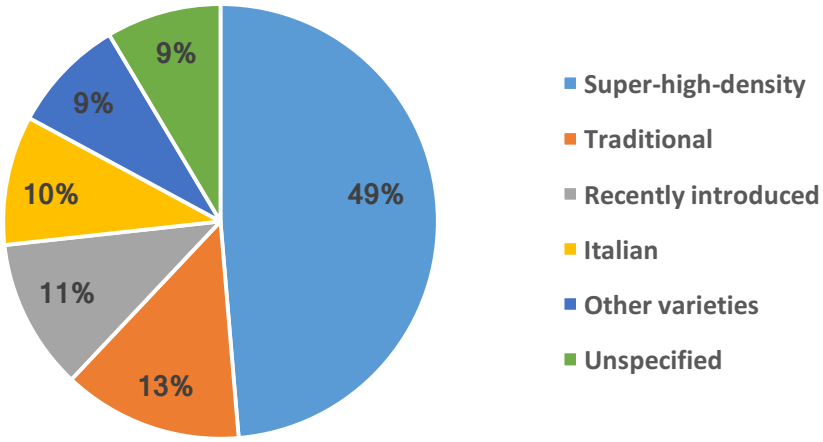
**Table 2. Samples by variety or blends (187 samples)**

| Variety | OOCC samples | Handler samples | Total samples (%) |
|---|---|---|---|
| *Arbequina* | 16 | 27 | 43 (23.0%) |
| *Arbosana* | 10 | 11 | 21 (11.2%) |
| *Ascolano* | 0 | 2 | 2 (1.1%) |
| *Barnea* | 2 | 1 | 3 (1.6%) |
| *Coratina* | 1 | 1 | 2 (1.1%) |
| *Don Carlo* | 1 | 1 | 2 (1.1%) |
| *Favolosa* | 0 | 1 | 1 (0.5%) |
| *Frantoio* | 2 | 2 | 4 (2.1%) |
| *Hojiblanca* | 1 | 2 | 3 (1.6%) |
| *Koroneiki* | 6 | 9 | 15 (8.0%) |
| *Leccino* | 3 | 1 | 4 (2.1%) |
| *Manzanillo* | 1 | 4 | 5 (2.7%) |
| *Mission* | 2 | 4 | 6 (3.2%) |
| *Moraiolo* | 1 | 0 | 1 (0.5%) |
| *Oliana* | 1 | 0 | 1 (0.5%) |
| *Picual* | 3 | 4 | 7 (3.7%) |
| *Sevillano* | 2 | 4 | 6 (3.2%) |
| *Taggiasca* | 3 | 2 | 5 (2.7%) |
| *Tosca* | 1 | 1 | 2 (1.1%) |
| *11.49% Arbequina, 85.35% Arbosana, 1.62% 9803-20, 1.54% 9806-10* | 1 | 1 | 2 (1.1%) |
| *22% Arbequina, 49% Arbosana, 29% Tuscan* | 0 | 1 | 1 (0.5%) |
| *22.22% Arbequina, 75.1% Arbosana, 2.68% Koroneiki* | 1 | 1 | 2 (1.1%) |

| | | | |
|---|---|---|---|
| *26.7% Arbequina, 73.3% Arbosana* | 1 | 1 | 2 (1.1%) |
| *30% Arbequina, 30% Arbosana, 30% Koroneiki, 10% Picual* | 0 | 1 | 1 (0.5%) |
| *31.4% Leccino, 24.3% Coratina, 38.5% Frantoio, 5.7% Pendolino* | 1 | 1 | 2 (1.1%) |
| *35% Manzanillo, 65% Arbequina* | 0 | 1 | 1 (0.5%) |
| *39% Leccino, 33% Frantoio, 10%Pendolino, 9% Moraiolo, 4% Coratina, 3% Leccio del corno, 2% Maurino* | 1 | 1 | 2 (1.1%) |
| *50% Arbosana, 50% Arbequina* | 0 | 1 | 1 (0.5%) |
| *50% Mission, 20% Frantoio, 25% Coratina, 5% Sevillano* | 1 | 1 | 2 (1.1%) |
| *50% Mission, 50% Manzanillo* | 0 | 2 | 2 (1.1%) |
| *40% Mission, 60% Manzanillo* | 2 | 0 | 2 (1.1%) |
| *55% Manzanillo, 45% Arbequina* | 0 | 1 | 1 (0.5%) |
| *55.17% Arbequina, 41.81% Arbosana, 3.02% Koroneiki* | 0 | 1 | 1 (0.5%) |
| *55.77% Arbequina, 4.87% Arbosana, 39.37% Koroneiki* | 0 | 1 | 1 (0.5%) |
| *65% Ascolano, 22% Arbequina, 4% Picual, 3% Mission, 6% Hojiblanca* | 0 | 1 | 1 (0.5%) |
| *71.33% Arbequina, 28.67% Arbosana* | 0 | 1 | 1 (0.5%) |
| *79% Mission, 21% Manzanillo* | 1 | 1 | 2 (1.1%) |
| *80.32% Arbequina, 19.3% Arbosana, 0.02% Leccino, 0.02% Frantoio* | 1 | 1 | 2 (1.1%) |
| *82.35% Arbequina, 17.66% Arbosana, 3.02% Koroneiki* | 1 | 1 | 2 (1.1%) |
| *85.87% Arbequina, 12.02% Arbosana, 2.09% Koroneiki* | 1 | 1 | 2 (1.1%) |
| *Hillside 7 (15% Itrana, 23% Frantoio, 7% Grappollo, 13% Pendalino, 15% Leccino, 8% Kalamata, 19% San Felice)* | 0 | 1 | 1 (0.5%) |
| *Italian Blend (33% Frantoio, 33% Pendolino, 34% Leccino)* | 0 | 1 | 1 (0.5%) |
| *Lunigiana (45% Leccino, 45% Frantoio, 5% Pendolino, 5% Maurino)* | 0 | 1 | 1 (0.5%) |
| *Tuscan (55% Frantoio, 40% Leccino, 5% Pendalino)* | 1 | 1 | 2 (1.1%) |
| *Variety or variety percentage unspecified* | 9 | 7 | 16 (8.6%) |
| ***Total*** | **78** | **109** | **187 (100%)** |

As illustrated in Chart 1, 91 of the 187 samples (49 percent) were from the major super-high-density varieties (Arbequina, Arbosana, Koroneiki, and blends of these varieties); 25 samples (13 percent) were from traditional varieties that have been grown in California for more than a century (Mission, Manzanillo, Sevillano, Ascolano, and blends of these varieties); 21 samples (11 percent) were from varieties that have been planted in California mainly in the past few years (Barnea, Coratina, Don Carlo, Favolosa, Hojiblanca, Oliana, Picual and Tosca); 18 samples (10 percent) were from Italian varieties that have been planted in California primarily in the past 25 years (Frantoio, Leccino, Moraiolo, Pendolino, Taggiasca and blends of these varieties); 16 samples (9 percent) were blends that do not fit in the above categories; and 16 samples (9 percent) were unspecified.

**Chart 1. Categories of olive varieties tested**




Handlers identified the grade of lots prior to testing the samples from those lots and reported this information to the OOCC, and CDFA/OOCC officials randomly tested handler lots and corroborated handler grades. Based on matching OOCC ID and lot numbers, we were able to confirm that 64 of 78 OOCC samples (82 percent) were from the same lots tested by the Handler and we also determined the grade that the Handler had designated for the samples prior to testing.

A total of 161 of the 187 samples (86 percent) were designated by Handlers as Extra Virgin grade prior to testing, 12 samples (6 percent) were designated as lower grades, and 14 samples (7 percent) were unidentified by grade prior to testing.

## RESULTS FOR QUALITY TESTS

As shown in Table 3, all 161 samples (102 Handler samples and 59 OOCC samples) that Handlers had designated prior to testing as Extra Virgin grade were confirmed by Handler testing to be Extra Virgin grade, in other words, with 100 percent grade designation accuracy. OOCC testing found that three of these samples were Virgin grade with 95 percent grade designation accuracy. Overall, there was a 98 percent grade designation accuracy rate in the 161 samples.

**Table 3. Overview of Extra Virgin grade samples**

| | Handler | OOCC | Total |
|---|---|---|---|
| ***Total samples collected*** | 109 | 78 | 187 |
| ***Samples designated as Extra Virgin grade prior to testing by Handlers*** | 102 | 59 | 161 |
| ***Samples confirmed as Extra Virgin grade by testing*** | 102 (100%) | 56 (95%) | 158 (98%) |
| ***Total samples met Extra Virgin grade*** | 103 (94%) | 70 (90%) | 173 (93%) |

Eleven of the 12 samples that Handlers had designated as lower grades prior to testing were confirmed by Handler testing to be either Virgin or Crude grade. There were two samples in which the OOCC and

Handlers had inconsistent results: one sample was designated as Virgin grade by the Handler and was deemed Extra Virgin grade by Handler testing and Virgin grade by OOCC testing. Another sample was designated as Virgin grade by the Handler and was confirmed as Virgin grade by Handler testing but was considered Extra Virgin grade by OOCC testing. Thirteen of the 14 samples in which the grade was unidentified prior to testing met Extra Virgin grade, with one sample tested by OOCC as Crude grade.

In total, 173 of 187 samples (93 percent) met California standards for Extra Virgin grade: 70 of 78 OOCC samples (90 percent) and 103 of 109 Handler samples (94 percent). Ten Handlers did not conduct all of the required tests for 43 samples, so it is unknown whether complete data would have shown a different Extra Virgin rate. Fourteen of the 187 samples (7 percent) met California standards for Virgin and Crude grades.

Table 4 indicates that the average values for the samples tested as Extra Virgin grade were well within the limits of California standards. The small standard deviations show that results from different producers did not deviate much from the average.

**Table 4. Summary of quality testing results for Extra Virgin samples (173 of 187 samples)**

| *Test (CA Extra Virgin Standard)* | Average value | Standard deviation |
|---|---|---|
| ***Free Fatty Acidity (≤0.5)*** | 0.1 | 0.1 |
| ***Peroxide Value (≤15.0)*** | 5.3 | 2.6 |
| ***UV $K_{232}$ (≤2.40)*** | 1.67 | 0.20 |
| ***UV $K_{270}$ (≤0.22)*** | 0.12 | 0.03 |
| ***UV ΔK (≤/0.01/)*** | 0 | 0 |
| ***Moisture and Volatile Matter (≤0.2)*** | 0.1 | 0 |
| ***Insoluble Impurities (≤0.1)*** | 0 | 0 |
| ***Pyropheophytins (≤17)*** | 1 | 1 |
| ***1,2-Diacylglycerols (≥35)*** | 91 | 6 |
| ***Organoleptic (MeF>0)*** | 3.6 | 0.7 |

Table 5 provides the details of the 14 samples tested as lower grades. Two samples were designated as "second extraction" by a Handler and both samples were confirmed as Crude grade by Handler testing. There were five instances in which the OOCC and the Handler test results did not agree on grade designation. Three samples (10095, OCTOBER 2017 and 079) were assumed by Handlers to be Extra Virgin grade prior to testing and confirmed by Handler testing results as Extra Virgin grade, while OOCC testing designated the same samples as Virgin grade. Two samples (Tosca and 100298WDT911 TB 17/406) were assumed by Handlers to be Virgin grade prior to testing but were found in testing either by the Handler or the OOCC to meet Extra Virgin grade standards.

Overall, the major discrepancies were from organoleptic results, which could be caused by improper sampling techniques and/or variances among sensory panels. In one sample (OCTOBER 2017) the $K_{270}$ value as tested by the Handler was 0.20 and within the limit of Extra Virgin grade, while OOCC testing found that the $K_{270}$ value to have a rounded-up value of 0.23, exceeding the Extra Virgin limit at 0.22. Organoleptic results were not provided on this sample.

**Table 5. Summary of quality testing results for lower grade samples (14 of 187 samples)**

| *Sample ID* | Agency | FFA | PV | UV $K_{270}$ | Organoleptic | Handler assumed grade | Tested grade | Possible cause(s) of lower grade |
|---|---|---|---|---|---|---|---|---|
| ***CA Extra Virgin Standard*** | | ≤0.5 | ≤15.0 | ≤0.22 | MeD=0 | | | |
| ***71260*** | Handler | - | - | - | 1.1 F, 0.5 R | Virgin | Virgin* | 1, 2 |
| | OOCC | - | - | - | 2.1 F/MS, 0.45 R | | Virgin** | |
| ***Tosca*** | Handler | - | - | - | 0.9 (defect not specified) | Virgin | Virgin* | 3 |
| | OOCC | - | - | - | - | | Extra Virgin** | - |
| ***100602WDT901 18/010*** | Handler | 1.7 | - | - | 1.5 R | Crude | Crude* | 1, 2 |
| | OOCC | 1.78 | - | - | 2.65 F/MS, 1.15 R | | Crude* | |
| ***100600WDTISO1 17/450*** | Handler | - | - | 0.29 | - | Second Extraction | Crude* | 2 |
| ***100600WDTISO2 18/021*** | Handler | 0.8 | 15.6 | - | 3.0 F | Second Extraction | Crude* | 1, 2 |
| ***34617*** | Handler | - | - | - | Not Tested - Not selling as EVOO | Crude | Crude* | 3 |
| | OOCC | - | - | - | 4 F/MS, 2.4 R | | Crude** | 1, 2 |
| ***10095*** | Handler | - | - | - | - | Extra Virgin | Extra Virgin* | - |
| | OOCC | - | - | - | 2.35 F/MS, 2.3 R | | Virgin** | 1, 2 |
| ***SV2727*** | OOCC | 0.67 | - | - | 0.65 F/MS, 3.25 R | N/A | Crude** | 1 |
| ***OCTOBER 2017*** | Handler | - | - | - | - | Extra Virgin | Extra Virgin* | - |
| | OOCC | - | - | 0.23 | - | | Virgin** | 2 |
| ***079*** | Handler | - | - | - | - | Extra Virgin | Extra Virgin* | - |
| | OOCC | - | - | - | 0.95 F/MS | | Virgin** | 1 |
| ***100298WDT911 TB 17/406*** | Handler | - | - | - | - | Virgin | Extra Virgin* | - |
| | OOCC | - | - | - | 1.55 F/MS | | Virgin** | 1 |

[-] Data not provided; [N/A] Data not available; [F] Fusty; [F/MS] Fusty/Muddy Sediment; [R] Rancid; [*] When tested by Handler; [**] When tested by OOCC; [1] Olives had fermented or undergone hydrolysis prior to processing or oil was stored on sediment for extended period (indicated by F or F/MS defect); [2] Oil had become oxidized (indicated by elevated PV, $K_{270}$ and rancid defect); [3] Organoleptic defect not identified/specified so cause of defect undeterminable.

Table 6 provides a summary of grading agreement over the past four seasons. The 2017/18 season had a grading consistency of 92 percent (59 of 64 lots) when the same lot was tested by both the OOCC and Handlers. While high, the consistency percentage is less than the previous two seasons, which may be related to the variances in labs from year to year, as well as the larger number of samples in the 2017/18 season compared to previous seasons.

**Table 6. Olive oil grading consistency for same lots from 2014/15 to 2017/18 harvest seasons**

| | 2014/15 | 2015/16 | 2016/17 | 2017/18 |
|---|---|---|---|---|
| *Number of lots tested by both Handlers and the OOCC* | 26 | 41 | 51 | 64 |
| *Number of samples in agreement* | 22 | 39 | 51 | 59 |
| *Percentage of grading agreement (%)* | 85 | 95 | 100 | 92 |

As previously indicated, 43 samples did not include data for all of the quality tests required in California standards, and the missing tests for these samples are summarized in Table 7. For example, Handler C did not provide organoleptic data for all seven samples tested. All 43 samples were assumed by Handlers to be Extra Virgin grade prior to testing, and all met Extra Virgin grade standards for the tests that Handlers had performed. It is not known whether these samples would have met Extra Virgin grade if Handlers had provided complete data. Having complete data could also be helpful in understanding grading discrepancies shown in Tables 5.

**Table 7. Handlers with incomplete test data**

| *Handler* | Total samples collected by each Handler | Samples with complete tests from each Handler | | | | | Total samples with incomplete tests |
|---|---|---|---|---|---|---|---|
| | | Moisture and volatile matter | Insoluble impurities | PPP | DAGs | Organoleptic | |
| ***C*** | 7 | 7 | 7 | 7 | 7 | 0 | 7 |
| ***D*** | 13 | 12 | 13 | 13 | 13 | 13 | 1 |
| ***E*** | 13 | 13 | 13 | 13 | 13 | 0 | 13 |
| ***I*** | 6 | 6 | 6 | 6 | 6 | 0 | 6 |
| ***J*** | 2 | 0 | 0 | 0 | 0 | 2 | 2 |
| ***K*** | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| ***M*** | 5 | 5 | 5 | 5 | 5 | 3 | 2 |
| ***P*** | 13 | 6 | 6 | 6 | 6 | 6 | 7 |
| ***Q*** | 12 | 12 | 12 | 9 | 9 | 12 | 3 |
| ***S*** | 5 | 5 | 5 | 5 | 5 | 4 | 1 |
| ***Total*** | **77** | **67** | **67** | **65** | **65** | **41** | **43** |

The 2017/18 chemical quality data for Extra Virgin samples was superior to the three previous seasons as shown in the summary in Table 8. Compared to the 2014/15 season the average values in the 2017/18 season have moved toward higher quality: FFA decreased by 50 percent, PPP declined by 50 percent, PV

dropped by 27 percent and DAGs increased by 11 percent. These trends suggest that postharvest fruit quality, handling and processing have improved over the past four seasons. Conversely the median intensity of fruitiness was the lowest in four years after three seasons of increased intensity.

**Table 8. Summary of quality testing results for Extra Virgin samples from 2014/15 to 2017/18 harvest seasons**

| *Test (CA Extra Virgin Standard)* | 2014/15 | | 2015/16 | | 2016/17 | | 2017/18 | |
|---|---|---|---|---|---|---|---|---|
| | **Average Value** | **Standard Deviation** | **Average Value** | **Standard Deviation** | **Average Value** | **Standard Deviation** | **Average Value** | **Standard Deviation** |
| *Free Fatty Acidity (≤0.5)* | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 |
| *Peroxide Value (≤15.0)* | 7.3 | 2.8 | 5.9 | 2.9 | 5.5 | 2.5 | 5.3 | 2.6 |
| *UV K232 (≤2.40)* | 1.69 | 0.25 | 1.77 | 0.21 | 1.78 | 0.22 | 1.67 | 0.20 |
| *UV K270 (≤0.22)* | 0.12 | 0.03 | 0.12 | 0.03 | 0.13 | 0.03 | 0.12 | 0.03 |
| *UV ΔK (≤/0.01/)* | <0.003 | 0 | <0.003 | 0 | 0 | 0 | 0 | 0 |
| *Moisture and Volatile Matter (≤0.2)* | 0.1 | 0 | 0.1 | 0 | 0.1 | 0 | 0.1 | 0 |
| *Insoluble Impurities (≤0.1)* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyropheophytins (≤17)* | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 |
| *1,2-Diacylglycerols (≥35)* | 82 | 10 | 88 | 6 | 89 | 7 | 91 | 6 |
| *Organoleptic (MeF>0)* | 4.2 | 0.7 | 4.4 | 0.7 | 4.6 | 0.8 | 3.6 | 0.7 |

**RESULTS FOR PURITY TESTS**

The OOCC sent 47 of the 78 samples that were collected by the third-party sampling agency to Eurofins Central Analytical Laboratories to conduct purity tests required by California standards. Forty-five of the samples (96 percent percent) were within the limits required under California standards and two of the samples (4 percent) were outside the limits:

- a Koroneiki sample did not meet the standard of Apparent β-sitosterol with a value of 92.5 (California standard ≥ 93.0) nor the standard of total sterols with a value of 936 (California standard ≥ 1000), and
- a Sevillano sample exceeded the limit for heptadecenoic acid (C17:1) with a value of 0.4 (California standard ≤ 0.3).

Sterols and fatty acids can be affected by factors unrelated to the authenticity of an oil, such as geographical origin[5], climate and altitude[6], and cultivar and harvest period[7]. The third-party sampling agency did not collect data on the harvest location or harvest dates for the samples, so it is unknown how these factors, other than cultivar, contributed to the results. Currently, the UC Davis Olive Center is analyzing fatty acid and sterol profiles data of 275 California single-variety olive oil samples collected over a six-year period. We found that significant numbers of California olive oil samples also were outside the limits for the same standards as the two samples cited above: 18 samples (7 percent) were outside the parameter for Apparent β-sitosterol, 11 samples (4 percent) did not reach the minimum for total sterols and 80 samples (29 percent) had a heptadecenoic acid (C17:1) content that was equal to or exceeded the California limit. This last finding is consistent with our recommendation[8] that CDFA consider modifying the C17:1 standard from the current 0.3 percent to the revised IOC standard of 0.6 percent.

**CONCLUSIONS AND RECOMMENDATIONS**

- Of 161 samples designated as Extra Virgin prior to testing, 158 (98 percent) met California standards for Extra Virgin grade, although 43 Handler samples from ten Handlers did not have data for all the tests required under California standards. The OOCC may want to consider adopting a policy to ensure that complete Handler data, including for blend composition and all tests, are received by the commission by the commission's deadline.

- Two out of 109 Handler samples were designated as "second extraction" by a Handler and both samples were confirmed as Crude grade by Handler testing. The OOCC may want to consider how to address "second extraction" oil in California standards.

- One defective Handler sample was reported without specifying the defect(s). The OOCC may wish to consider requiring Handlers to specify organoleptic defect(s) in the Handler data-submission form and also require Handlers to use laboratories and sensory panels that have been accredited by the International Olive Council (IOC) or American Oil Chemists' Society (AOCS). The OOCC may also consider requiring accredited sensory panels to report grades to Handlers and the OOCC based on California grades.

- The third-party sampling agency did not report the grade of the lot designated by the Handler prior to testing, nor did the sampling agency record the olive varieties for each lot. The sampling agency also did not report harvest location of the samples, which would be helpful in analyzing purity data. The OOCC may want to consider requiring the third-party agency to verify and report

[5] (a) Giacalone, R., Giuliano, S., Gulotta, E., Monfreda, M., & Presti, G. (2015). Origin assessment of EV olive oils by esterified sterols analysis. Food chemistry, 188, 279-285. (b) Borges, T. H., Pereira, J. A., Cabrera-Vique, C., Lara, L., Oliveira, A. F., & Seiquer, I. (2017). Characterization of Arbequina virgin olive oils produced in different regions of Brazil and Spain: Physicochemical properties, oxidative stability and fatty acid profile. Food chemistry, 215, 454-462.

[6] (a) Uncu, O., & Ozen, B. (2016). Geographical differentiation of a monovarietal olive oil using various chemical parameters and mid-infrared spectroscopy. Analytical Methods, 8(24), 4872-4880. (b) Rouas, S., Rahmani, M., El Antari, A., Idrissi, D. J., Souizi, A., & Maata, N. (2016). Effect of geographical conditions (altitude and pedology) and age of olive plantations on the typicality of olive oil in Moulay Driss Zarhoun. Mediterranean Journal of Biosciences, 1(3), 128-137.

[7] (a) Alowaiesh, B., Singh, Z., Fang, Z., & Kailis, S. G. (2018). Harvest time impacts the fatty acid compositions, phenolic compounds and sensory attributes of Frantoio and Manzanilla olive oil. Scientia Horticulturae, 234, 74-80. (b) Bilušić, T., Žanetić, M., Ljubenkov, I., Mekinić, I. G., Štambuk, S., Bojović, V. & Magiatis, P. (2018). Molecular characterization of Dalmatian cultivars and the influence of the olive fruit harvest period on chemical profile, sensory characteristics and oil oxidative stability. European food research and technology, 244(2), 281-289.

[8] Heptadecenoic acid (C17:1) in California Olive Oil: A Review (2018). *UC Davis Olive Center.*

the OOCC ID with Handler's lot number, Handler's designated-grade prior to testing, harvest location and variety (or the percentages of varieties in blends).

- To increase the traceability of the data and sample confidentiality for the Handlers, the OOCC and the third-party sampling agency may wish to standardize IDs that can be used to differentiate the samples without revealing the identities of the Handlers. A format of harvest year three digits random code (ex. 17/18_XXX) will ensure that unique IDs are used each year.

**APPENDIX**

Quality tests in California olive oil standards

| PARAMETER | DETERMINATION | INDICATOR | METHODOLOGY | CA EXTRA VIRGIN STANDARD |
|---|---|---|---|---|
| Free Fatty Acids (FFA) | Free fatty acids are formed by the hydrolysis of the triacylglycerols during extraction, processing and storage. | An elevated level of free fatty acid indicates hydrolyzed fruits and/or poor quality oil made from unsound fruit, improperly processed or stored oil. | Analytical Titration | ≤ 0.5 % as oleic acid |
| Peroxide Value (PV) | Peroxides are primary oxidation products that are formed when oils are exposed to oxygen, producing undesirable flavors and odors. | An elevated level of peroxides indicates oxidized and/or poor quality oil. | Analytical Titration | ≤ 15 meq $O_2$/kg oil |
| Ultraviolet absorbance (UV) | Conjugated double bonds are formed from natural non-conjugated unsaturation in oils upon oxidation. The K232 measures primary oxidation products and K270 measures secondary oxidation products. | An elevated level of UV absorbance indicates oxidized and/or poor quality oil. | UV spectrophotometry | K232: ≤ 2.40 $K^{1\%}_{1cm}$; K270: ≤ 0.22 $K^{1\%}_{1cm}$; ΔK: ≤ 0.01 $K^{1\%}_{1cm}$ |
| 1,2-Diacylglycerols (DAGs) | Fresh extra virgin olive oil contains a high proportion of 1,2-diacylglycerols to 1,2- and 1,3-diacylglycerols, while olive oil from poor quality fruits and refined olive oils have higher level of 1,3-DAGs than fresh extra virgin olive oils. | A low ratio of 1,2-diacylglycerols to 1,2- and 1,3-diacylglycerols is an indicator for oil that is hydrolyzed, oxidized, and/or of poor quality. | Gas Chromatography (GC) | ≥ 35% |
| Pyropheophytins (PPP) | Chlorophyll pigments break down to pheophytins and then pyropheophytins upon thermal degradation of olive oil. | An elevated level of pyropheophytins is an indicator for oil that is oxidized and/or adulterated with refined oil. | High performance liquid chromatography (HPLC) | ≤ 17% |
| Organoleptic | Organoleptic attributes refer to taste, odor and mouthfeel | Organoleptic assessment can help identify oils that are of poor quality, oxidized, and/or adulterated with other oils. | IOC-recognized panel of 8-12 people evaluates oils for sensory characteristics. | Median of defects = 0.0; median of fruity > 0.0 |