Evaluation of 50 California Olive Oil at Marketplaces 2016

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Olive Oil Commission of California

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UC DAVIS OLIVE CENTER
at the Robert Mondavi Institute

Evaluation of 50 California olive oil at marketplaces

The Olive Oil Commission of California (OOCC) contracted with the UC Davis Olive Center to analyze 50 California olive oil samples purchased from retail outlets that were approximately one year or more from the sample harvest dates. This report summarizes the data, evaluates the results and provides recommendations.

METHODOLOGY

The study team began by visiting a number of supermarkets and warehouse clubs/supercenters in the Sacramento region to get a list of brands of California extra virgin olive oil available on the shelves. We also examined two primary sources in determining which olive oil samples to select for analysis:

- **United States Department of Agriculture (USDA).** The study team consulted the website for the USDA Economic Research Service for information on retail trends. The USDA website states that traditional food stores such as supermarkets accounted for 70 percent of food-at-home sales as of 2011. Sales at warehouse clubs/supercenters followed at 16 percent, non-store sales (mail order, home delivery, and direct sales by farms, processors, and wholesalers) accounted for almost 9 percent, and the remaining 6 percent of sales came from mass merchandisers and nontraditional food stores such as drug stores and dollar stores.[i]

- **Olive oil sales data.** The study team consulted data from Information Resources, Inc. (IRI) on olive oil brand sales at several large food stores and supercenters, as well as aggregate data for private label brands, examining data for a 52-week period ending October 2, 2016.

The study team then compiled a list of retail outlets and brands, including private label brands, that would approximate the sales volume described in the USDA and IRI data. We oversampled from traditional food stores due to a limited number of California brands at warehouse/supercenters and the absence of California olive oil at drug stores and dollar stores.

Ultimately the study team purchased 50 extra virgin olive oil samples: 40 samples (80 percent) from seven traditional food stores, six samples (12 percent) from three warehouse clubs/supercenters, three samples (6 percent) from Amazon and one sample (2 percent) from the tasting room of an olive oil producer. Thirty-one samples (62 percent) came from OOCC members, 11 samples (22 percent) came from producers that were not OOCC members during the year when the oils were produced and eight samples (16 percent) came from store brands that presumably were sourced from OOCC members.
The study team purchased 45 samples on November 4, 2016 from supermarket and warehouse club/supercenter stores in Sacramento and Yolo Counties. The study team also purchased three samples from Amazon, one sample at a tasting room in Sonoma County, and one sample at a warehouse club store in Sacramento County between November 5 and November 12, 2016.

The study team minimized the impact of heat and light during the collection process by covering the samples in the vehicle and parking in the shade when possible. The temperature in the vehicle transporting the samples ranged from 69°F to 82°F, with the higher temperatures occurring for brief periods while the study team was in a store purchasing samples. Samples were taken to the UC Davis Olive Center laboratory, where the samples were protected from light and stored at 65°F to 68°F.

All samples were analyzed based on California olive oil standards. A description of the chemistry and sensory tests addressed in the standards are in Table 1.

The UC Davis Olive Center Laboratory provided chemistry analysis of the samples in January 2017. If a sample failed chemistry analysis the study team sent it to the Eurofins Central Analytical Laboratories in New Orleans for retesting. Eurofins' results agreed with UC Davis' results for all re-tested samples.

Sensory analysis was performed by the panel managed by Applied Sensory, LLC in December 2017. The panel is accredited by the American Oil Chemists' Society. If a sample failed the sensory standard for Extra Virgin grade the panel re-evaluated the sample in January 2017. The study team also sent a sample that failed the first panel test for sensory analysis by the Australian Oils Research Laboratory, which is accredited by the International Olive Council.

The study team considered a sample to have failed California extra virgin standards if it failed any chemistry standard and/or failed at least two of three sensory panel tests.

STORE INFORMATION

At each warehouse/supercenter and traditional food store the study team recorded the temperature from the bottom shelves and top shelves of the olive oil section by using an infrared thermometer. As shown in Figure 1, minimum temperatures ranged from 60°F to 70°F and maximum temperatures ranged from 65°F to 73°F.

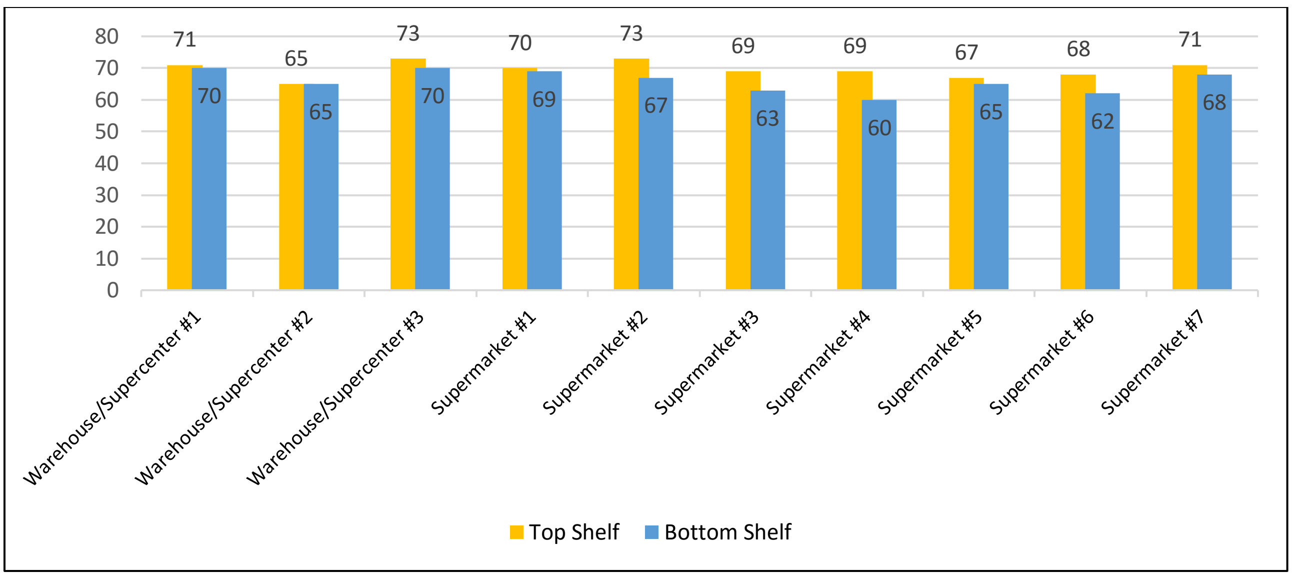

FIGURE 1. Temperature at shelf (°F)

TABLE 1. Chemistry and sensory tests for olive oil quality analysis

PARAMETER	**DETERMINATION**	**INDICATOR**	**METHODOLOGY**	**CA EVOO 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 nonconjugated unsaturation in oils upon oxidation. The K_{232} measures primary oxidation products and K_{270} measures secondary oxidation products.	An elevated level of UV absorbance indicates oxidized and/or poor quality oil.	UV spectrophotometry	K_{232}: ≤ 2.40 $K^{1\%}_{1cm}$; K_{270} ≤ 0.22 $K^{1\%}_{1cm}$; ΔK: ≤ 0.01 $K^{1\%}_{1 cm}$
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.	The 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%
Sensory	Sensory refers to taste, odor and mouthfeel	Sensory 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 the fruity>0.0
Induction Time*	The aging process is accelerated by means of heating up the reaction vessel and by passing air continuously through the sample.	Oxidative stability (in hours) denotes the resistance of oils to oxidation. The longer the induction time, the more stable the sample is.	Rancimat (120°C, 20L/h, 3g)	NA

*not a required test in California standards

The study team counted the number of olive oil brands for all grades, the number of selections for all brands, and the number of California olive oil brands and selections, including flavored olive oils. As shown in Figure 2, the number of all olive oil selections ranged from a low of four to a high of 80, and the California selections ranged from a low of one to a high of 34.

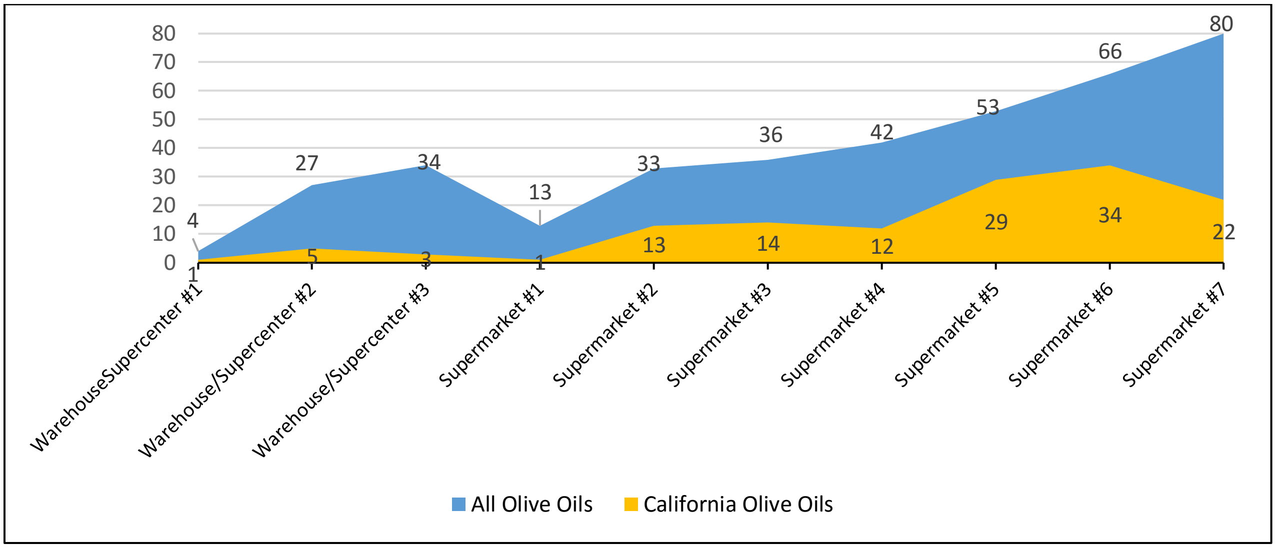

FIGURE 2. Number of olive oils at each store

The study team also measured the amount of linear shelf space occupied by olive oil of all grades, as well as the proportion of California olive oil of that total. Figure 3 shows the results in inches, with a low of 102 inches at Supermarket #1 to a high of 575 inches at Supermarket #6 for all olive oils, and a low of 10 inches at Supermarket #1 to a high of 255 inches at Supermarket #6 for California olive oils. The percentage of California olive oils ranged from a low of five percent at Warehouse/Supercenter #3 to a high of 55 percent at Supermarket #5.

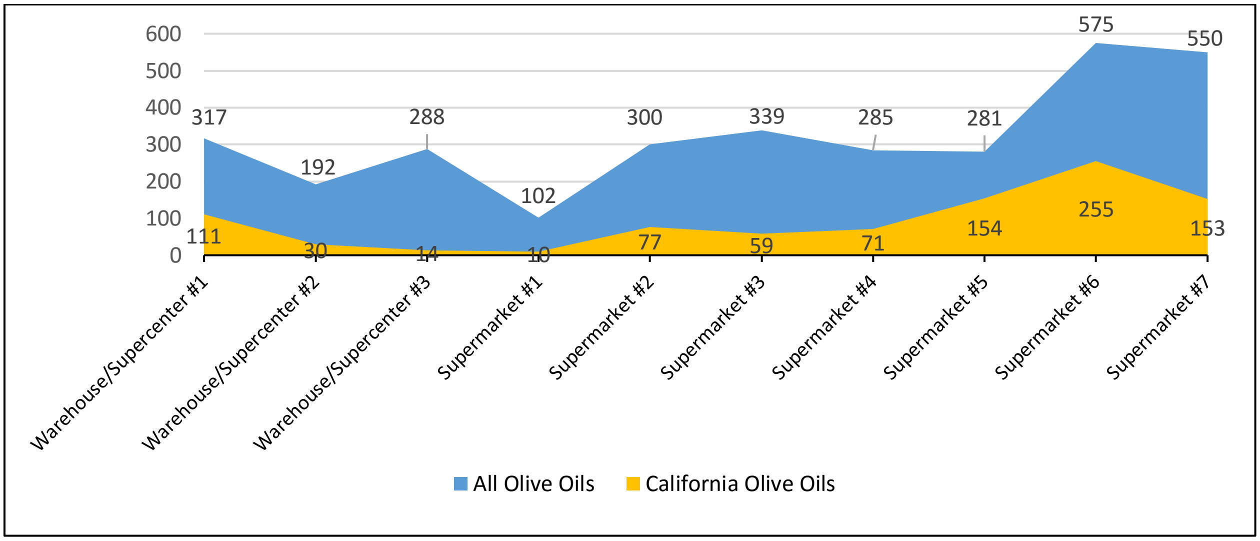

FIGURE 3. Shelf inches for olive oils at each store

The study team recorded the placement of the samples on store shelves. Figure 4 shows the shelving locations of the samples. More than half of the samples were located on the second or third shelf from the top.

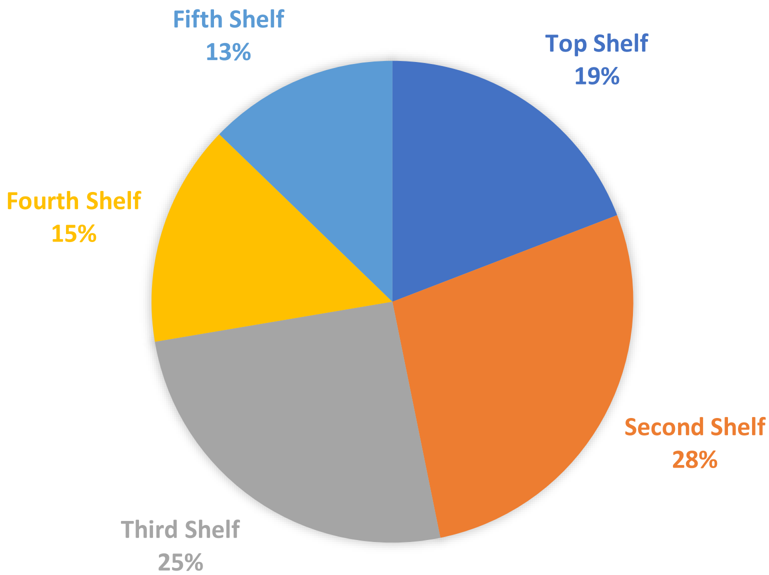

FIGURE 4. Shelving location for the purchased samples from stores

CHEMISTRY AND SENSORY RESULTS

Of the 31 samples from OOCC members, 28 samples (90 percent) met California Extra Virgin standards. Only two of 11 samples (18 percent) from non-OOCC member samples met the standards, while seven of eight store-brand samples (88 percent) met the standards. No clear correlation between the failed samples and the shelving location (Figure 4) was observed.

Figure 5 shows that OOCC samples passed every test at a 100 percent rate except for PPP, in which 28 of 31 samples (90 percent) passed the California Extra Virgin standard. Store brands passed every test except that one of the eight store-brand samples failed the sensory test. Non-OOCC member samples had low pass rates for K_{232} (six of 11 samples or 55 percent), PPP (five of 11 samples or 45 percent) and Sensory (two of 11 samples or 18 percent) with higher pass rates for PV (eight of 11 samples or 73 percent) and K_{270} (ten of 11 samples or 91 percent).

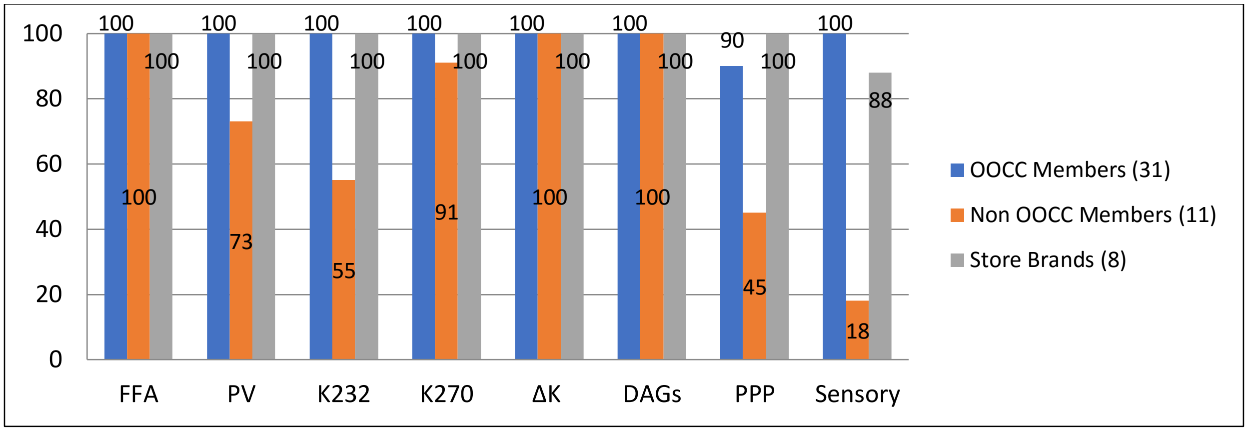

FIGURE 5. Passage rate for OOCC members and non-members (%)

Overall, 37 of 50 samples (74 percent) passed all California Extra Virgin standards while 13 samples (26 percent) failed at least one California standard for the grade. The percentage of samples passing or failing each test is summarized in Figure 6. One-hundred percent of samples passed the standards for FFA, ΔK and DAGs; 98 percent passed the standard for K_{270}; 94 percent passed the standard for PV; 88 percent passed the standard for K_{232}; and 80 percent passed the standard for PPP and Sensory.

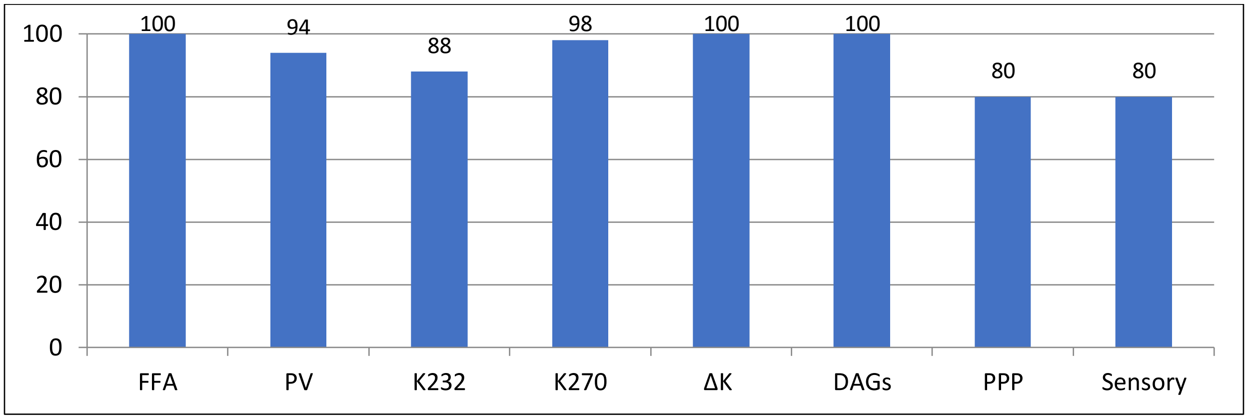

FIGURE 6. Passage rate; CA EVOO standards (%)

Table 2 shows the chemistry and sensory data for the 50 samples. Eight of the 13 failed samples (Samples 2, 3, 4, 5, 19, 39, 40 and 46) met the California standard for Virgin grade and five of the 13 failed samples (Samples 1, 11, 14, 20 and 30) met the California standard for Crude grade. It also shows that five of the eight Virgin samples (Samples 2, 3, 4, 39 and 40) barely failed one of the California Extra Virgin standards. The sensory data in Table 2 is solely from the two sessions of the Applied Sensory, LLC panel – the Australian panel did not supply data of sensory defects from sensory panel sessions. The distribution of chemistry results is summarized in Figures 7 - 12. The distribution of positive and negative sensory attributes is shown in Figure 13.

SAMPLE #	HARVEST YEAR	FFA	PV	K_{232}	K_{270}	Δ K	DAGs	PPP	INDUCTION TIME*	SENSORY DEFECTS	GRADE
		≤0.5	*≤15*	*≤2.40*	*≤0.22*	*≤0.01*	*≥35*	*≤17*		*MeD=0.0*	*Extra Virgin*
		≤1.0	*≤20*	*≤2.60*	*≤0.25*	*≤0.01*	*N/A*	*N/A*		*0.0<MeD≤2.5*	*Virgin*
		>1.0	*>20*	*>2.60*	*>0.25*	*≤0.01*	*N/A*	*N/A*		*MeD>2.5*	*Crude*
1	2015	0.16	20.0	2.80	0.16	0.00	55	12	4.4	Rancid: 1.1, 0.4	Crude
2	2015	0.20	4.5	1.60	0.13	0.00	50	18	11.6		Virgin
3	2015	0.20	5.5	1.62	0.13	0.00	49	19	11.2		Virgin
4	2015	0.15	6.6	1.73	0.12	0.00	54	18	9.2		Virgin
5	2015	0.25	11.1	2.50	0.17	0.00	40	22	9.2	Rancid: 1.7, 0.7	Virgin
6	2015	0.17	7.1	1.61	0.13	0.00	58	14	8.8		Extra Virgin
7	2015	0.25	6.7	1.61	0.12	0.00	48	16	10		Extra Virgin
8	2015	0.18	7.4	1.66	0.10	0.00	54	14	8.6		Extra Virgin
9	2015	0.20	5.5	1.59	0.12	0.00	53	15	12.4		Extra Virgin
10	2015	0.18	6.5	1.63	0.12	0.00	53	14	12.1		Extra Virgin
11	2015	0.27	11.1	2.60	0.21	0.00	39	39	9.3	Rancid: 2.7, 2.6; Fusty: 1.6, 1.0	Crude
12	2015	0.21	11.1	1.33	0.10	0.00	56	11	6.7		Extra Virgin
13	2015	0.17	10.5	1.71	0.13	0.00	59	14	11.1		Extra Virgin
14	2015	0.27	5.7	1.73	0.20	0.00	39	46	10.8	Rancid: 2.7, 2.7; Fusty: 1.6, 1.0	Crude
15	2015	0.19	5.5	1.60	0.12	0.00	55	14	10.4		Extra Virgin
16	2015	0.25	7.6	1.55	0.13	0.00	49	10	10.8		Extra Virgin
17	2015	0.18	4.9	1.59	0.11	0.00	53	14	10.4		Extra Virgin
18	2015	0.19	5.0	1.55	0.11	0.00	51	14	10.4		Extra Virgin
19	2015	0.27	7.0	1.79	0.13	0.00	39	22	9.1	Rancid: 1.1, 1.9	Virgin
20	2014	0.24	19.2	2.88	0.27	0.00	36	42	4.7	Rancid: 2.6, 1.9; Fusty: 0.7, 0.8	Crude
21	2015	0.14	10.4	2.20	0.15	0.00	74	7	9.9		Extra Virgin
22	2015	0.18	7.0	1.82	0.15	0.00	52	17	12.4		Extra Virgin
23	2015	0.29	5.6	1.64	0.09	0.00	44	14	9.7		Extra Virgin
24	2015	0.18	5.5	1.66	0.07	0.00	53	15	11.6		Extra Virgin
25	2015	0.13	12.5	2.34	0.08	0.00	66	9	8.5		Extra Virgin
26	2015	0.31	6.3	2.25	0.19	0.00	45	12	15.5		Extra Virgin
27	2015	0.31	4.7	1.62	0.07	0.00	43	15	13		Extra Virgin
28	2015	0.29	4.5	1.54	0.08	0.00	45	16	9.9		Extra Virgin
29	2015	0.22	8.1	1.85	0.07	0.00	53	13	6.8		Extra Virgin
30	2015	0.26	12.4	2.69	0.20	0.00	37	39	8.2	Rancid: 2.6, 2.9; Fusty: 0.4, 0.5	Crude
31	2015	0.21	3.9	1.66	0.17	0.00	58	10	11.3		Extra Virgin
32	2015	0.19	4.5	1.68	0.15	0.00	59	11	12.2		Extra Virgin
33	2015	0.19	4.7	1.58	0.12	0.00	60	11	11.9		Extra Virgin
34	2015	0.18	8.9	1.11	0.14	0.00	62	6	10.9		Extra Virgin
35	2015	0.16	5.4	1.71	0.13	0.00	61	12	8.7		Extra Virgin
36	2015	0.16	6.9	1.76	0.16	0.00	59	12	7.8		Extra Virgin
37	2015	0.20	5.3	1.59	0.10	0.00	61	9	10.7		Extra Virgin
38	2015	0.19	9.3	2.14	0.15	0.00	56	15	11.6		Extra Virgin
39	2015	0.19	9.6	2.11	0.10	0.00	59	12	5	Rancid: 0.4, 0.2	Virgin
40	2015	0.15	6.2	1.83	0.12	0.00	67	10	10.3	Rancid: 0.3, 0.2	Virgin
41	2015	0.31	5.5	1.59	0.12	0.00	44	15	9.2		Extra Virgin
42	2015	0.20	6.7	1.55	0.12	0.00	53	12	10		Extra Virgin
43	2015	0.30	7.7	1.70	0.17	0.00	44	14	11.3		Extra Virgin
44	2015	0.20	8.5	1.61	0.13	0.00	52	15	10.1		Extra Virgin
45	2015	0.18	6.5	1.48	0.10	0.00	58	12	10.8		Extra Virgin
46	2014	0.34	18.1	2.56	0.17	0.00	36	22	5.9	Rancid: 2.1, 2.6; Fusty: 1.1, 0.7	Virgin
47	2015	0.20	7.1	1.70	0.10	0.00	58	12	11.2		Extra Virgin
48	2015	0.22	5.9	1.49	0.11	0.00	52	15	11.2		Extra Virgin
49	2015	0.18	4.2	1.49	0.10	0.00	60	10	12.1		Extra Virgin
50	2015	0.21	5.7	1.56	0.13	0.00	52	13	11.4		Extra Virgin

TABLE 2. Chemistry and sensory data for samples
*not a required test in California standards.

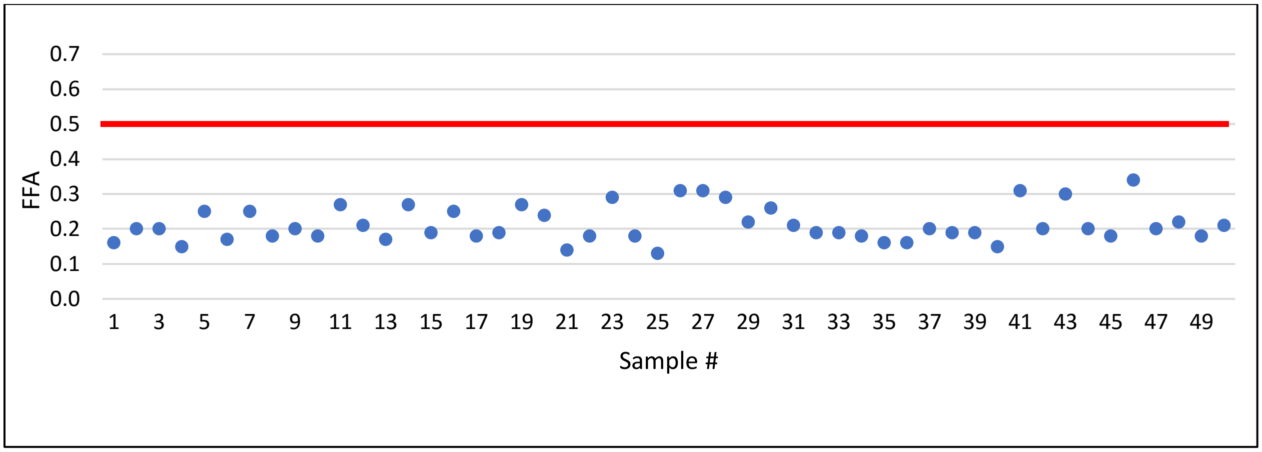

FIGURE 7. Free fatty acidity (CA EVOO ≤ 0.5)

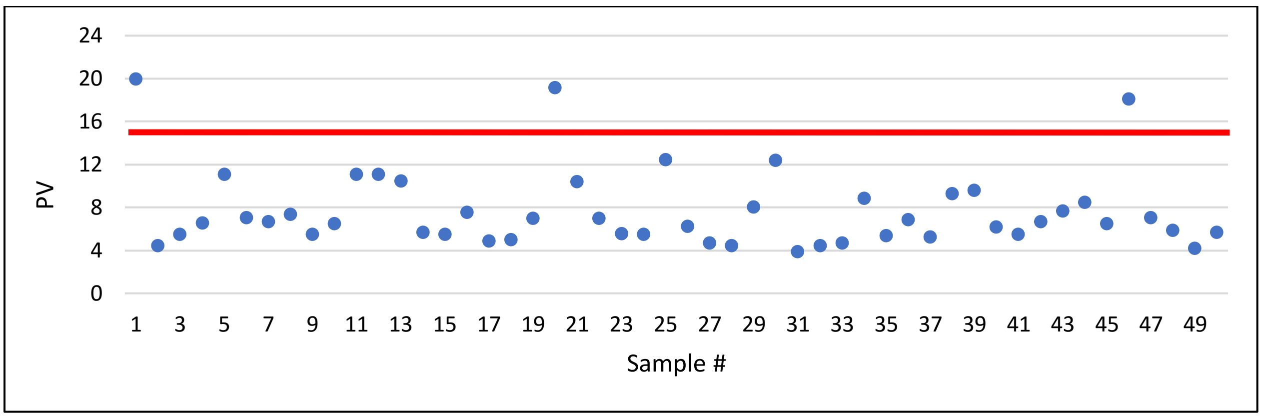

FIGURE 8. Peroxide value (CA EVOO ≤ 15)

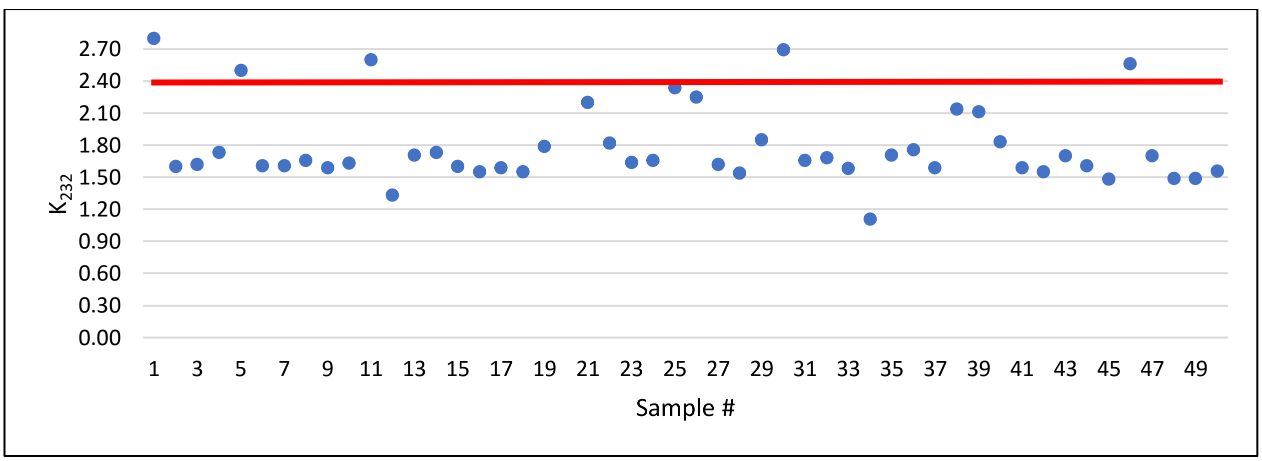

FIGURE 9. Absorbency in ultraviolet K_{232} (CA EVOO ≤ 2.40)

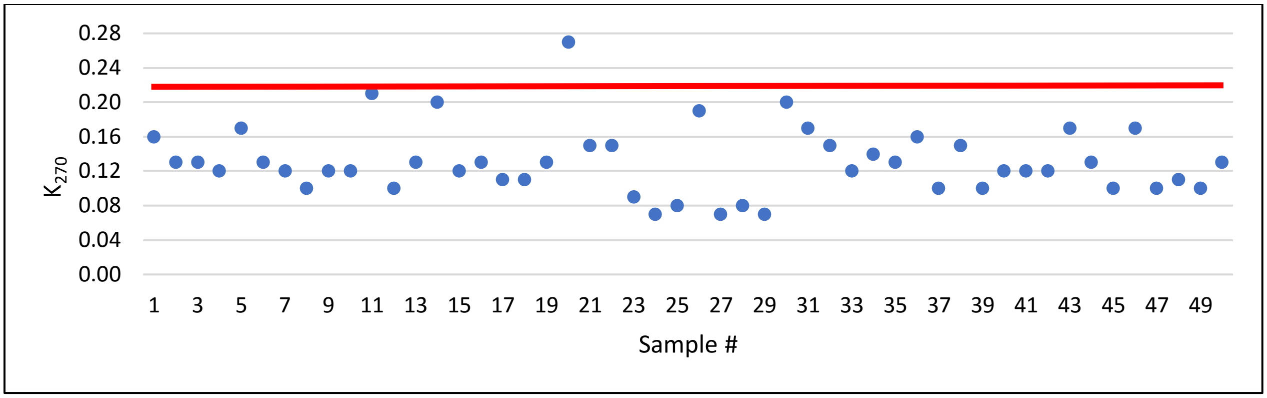

FIGURE 10. Absorbency in ultraviolet K_{270} (CA EVOO ≤ 0.22)

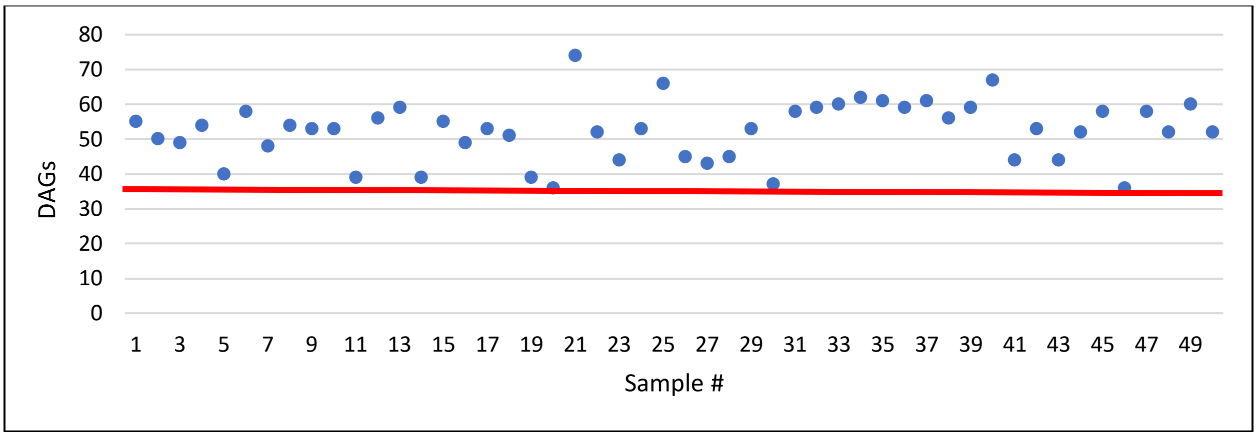

FIGURE 11. 1,2-Diacylglycerols (CA EVOO ≥ 35)

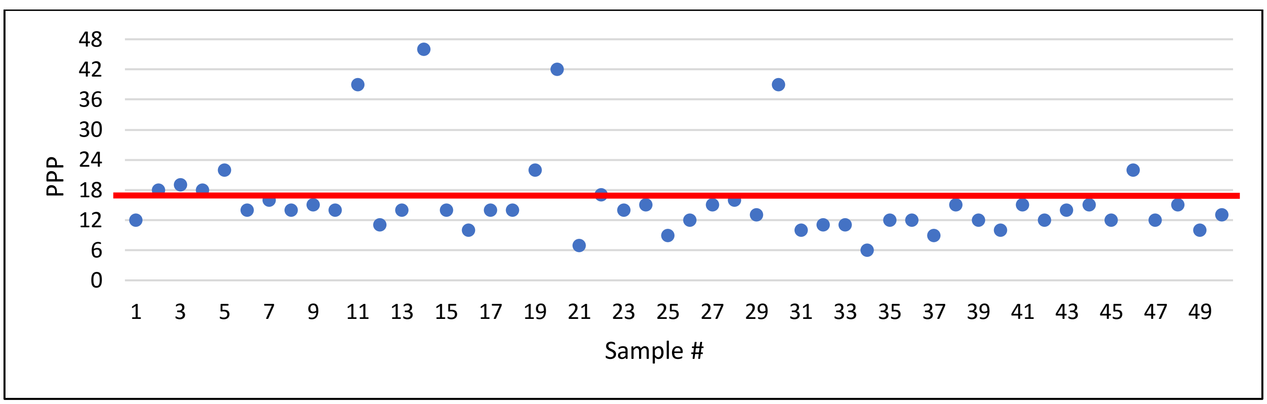

FIGURE 12. Pyropheophytin a (CA EVOO ≤ 17)

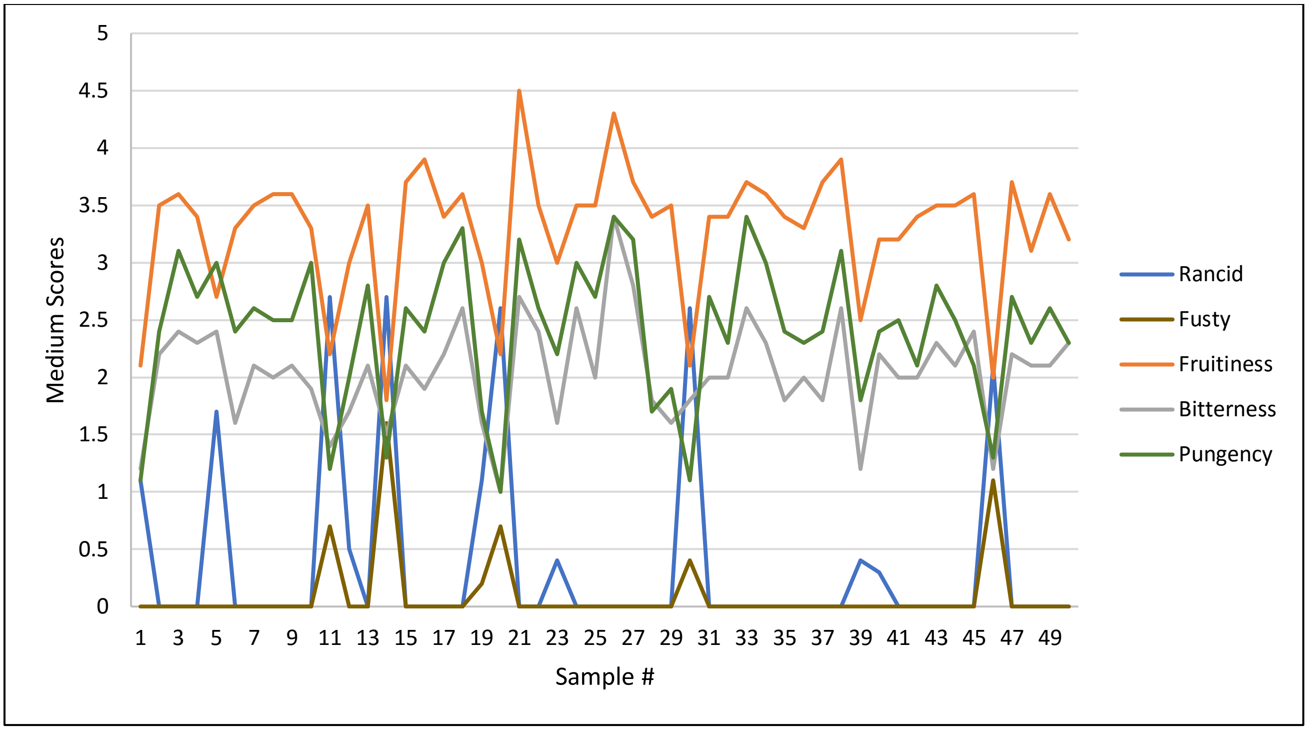

FIGURE 13. Medium scores of sensory attributes on rancid, fusty, fruitiness, bitterness and pungency

The performance of 50 samples for each of the tests in Table 2 is analyzed below.

FFA Free fatty acids, which are flavorless, come from the breakdown of triacylglycerols through a chemical reaction called hydrolysis. Factors that can lead to a high FFA in an oil include poor quality of fruit, fruit fly infestation, fungal diseases, delays between harvesting and milling, poor extraction methods and improper storage of the oil (such as on sediment). The samples had FFA values ranging from 0.14 – 0.34, well below the California Extra Virgin standard of 0.5. FFA values do not change substantially under proper storage condition during the shelf life of the oil.

PV Peroxide value is a crude measurement of initial oxidation in the oil. Oxidation can cause peroxides to transform into aldehydes and other compounds that are responsible for rancid flavors. Oxidation is a natural process and PV is expected to increase as the oil ages, although PV can later decrease as the primary oxidation products transform during secondary oxidation. Three samples (Sample 1, 20 and 46) had PV values between 15 - 20 which would place them in the Virgin grade. All three samples failed at least one other Extra Virgin chemistry standard, and all three had rancid defects. These oils were oxidized, either due to natural aging or suboptimal storage or transport conditions. The other rancid samples passed the PV extra virgin standard, indicating the limitations of PV test in assessing olive oil quality.

K_{232} Similar to PV, K_{232} measures initial oxidation products in the oil. Three samples (Sample 5, 11 and 46) had K_{232} values $\geq 2.40 \leq 2.60$ which would place these samples in the Virgin grade, and three samples (Samples 1, 20 and 31) exceeded 2.60 which would categorize them as Crude grade. All six samples also had rancid defects and elevated PV (greater than 11). These oils were oxidized, either due to natural aging or suboptimal storage conditions.

K_{270} K_{270} (or K_{268}) measures secondary oxidation products, which indicate that oxidation has advanced past initial oxidation. All but one of the 50 samples passed the California Extra Virgin standard of 0.22, and the Extra Virgin samples did not exceed 0.17. The one sample that failed K_{270} (Sample 20) had a value of 0.27, which met the Crude standard. This sample also had a high level of PV and K_{232}, and a significant intensity of rancid defect, suggesting that advanced oxidation has taken place. The study team confirmed that this sample was produced during the 2014 harvest, making it one of the two oldest samples in the study.

ΔK ΔK measures the difference between the absorbance at 270nm and 266-274nm, and is useful to detect the presence of refined or pomace oil. All samples were below the California Extra Virgin standard of 0.01.

DAGs Diacylglycerols are formed when a triacylglycerol molecule undergoes hydrolysis. The resulting DAG contains two fatty acids on a glycerol backbone in a 1,2 position. As oil ages or is heated, these molecules equilibrate, in a predictable and linear manner, to a 1,3 positon. The DAGs test assesses the extent of aging or heating by analyzing the ratio of 1,2 and 1,3 DAGs. DAGs are also related to the hydrolysis reaction, in a manner similar to FFA, and therefore can be affected by the quality of olives and post-harvest practices. A high level of FFA in fresh oil and elevated storage temperature affect the rate of hydrolysis and cause DAGs to decrease more rapidly. A fresh high-quality oil will have a DAGs ratio above 90 percent, and this percentage will drop as the oil ages and the fatty acids shift from the 1,2 position to the 1,3 position. Because the samples in this study were tested a year or more after harvest, it's expected that none of the samples had very high DAGs values (> 80 percent). While all the oils passed the DAGs standard of ≥ 35 for Extra Virgin grade, the samples with a fusty defect (Samples 11, 16, 20, 30 and 46) had a low DAGs level between 36 and 39. Most of the samples that failed either PV, K_{232}, K_{270} or had a rancid defect also had a low DAGs level of between 36 and 40.

PPP Pyropheophytins are degradation products of chlorophyll a as a result of aging or heating. Chlorophyll *a* converts to pheophytins *a* and then to pyropheophytins *a*. The ratio of pyropheophytin *a* to the total pheophytins is useful to detect oils that are aged or have been heated in the refining process as this ratio increases linearly with time. Fresh quality oils typically have a PPP close to zero. Ten samples (Samples 2, 3, 4, 5, 11, 14, 19, 20, 30 and 46) exceeded the California Extra Virgin standard of 17. Seven of these samples failed other standards and had rancid defects, although three of the samples (Samples 2, 3 and 4) had PPP values just outside the limit and did not fail any other standards. These three samples may have been stored in suboptimal conditions as temperature and light can significantly affect the rate of chlorophyll a degradation.

Sensory Of the 50 samples, 10 samples (Samples 1, 5, 11, 14, 19, 20, 30, 39, 40 and 46) failed the Extra Virgin grade for at least two of three sensory panel evaluations. All 10 of these samples had a rancid defect, and five of these samples (Samples 11, 14, 20, 30 and 46) also had a fusty defect. The five fusty samples indicate that the oil had a fermentation defect that starts with substandard fruit, processing or storage. This defect does not develop due to aging and therefore the oils should not have been packaged as Extra Virgin grade. None of the fusty samples were from OOCC members. Seven of the 10 failed samples (Samples 2, 3, 4, 5, 39, 40 and 46) met the standard for Virgin grade based on the median of defect of ≤ 2.5, while three of the 10 samples (Samples 14, 19, 20) met the standard for Crude grade with a median of defect of greater than 2.5. None of the Crude graded samples were from OOCC members. There was generally a strong relationship between the sensory results and chemistry results: eight of the 10 samples that failed the sensory standard also failed at least one chemistry standard (Samples 1, 5, 11, 14, 19, 20, 30 and 46.)

Induction time In addition to analyzing the samples for the quality parameters in California olive oil standards, the research team also analyzed induction time using a Rancimat instrument. Induction time estimates a sample's oxidative stability by accelerating the aging process. The Rancimat subjects the sample to excessive heat while passing air continuously through the sample. Induction time allows a simple assessment of the relative stability of oils, although the method does not provide an accurate assessment of shelf life due to the complex chemical reactions that occur during the oxidative process. Table 3 shows that induction time for the 50 samples ranged from 4.4 hours to 15.5 hours. If induction time accurately predicted shelf life then one would expect that oils that fail Extra Virgin standards would have the lowest induction times. Table 3 shows that this expectation is often true (Samples 1, 20, 39 and 46) but frequently is not. To look at this data in a more visual way, Figure 14 shows the induction time of the 50 samples, with the samples that failed Extra Virgin standards shown in red.

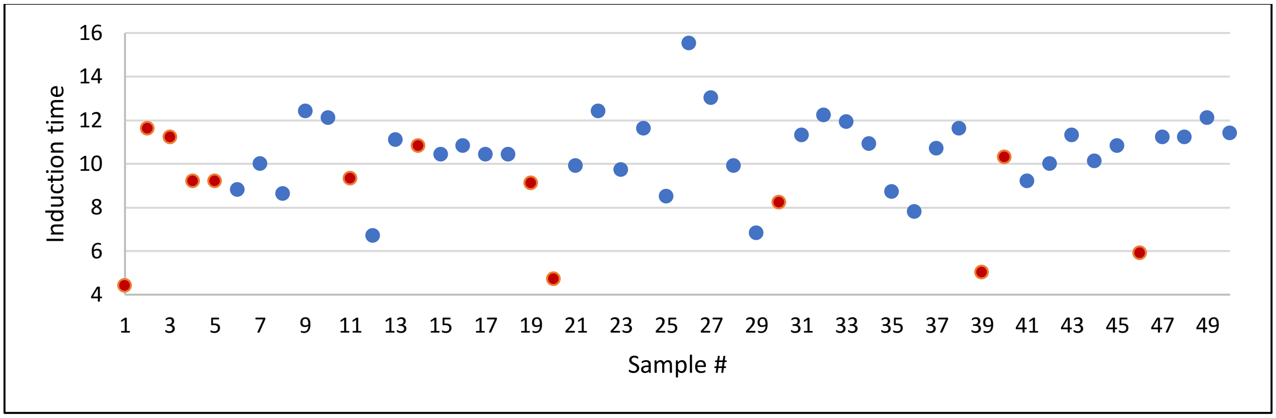

FIGURE 14. Induction time of olive oil samples

We further explore induction time in Figures 15 – 19, which include R^2 values to show correlations between induction time and olive oil chemistry tests. Higher R^2 value indicates a stronger correlation. Among the chemistry tests, PV and K_{232} showed the strongest correlations with induction time, while there were weak correlations with PPP, DAGs and best-before date. These results suggest that induction time is related to primary oxidation markers but high induction time does not necessarily indicate freshness and therefore should not be used as the sole tool for shelf-life prediction.

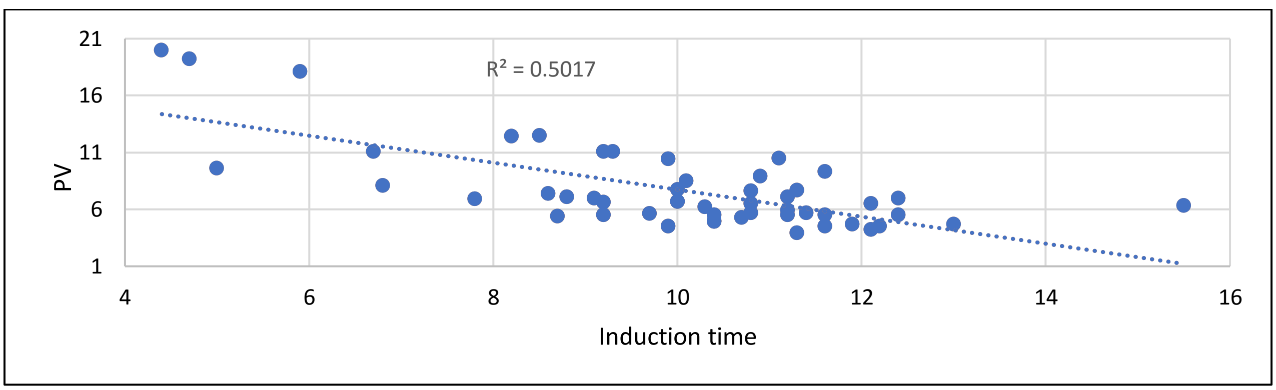

FIGURE 15. Correlations between induction time and PV in 50 samples

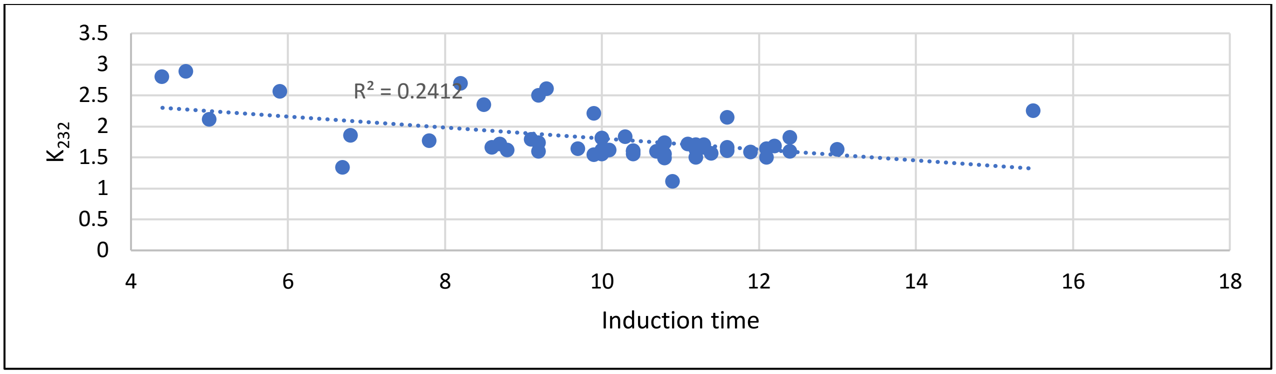

FIGURE 16. Correlations between induction time and K_{232} in 50 samples

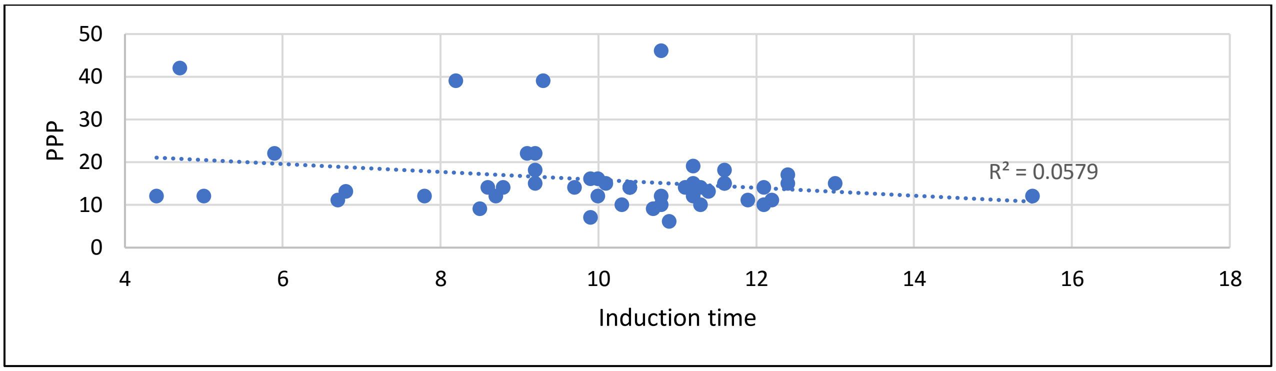

FIGURE 17. Correlations between induction time and PPP in 50 samples

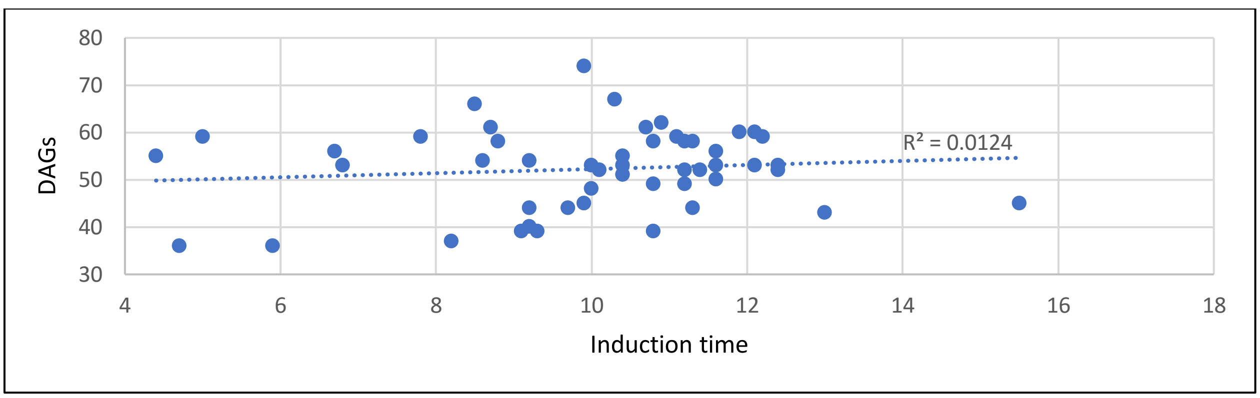

FIGURE 18. Correlations between induction time and DAGs in 50 samples

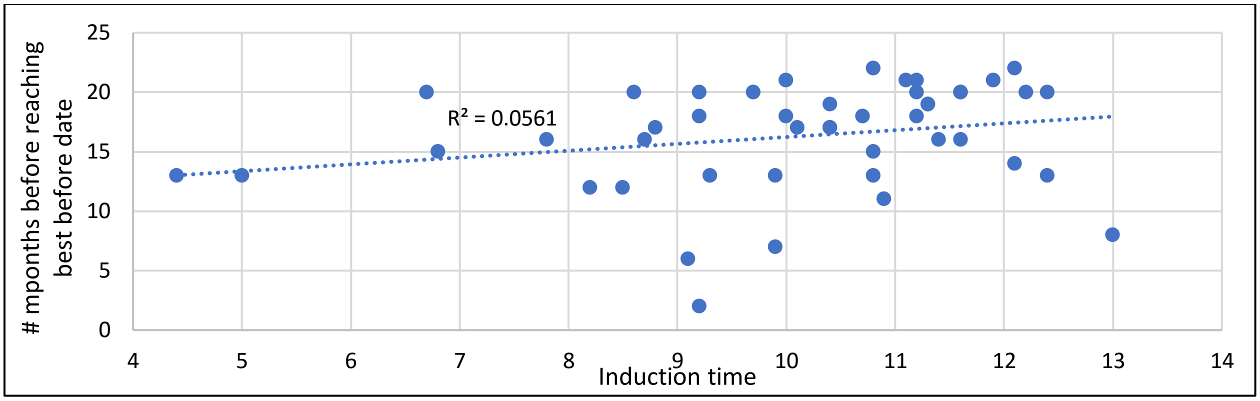

FIGURE 19. Correlations between induction time and number of months before reaching best before date in 46 samples

The 37 samples that tested as Extra Virgin had a range of values as summarized in Table 3.

TABLE 3. Range of values for samples graded as Extra Virgin

TEST	EVOO SAMPLE RANGE	CA LIMIT
FFA	0.14 - 0.31	≤ 0.5
PV	3.9 - 12.5	≤ 15.0
K_{232}	1.11 - 2.34	≤ 2.40
K_{270}	0.07 - 0.19	≤ 0.22
ΔK	0.00 - 0.00	≤ 0.01
DAGs	43 - 74	≥ 35
PPP	6 - 17	≤ 17

The research team compared the samples' average chemistry values for each of the three grades as shown in Table 4. The averages show that the grade has a positive relationship to the chemistry values, where the samples graded as Extra Virgin have the most favorable quality values and the samples graded as Crude have the least desirable quality values. These averages can serve as benchmark data for the commission to reference in future years.

TABLE 4. Averages by grade

	# OF SAMPLES	FFA	PV	K_{232}	K_{270}	DAGs	PPP	INDUCTION TIME*
EVOO	37	0.22	6.7	1.67	0.12	54.4	12.8	10.6
VIRGIN	8	0.24	8.6	1.97	0.13	49.3	17.9	8.9
CRUDE	5	0.26	13.7	2.54	0.21	41.2	35.6	7.5

*not a required test in California standards.

BEST-BEFORE DATE MODELING

Given the commission's interest in assessing prediction models for best-before dates, the study team examined the correlations between best-before dates and the chemistry/sensory data.

We first examined the 50 samples for harvest dates, best-before dates and bottling dates, finding that 36 samples had a harvest or milling date, 46 had a "best-before" date, three had a bottling date and one did not have any of this information. The research team deduced from this information that 48 samples were from the 2015 harvest season and two samples were from the 2014 harvest season. Of the 46 samples with "best-before" dates, the number of months left from the purchasing date ranged from two to 22 months. Samples that failed one or more chemistry parameters or at least two of three sensory panel tests were two to 20 months away from the best-before dates.

We then examined how the data from each chemistry test correlated with the best-before dates, which is summarized in Figures 20 – 25 and presented in the order of strongest to weakest correlation as shown by the R^2 values. Of all the chemical parameters, DAGs, K_{270} and PPP (Figures 20 - 22) showed the strongest correlations (highest R^2 values) with the number of months before reaching the best-before date claimed by the handler on the label. This data may be useful as the commission considers best-before date models in the future.

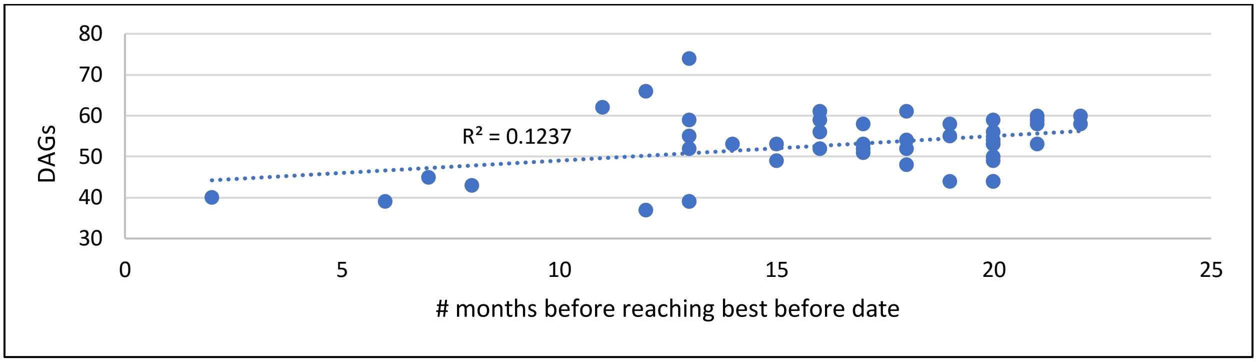

FIGURE 20. Correlations between number of months before reaching best before date and DAGs in 46 samples

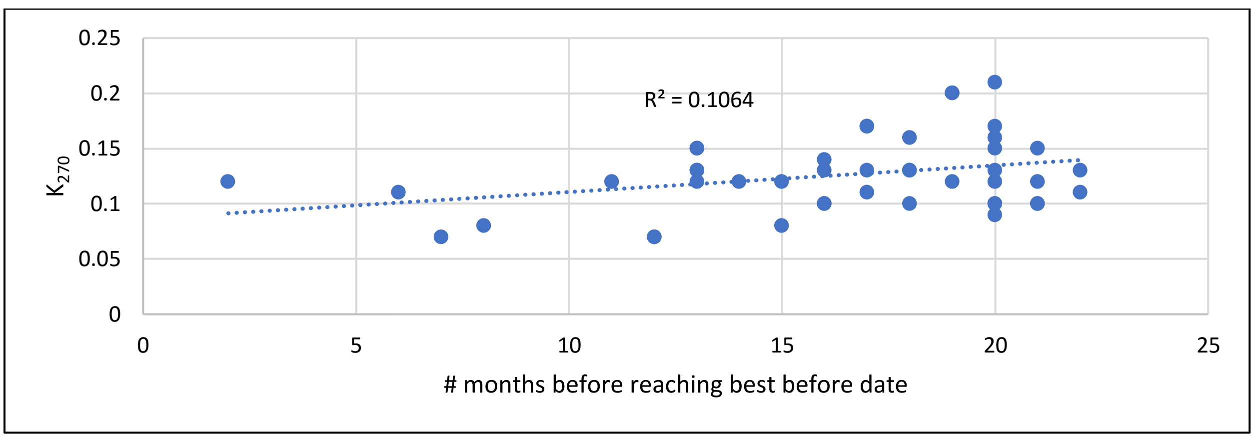

FIGURE 21. Correlations between number of months before reaching best before date and K_{270} in 46 samples

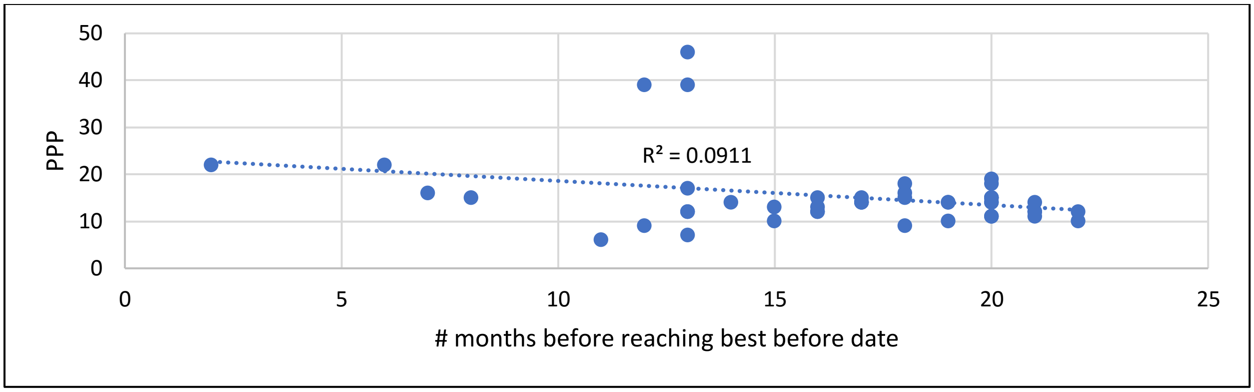

FIGURE 22. Correlations between number of months before reaching best before date and PPP in 46 samples

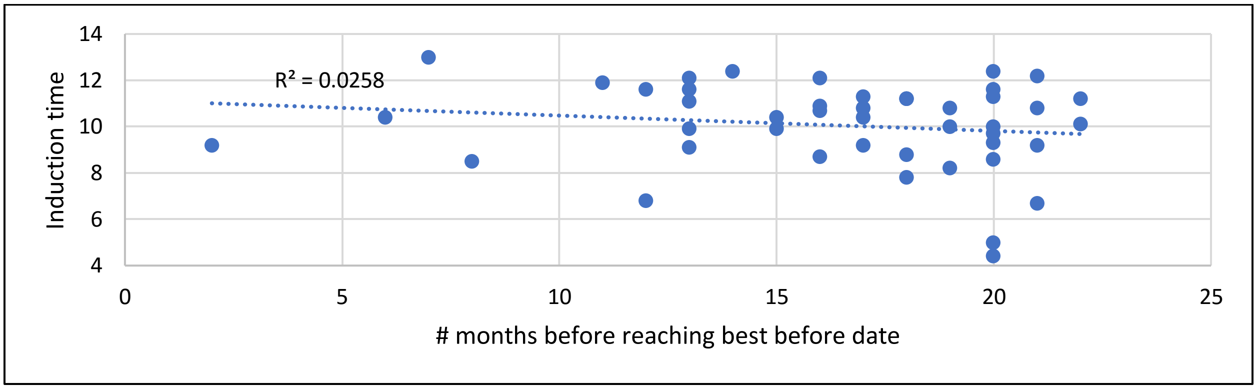

FIGURE 23. Correlations between number of months before reaching best before date and induction time in 46 samples

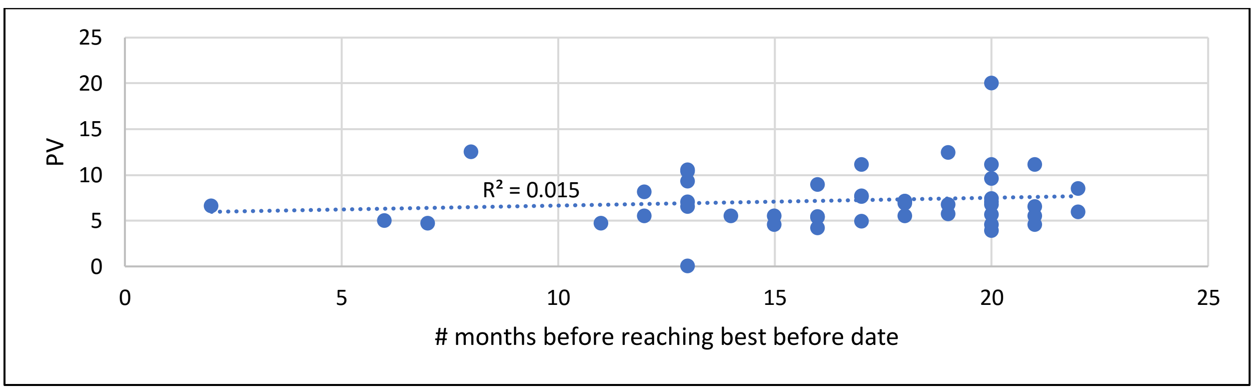

FIGURE 24. Correlations between number of months before reaching best before date and PV in 46 samples

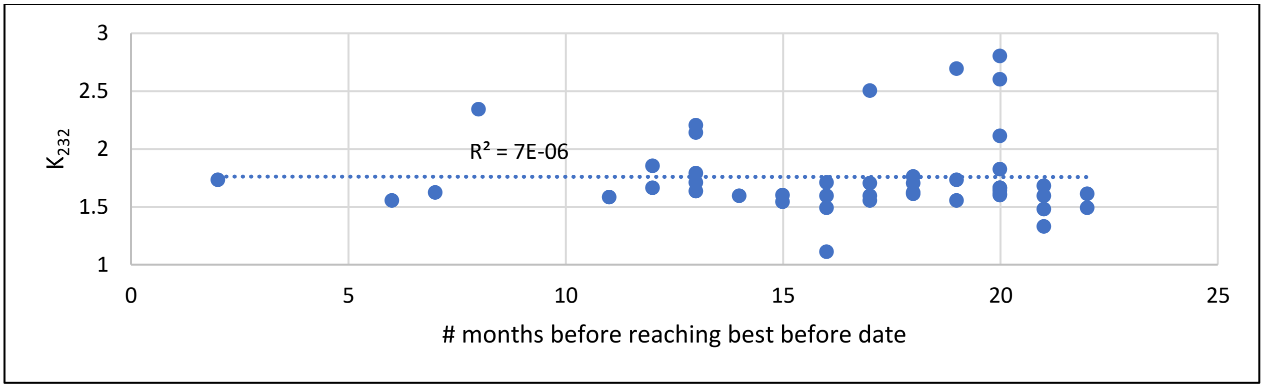

FIGURE 25. Correlations between number of months before reaching best before date and K_{232} in 46 samples

CONCLUSIONS

The quality of Extra Virgin olive oils gradually declines due to oxidation. Producers have the challenge of minimizing the oxidation rate to ensure that Extra Virgin olive oils meet grade standards one year or more after the harvest date. This study provided a first look at the performance of California olive oils approximately one year after harvest sold through common retail channels.

The 39 olive oil samples from OOCC members and store brands passed California Extra Virgin standards at 90 percent and 88 percent, respectively, even with California standards being stricter than international standards. The results suggest that the OOCC and its assessed growers and handlers are advancing a reputable level of Extra Virgin quality.

The 11 samples from handlers that are not among OOCC growers and handlers had a far lower pass rate of 18 percent. The five fusty samples were from producers outside of the OOCC – these samples were defective because of substandard fruit, processing or storage and should not have been packaged as Extra Virgin grade. The five samples graded as Crude also were from producers outside of the OOCC. These handlers would benefit from education on best practices as well as careful monitoring of their product shelf life.

The data produced in this report can serve as baseline data for the commission to compare the performance of California olive oils in future years and to consider the data in assessing shelf-life prediction models.

RECOMMENDATIONS

- The OOCC may wish to investigate whether there are growers and handlers currently handling more than 5,000 gallons of California olive oil annually testing without complying to the assessment requirements of the commission.

- The OOCC should include in this education that oils with a fermentative defect should not be released as Extra Virgin grade and excessively aged oil should not be available for purchase as Extra Virgin grade.

- The OOCC may wish to consider immediately alerting a handler when a sample collected from the handler through the commission's mandatory testing program fails extra virgin standards. The alert may help prevent a failed lot from entering the market.

- The OOCC may wish to regularly provide OOCC handlers information on best practices for post-harvest, processing and storage related to olive oil production, particularly for handlers testing indicates substandard quality.

- The OOCC may wish to develop and distribute guidelines to retailers that would help minimize oxidation when California olive oils are on the shelf or in storage.

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[i] https://www.ers.usda.gov/topics/food-markets-prices/retailing-wholesaling/retail-trends.aspx