Report

Evaluation of Extra-Virgin Olive Oil Sold in California

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NOTE: The findings in this report are based on samples purchased from California retailers in 2010 and reflect results found at that time. The results should not be used to characterize the current quality or authenticity of olive oil available in California or elsewhere.

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UC DAVIS OLIVE CENTER
at the Robert Mondavi Institute

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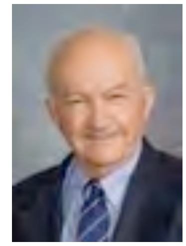
AUTHORS



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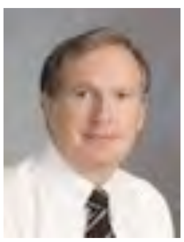

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EXECUTIVE SUMMARY

While there are many excellent imported and domestic extra virgin olive oils available in California, our findings indicate that the quality level of the largest imported brand names is inconsistent at best, and that most of the top-selling olive oil brands we examined regularly failed to meet international standards for extra virgin olive oil.

In this second and final report in a year-long study, UC Davis again worked with the Australian Oils Research Laboratory to evaluate the quality of extra virgin olive oils sold on retail shelves in California. The two laboratories evaluated the oils based on standards and testing methods established by the International Olive Council (IOC) . The laboratories also examined oils based on methods adopted in Germany and Australia. The labs evaluated oils in the same manner as if the oils had been submitted by a private party seeking an evaluation. The average purchase price of the top-selling imported brands was $0.47/ounce, the California brand was $0.46/ounce, Australian brand was $0.42/ounce, and the top-selling premium Italian brand was $0.89/ounce.

In contrast to the first UC Davis report of July 2010, which analyzed 52 samples of 14 brands, this report's aim was to analyze fewer brands but more samples of each brand so as to improve the analysis of each brand. In addition, this study used <u>two</u> IOC-accredited sensory panels to conduct analysis based on the IOC sensory standards for extra virgin olive oil, in contrast to the July study, which used a single sensory panel to analyze samples. With this study and the July 2010 study, the research team has analyzed a total of 186 extra virgin olive oil samples in the past year, offering a statistically significant picture of olive oil quality sold in California, the most-populous state in the world's third-largest olive oil consuming nation. Among the findings:

- Of the five top-selling imported "extra virgin" olive oil brands in the United States, 73 percent of the samples failed the IOC sensory standards for extra virgin olive oils analyzed by two IOC-accredited sensory panels. The failure rate ranged from a high of 94 percent to a low of 56 percent depending on the brand and the panel. None of the Australian and California samples failed both sensory panels, while 11 percent of the top-selling premium Italian brand samples failed the two panels. Sensory defects are indicators that these samples are oxidized, of poor quality, and/or adulterated with cheaper refined oils.

- All of the oil samples passed the IOC chemistry standards for free fatty acids (FFA), fatty acid profile (FAP) and peroxide value (PV), but several of the imported samples failed the IOC's ultraviolet absorption (UV) tests.

- 70 percent of the samples from the five top-selling imported brands failed the German/Australian 1,2-diacylglycerol content (DAGs) test and 50 percent failed the German/Australian pyropheophytin (PPP) test. All of the 18 samples of the California brand passed the DAGs test and 89 percent of the samples passed the PPP test. The Italian premium brand failed the DAGs and PPP tests in about one-third of the samples. The Australian brand passed the DAGs test in all cases and failed the PPP test in all cases.

- The strongest relationship between chemical analysis and negative sensory results was found in the DAGs test (65 percent), followed by the PPP test (49 percent), UV K268 for conjugated trienes (34 percent), UV K232 for conjugated dienes (12 percent) and UV ΔK (6 percent). The FFA, FAP and PV tests did not confirm negative sensory results. The IOC standards would be more effective in assessing and enforcing olive oil quality by including the DAGs and PPP standards.

Our testing indicated that the samples failed extra virgin olive oil standards according to one or more of the following: (a) oxidation by exposure to elevated temperatures, light, and/or aging; (b) adulteration with cheaper refined olive oil; and (c) poor quality oil made from damaged and overripe olives, processing flaws, and/or improper oil storage.

We recommend pursuing further research on the following topics: (1) investigate chemical markers of sensory defects, (2) determine the effects of minor constituents on oxidative stability and flavor deterioration and (3) establish chemical profiles of California olive oils.

INTRODUCTION

While there are many excellent imported and domestic extra virgin olive oils available in California, our findings indicate that the quality level of the largest imported brand names is inconsistent at best, and that most of the top-selling olive oils we examined regularly failed to meet international standards for extra virgin olive oil.

"Extra virgin" is the top grade of olive oil according to standards established by the International Olive Council (IOC) and the United States Department of Agriculture (USDA). In addition to establishing chemistry standards for extra virgin olive oil, the IOC and USDA have established a sensory standard — the oil must have zero defects and greater than zero fruitiness.

The IOC "is the world's only international intergovernmental organisation in the field of olive oil and table olives. It was set up in Madrid, Spain, in 1959, under the auspices of the United Nations."[1] The IOC's duties include adopting standards for industry, developing chemical and sensory testing methods to assess olive oil quality, and providing official recognition to laboratories that demonstrate proficiency in employing the IOC's recommended testing methods.[2] Although the United States is not a member of the IOC, the USDA recently adopted[3] olive oil standards that closely correspond to the IOC standards.[4] For simplicity, this report will reference the IOC standards and not the USDA standards. The IOC olive oil standards include the grades of extra virgin, virgin, refined olive oil and "olive oil" (a blend of virgin olive oil and refined olive oil).

In July 2010 the UC Davis Olive Center issued a report showing that 69 percent of imported olive oils labeled as "extra virgin" failed the IOC sensory standard - in other words, these oils were defective and failed to meet the international standard for extra virgin olive oil. In the months since the release of the study, similar quality problems have been found in Andalusia, the world's most productive olive oil region, by Spanish authorities.[5]

In this second and final report of a year-long study, UC Davis again worked with the Australian Oils Research Laboratory to evaluate the quality of extra virgin olive oils sold on retail shelves in California. UC Davis and the Australian laboratory evaluated the oils based on standards and testing methods established by the IOC. Additionally, the two laboratories analyzed the oils using two testing methods adopted in Germany and Australia. The Australian Olive Association adopted these tests to help detect extra virgin olive oils that were old and oxidized and not up to extra virgin olive oil standards.

With this study and the July 2010 study, the research team has analyzed a total of 186 extra virgin olive oil samples in the past year, all purchased in California. In contrast, the IOC's quality control program assessed an average of 116 extra virgin olive oil samples per year purchased in the entire United States and Canada in the 2008-2009 period.[6] The UC Davis studies offer a statistically significant picture of extra virgin olive oil quality sold in California, the most-populous state in the world's third-largest olive oil consuming nation.

METHODOLOGY

Testing methods. The UC Davis and Australian laboratories examined oils in the same manner as if the oils had been submitted by a private party seeking an evaluation. The analytical methods used in this study, summarized in Table 1, include the chemistry and sensory testing methods adopted by the IOC. While not all of the IOC chemical tests were included in this study, the primary tests used by producers worldwide - free fatty acids (FFA), peroxide value (PV),

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[1] International Olive Council (IOC) website (http://www.internationaloliveoil.org/), English version, viewed February 5, 2011.

[2] See IOC COI/T.15/NC No 3/Rev. 5 November 2010 for olive oils standards; IOC COI/OT/NC No. 1-December 2004 for table olives standards;; Table 1 of this report for chemistry and sensory testing methods; and http://www.internationaloliveoil.org/estaticos/view/226-laboratories-panels regarding IOC recognition of chemical and sensory testing laboratories.

[3] See USDA, "United States Standards for Grades of Olive Oil and Olive-Pomace Oil," *Federal Register*, April 28, 2010.

[4] There are some differences between the IOC and USDA standards, such as allowable limits for campesterol in the grade of extra virgin olive oil and median panel scores for defects in the grade of virgin olive oil.

[5] See Olive Oil Times, December 5, 2010.

[6] See International Olive Council, CONV./R.36/Doc. No 2, October 2009.

ultraviolet absorption (UV), fatty acid profile (FAP) and sensory, were included. The UV tests were particularly useful in our July 2010 study. The study also employed supplementary standards that have been adopted by the German government and the Australian Olive Association (AOA) as useful tools to assess olive oil quality.[7] These methods, known as1,2-diacylglycerol content (DAGs) and pyropheophytins (PPP), were developed by the German Fat and Oil Society (DGF). All tests were performed "blind," without knowledge of brand name or origin, by research and technical personnel within the California and Australian laboratories and by the sensory panelists.

Sample selection. In contrast to the UC Davis report of July 2010, which analyzed 52 samples of 14 brands, this report's aim was to analyze fewer brands but more samples of each brand to improve the analysis of each brand. In addition, this study used <u>two</u> IOC-accredited sensory panels to conduct analysis based on the IOC sensory standards for extra virgin olive oil, in contrast to the July study, which used a single sensory panel to analyze samples. The UC

Table 1. Chemistry and sensory testing methods used in this study

	ANALYSIS	DETERMINATIONS	INDICATORS*	ANALYSES	EXTRA VIRGIN STANDARDS
IOC TESTS	**Free Fatty Acids (FFA)**	Free fatty acids are formed by the hydrolysis of the triacylglycerols in oils during extraction, processing, and storage.	An elevated level of free fatty acid indicates hydrolyzed, oxidized and/or poor-quality oil.	Analytical titration (AOCS Ca 5a-40).	Units: % as oleic acid. Limit: ≤ 0.8.
IOC TESTS	**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 (ISO 3960).	Units: mEq O_2/ kg oil. Limit: ≤ 20.
IOC TESTS	**UV Absorption (for conjugated double bonds)**	Conjugated double bonds are formed from natural nonconjugated unsaturation in oils upon oxidation.	An elevated level of UV absorbance indicates oxidized and/or poor quality oil.	UV spectrophotometry (COI/T20/Doc. No. 0019/Rev.3/2010).	Units: $K^{1\%}_{1cm.}$ Limits for K232, K268 and ΔK: ≤ 2.50, ≤ 0.22, and ≤ 0.01.
IOC TESTS	**Fatty Acid Profile (FAP)**	Fatty acids constitute the principal component of fats (saturated or unsaturated). Fatty acid profiles (FAP) are distinguishable markers between olive oils and some seed/nut oils (FAPs vary slightly depending on the varieties and growing region of olives).	Analysis of the fatty acid profile provides information on the authenticity of the olive oil; an indicator for adulteration with refined oils.	Gas chromatography (GC) (IOC COI/T.20/Doc No. 24-2001).	Units: % of total fatty acids.
IOC TESTS	**Sensory (Organoleptic)**	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 (IOC COI/T.20/Doc No. 15/Rev. 3, 11-2010, IOC COI/T.15/NC No 3/Rev. 5, 11-2010).	Panel must find median of defects = 0 and median of the fruity attribute > 0.
GERMAN/AUSTRALIAN TESTS	**1,2-Diacylglycerol Content (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, of poor quality, and/or adulterated with refined oil.	Gas chromatography (GC) (DGF Standard Method C-VI 16(06) – ISO 29822:2009).	Units: % total 1,2- and 1,3-diacylglycerols. Australian Olive Association (AOA) limit: ≥ 40.
GERMAN/AUSTRALIAN TESTS	**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) (DGF Standard Method C-VI-15(06) – ISO 29841:2009.)	Units: % total pheophytins. Australian Olive Association (AOA) limit: ≤ 15.

***Hydrolyzed** means oils in which triacylglycerols have been broken down via addition of water.
Oxidized means oils that have become stale and rancid through oxidation, a chemical reaction that is promoted by exposure to oxygen, heat, light, and/or age.
Refined means cheaper, lower-grade oils that often are solvent extracted, thermally deodorized and bleached.
Poor quality means oils that were made from poor-quality olives, improperly processed, and/or improperly stored after processing.

[7] The methods were developed in Germany by Dr. Christian Gertz at the DGF http://www.dgfett.de/. The DGF mission: "The DGF is the German network for science and technology of fats, oils and lipids. It will bring together professionals of science, technology and business together to promote scientific research and practical, to improve training and to facilitate information exchange." The DAGs and PPP standards must be met by members of the Australian Olive Association (AOA) to receive AOA certification for extra virgin olive oil. The Australian government is soliciting comment on a proposed national olive oil standard that includes the DAGs and PPP methods.

Davis research team identified eight brands of extra virgin olive oil for analysis, including the five top-selling brands in the United States[8] (Filippo Berio, Bertolli, Pompeian, Colavita, and Star) as well as the top-selling brand from California (California Olive Ranch), the top-selling brand from Australia (Cobram Estate), and the top-selling premium Italian brand (Lucini).

Sample collection. The research team collected the oils from three different regions of California (County of Sacramento, San Francisco Bay Area, and County of Los Angeles) from September 9, 2010 to October 21, 2010. A member of the research team purchased each brand in two outlets of three leading supermarkets in each of the three regions for each of the eight brands, for a total of 18 samples of each brand (except for Cobram Estate, in which a total of eight samples were found among the supermarkets visited). A total of 134 samples were analyzed by the research team. Price information is provided in several of the tables, with the average purchase price of the top-selling brands at $0.47/ounce, the California brand at $0.46/ounce, the Australian brand at $0.42/ounce, and the top-selling premium Italian brand at $0.89/ounce.

Sample handling. A member of the research team transported the samples from the supermarket collection points to the UC Davis Olive Oil Chemistry Laboratory. Sacramento area samples arrived at the lab within three hours of collection and from the San Francisco Bay Area within four hours of collection. The Los Angeles area samples were shipped by overnight delivery to UC Davis. Ambient daytime temperature at time of collection ranged between 48℉ (9℃) and 58℉ (14℃). Once the samples arrived in the lab, the research team wrapped the samples in foil and stored them in a dark, secure cabinet. Temperature of the UC Davis laboratory was maintained at 64℉ (18℃).

Australia analysis. On November 12, 2010, the UC Davis olive oil research project team shipped 134 unopened bottles (18 samples of seven brands and eight samples of one brand) to the Australian Oils Research Laboratory in Wagga Wagga, New South Wales. The samples were shipped by FedEx and were five days in transit. The laboratory is recognized by the IOC to provide chemical analysis of olive oil. The Australian laboratory directed the Australian Olive Oil Sensory Panel in Wagga Wagga to conduct sensory analysis of the samples. This panel is recognized by the IOC as qualified to provide sensory analysis of olive oil. The Australian sensory panel leader directed that the oils be first analyzed by "show judging" to determine whether some oils could be screened so as to reduce the time and cost of subjecting all of the oils to a full panel analysis. The "show judging" screened out any oils that achieved a score of 11.5 or higher on a 20-point scale (a score of 13 is the minimum for a Bronze medal in Australian show judging). Any oils that achieved a score of 11.5 or higher was assumed by the research team to be "extra virgin" grade for purposes of the Australian analysis. The Australian Oils Research Laboratory used the chemical testing methods listed in Table 1 and the Australian Olive Oil Sensory Panel used the sensory methods identified in Table 1.

UC Davis analysis. UC Davis analyzed the same (by lot number) unopened 134 samples that were analyzed by the Australian laboratory and sensory panel using the methods and standards identified in Table 1. The UC Davis Olive Oil Chemistry Laboratory analytical team was supervised by Dr. Selina C. Wang and Dr. Charles F. Shoemaker. The UC Davis laboratory is working to meet the requirements for achieving IOC recognition, and while the results of the analyses were comparable to the the Australian laboratory, this report is based on chemical data solely from the Australian laboratory. The same 134 samples were analyzed by the UC Davis Olive Oil Taste Panel, which has been recognized by the IOC as qualified to provide sensory analysis of olive oil. Dr. Jean-Xavier Guinard and Nicole Sturzenberger supervised the work of the taste panel. Dr. Edwin N. Frankel served as scientific advisor to the research team.

RESULTS BASED ON IOC STANDARDS FOR EXTRA VIRGIN OLIVE OILS

Table 2 and Table 3 show the results based on IOC standards for extra virgin olive oils. Table 2 shows that, of the five top-selling imported "extra virgin" olive oils in the United States, 73 percent of the samples (66 of 90 samples) failed the IOC sensory standards for extra virgin olive oil as analyzed by two IOC-accredited sensory panels. The July 2010 UC Davis study found the same failure rate of 73 percent for these five top-selling brands (11 of 15 samples). The UC Davis and Australian sensory panels found that each of the failed samples contained sensory defects of greater than zero, particularly the defect of rancidity, which is caused by oxidation (which can occur before or after bottling), and fustiness, which is caused from olives allowed to undergo an advanced state of fermentation prior to processing. Table

[8] Information Resources, Inc., October 1, 2009

2 shows that the failure rate for the top-selling brands ranged from a high of 94 percent to a low of 56 percent depending on the brand. Sensory defects are indicators that these samples were oxidized, of poor quality, and/or adulterated with cheaper refined oils. None of the Australian and California samples failed both sensory panels, while 11 percent of the top-selling premium Italian brand samples failed the two panels. Table 3 shows that all of the oil samples passed the IOC chemistry standards for free fatty acids (FFA), fatty acid profile (FAP) and peroxide value (PV), but several of the samples failed the ultraviolet absorption (UV) tests.

Table 2. Both sensory panels find that top-selling brands usually fail IOC extra virgin standards

	BRAND	$/OZ	# SAMPLES	# FAILING BOTH SENSORY PANELS	% FAILING BOTH SENSORY PANELS
	California Olive Ranch	0.46	18	0	0
	Cobram Estate	0.42	8	0	0
	Lucini	0.89	18	2	11
TOP-SELLING BRANDS	Colavita	0.61	18	10	56
	Star	0.39	18	11	61
	Bertolli	0.47	18	13	72
	Filippo Berio	0.47	18	15	83
	Pompeian	0.39	18	17	94
	Avg, Top-Selling Brands	0.47	18	13	73

Table 3. IOC chemical tests show low failure rates for most brands

	BRAND	$/OZ	# SAMPLES	% FAILING FFA	% FAILING PV	% FAILING FAP	% FAILING UV K232	% FAILING UV K268	% FAILING UV ΔK
	California Olive Ranch	0.46	18	0	0	0	0	0	0
	Cobram Estate	0.42	8	0	0	0	0	0	0
	Lucini	0.89	18	0	0	0	0	11	0
TOP-SELLING BRANDS	Star	0.39	18	0	0	0	0	0	0
	Bertolli	0.47	18	0	0	0	11	0	0
	Colavita	0.61	18	0	0	0	0	39	0
	Filippo Berio	0.47	18	0	0	0	6	39	0
	Pompeian	0.39	18	0	0	0	33	61	22
	Avg, Top-Selling Brands	0.47	18	0	0	0	10	28	4

RESULTS BASED ON GERMAN/AUSTRALIAN STANDARDS FOR EXTRA VIRGIN OLIVE OILS

A low level of DAGs indicates that a sample is hydrolyzed, oxidized, of poor quality, and/or adulterated with cheaper refined oils, while an elevated level of PPP indicates that a sample is oxidized and/or adulterated with cheaper refined oils. With time and possibly accelerated with the application of heat, the levels of PPP increase, but with enough time and oxidation levels of PPP disappear and cannot be detected. Table 4 on page 7 indicates that 70 percent of the samples from the five top-selling imported brands failed the DAGs test and 50 percent failed the PPP test. All of the 18 samples of the California brand passed the DAGs test and 89 percent of the samples passed the PPP test. The Italian premium brand failed the DAGs and PPP tests in about one-third of the samples. The Australian brand passed the DAGs test in all cases and failed the PPP test in all cases.

Table 4. German/Australian chemical tests show significant failure rates

	BRAND	$/OZ	# SAMPLES	% FAILING DAGs	% FAILING PPP
	California Olive Ranch	0.46	18	0	11
	Lucini	0.89	18	33	28
	Cobram Estate	0.42	8	0	100
TOP-SELLING BRANDS	Filippo Berio	0.47	18	33	17
	Bertolli	0.47	18	61	50
	Colavita	0.61	18	78	39
	Star	0.39	18	78	50
	Pompeian	0.39	18	100	94
	Avg, Top-Selling Brands	0.47	18	70	50

RELATIONSHIP BETWEEN SENSORY AND CHEMISTRY ANALYSIS

The relationship between the samples that failed the IOC sensory standard for both sensory panels and also failed chemical tests is examined in Table 5 below. Table 5 shows, for example, that of the two Lucini samples that failed both

Table 5. German/Australian chemical tests confirm failed sensory samples more frequently than IOC tests

			PERCENTAGE OF SAMPLES FAILING BOTH SENSORY PANELS THAT WERE CONFIRMED BY CHEMICAL TESTS							
			IOC TESTS						GERMAN/AUST TESTS	
	BRAND	# OF SAMPLES FAILING BOTH SENSORY PANELS	FFA	FAP	PV	UV K232	UV K268	UV ΔK	DAGs	PPP
	California Olive Ranch	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Cobram Estate	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Lucini	2	0	0	0	0	100	0	0	0
TOP-SELLING BRANDS	Filippo Berio	15	0	0	0	7	33	0	33	20
	Star	11	0	0	0	0	0	0	64	27
	Bertolli	13	0	0	0	8	0	0	62	46
	Colavita	10	0	0	0	0	50	0	70	50
	Pompeian	17	0	0	0	35	65	24	100	94
	Average, All Brands	68 (total)	0	0	0	12	34	6	65	49

sensory panels, 100 percent of those two samples failed the UV K268 test, and that none of the other chemical tests confirmed the negative sensory result for the two Lucini samples. Table 5 shows that the strongest relationship between chemical analysis and negative sensory results was found in the DAGs test (65 percent), in other words, of the 68 samples that failed both sensory panel tests, 65 percent of those samples also failed the DAGs test. The PPP test had the next highest confirmation rate (49 percent), followed by K268 (34 percent), K232 (12 percent) and ΔK (6 percent). The FFA, FAP and PV tests were not useful in confirming negative sensory results. These results are consistent with the results from the July 2010 UC Davis study, in which the DAGs test had the highest confirmation rate at 83 percent, followed by the PPP test at 50 percent, followed by the UV K232 test at 30 percent, UV K268 test at 3 percent, and FFA at 3 percent. In the July 2010 study the IOC standards for FAP, PV, and ΔK tests were not useful in confirming negative sensory results.

CONCLUSIONS

Our laboratory tests found that the top-selling imported brands of "extra virgin" olive oil sold in the United States and purchased at retail locations throughout California often failed the IOC's sensory standards for extra virgin olive oil. Sensory analysis showed that these failed samples had objectionable descriptors such as rancid and fusty. Sensory analysis is a sensitive tool to analyze olive oil quality and is an essential component of the IOC olive oil standards, but sensory analysis should be supported by gas chromatographic analyses and other analytical methods. It is essential to support sensory evaluations by chemical tests for volatile compounds that are known to be produced by lipid oxidation.

Our chemical tests indicate that the samples usually pass the IOC's chemical tests even when those samples failed two IOC-accredited sensory panels. Chemical confirmation of the negative sensory results were strongest with the German/Australian DAGs and PPP tests, followed by IOC tests for UV absorption. The IOC and USDA standards would be more effective in assessing and enforcing olive oil quality by including the German/Australian DAGs and PPP standards.

Our testing indicated that the samples failed extra virgin olive oil standards for reasons that include one or more of the following: (a) oxidation by exposure to elevated temperatures, light, and/or aging; (b) adulteration with cheaper refined olive oil; and (c) poor quality oil made from damaged and overripe olives, processing flaws, and/or improper oil storage.

RECOMMENDATIONS FOR FUTURE RESEARCH

We recommend pursuing further research on the following topics:

- **Investigate chemical markers for sensory defects.** Determine key volatile flavor compounds by gas chromatographic analyses to obtain more direct evidence for oxidation or other sources of flavor deterioration.

- **Determine the effects of minor constituents on oxidative stability and flavor deterioration.** Develop methods to evaluate traces of chlorophylls, metal impurities and minor constituents known to affect the oxidative stability of polyunsaturated vegetable oils.

- **Establish chemical profiles of California olive oils.** Evaluate the olive oils for major chemical constituents in a range of climates, elevations and varietals.

UC DAVIS OLIVE CENTER at the Robert Mondavi Institute

The UC Davis Olive Center is the only academic center of its kind in North America, a leader in education and research on olive growing and processing. Learn more at www.olivecenter.ucdavis.edu and on facebook.

Appendix: Evaluation of Extra-Virgin Olive Oil Sold in California

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Sample Information

	Sample #	Type of Bottle	Use by Date	Purchased Store	Lot Numbers	Cost $/once
Filippo Berio	1	Plastic, clear	10/1/2011	Walmart 1A	LE24BE	0.36
	2	Plastic, clear	2/2/2012	Walmart 2A	LE22FE	0.36
	3	Glass, clear	12/2/2011	Save Mart 1A	LE02DE	0.47
	4	Glass, clear	10/4/2011	Save Mart 2A	LE09BE	0.47
	5	Glass, clear	10/1/2011	Safeway 1A	LE09BE	0.57
	6	Glass, clear	7/2/2011	Safeway 2A	LE04MD	0.57
	7	Plastic, clear	10/1/2011	Walmart 1B	LE24BE	0.36
	8	Plastic, clear	2/1/2011	Walmart 2B	LE15FD01	0.36
	9	Glass, clear	9/8/2011	Lucky 1B	LE11AE	0.47
	10	Glass, clear	12/2/2011	Lucky 2B	LE02DE	0.47
	11	Glass, clear	2/2/2012	Safeway 1B	LE25FE	0.57
	12	Glass, clear	7/2/2011	Safeway 2B	LE04MD	0.57
	13	Plastic, clear	10/1/2011	Walmart 1C	LE24BE	0.37
	14	Plastic, clear	10/1/2011	Walmart 2C	LE24BE	0.37
	15	Glass, clear	10/1/2011	Ralphs 1C	LE09BE	0.53
	16	Glass, clear	10/4/2011	Ralphs 2C	LE09BE	0.53
	17	Glass, clear	10/3/2011	Vons 1C	LE09BE	0.53
	18	Glass, clear	9/4/2011	Vons 2C	LE11AE	0.53
Bertolli	1	Glass, clear	10/31/2011	Walmart 1A	L0420T H1252	0.37
	2	Glass, clear	9/30/2011	Walmart 2A	L0515R H1035	0.37
	3	Glass, clear	9/30/2011	Foods Co 1A	L0217T H1209	0.50
	4	Glass, clear	9/30/2011	Foods Co 2A	L0217T H1557	0.50
	5	Glass, clear	9/30/2011	Safeway 1A	L0217T H1542	0.58
	6	Glass, clear	9/30/2011	Safeway 2A	L0117T H1238	0.58
	7	Glass, clear	9/30/2011	Walmart 1B	L0515R H1042	0.37
	8	Glass, clear	10/31/2011	Walmart 2B	L0420T H1252	0.37
	9	Glass, clear	10/31/2011	Foods Co 1B	L0520T H2251	0.47
	10	Glass, clear	9/30/2011	Foods Co 2B	L0217T H1557	0.47
	11	Glass, clear	9/30/2011	Safeway 1B	L0117T H1220	0.58
	12	Glass, clear	9/30/2011	Safeway 2B	L0117T H0649	0.58
	13	Glass, clear	11/30/2011	Walmart 1C	L0126T H0644 I.GR.E.TU	0.37
	14	Glass, clear	10/31/2011	Walmart 2C	L0420T H0020	0.37
	15	Glass, clear	11/30/2011	Ralphs 1C	L0525T H1611 I.GR.E.TU	0.45
	16	Glass, clear	11/30/2011	Ralphs 2C	L0525T H1611 I.GR.E.TU	0.45
	17	Glass, clear	6/30/2011	Vons 1C	L0305R H1904	0.53
	18	Glass, clear	6/30/2011	Vons 2C	L0305R H1904	0.53

Pompeian	1	Plastic, clear	12/30/2011	Walmart 1A	91230259	0.32
	2	Plastic, clear	1/4/2012	Walmart 2A	100104262	0.32
	3	Glass, clear	6/24/2012	Foods Co 1A	100624625	0.41
	4	Glass, clear	6/24/2012	Foods Co 2A	100624625	0.41
	5	Plastic, clear	6/9/2012	Save Mart 1A	100609611	0.41
	6	Plastic, clear	6/9/2012	Save Mart 2A	100609611	0.41
	7	Plastic, clear	1/12/2012	Walmart 1B	100112284	0.32
	8	Plastic, clear	1/20/2012	Walmart 2B	100120301	0.32
	9	Glass, clear	1/27/2012	Foods Co 1B	100127319	0.41
	10	Glass, clear	6/24/2012	Foods Co 2B	100624622	0.41
	11	Plastic, clear	6/9/2012	Lucky 1B	100609611	0.41
	12	Plastic, clear	6/9/2012	Lucky 2B	100609611	0.41
	13	Plastic, clear	3/23/2012	Walmart 1C	100323444	0.33
	14	Plastic, clear	3/17/2012	Walmart 2C	100317422	0.33
	15	Plastic, clear	7/2/2012	Ralphs 1C	100702635	0.41
	16	Plastic, clear	7/2/2012	Ralphs 2C	100702635	0.41
	17	Plastic, clear	9/12/2011	Vons 1C	90912301	0.48
	18	Plastic, clear	8/11/2011	Vons 2C	90811211	0.48
Colavita	1	Glass, clear	4/1/2012	Walmart 1A	L10113 10:34	0.47
	2	Glass, clear	2/1/2012	Walmart 2A	L10056 10:19	0.47
	3	Glass, clear	n/a	Save Mart 1A	L09204 10:58	0.70
	4	Glass, clear	n/a	Save Mart 2A	L09204 16:13	0.70
	5	Glass, clear	2/1/2012	Raleys 1A	L10036 10:06	0.70
	6	Glass, clear	3/1/2012	Raleys 2A	L10075 14:21	0.70
	7	Glass, clear	5/1/2012	Walmart 1B	L10131 09:22	0.47
	8	Glass, clear	n/a	Walmart 2B	L09357V63	0.59
	9	Glass, clear	4/1/2012	Lucky 1B	L10112 12:08	0.70
	10	Glass, clear	2/1/2012	Lucky 2B	L10036 10:46	0.70
	11	Glass, clear	n/a	Raleys 1B	L10008 11:55	0.70
	12	Glass, clear	8/1/2012	Raleys 2B	L10217 14:13	0.51
	13	Glass, clear	4/1/2012	Walmart 1C	L10097 09:13	0.46
	14	Glass, clear	n/a	Walmart 2C	L09363 16:21	0.46
	15	Glass, clear	2/1/2012	Albertsons 1C	L10047 14:42	0.58
	16	Glass, clear	4/1/2012	Albertsons 2C	L10105 11:06	0.67
	17	Glass, clear	3/1/2012	Ralphs 1C	L10076 13:02	0.70
	18	Glass, clear	3/1/2012	Ralphs 2C	L10076 13:02	0.70
Star	1	Glass, clear	12/5/2011	Walmart 1A	109819-05/12	0.36
	2	Glass, clear	1/7/2012	Walmart 2A	110489-07/01	0.36
	3	Glass, clear	7/9/2012	Foods Co 1A	105160-09/07	0.34
	4	Glass, clear	7/9/2012	Foods Co 2A	105160-09/07	0.34
	5	Glass, clear	5/5/2012	Safeway 1A	103360-05/05	0.53
	6	Glass, clear	4/14/2012	Safeway 2A	102860-14/04	0.53

Star (Continued)	7	Glass, clear	1/7/2012	Walmart 1B	110489-07/01	0.36
	8	Glass, clear	1/7/2012	Walmart 2B	110489-07/01	0.36
	9	Glass, clear	6/8/2012	Foods Co 1B	103930-08/06	0.39
	10	Glass, clear	7/9/2012	Foods Co 2B	105160-09/07	0.39
	11	Glass, clear	3/22/2012	Safeway 1B	102240-22/03	0.30
	12	Glass, clear	3/22/2012	Safeway 2B	102240-22/03	0.30
	13	Glass, clear	1/30/2012	Walmart 1C	100630-30/01	0.37
	14	Glass, clear	1/30/2012	Walmart 2C	100630-30/01	0.37
	15	Glass, clear	6/29/2012	Ralphs 1C	104730-29/06	0.53
	16	Glass, clear	7/9/2012	Ralphs 2C	105160-09/07	0.53
	17	Glass, clear	3/22/2012	Vons 1C	102240-22/03	0.35
	18	Glass, clear	3/22/2012	Vons 2C	102240-22/03	0.35
California Olive Ranch	1	Glass, green	6/1/2012	Walmart 1A	DW18119	0.50
	2	Glass, green	8/1/2012	Walmart 2A	DW21710	0.50
	3	Glass, green	9/1/2012	Save Mart 1A	101029	1.06
	4	Glass, green	7/1/2012	Save Mart 2A	DW20810	1.06
	5	Glass, green	7/1/2012	Raleys 1A	DW20710	0.98
	6	Glass, green	7/1/2012	Raleys 2A	DW20710	0.98
	7	Glass, green	6/1/2012	Walmart 1B	DW18110	0.40
	8	Glass, green	6/1/2012	Walmart 2B	DW18110	0.38
	9	Glass, green	5/1/2012	Lucky 1B	DW130100858	0.53
	10	Glass, green	5/1/2012	Lucky 2B	DW130100829	0.53
	11	Glass, green	7/1/2012	Raleys 1B	DW20710	0.52
	12	Glass, green	7/1/2012	Raleys 2B	DW20710	0.52
	13	Glass, green	7/1/2012	Walmart 1C	DW20810	0.37
	14	Glass, green	5/1/2012	Walmart 2C	DW131101357	0.38
	15	Glass, green	5/1/2012	Albertsons 1C	DW130100720	0.53
	16	Glass, green	5/1/2012	Albertsons 2C	DW131100850	0.53
	17	Glass, green	9/1/2012	Ralphs 1C	DW26010	0.51
	18	Glass, green	7/1/2012	Ralphs 2C	DW20710	0.51
Lucini	1	Glass, clear	n/a	Walmart 1A	C 198 209	0.49
	2	Glass, clear	n/a	Walmart 2A	C 198 209	0.49
	3	Glass, clear	n/a	Raleys 1A	C 198 229	1.18
	4	Glass, clear	n/a	Raleys 2A	C 209 067	1.18
	5	Glass, clear	n/a	Safeway 1A	C 199 350	1.03
	6	Glass, clear	n/a	Safeway 2A	C 209 067	1.03
	7	Glass, clear	n/a	Walmart 1B	C 209 081	0.53
	8	Glass, clear	n/a	Walmart 2B	C 198 320	0.53
	9	Glass, clear	n/a	Raleys 1B	C 209 067	1.18
	10	Glass, clear	n/a	Raleys 2B	C 209 067	1.18
	11	Glass, clear	n/a	Safeway 1B	C 209 046	1.15
	12	Glass, clear	n/a	Safeway 2B	C 209 067	1.03

Lucini (Continued)	13	Glass, clear	n/a	Walmart 1C	C 198 230	0.50
	14	Glass, clear	n/a	Walmart 2C	C 209 091	0.50
	15	Glass, clear	n/a	Ralphs 1C	C 198 229	1.06
	16	Glass, clear	n/a	Ralphs 2C	C 209 067	1.06
	17	Glass, clear	n/a	Vons 1C	C 209 067	0.98
	18	Glass, clear	n/a	Vons 2C	C 209 067	0.98
Cobram Estate	1	Glass, green	7/24/2011	Save Mart 1A	9205	0.47
	2	Glass, green	7/24/2011	Save Mart 2A	9208	0.47
	3	Glass, green	7/24/2011	Raleys 1A	9208	0.36
	4	Glass, green	7/24/2011	Raleys 2A	9208	0.36
	5	Glass, green	7/24/2011	Lucky 1B	9205	0.47
	6	Glass, green	7/24/2011	Lucky 2B	9208	0.47
	7	Glass, green	7/24/2011	Raleys 1B	9208	0.38
	8	Glass, green	7/24/2011	Raleys 2B	9208	0.38

Walmart 1A: 755 Riverpoint Dr, West Sacramento, CA 95691
Walmart 2A: 5821 Antelope Rd, Sacramento, CA 95842
Foods Co 1A: 3625 Northgate Blvd, Sacramento, CA 95834
Foods Co 2A: 5330 Stockton Blvd, Sacramento, CA 95820
Safeway 1A: 2851 Del Paso Rd, Sacramento, CA 95835
Safeway 2A: 1025 Alhambra Blvd, Sacramento, CA 95816
Save Mart 1A: 3291 Truxel Rd, Sacramento, CA 95833
Save Mart 2A: 2735 Marconi Ave, Sacramento, CA 95821
Raleys 1A: 4650 Natomas Blvd, Sacramento, CA 95835
Raleys 2A: 3518 Marconi Ave, Sacramento, CA 95821
Walmart 1B: 7011 Main St, American Canyon, CA 94503
Walmart 2B: 235 East Dorset Dr, Dixon, CA 95620
Foods Co 1B: 1250 MacDonald Ave, Richmond, CA 94801
Foods Co 2B: 300 Atlantic Ave, Pittsburg, CA 94565
Safeway 1B: 733 S. Wolfe Rd, Sunnyvale, CA 96086
Safeway 2B: 785 East El Camino Real, Sunnyvale, CA 94807
Lucky 1B: 3705 El Camino Real, Santa Clara, CA 95051
Lucky 2B: 1740 Tuolumne St, Vallejo, CA 94589
Raleys 1B: 4300 Sonoma Blvd, Vallejo, CA 94589
Raleys 2B: 3360 San Pablo Dam Rd, El Sobrante, CA 94803
Walmart 1C: 8500 Washington Blvd, Pico Rivera, CA 90660
Walmart 2C: 26471 Carl Boyer Dr, Santa Clarita, CA 91350
Ralphs 1C: 1100 N San Fernando Blvd, Burbank, CA 91504
Ralphs 2C: 25 E Alameda Ave, Burbank, CA 91502
Vons 1C: 561 N Glendale Ave, Glendale, CA 91206
Vons 2C: 311 W Los Feliz Rd, Glendale, CA 91204
Albersons 1C: 1000 S Central Ave, Glendale, CA 91204
Albersons 2C 2035 Hillhurst Ave, Los Angeles, CA 90027

Samples that Failed both Australian Oils Research Laboratory and UC Davis Panels

	Sample #
Filippo Berio	1
	3
	4
	5
	6
	7
	8
	9
	10
	11
	12
	13
	15
	17
	18
Bertolli	1
	2
	3
	5
	6
	7
	8
	9
	10
	12
	13
	15
	18
Pompeian	1
	2
	3
	4
	5
	6
	7
	8

Pompeian (Continued)	9
	11
	12
	13
	14
	15
	16
	17
	18
Colavita	1
	3
	4
	5
	6
	7
	9
	10
	14
	17
	18
Star	1
	3
	4
	5
	6
	9
	10
	11
	15
	16
	18
Lucini	3
	8

Samples that Failed UV Absorbance

	Sample #	UV absorbance ($K^{1\%}_{1cm}$)		
		K232	**K268**	**ΔK**
Filippo Berio	1	2.33	0.23	0.005
	2	2.18	0.26	0.009
	7	2.32	0.23	0.006
	8	2.52	0.25	0.007
	10	2.23	0.23	0.007
	11	2.09	0.27	0.010
	14	2.33	0.25	0.007
Bertolli	17	2.58	0.18	<0.003
	18	2.57	0.20	<0.003
Pompeian	1	2.54	0.26	0.009
	2	2.64	0.25	0.008
	5	2.40	0.23	0.006
	6	2.43	0.23	0.006
	7	2.49	0.33	0.013
	8	2.55	0.37	0.015
	9	2.62	0.22	0.005
	11	2.39	0.25	0.010
	13	2.43	0.32	0.013
	14	2.34	0.28	0.011
	17	2.57	0.26	0.008
	18	2.80	0.29	0.010
Colavita	3	2.46	0.26	0.009
	4	2.50	0.26	0.009
	5	2.20	0.24	0.010
	8	2.13	0.24	0.008
	9	2.25	0.23	0.008
	10	2.39	0.24	0.010
	11	1.99	0.23	0.010
Lucini	3	2.37	0.26	0.010
	8	2.31	0.24	0.008

Samples that Failed Pyropheophytins (PPP) and/or 1,2-Diacylglycerols (DAGs)

	Sample #	PPP (% of total pheophytins)	DAGs (% of 1,2-DAGs to total 1,2 & 1,3 DAGs)
Filippo Berio	2	12.6	39.9
	3	11.1	35.7
	6	19.3	26.6
	8	23.1	31.6
	10	11.8	35.9
	12	19.5	27.2
Bertolli	1	18.0	30.9
	2	14.5	33.9
	7	16.7	33.2
	8	20.6	31.8
	9	14.7	35.4
	13	26.9	30.4
	14	16.5	32.9
	15	21.7	31.4
	16	21.5	31.9
	17	18.9	30.0
	18	19.1	31.2
Pompeian	1	21.2	26.9
	2	20.6	26.6
	3	24.0	30.2
	4	24.0	29.9
	5	22.6	29.5
	6	22.3	30.2
	7	22.0	27.2
	8	20.8	27.0
	9	18.6	28.2
	10	25.3	29.5
	11	21.5	30.3
	12	21.3	30.7
	13	14.9	30.5
	14	17.5	33.2
	15	26.0	30.0
	16	25.9	30.3
	17	18.0	29.2
	18	17.2	28.3
Colavita	1	10.5	35.0

Colavita (Continued)	2	12.4	36.2
	3	Not Detected	29.6
	4	Not Detected	29.9
	5	Not Detected	44.8
	6	12.2	33.0
	7	11.1	31.9
	8	Not Detected	49.7
	9	Not Detected	35.4
	10	16.2	44.3
	11	Not Detected	36.8
	12	10.2	35.4
	13	11.9	35.1
	15	8.8	37.9
	16	11.1	34.9
	17	9.7	34.3
	18	9.7	34.5
Star	1	21.6	27.6
	2	20.8	27.8
	3	11.8	39.6
	5	12.7	39.0
	6	11.4	38.0
	7	28.6	27.5
	8	38.4	27.4
	9	14.8	36.1
	11	16.4	33.2
	12	16.4	33.9
	13	32.2	28.3
	14	33.2	27.9
	17	13.8	33.6
	18	16.7	33.7
California Olive Ranch	7	21.7	65.5
	16	32.2	65.0
Lucini	1	20.4	34.0
	2	16.9	39.4
	3	Not Detected	35.9
	8	42.3	33.9
	13	10.9	34.3
	15	17.9	39.1
Cobram Estate	1	19.9	49.9
	2	19.4	64.5
	3	18.6	50.4
	4	19.4	51.2

Cobram Estate (Continued)	5	24.9	48.6
	6	16.4	58.9
	7	18.0	50.7
	8	19.0	48.6