Evaluation of 50 California Olive Oil Samples at Least One Year after Harvest 2017

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UCDAVIS
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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 harvest dates. This report summarizes the data, evaluates the results and provides recommendations.

METHODOLOGY

The study team examined two primary sources in determining retail outlets in which to purchase samples:

- **United States Department of Agriculture (USDA).** The study team consulted the website for the USDA Economic Research Service (ERS) for information on retail trends. The USDA website includes a 2017 report with recent information on retail expenditures for food to consume at home. The report found that traditional food stores (primarily supermarkets of more than 9,000 square feet with nonfood sales under 15 percent, such as Safeway and Trader Joe's) accounted for 61 percent of food-at-home expenditures as of 2012. Market share for supermarkets has slipped since 1999, when the share was 80 percent. Expenditures at supercenters, which are mass merchandisers combined with full supermarkets (e.g., Walmart Supercenter and Super Target), have grown from 3 percent to 18 percent between 1999 and 2012. Club stores, which are large-format stores requiring membership, such as Costco and Sam's Club, accounted for 9 percent of food-at-home sales, followed by mass merchandisers, which are large department stores that carry limited grocery products, such as older Walmart and Target stores, accounting for 3 percent of expenditures. Drug stores, dollar stores and convenience stores combined for 5 percent of expenditures, and other outlets such as commissaries and farmers' markets accounted for 4 percent.[1]

- **IRI 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 also was interested in getting a broad range of samples from a single metropolitan area. This year the study team focused on the Fresno metropolitan area, which is the 7th largest metropolitan statistical area in California and 55th largest in the nation.[2] The study team compiled a list of retail outlets in Fresno to approximate the sales described in the USDA and IRI data. Forty-four samples were purchased in the Fresno area on October 25 and October 26, 2017 from deli markets, supermarkets, warehouse club/supercenter stores, and a tasting room; six samples were collected through the UC Davis Student Housing Dining Service on November 22, 2017. The study team oversampled from delicatessens to take in a broader range of brands than in the previous study, to account for the limited number of California brands at supercenters and club stores, and in recognition that California brands are largely absent from drug stores, dollar stores and convenience stores.

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[1] Volpe, R., Kuhns, A., & Jaenicke, T. (2017). Store Formats and Patterns in Household Grocery Purchases. *Economic Research Service at the United States Department of Agriculture.*

[2] Wikipedia, "List of metropolitan statistical areas," rank as of July 1, 2017 as estimated by the United States Census Bureau.

In total, the study team purchased 50 extra virgin olive oil samples: 30 samples (60 percent) from seven supermarkets, nine samples (18 percent) from two delicatessens and an olive oil specialty store, four samples (8 percent) from two supercenters, one sample (2 percent) from a club store and six samples (12 percent) through the UC Davis Student Housing Dining Service. There were 23 brands represented in the 50 samples, compared to 18 brands in the previous year's study.

Thirty-one samples (62 percent) came from OOCC members, 14 samples (28 percent) came from producers that were not OOCC members (during the year when the oils were produced) and five samples (10 percent) came from store brands that presumably were sourced from OOCC members.

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 67°F to 81.5°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.

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 O2/kg oil
Ultraviolet absorbance (UV)	Conjugated double bonds are formed from natural nonconjugated 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%
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)	Not required in California olive oil standards

The UC Davis Olive Center Laboratory conducted chemistry analysis of the samples in January and February 2018. When a sample failed chemistry analysis, it was sent it to the Eurofins Central Analytical Laboratories in New Orleans for retesting.

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. For samples that failed the sensory standard for Extra Virgin grade, the panel re-evaluated them in January 2018.

The study team considered a sample to have failed California extra virgin standards if it failed any chemistry standard from both laboratories and/or failed both sensory panel tests.

STORE INFORMATION

At each warehouse/supercenter and traditional food store/supermarket, 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 at the bottom shelves ranged from 65°F to 75°F and maximum temperatures from the top shelves ranged from 68.5°F to 76.5°F. These temperatures were warmer than the 2016 study, in which the minimum store temperatures ranged from 60°F to 70°F and the maximum temperatures ranged from 65°F to 73°F.[3]

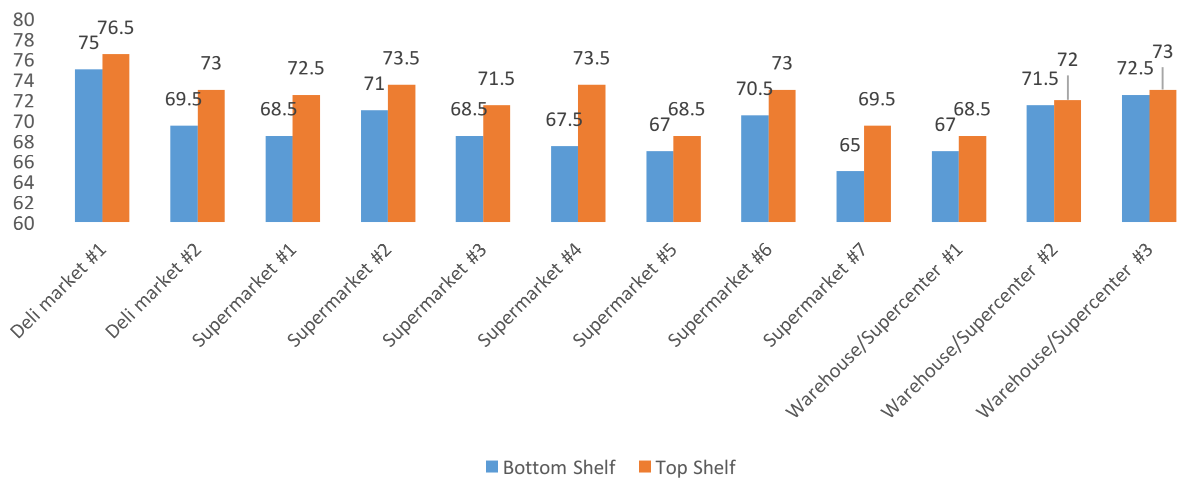

FIGURE 1. Temperature at shelf (°F)

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 74 (last year the range was four to 80) and the California selections ranged from one to 20 (last year the range was from one to 34).

[3] Evaluation of 50 California Olive Oil at Marketplaces (2016). *UC Davis Olive Center.*

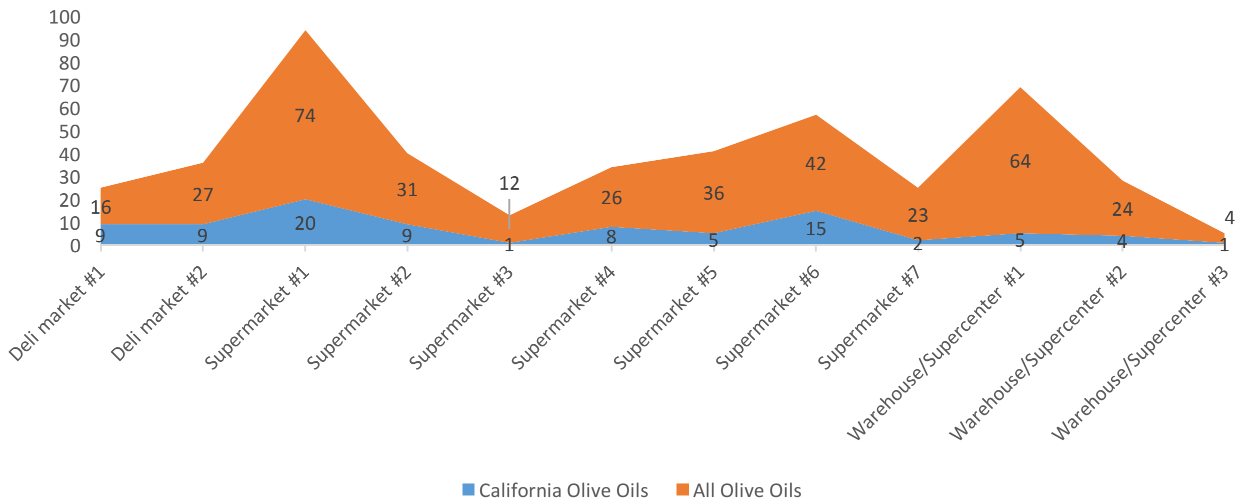

FIGURE 2. Number of olive oils at each store

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 86 inches at Deli market #1 to a high of 564 inches at Supermarket #1 for all olive oils (the range last year was 102 inches to 575 inches), and a low of nine inches at Supermarket #7 to a high of 134 inches at Supermarket #1 for California olive oils (the range last year was from 10 inches to 255 inches). The percentage of California olive oils ranged from a low of eight percent at both Supermarket #7 and Warehouse/Supercenter #1 to a high of 41 percent at Deli market #1 (the range last year was five to 55 percent.)

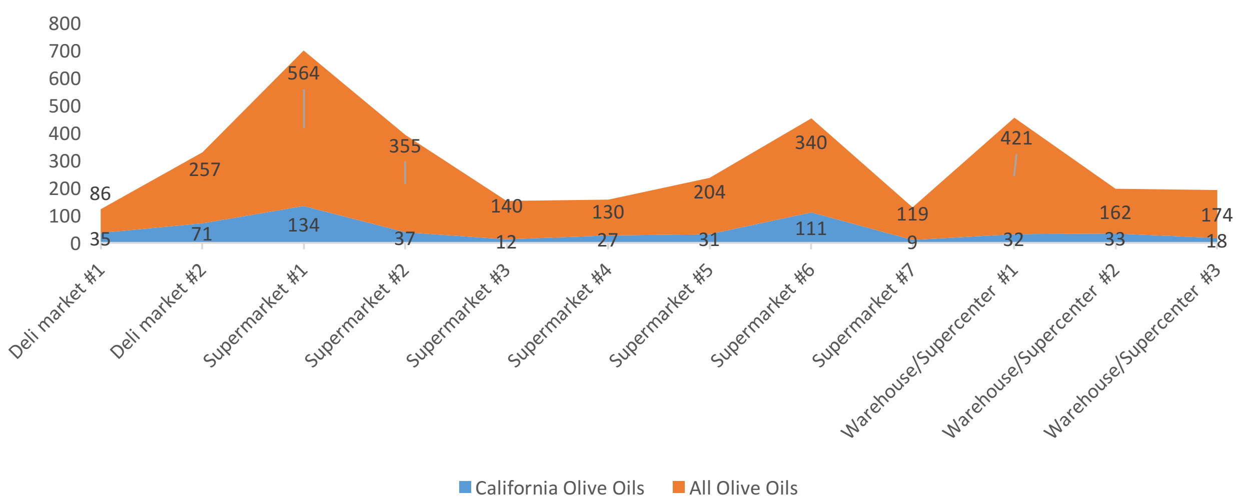

FIGURE 3. Shelf space (inches) for olive oils at each store

The study team recorded the placement of the samples on store shelves. Placement on the top shelf is undesirable because it has the warmest temperature and the greatest exposure to light, which can hasten the aging of the oil. Figure 4 shows the shelving locations of the samples. Seven percent of the samples were taken from the top shelf (compared to 19 percent in the previous year), and 47 percent of samples were taken from the next two shelves below (compared to 53 percent in the previous year).

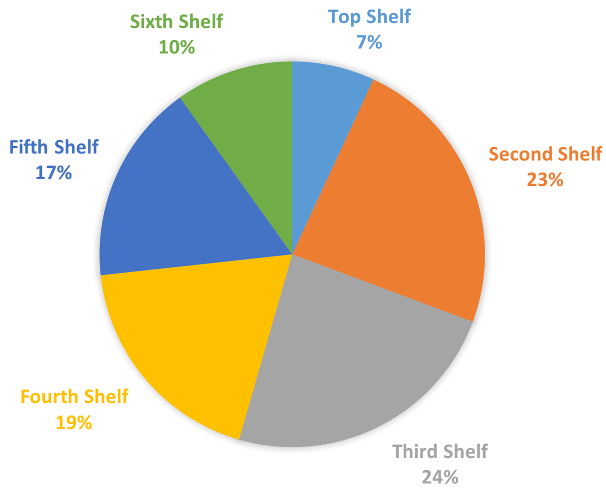

FIGURE 4. Shelving location for the purchased samples from stores

CHEMISTRY AND SENSORY RESULTS

Of the 31 samples from the OOCC members, 74 percent (23 samples) met California Extra Virgin standards (last year the passage rate was 90 percent). Of the 14 samples not overseen by the OOCC, 50 percent (7 samples) met the standards. This was an improvement over last year's passage rate for non-OOCC samples, which was 18 percent. Eighty percent of the five store-brand samples (4 samples) met the standards (last year the rate was 88 percent). No clear correlation between the failed samples and the shelving location (Figure 4) was observed.

Figure 5 shows that all the samples passed the FFA and ΔK tests at a 100 percent rate. The 31 OOCC samples passed the rest of the tests at rates above 90 percent except for sensory with a 77 percent passage rate. Four of the five store-brand samples passed all tests, with one sample failing the K_{232} and K_{270} UV tests. The 14 samples from non-OOCC members had lower pass rates than either the OOCC or store-brand samples for most tests: PV (86 percent), K_{270} (86 percent), K_{232} (79 percent), PPP (79 percent) and sensory (57 percent) and DAGs (93 percent).

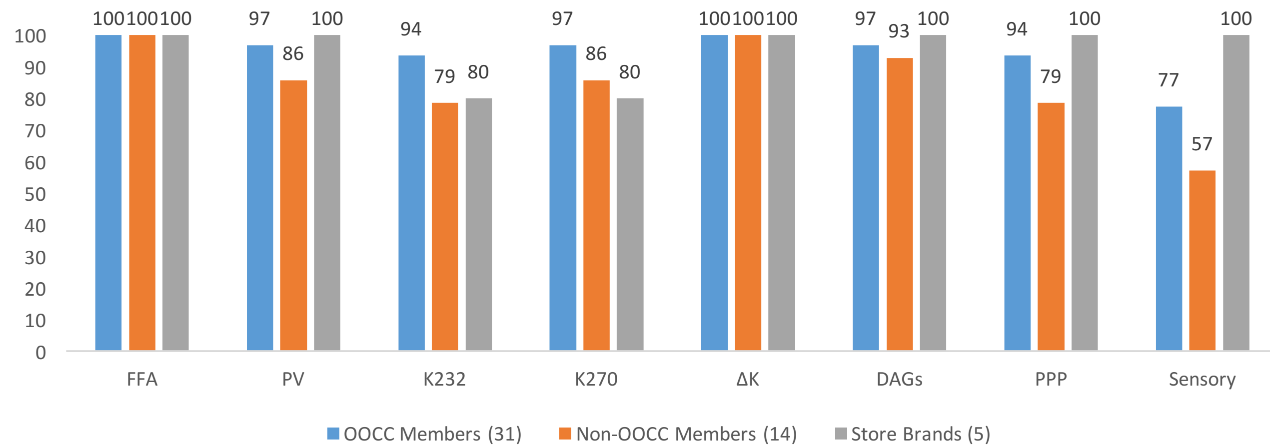

FIGURE 5. Pass rate for OOCC members and non-members (%)

Overall, 68 percent of the 50 samples (34 samples) passed all California Extra Virgin standards (last year the rate was 74 percent) and 32 percent (16 samples) failed at least one California standard for the grade (last year 26 percent). The percentage of samples passing or failing each test is summarized in Figure 6. One-hundred percent of samples passed the standards for FFA and ΔK; 96 percent passed the standard for DAGs; 94 percent passed the standard for PV; 92 percent passed the standard for K_{270}; 90 percent passed the standard for PPP; 88 percent passed the standard for K_{232}; and 74 percent passed the standard for sensory.

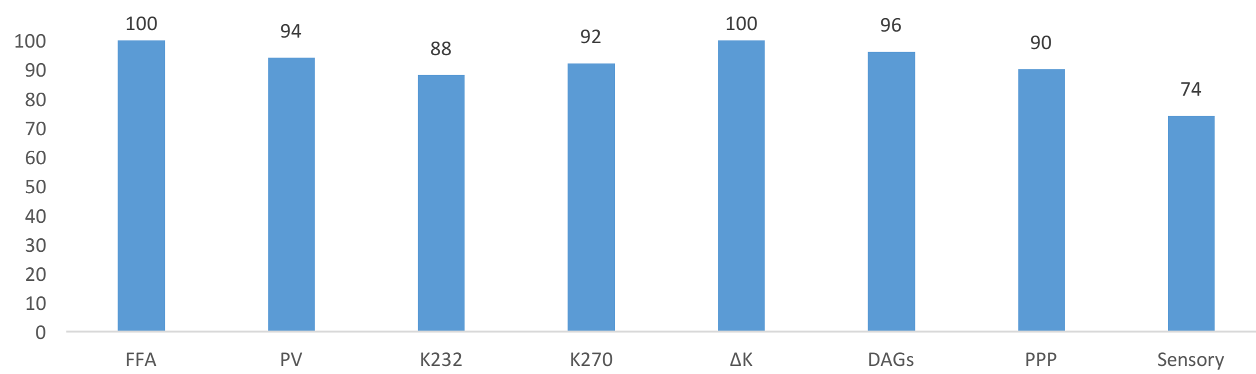

FIGURE 6. Passage rate for the 50 samples; CA EVOO standards (%)

Table 2 shows the chemistry and sensory data for the 50 samples. Of the 16 samples not classified as Extra Virgin grade, 11 met the California standard for Virgin grade (Samples 1, 3, 8, 12, 14, 19, 21, 37, 43, 45 and 47) and five met the California standard for Crude grade (Samples 6, 23, 27, 29 and 39). The distribution of chemistry results is summarized in Figures 7 – 12. The distribution of positive and negative sensory attributes is shown in Figure 13.

TABLE 2. Chemistry and sensory data for the 50 samples

SAMPLE #	HARVEST YEAR	FFA	PV	K232	K270	ΔK	DAGs	PPP	INDUCTION TIME	SENSORY DEFECTS	GRADE
		≤0.5	*≤15*	*≤2.40*	*≤0.22*	*≤0.01*	*≥35*	*≤17*	*N/A*	*MeD=0.0*	*Ex Virgin*
		≤1.0	*≤20*	*≤2.60*	*≤0.25*	*≤0.01*	*N/A*	*N/A*	*N/A*	*0.0<MeD≤2.5*	*Virgin*
		>1.0	*>20*	*>2.60*	*>0.25*	*≤0.01*	*N/A*	*N/A*	*N/A*	*MeD>2.5*	*Crude*
1	2016	0.15	9.1	2.01	0.14	0.00	49	26	11.7	Rancid: 0.9, 1.0	Virgin
2	2016	0.19	13.1	2.15	0.13	0.00	57	8	8.5		Extra Virgin
3	2016	0.35	14.7	2.37	0.15	0.00	38	19	6.1	Rancid: 0.6, 0.7	Virgin
4	2016	0.20	5.3	1.60	0.11	0.00	59	10	12.3		Extra Virgin
5	2015	0.16	8.0	1.93	0.13	0.00	48	15	10.6		Extra Virgin
6	2016	0.16	18.4	3.15	0.15	0.00	53	17	7.1		Crude
7	2016	0.20	10.6	2.23	0.17	0.00	59	15	9.6		Extra Virgin
8	2016	0.31	9.8	2.18	0.13	0.00	41	13	7.9	Rancid: 0.6, 0.8	Virgin
9	2016	0.22	6.2	1.57	0.09	0.00	58	9	8.1		Extra Virgin
10	2016	0.33	6.8	1.68	0.14	0.00	41	15	13.2		Extra Virgin
11	2016	0.15	5.5	1.72	0.13	0.00	66	11	14.0		Extra Virgin
12	2016	0.49	8.5	2.24	0.21	0.00	36	14	16.8	Rancid: 1.0, 0.5	Virgin
13	2016	0.18	8.9	1.97	0.12	0.00	62	11	11.5		Extra Virgin
14	2016	0.27	7.5	1.71	0.12	0.00	41	15	8.8	Rancid: 0.5, 1.0	Virgin
15	2016	0.30	4.7	1.77	0.12	0.00	41	16	9.3		Extra Virgin
16	N/A	0.19	4.8	1.79	0.15	0.01	49	13	8.4		Extra Virgin
17	2016	0.18	6.0	1.81	0.17	0.00	59	13	13.4		Extra Virgin
18	2016	0.22	6.6	1.69	0.12	0.00	47	14	9.8		Extra Virgin
19	2016	0.27	2.3	1.71	0.13	0.00	40	17	9.2	Rancid: 0.9, 0.9	Virgin
20	2016	0.19	2.9	1.68	0.14	0.00	55	15	9.8		Extra Virgin
21	2016	0.47	6.6	1.62	0.13	0.00	38	10	10.5	Rancid: 0.5, 0.8	Virgin
22	2016	0.23	6.7	1.72	0.11	0.00	45	13	9.5		Extra Virgin
23	2015	0.23	18.5	3.37	0.24	0.00	41	17	5.9	Rancid: 1.2, 1.3	Crude
24	2016	0.20	5.8	1.70	0.12	0.00	43	17	10.9		Extra Virgin
25	2016	0.31	6.8	1.72	0.13	0.00	36	12	12.0		Extra Virgin
26	2016	0.27	7.1	1.83	0.11	0.00	41	14	9.4		Extra Virgin
27	2015	0.21	10.4	2.46	0.28	0.01	43	32	10.8	Rancid: 1.1, 1.3	Crude
28	2016	0.27	6.4	1.84	0.12	0.00	43	13	9.3		Extra Virgin
29	2016	0.17	11.1	3.13	0.27	0.01	45	17	7.4		Crude
30	2016	0.26	6.6	1.83	0.12	0.00	46	14	10.4		Extra Virgin
31	2016	0.31	6.5	1.49	0.11	0.00	38	16	10.5		Extra Virgin
32	2016	0.21	6.6	1.67	0.09	0.00	45	13	8.6		Extra Virgin
33	2016	0.30	7.3	1.55	0.13	0.00	37	14	11.9		Extra Virgin
34	2016	0.28	8.3	1.82	0.10	0.00	42	13	8.9		Extra Virgin
35	2016	0.28	7.4	1.76	0.10	0.00	42	14	9.5		Extra Virgin
36	2016	0.29	8.4	1.86	0.11	0.00	38	16	8.8		Extra Virgin
37	2016	0.18	8.3	1.98	0.12	0.00	49	21	11.1		Virgin
38	2016	0.23	5.7	1.57	0.09	0.00	47	17	11.5		Extra Virgin
39	2014	0.35	25.5	3.74	0.26	0.00	33	17	4.1	Rancid: 1.5, 1.9	Crude
40	2016	0.30	10.1	1.99	0.12	0.00	46	10	8.6		Extra Virgin
41	2016	0.32	9.2	1.97	0.15	0.00	40	13	11.4		Extra Virgin
42	2016	0.18	7.9	1.91	0.15	0.00	61	13	13.5		Extra Virgin
43	2016	0.37	7.7	1.68	0.14	0.00	34	19	9.4	Rancid: 0.7, 1.0	Virgin
44	2016	0.43	9.8	2.32	0.22	0.01	37	15	17.5		Extra Virgin
45	2016	0.28	12.5	2.55	0.12	0.00	38	11	6.4	Rancid: 0.4, 0.8	Virgin
46	2016	0.27	7.8	1.86	0.11	0.00	42	12	9.1		Extra Virgin
47	2016	0.17	9.2	1.92	0.13	0.00	54	15	9.5	Rancid: 1.5, 1.9	Virgin
48	2016	0.18	6.6	1.82	0.11	0.00	64	12	12.7		Extra Virgin
49	2016	0.18	6.4	1.86	0.17	0.00	63	14	13.4		Extra Virgin
50	2016	0.22	3.6	1.45	0.09	0.00	52	12	12.7		Extra Virgin

The performance of the 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). All samples had FFA values below the California Extra Virgin standard of 0.5. Forty-six of 50 samples (92 percent) had FFA values ranging from 0.15 – 0.35 with only four samples having FFA values above 0.35. FFA values do not change substantially under proper storage conditions during the shelf life of the oil.

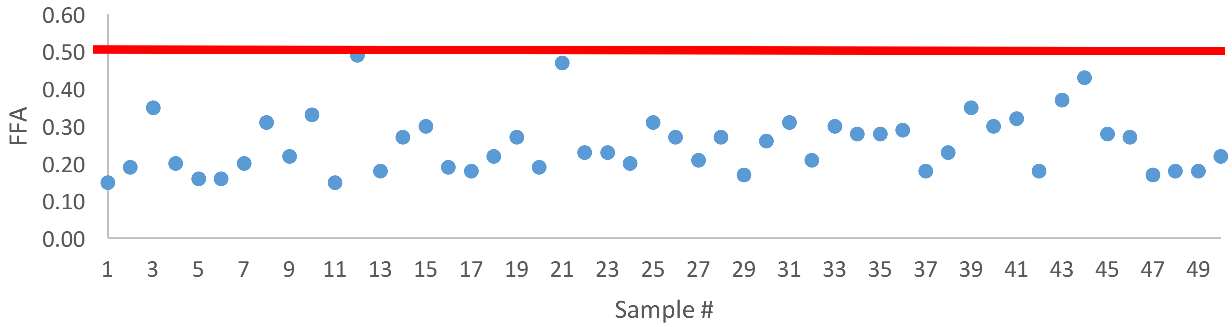

FIGURE 7. Free fatty acidity (CA EVOO ≤ 0.5)

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 (Samples 6, 23 and 39) had PV greater than 15 which would place them in the Virgin grade. All three samples failed at least one other Extra Virgin chemistry standard, including one of the UV tests and/or sensory. All of the failed samples were oxidized, likely due to natural aging or suboptimal storage or transport conditions. Similar to last year, other rancid samples passed the PV Extra Virgin standard, suggesting the limitations of the PV test in assessing olive oil quality.

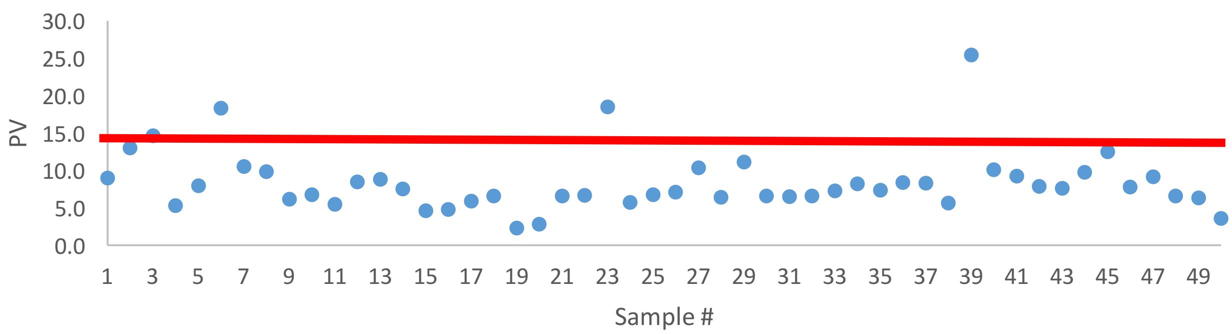

FIGURE 8. Peroxide value (CA EVOO ≤ 15)

K_{232} Similar to PV, K_{232} measures initial oxidation products in the oil. Samples 27 and 45 had K_{232} values between 2.40 and 2.60 which would place them in the Virgin grade while Samples 6, 23, 29 and 39 exceeded 2.60 which would categorize them as Crude grade. Four of these six samples also had rancid defects and elevated PV (greater than 10). These oils were oxidized, likely due to natural aging or suboptimal storage or transport conditions.

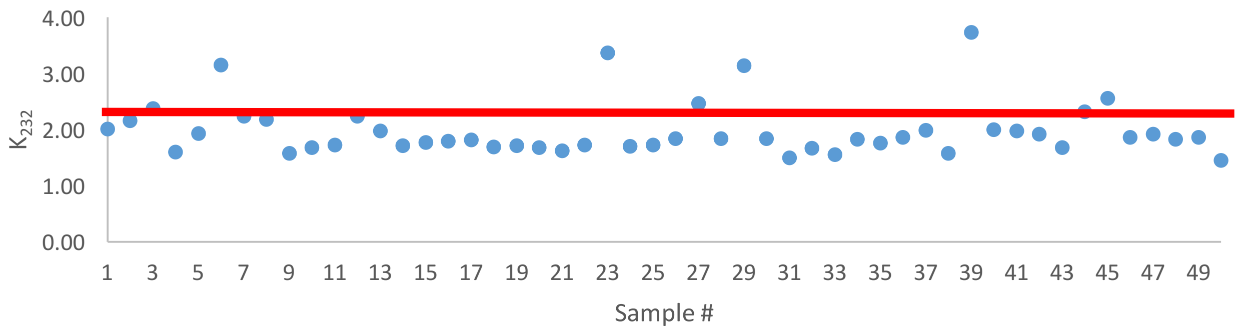

FIGURE 9. Absorbency in ultraviolet K_{232} (CA EVOO ≤ 2.40)

K_{270} K_{270} (or K_{268}) measures secondary oxidation products, which indicate that oxidation has advanced past initial oxidation. Four samples (Samples 23, 27, 29 and 39) exceeded the California Extra Virgin standard of 0.22 while one Extra Virgin sample (Sample 44) was on the K_{270} borderline of 0.22. The failed samples had K_{270} values ranging from 0.24 to 0.28, and three of them would meet the Crude standard (K_{270} > 0.25). Three of the four samples also had a high level of K_{232} (greater than 2.40) and a significant intensity of rancid defect (greater than 1.0), suggesting that advanced oxidation has taken place. Three of the four samples were among the oldest in the study (two years or more from harvest).

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.

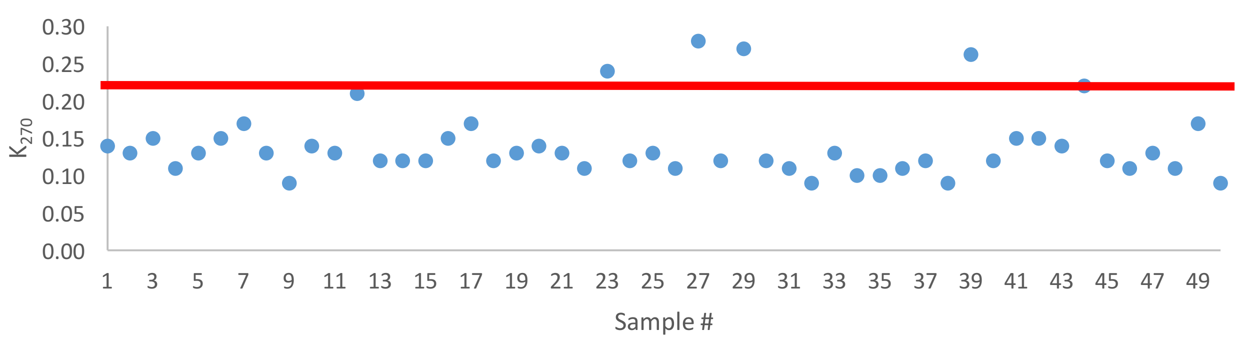

FIGURE 10. Absorbency in ultraviolet K_{270} (CA EVOO ≤ 0.22)

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 is reasonable that none of the samples would have the high DAGs values found in fresh oils (> 90 percent). Two samples (Samples 39 and 43) failed the California Extra Virgin standard with DAGs values below 35. An additional nine samples (Samples 3, 12, 21, 25, 31, 33, 36, 44 and 45) had borderline DAGs levels between 36 and 38, with four of these samples categorized by sensory analysis as Virgin grade.

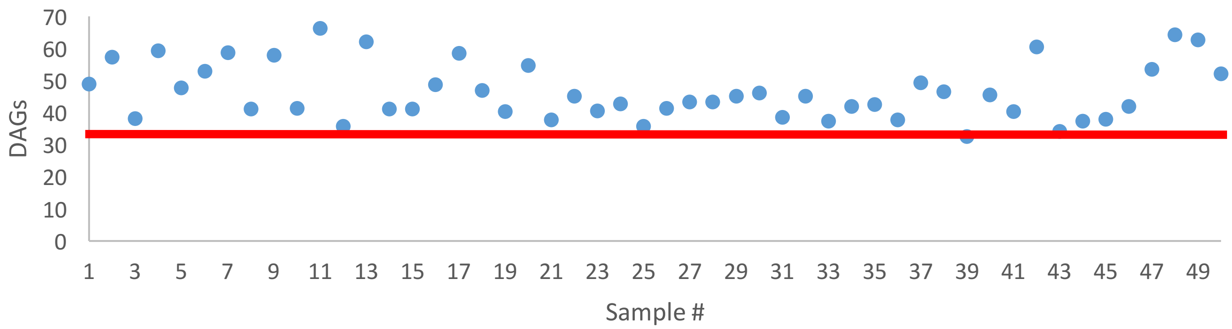

FIGURE 11. 1,2-Diacylglycerols (CA EVOO ≥ 35)

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. Five samples (Samples 1, 3, 27, 37 and 43) exceeded the California Extra Virgin standard of 17. Four of these samples failed other standards and had rancid defects. These samples may have been stored in suboptimal packaging or conditions as temperature and light can significantly affect the rate of chlorophyll *a* degradation.

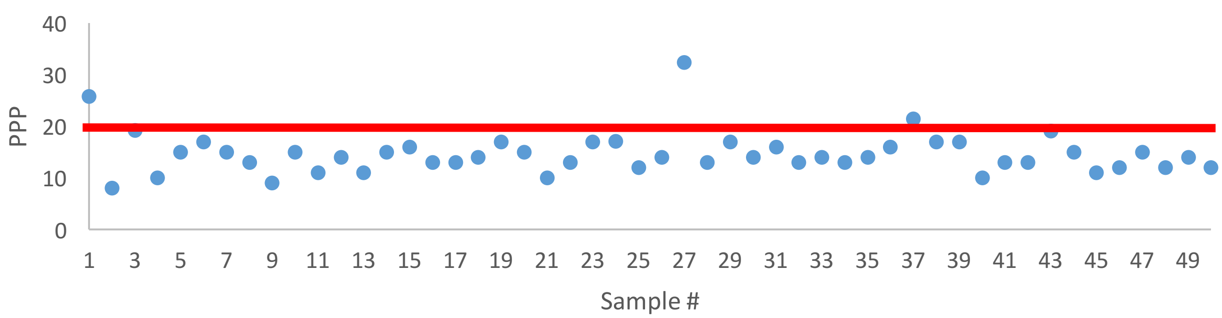

FIGURE 12. Pyropheophytins (CA EVOO ≤ 17)

Sensory Thirteen samples (Samples 1, 3, 8, 12, 14, 19, 21, 23, 27, 39, 43, 45 and 47) failed the Extra Virgin grade for both sensory panel evaluations. All of these samples had a rancid defect within the Virgin grade (median of defect of ≤ 2.5). There was generally a strong relationship between the sensory results and chemistry results: seven of the 13 samples that failed the sensory standard also failed at least one chemistry standard (Samples 1, 3, 23, 27, 39, 43 and 45). Three of the four samples that had the median of rancid defect over 1.0 also had high values of K_{232} and/or K_{270} while one of the four had a significantly elevated value of PPP at 32 – all four samples were categorized as Crude grade.

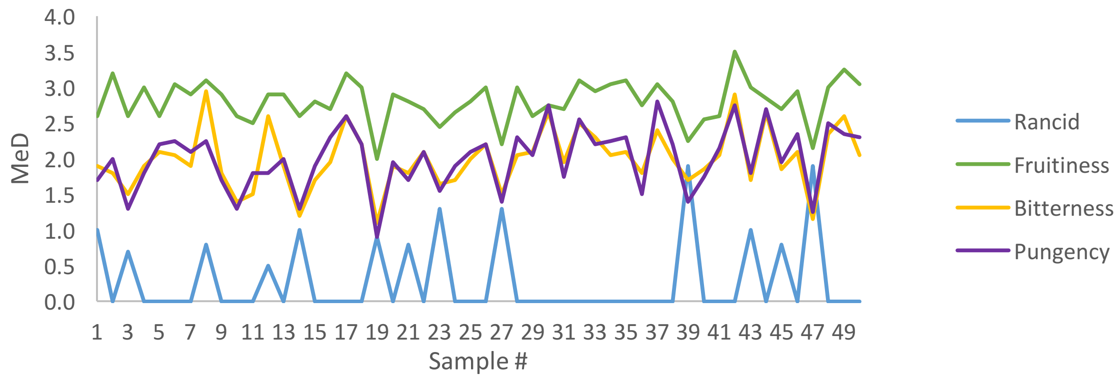

FIGURE 13. Medium scores of sensory attributes on rancid, fruitiness, bitterness and pungency

Induction time In addition to analyzing the samples for the quality parameters in California olive oil standards, the research team also measured 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. Figure 14 shows that induction time for the 50 samples ranged from 4.1 hours to 17.5 hours. If induction time accurately predicted shelf life then one would expect that oils that fail Extra Virgin standards (indicated by red dots Figure 14) would have the lowest induction times, however, only 11 out of 16 failed samples had induction time lower than 10 hours (Samples 3, 6, 8, 14, 19, 23, 29, 39, 43, 45 and 47).

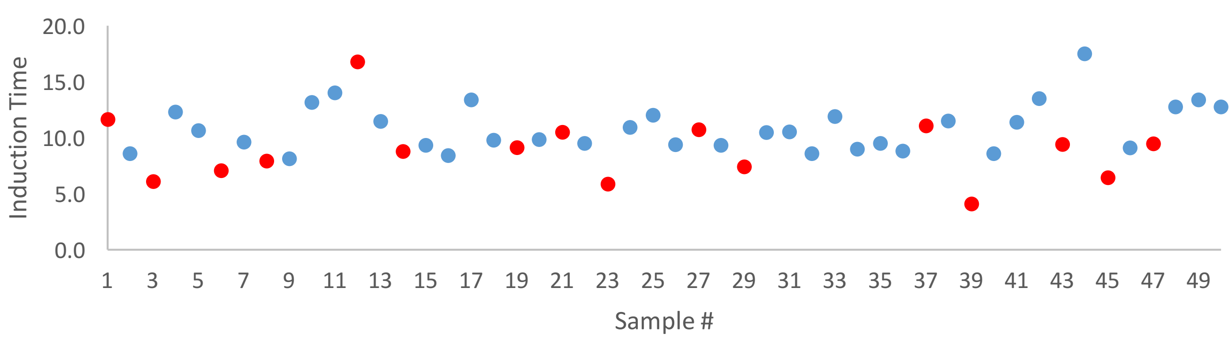

FIGURE 14. Induction time of olive oil samples

COMPARING 2016 RESULTS TO 2017 RESULTS

The study team compared the results of this study and last year's study to provide some insights as to potential reasons for why the values in the 2016 data differed in some ways from the 2017 data. In providing this comparison, it is important to bear in mind that the sample sets were not identical in the two studies. For example, the 2016 study included 18 brands while the 2017 study had 23 brands. Eighty percent of the 2016 samples came from supermarkets compared to 60 percent for the 2017 samples. A higher proportion of the 2016 samples came from the largest processors (54 percent) compared to 2017 (48 percent). With these caveats in mind, we examine key differences in the 2017 data compared to the 2016 data.

Slightly wider and/or less favorable range for some chemistry tests in 2017 compared to 2016 Extra Virgin samples collected from Fresno and San Joaquin Counties in 2017 had slightly wider ranges for FFA, PV, K_{270} and ΔK compared to Extra Virgin samples collected from the Sacramento region in 2016. The values in 2017 came closer to the limits for the grade than in 2016.

For DAGs, the 2017 data range of 36 to 66 was less favorable compared to 2016 (43 to 74). Higher DAGs values are found in fresher olive oil samples.

TABLE 3. Comparison of range of values for samples graded as Extra Virgin in 2016 and 2017

	EVOO SAMPLE RANGE		CA LIMIT
YEAR OF STUDY	2016 (37 out of 50 samples)	2017 (34 out of 50 samples)	
STORE LOCATION (COUNTY)	Yolo, Sacramento and Sonoma	Fresno and San Joaquin	
FFA	0.13 - 0.31	0.15 - 0.43	≤ 0.5
PV	3.9 - 12.5	2.9 - 13.1	≤ 15.0
K_{232}	1.11 - 2.34	1.45 - 2.32	≤ 2.40
K_{270}	0.07 - 0.19	0.09 - 0.22	≤ 0.22
ΔK	0.00 - 0.00	0.00 - 0.01	≤ 0.01
DAGs	43 - 74	36 - 66	≥ 35
PPP	6 - 17	8 - 17	≤ 17

Percentage of Extra Virgin samples was lower for OOCC samples in 2017 Table 4 compares the grade of the samples collected in 2016 to the grade of samples collected in 2017. The total number of OOCC samples was the same for both years at 62 percent (31 of 50 samples), however, the percentage of Extra Virgin samples decreased from 90 percent (28 of 31 samples) to 74 percent (23 of 31 samples) from 2016 to 2017 while the numbers of Virgin samples increased from 10 percent (three of 31 samples) to 19 percent (six of 31 samples) and Crude samples from zero to six percent (two of 31 samples). Table 4 also shows that the number of "non-OOCC members" increased from 22 percent (11 of 50 samples) to 28 percent (14 of 50 samples) from 2016 to 2017, and that the number of Extra Virgin samples increased from 18 percent (two of 11 samples) in 2016 to 50 percent (seven of 14 samples) in 2017.

TABLE 4. Distribution of samples in three grades (EVOO, Virgin and Crude)

		OOCC MEMBER	NON-OOCC MEMBER	STORE BRAND
# OF SAMPLES	2016	62% (31 of 50)	22% (11 of 50)	16% (8 of 50)
	2017	62% (31 of 50)	28% (14 of 50)	10% (5 of 50)
EVOO	2016	90% (28 of 31)	18% (2 of 11)	88% (7 of 8)
	2017	74% (23 of 31)	50% (7 of 14)	80% (4 of 5)
Virgin	2016	10% (3 of 31)	54% (6 of 11)	12% (1 of 8)
	2017	19% (6 of 31)	38% (5 of 14)	0 (0 of 5)
Crude	2016	0 (0 of 31)	27% (3 of 11)	0 (0 of 8)
	2017	6% (2 of 31)	14% (2 of 14)	20% (1 of 5)

Rancidity was the only sensory defect in 2017 In 2016, five samples had fusty/muddy sediment defects in addition to rancidity defects whereas in 2017 the only detectable sensory defect was rancidity. This suggests that growers and handlers were able to avoid processing substandard/fermented fruit prior to processing in 2017, or at least not classifying the resulting oil as Extra Virgin grade.

There are several potential explanations for the differences between the 2016 and 2017 results:

- Selecting a broader number of brands in 2017 compared to 2016 (23 and 18, respectively) led to a slightly broader range of some chemical quality parameters in 2017.
- The 2017 samples experienced higher temperatures than the 2016 samples. As previously noted, the study team found higher shelf temperatures in 2017 compared to 2016 (Figure 1). Moreover, the average annual temperatures in Fresno and San Joaquin Counties is higher than in the 2016 study's Sacramento, Yolo and Sonoma Counties. For example, the average summer temperature in Fresno and San Joaquin Counties is 96°F while that of the Sacramento Region is 92°F.[4]
- There were four 2017 samples that were at least two years old, double the amount in 2016. Older samples tended to have the lowest chemical quality.

Variability in the two studies might also be related to warehouse temperatures and product-turnover rate, but these factors were beyond the scope of the study.

CONCLUSIONS

Samples from OOCC members passed California Extra Virgin standards at 74 percent and store brands passed the standards at 80 percent. These passage rates are lower than the rates of the samples analyzed in the 2016 study (90 percent and 88 percent, respectively). The difference in the two studies may be related to a larger number of brands in 2017 with more variability, higher temperatures in 2017 in the Fresno region and on the shelves, and a larger number of samples more than two years old in this year's study.

[4] https://www.ncdc.noaa.gov/. *National Centers for Environmental Information.*

The 14 samples from handlers outside of the OOCC had a passage rate of 50 percent, which was significantly higher than the 18 percent rate in last year's study. These growers and handlers may benefit from better processing and storage practices and improved tracking of their product shelf life.

The sensory and chemistry results suggested that oxidation was the major reason why some samples did not pass California Extra Virgin standards, as indicated by results for the PV, UV, PPP and sensory. Minimizing oxidation is the key challenge for handlers, distributors and retailers to protect olive oil quality over its shelf life.

RECOMMENDATIONS

- The OOCC may wish to conduct workshops to disseminate the lessons learned from the last two year's studies and best practices on post-harvesting, processing and storage. The OOCC may revisit the study in two or three years, using the results from 2016 and 2017 as a quality benchmark for California olive oil.

- The OOCC may wish to develop and distribute guidelines to producers and retailers that would help minimize oxidation when California olive oils are in transit, on the shelf and in storage. For example, the commission may wish to investigate the feasibility of using temperature log instruments in olive oil cases or bottles to track temperatures in transportation and storage and to encourage retailers to move the olive oil category to a cooler section of the store.

- The OOCC may help to develop best practices on the labelling of best-before date and lot number for the purpose of tracking product quality. Several samples that did not pass California Extra Virgin standards lack the information of lot number and/or best-before date on the label, which made it difficult to assess the possible cause(s) for quality degradation.

- The OOCC may wish to investigate whether there are growers and handlers handling more than 5,000 gallons of California olive oil annually and who are not currently being assessed by the commission.