Evaluation of Mandatory Testing California Olive Oil 2020/21 Season

Submitted to the

Olive Oil Commission of California

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UC **DAVIS** Olive Center at the Robert Mondavi Institute

Evaluation of Mandatory Testing, California Olive Oil, 2020/21 Season

SUMMARY

The Olive Oil Commission of California (OOCC) contracted with the UC Davis Olive Center to analyze and report on the 2020/21 data produced under the mandatory government sampling and testing program requirements of California olive oil standards (Appendix, Table 1)[1].

Under the program, the OOCC through the California Department of Food and Agriculture (CDFA) collects up to six samples from lots chosen at random at each compulsory handler[2] and sends the samples to an accredited edible oil analytical laboratory and sensory panel designated by the Commission for testing. Voluntary handlers[3] are put into a lottery and only sampled if they are chosen[4]. Handlers are required to designate presumed grades of all lots prior to testing and separately sample and test every lot in inventory, regardless of harvest year, for the quality parameters specified in California standards.

Of the 151 samples collected (59 samples by the OOCC and 92 samples by 12 compulsory handlers), we found that:

- 113 out of 114 samples (99 percent) that were presumed at Extra Virgin grade were confirmed as Extra Virgin while one sample was tested as Crude.
- 7 out of 9 samples (78 percent) that were presumed at Virgin grade were confirmed as Virgin while two samples were tested as Crude.
- 3 out of 4 samples (75 percent) that were presumed at Crude grade were confirmed as Crude while one sample was tested as Virgin.
- 4 samples were tested at various grades but had no presumed grade provided by handlers.
- 20 samples had undeterminable grades due to incomplete testing data.
- A grading consistency of 93 percent was achieved for 55 lots tested by both the handlers and the OOCC.
- 4 out of 28 samples (14 percent) sent for purity testing by the OOCC did not meet certain purity parameters required in California olive oil standards.

To facilitate the Commission's goal to deliver faster testing results in the 2021/22 season, the Commission may wish to consider:

- ensuring that the CDFA inspector completes sampling all participating handlers by the end of January 2022;
- setting up reminders and checking in with handlers periodically during November 2021 and January 2022 to ensure that handlers provide complete data required in Form A such as presumed grade, variety, variety percentage, handler internal and OOCC sampling dates, and quality testing results including specific sensory defect(s);
- ensuring the certified testing laboratory chosen by the Commission perform the induction time analysis using the parameters listed in the Modern Olives model (e.g. flowrate at 20 L/h)[5] so the use-by-date can be calculated accordingly;

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[1] California Department of Food and Agriculture, "2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil", effective September 30, 2020 through June 30, 2021 unless amended or terminated.

[2] "Handler" is defined by Section 5.14 of the California standards as "is 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] Section 9, OOCC VOLUNTARY MEMBERSHIP AND STANDARD PARTICIPATION, Appendix A: Sampling, Testing and Grading Methodology for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil, 2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.

[4] Olive Oil Commission of California (October 2020), "Notice to Industry and Harvest Mandatory Requirements".

[5] Guillaume, C., & Ravetti, L. (2016). Shelf-life prediction of extra virgin olive oils using an empirical model based on standard quality tests. *Journal of Chemistry*, *2016*.

- continuing to provide feedback and education to individual handlers on post-harvest and processing practices to maximize quality; and
- modifying California olive oil purity standards to accommodate the natural variances of authentic California olive oil.

INTRODUCTION

The Olive Oil Commission of California contracted with the UC Davis Olive Center to analyze the data produced under the mandatory government sampling and testing program in the 2020/21 season. The oils were sampled and tested in accordance with California olive oil standards 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 CDFA or by an approved independent third party (sampling party). The sampling party (usually the CDFA inspector) must take up to six samples from lots chosen at random from each handler following the sampling procedures and protocols of the International Organization for Standardization (ISO)[6] and Appendix A[7] in the California olive oil standards, and send the samples to an accredited laboratory for analysis. Standards also require the sampling party to randomly select a number of samples for testing based on the purity parameters indicated in the standards at an analytical laboratory designated by the Commission. California standards do not allow lots that fail purity testing to be sold as olive oil, refined olive oil or olive-pomace oil, although standards do allow the Commission to provide exceptions upon the Commission's review and acceptance[8] of the handler's traceability documentation[9].

In addition to the sampling and testing conducted by the OOCC/CDFA inspector, the standards require each handler to sample, test, and grade all lots of olive oil inventory, regardless of harvest year, by a certified laboratory chosen by the handler, including the handler's own laboratory if certified, following an official testing method described in the standards and submit all the information required in Form A (Appendix, Table 2) to the Commission. Grading is based on the quality standards summarized in Table 1, with descriptions of the tests in Appendix Table 1.

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 (MOI) %	≤0.2	≤0.2	≤0.3
Insoluble Impurities (INI) %m/m	≤0.1	≤0.1	≤0.2
Pyropheophytin a (PPPs) %	≤17	N/A	N/A
1,2–Diacylglycerols (DAGs) %	≥35	N/A	N/A
Organoleptic/Sensory Median of Defects (MeD)	=0.0	0.0<MeD≤2.5	>2.5
Organoleptic/Sensory Median of Fruity (MeF)	>0.0	>2.5	N/A

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[6] ISO 5555:2001- International Standard, Animal and Vegetable Fats and Oils-Sampling.
[7] Appendix A: Sampling, Testing and Grading Methodology for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil, 2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.
[8] Section 7.2, GRADING, Appendix A: Sampling, Testing and Grading Methodology for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil, 2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.
[9] Section 12.0, TRACEABILITY, 2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.

SAMPLE INFORMATION

A total of 151 samples were collected in the 2020/21 season by the OOCC/CDFA inspector and handlers:

- The OOCC/CDFA inspector collected 59 samples (39 percent) from 13 handlers (12 compulsory handlers and one voluntary handler). *Compulsory handler S* was not sampled by the CDFA inspector. Based on lot codes provided by the OOCC, 55 of 59 OOCC samples (93 percent) were from the same lots tested by 12 compulsory handlers.
- Twelve compulsory handlers collected a total of 92 samples (61 percent). *Compulsory handler S* and three voluntary handlers did not provide any sampling information and testing data required in Form A (Appendix, Table 2) to the Commission.

The OOCC sampling was required to be completed by February 5, 2021 with results delivered back to the handler by March 15, 2021[4]. The majority of the OOCC samples were collected by the CDFA inspector from handler lots by February 12 with one exception that *compulsory handler I* was sampled on March 5. The OOCC sent the collected samples to Eurofins Central Analytical Laboratories (New Orleans, Louisiana) for chemical testing and to Applied Sensory (Fairfield, California) for sensory analysis. Samples that did not meet the chemistry and/or sensory standards for Extra Virgin grade were retested by Eurofins Central Analytical Laboratories and/or the Applied Sensory panel.

Each handler also sent samples from all lots to a certified laboratory, including the handler's own laboratory if certified, and was required to submit the sample information and testing results listed in Form A (Appendix, Table 2) to the Commission by February 26 or apply for an extension by the same date[4].

The OOCC requires handlers to assign presumed grades when reporting lots prior to testing. In the 2020/21 season, handlers had provided presumed grades for 141 of the 151 samples (93 percent). This presumed grading percentage was the same as the 2019/20 season[10]. The CDFA annual sampling guidance also specifies that prior to the CDFA inspector's visit, the handler should have a copy of Form A ready with information showing lot code, quantity in gallon, variety (including percentages of each variety in a blend), and harvest year[11]. Of the 12 compulsory handlers who submitted Form A, 11 handlers listed lot sizes which varied from less than 100 gallons to more than 170,000 gallons and provided information on harvest time either by specific date or by harvest year. Ten of the 12 compulsory handlers also provided complete internal sampling dates ranged from November 11, 2020 and March 17, 2021 with only one sample being internally sampled after February 26, 2021.

All 13 handlers sampled by the OOCC provided complete or partial variety information on 151 samples. Table 2 shows that 94 samples (62 percent) were single-variety, 47 samples (31 percent) were blends and 10 samples (7 percent) were unspecified.

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[10] UC Davis Olive Center (2020). Evaluation of Mandatory Testing California Olive Oil 2019/20 Season.
[11] Olive Oil Commission of California (January 2020), "CDFA Annual Sampling Guidance Document".

Table 2. Samples by variety or blends (151 samples)

Variety	OOCC Samples	Handler Samples	Total Samples (%)
Arbequina	17	26	43 (28.5%)
Arbosana	6	10	16 (10.6%)
Ascolano	0	1	1 (0.7%)
Favolosa	1	1	2 (1.3%)
Frantoio	2	2	4 (2.6%)
Koroneiki	4	5	9 (6.0%)
Leccino	1	0	1 (0.7%)
Lucca	1	0	1 (0.7%)
Manzanillo	0	1	1 (0.7%)
Mission	1	2	3 (2.0%)
Picual	3	2	5 (3.3%)
Sevillano	2	5	7 (4.6%)
Taggiasca	0	1	1 (0.7%)
Blends	17	30	47 (31.1%)
Unspecified	4	6	10 (6.6%)
TOTAL	59	92	151 (100%)

A total of 108 samples (72 percent) were produced from varieties or blends that grow in the super-high-density (SHD) system, 33 samples (22 percent) were from varieties or blends that grow in other planting systems and 10 samples (7 percent) did not specify the varieties, including two crude blends.

RESULTS FOR QUALITY TESTS

Based on gallons reported by handlers to the OOCC in Form A, our review of testing data confirmed that handler production of California olive oil was graded at 90.5 percent Extra Virgin, 5.2 percent Virgin, 0.2 percent Crude and 4.1 percent undeterminable due to lack of complete data. The total gallons from the 2020/21 season had dropped significantly from the 2019/20 season due to olive's alternate bearing cycle and limited harvest and mill crews due to COVID-19. The percentage of Virgin grade oils had gone up from 1 percent to 5.2 percent while the percentage of Crude grade oils had decreased from 1 percent to only 0.2 percent.

Of the 151 samples reported, 76 percent (115 samples) tested as Extra Virgin, 6 percent (9 samples) tested as Virgin and 5 percent (7 samples) tested as Crude. The 76 percent Extra Virgin grade rate was comparable to that in the 2019/20 season at 77.5 percent. However, one sample presumed at Extra Virgin grade was tested as Crude by the OOCC. In the previous season[10], none of the samples (with complete quality testing data) tested differently from the presumed grade of Extra Virgin.

Table 3. Overview of 151 samples by grade

Tested Grade	Sample Description	# of Samples	Total # of Samples by Grade	Total % of Samples
Extra Virgin	Reported presumed grade as Extra Virgin and tested as Extra Virgin	113	115	76
	Did not report presumed grade but tested as Extra Virgin	2		
Virgin	Reported presumed grade as Extra Virgin but tested as Virgin	0	9	6
	Reported presumed grade as Virgin and tested as Virgin	7		
	Reported presumed grade as Crude but tested as Virgin	1		
	Did not report presumed grade but tested as Virgin	1		
Crude	Reported presumed grade as Extra Virgin but tested as Crude	1	7	5
	Reported presumed grade as Virgin but tested as Crude	2		
	Reported presumed grade as Crude and tested as Crude	3		
	Did not report presumed grade but tested as Crude	1		
Incomplete	Grade was not determinable due to incomplete testing data	20	20	13

Grades could not be determined for 20 samples (13 percent) due to incomplete data (Table 4). Similar to last season, all 20 samples from four compulsory handlers did not report sensory data. *Handler I* missed reporting presumed oil grades and quality testing results from three out of seven lots while *handler L* only reported varieties of each lot and presumed oil grades.

Table 4. Samples with incomplete testing data

Handler	Total # of Samples	FFA	UV	PV	Moisture & Volatile Matter	Insoluble Impurities	PPP	DAGs	Sensory
C	5	0	0	0	0	0	0	0	5
I	3	3	3	3	3	3	3	3	3
L	5	5	5	5	5	5	5	5	5
P	7	0	0	0	0	0	0	0	7
TOTAL	20	8	8	8	8	8	8	8	20

Table 5 summarizes quality testing results of 18 samples (from 11 lots) from handlers (9 samples) and the OOCC (9 samples) where:

- ten samples confirmed the presumed grade (seven Virgin and three Crude) designated by handlers;
- sample 10255 was designated as Extra Virgin grade by *handler C* but the grade was not confirmed due to missing sensory data. Sample C4 from the same lot was tested as Crude by the OOCC due to high K_{232} of 2.94 (CA standard ≤ 2.40). The sampling time difference between the handler and the CDFA inspector was just over a month, which was comparable to the sampling time difference at other handlers'. The drastic increase of K_{232} could be due to improper storage condition of that particular lot at *handler C*'s facility or mishandling by the CDFA inspector during sampling;
- sample 9-20-ST5 was designated as Crude grade by *handler L* but the grade was not confirmed due to the lack of chemistry and sensory tests. Sample L3 from the same lot was confirmed by the OOCC at Crude grade with a high FFA at 0.8 (CA standard ≤ 0.5) and a rancid defect at MeD of 2.6;
- sample US 20/371 from *handler Q* was designated as Crude grade but was tested as Virgin grade by the handler; and

- two undesignated samples Z1 and Z2 from handler Z were tested as Crude and Virgin grade by the OOCC, respectively, because of their high K_{232} values.

The OOCC does not require handlers to provide sensory analysis for lots that the handler presumes to be Crude grade if chemical testing are performed[12] although most of the samples designated as Crude grade were still tested on sensory. As a result, a total of 12 samples (seven virgin and five crude samples) had sensory defects, but seven of the samples from five handlers did not specify which defect(s). To pinpoint the potential cause(s) of the defect, it is critical for handlers to request this information from the sensory panel of chosen and provide it to the Commission. Compared to the 2019/20 season, samples from 2020/21 season did not show defects associated with wildfire and frost such as burnt and frostbitten in spite of the record wildfires and frost during the harvest season in 2020. Noticeably, elevated FFA values were found in 10 non-extra virgin samples (7 percent) produced in the 2020/21 season whereas only four samples (2 percent) in the 2019/20 season had FFA values slightly higher than 0.5 (CA standard). Similar to the 2018/19 season, low crop years generally bring challenges as higher levels of mummified fruit and increase in material-other-than-olives (MOO) are more common due to more aggressive harvesting, and longer times between harvest and delivery to the mill, since it takes longer to fill trucks[13]. All these factors hasten triacylglycerols hydrolysis in the fruit prior to processing which would yield higher initial FFA and lower initial DAGs in the produced oil.

Table 5. Summary of quality testing results indicating lower grade samples

Sampling Party	Handler Lot or OOCC ID	Handler Presumed Grade*	FFA	UV K_{232}	DAGs	Sensory	Tested Grade	Possible Cause(s) of Lower Grade
CA Extra Virgin Standard			**≤0.5**	**≤2.40**	**≥35**	**MeD=0**		
Handler	118647	Virgin	0.6	-	-	1.4 (defect not specified)	Virgin	1, 2
OOCC	A3		0.7	-	-	2.0 R	Virgin	
Handler	10255	Extra Virgin	-	-	-	No Data	Incomplete	2
OOCC	C4		-	2.94	-	-	Crude	
Handler	CR3030	Crude	> 1.1	-	32	3.0 (defect not specified)	Crude	1, 2
OOCC	D4		1.8	-	-	1.3 R, 2.7 F/MS	Crude	
Handler	VG2810	Virgin	0.7	-	-	1.3 (defect not specified)	Virgin	1
OOCC	D5		0.8	-	-	-	Virgin	
Handler	20/210301 AQ/AS	Virgin	-	-	-	1.3 (defect not specified)	Virgin	2
OOCC	F2		-	-	-	1.8 R	Virgin	
Handler	9-20-ST5	Crude	No Data				No Data	1, 2
OOCC	L3		0.8	-	-	2.6 R	Crude	
Handler	3070	Virgin	1.3	-	-	2 (defect not specified)	Crude	1, 2
OOCC	M4		1.3	-	-	2.4 R	Crude	
Handler	US 20/359	Virgin	0.9	-	-	2.0 (defect not specified)	Virgin	1
Handler	US 20/371	Crude	-	-	-	2.0 (defect not specified)	Virgin	3
OOCC	Z1	Undesignated	-	2.80	-	-	Crude	2
OOCC	Z2	Undesignated	-	2.41	-	-	Virgin	2

*: merged cells indicate the handler presumed grade applies to the two samples collected from the same lot by the handler and the OOCC, respectively; **-:** data within the standards for Extra Virgin grade; **No Data:** no data provided; **Undesignated:** presumed grade not designated by handlers; **Incomplete**: chemical and/or sensory tests not complete thus tested grade undeterminable.

Sensory defects: [R] Rancid; [F/MS] Fusty/Muddy-sediment.

Possible causes of lower grade: [1] Olives started anaerobic fermentation due to poor storage conditions (e.g. piling for extended period) or underwent hydrolysis prior to processing or oil was stored on sediment (indicated by decreased DAGs, elevated FFA and F/MS defect); [2] Oil had become oxidized (indicated by elevated K_{232} and R defect); [3] Sensory defect not identified/specified so cause of defect undeterminable.

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[12] Section 4.1.3 Crude Olive Oil, 2020-2021 Grade and Labeling Standards For Olive Oil, Refined-Olive Oil and Olive-Pomace Oil.

[13] Olive Oil Commission of California (December 2020), "California Olive Oil Crop Falls Short of 2.5 Million Gallon Estimate".

Table 6 provides a summary of the consistency of grading for identical lots that were sampled separately by the handlers and the OOCC over the past seven seasons. In the 2020/21 season, a total of 55 lots were tested by both the handlers and the OOCC. Four lots (7 percent) had grades that could not be determined:

- one lot designated and tested by *handler C* at Extra Virgin grade (based on the submitted incomplete data) but tested as Crude grade by the OOCC; and
- three lots from *handler I* did not provide the presumed grade prior to testing but they were tested as Extra Virgin grade by the OOCC.

Table 6. Olive oil grading consistency for same lots from 2014/15 to 2020/21 harvest seasons

	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Number of lots tested by both the handler and the OOCC	26	41	51	64	52	68	**55**
Number of samples in grading agreement	22	39	51	59	52	61	**51**
Percentage of samples in grading agreement	85%	95%	100%	92%	100%	90%	**93%**

Table 7 summarizes the average values of quality data for extra virgin samples over the past seven seasons. The 2020/21 season had highly comparable average values of FFA, PV, UV, moisture and volatile matter and insoluble impurities to previous seasons, suggesting proper storage conditions across handlers' facilities. However, a relatively high average of PPP and wider range of its standard deviation and a lower DAGs average were observed in the 2020/21 season. Of the 151 samples collected this year, six lots were from the 2019/20 harvest which resulted in a total of nine samples with averages of PPP and DAGs at 9 and 63, respectively. In addition, 5 percent and 42 percent of the extra virgin samples tested in the 2019/20 season had PPP over 6 and DAGs greater than 90, respectively, while these two rates were 13 percent and 19 percent for extra virgin samples tested in the 2020/21 season – both were unfavorable for oil quality and indicative of fruit quality to some extent.

The sensory results showed that this year's MeF at 3.4±0.8, which was lower than those in previous seasons[14]. In the 2020/21 season, 31 percent extra virgin samples had MeF lower than 3.0 while this rate was much lower in the previous season at only 6 percent.

Due to a shorter harvest season, many producers started milling earlier (around mid-October) which led to a longer duration for the produced oil to sit in the storage tank before getting sampled by the handler and the OOCC. Since racking is still commonly used in California olive oil industry, the higher amount of mummified fruit and MOO from the low crop year would also hasten oil degradation in the tank prior to sampling.

Table 7. Average of quality testing results for Extra Virgin grade samples from 2014/15 to 2020/21 harvest seasons

Harvest Season	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
CA Extra Virgin Standards	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	0.3±0.1	0.2±0.1	**0.2±0.1**
Peroxide Value (≤15.0)	7.3±2.8	5.9±2.9	5.5±2.5	5.3±2.6	4.3±1.6	4.9±1.9	**4.9±1.9**
UV K_{232} (≤2.40)	1.69±0.25	1.77±0.21	1.78±0.22	1.67±0.2	1.71±0.19	1.56±0.16	**1.68±0.24**
UV K_{270} (≤0.22)	0.12±0.03	0.12±0.03	0.13±0.03	0.12±0.03	0.12±0.03	0.11±0.03	**0.12±0.03**

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[14] (a) UC Davis Olive Center (2017). Evaluation of Mandatory Testing California Olive Oil 2016/17 Season. (b) UC Davis Olive Center (2018). Evaluation of Mandatory Testing California Olive Oil 2017/18 Season.

UV ΔK (≤/0.01/)	<0.003	<0.003	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	**0.00±0.00**
Moisture and Volatile Matter (≤0.2)	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	0.1±0.0	**0.1±0.0**
Insoluble Impurities (≤0.1)	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	**0.0±0.0**
Pyropheophytins (≤17)	2±1	2±1	2±1	1±1	1±1	2±2	**3±3**
1,2-Diacylglycerols (≥35)	82±10	88±6	89±7	91±6	86±6	86±9	**81±9**
Organoleptic/Sensory (MeF>0)	4.2±0.7	4.4±0.7	4.6±0.8	3.6±0.7	3.6±0.6	3.7±0.6	**3.4±0.8**

RESULTS FOR PURITY TESTS

Twenty-eight of the 59 samples collected by the CDFA were also subjected to purity tests required by California standards. Testing results indicated that 24 of 28 samples (86 percent) were within purity parameters while four samples (14 percent) had at least one fatty acid or sterol that was outside the limits:

- two Sevillano samples and one crude blend from the same handler from Stanislaus County and one Arbosana sample from Sonoma County exceeded the standard of heptadecenoic acid at 0.4 (California standard ≤ 0.3). This result is consistent with findings from previous seasons as well as literature review that has found that some varieties, including Sevillano and Arbosana, tend to have higher heptadecenoic acid values regardless of season or altitude[15]; and
- one Koroneiki sample from Fresno County exceeded the limit for campesterol at 5.1 (California standard ≤ 4.5) with a low apparent β-sitosterol value at 92.8 (California standard ≥ 93.0). This is also consistent with high campesterol and low apparent β-sitosterol values found in Koroneiki samples from the Central Valley in previous studies. Koroneiki samples have shown to have high campesterol content compared to other varieties in California[16] and other growing regions outside the US[17].

KEY FINDINGS

1. Based on gallons reported by handlers to the OOCC in Form A, the testing data confirmed that handler production of California olive oil was graded at 90.5 percent Extra Virgin, 5.2 percent Virgin, 0.2 percent Crude and 4.1 percent undeterminable due to lack of complete data. While the percentage at Extra Virgin and Virgin grades combined was almost identical to that of last season's, the total gallons from the 2020/21 season dropped significantly from the 2019/20 season due to olive's alternate bearing cycle and limited harvest and mill crews due to COVID-19.
2. Handlers who have reported "second extraction" as an oil grade in past seasons reported presumed grades following grades listed in California olive oil standards in 2020/21.
3. Incomplete information compromised the value of the mandatory testing requirement:
   - 33 percent of compulsory handlers (4 of 12 handlers) and all three voluntary handlers did not provide complete information required in Form A to the OOCC,
   - 7 percent of samples (10 of 151 samples) did not have a grade designated by the handler prior to testing, and
   - 13 percent of samples (20 of 151 samples) had incomplete quality data submitted by the handler.
4. Four out of 28 samples (14 percent) did not meet at least one purity parameter in California olive oil standards.

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[15] UC Davis Olive Center. (2018). Heptadecenoic Acid (C17:1) in California Olive Oil: A Review.
[16] UC Davis Olive Center. (2015-2020). Evaluation of Fatty Acid and Sterol Profiles California Olive Oil.
[17] Guillaume, C., Ravetti, L., Ray, D. L., & Johnson, J. (2012). Technological factors affecting sterols in Australian olive oils. Journal of the American Oil Chemists' Society, 89(1), 29-39.

5. Since the 2019-20 harvest, the OOCC has made the declaration of a use-by-date on olive oil packaging mandatory for its members and requested the use-by-date must be supported by technical evidence[18]. The 2020-2021 California olive oil standards added the induction time test to be conducted by the Commission in order to help handlers evaluate the Best By Dates that were assigned to their respective olive oils. However, the induction time data was not available in the 2020/21 season.

RECOMMENDATIONS

To improve the OOCC sampling and testing process, the Commission has updated its 2021/22 season checklist and timeline to collect samples earlier from handlers and return testing results back to handlers sooner. This effort also requires handlers to test and report their own oils earlier. Based on the testing program evaluation from the 2020/21 season, the Commission may want to consider:

- ensuring that the CDFA inspector completes sampling all participating handlers by the end of January 2022 as in the 2020/21 season, *compulsory handler S* was not sampled by the OOCC;
- setting up reminders and checking in with handlers periodically during November 2021 and January 2022 to ensure that handlers provide complete data required in Form A such as presumed grade, variety, variety percentage, handler internal and OOCC sampling dates, and quality testing results including specific sensory defect(s);
- ensuring the certified testing laboratory chosen by the Commission perform the induction time analysis using the parameters listed in the Modern Olives model (e.g. flowrate at 20 L/h)[5] so the use-by-date can be calculated accordingly;
- continuing to provide feedback and education to individual handlers on post-harvest and processing practices to maximize quality;
- modifying California olive oil purity standards to accommodate the natural variances of authentic California olive oil.

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[18] Olive Oil Commission of California (2020). Guidance Document for Determining Best By Date.

APPENDIX

Table 1. Quality tests in California olive oil standards

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 stored oil. High FFA accelerates oxidation.	AOCS Ca 5a-40 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.	AOCS Cd 8b-90 Analytical Titration	≤ 15 meq O_2/kg oil
Ultraviolet absorbance (UV)	UV absorbance provides three different measurements: K_{232} measures primary oxidation products (similar to PV); K_{270} measures secondary oxidation products; ΔK detects presence of refined or pomace oil.	An elevated level of UV absorbance indicates oxidized and/or poor quality oil.	AOCS Ch 5-91 UV spectrophotometry	K_{232}: ≤ 2.40 $K^{1\%}$1cm; K_{270}: ≤ 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.	ISO 29822:2009 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.	ISO 29841:2012 High performance liquid chromatography (HPLC)	≤ 17%
Organoleptic Analysis	Organoletptic or sensory analysis refers to taste, odor and mouthfeel	Sensory assessment can help identify oils that are of poor quality, oxidized, and/or adulterated with other oils.	COI/T.20/Doc. 15 IOC-recognized panel of 8-12 people evaluates oils for sensory characteristics.	Median of defects = 0.0; median of 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.	Modern Olives Model AOCS Cd 12b-92: 2017 Rancimat (110°C, _20L/h_, 2.5±0.2 g)	Not required in California olive oil standards but was added to the OOCC sampling protocol since the 2020/21 season

Table 2. Form A required to be completed by the handler and submitted to the Commission by February 26, 2021*

OOCC FORM A					
Handler		Laboratory used for Chemistry		Laboratory used for Sensory	
All data below mandatory to be entered. One column for each lot that you produced for the season. Should you need more columns, copy the last column to the right and repeat the data. Varietals are mandatory to list all, listing "blend" is not sufficient". Grades to select are those listed in the drop down only.					
SECTION I: TO BE COMPLETED PRIOR TO CDFA VISIT					
LOT ID					
Internal Sampling Date					
CDFA Sampling Date					
CDFA Sample Code					
Variety					
Variety Percentages					
Volume (gallons)					
Harvest Date					
Grade					
SECTION II: TO BE COMPLETED ONCE THIRD PARTY RESULTS ARE FINALIZED					
Free Fatty Acid Content (%m/m)					
Peroxide Value (PV) (meq O_2/kg oil)					
Absorbency in ultraviolet K_{232}					
Absorbency in ultraviolet K_{270}					
Absorbency in ultraviolet Delta K					
Moisture and volatile matter (MOI) (%m/m)					
Insoluble impurities (INI) (%m/m)					
Pyropheophytin a (PPPs) (%)					
1,2 Diacylglycerols (DAGs) (%)					
Organoleptic Analysis Median of Defects (MeD)					
Organoleptic Analysis Median of Fruity (MeF)					

* Handlers must report results of samples to the Commission, utilizing Form A, no later than February 26, 2021 or apply for an extension by the same date.