Relentless pursuit for edible oil quality, purity and safety

Selina C. Wang PhD

Department of Food Science and Technology

UCDAVIS

UC FoodQuality

Mission:

working together with the Food and Agriculture sectors to ensure food quality, authenticity and sustainability.

UCDAVIS

Report

Tests indicate that imported "extra virgin" olive oil often fails international and USDA standards

Frankel, E. N.; Waller, R. J.; Shoemaker, C. F.; Wang, S. C.; Flynn, J. D.

July 2010

UC DAVIS OLIVE CENTER

Robert Mondavi Institute for Wine and Food Science
University of California, Davis

Report

Evaluation of Extra-Virgin Olive Oil Sold in California

Frankel, E. N.; Waller, R. J.; Wang, S. C.; Shoemaker, C. F.; Guinard, J.-X.; Flynn, J. D.; Sturzenberger, M. D.

April 2011

UC DAVIS OLIVE CENTER

olivecenter.ucdavis.edu

Los Angeles Times

Lab tests cast doubt on olive oil's virginity

By P.J. HUFFSTUTTER AND KRISTENA HANSEN, LOS ANGELES TIMES JULY 15, 2010 | 12 AM

More than two-thirds of common brands of extra-virgin olive oil found in California grocery stores aren't what they claim to be, according to a report by researchers at UC Davis.

The findings, which come as the federal government rolls out new standards aimed at cleaning up what has long been a slippery business, highlight mounting concerns over labeling accuracy for olive oil in the U.S.

"This is only a beginning, but it's a clear warning," said Dan Flynn, executive director of UC Davis' Olive Center. Noting that the U.S. is the third-largest consumer of olive oil in the world, he added, "We need to be monitoring what is being sold to the public."

npr

NEWSLETTERS SIGN IN NPR SH

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FOOD

Your Olive Oil May Not Be The Virgin It Claims

JULY 24, 2010 · 7:00 PM ET

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Point-counterpoint on UC Davis olive oil re

Home > Stay Informed > INFORM magazine > Featured Articles

By Edwin N. Frankel, Rodney J. Mailer, Selina Wang, Charles F. Shoemaker, and Dan Flynn

January 2011

The International Olive Council (IOC; Madrid, Spain) is a nonprofit, intergovernmental c
Nations. IOC's prime concerns include the prevention of fraud and the protection of c
standards and the application of official methods are of key importance in achieving g
authorities of importing countries to harmonize and comply with the official IOC stand
quality and protect consumers. IOC standards are developed and revised in light of sc

The Council of Members of the IOC is the forum where members draw up and adopt
control of olive products in order to facilitate a fair international market for olive oils, o
consumption of these products. Speaking as the intergovernmental point of reference
competent authorities of producing and importing countries to harmonize their rules
might arise.

The IOC currently has 17 member states. Membership is open only to the governmen
conclusion, and application of international agreements, especially commodity agree

Article 1(2) of the *General Objectives* of the International Agreement on Olive Oil and T
characteristics of all the grades of olive oils and olive-pomace oils included in the trade standards adopted by Members for compulsory
application in international trade.

Davis Olive Center Responds to IOC Criticism of Report

By Lori Zanteson
Feb. 22, 2011 14:40 UTC

By Lori Zanteson
Olive Oil Times Contributor | Reporting from Los Angeles

Lawsuit Targets Olive Oil Brands Denounced in Davis Study

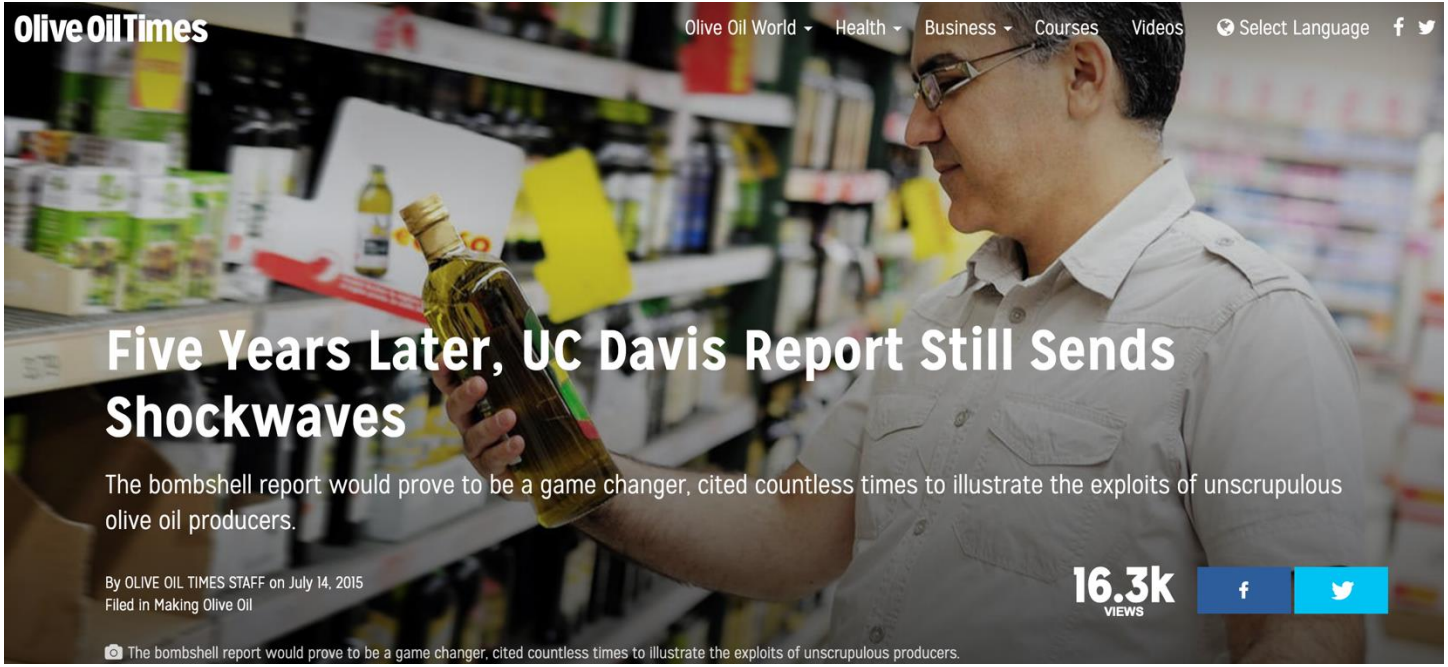
By Alex Beekman
Aug. 4, 2010 21:03 UTC

By Alex Beekman

U.S. House Ways and Means Committee Chairman Dave Camp

"Unenforced standards lead to mislabeled products, weakening the competitiveness of quality producers"

- USITC Report



"Since the UC Davis report, producers on both sides (domestic and import) of the ensuing debate have intensified efforts to improve the quality of their products and distinguish brands through designations of origin, competition awards and quality seals."

Trade Group Announces Olive Oil Quality Testing Initiative

Faced with low supply and high prices, the North American Olive Oil Association says it seeks to deter dishonest actors.

By Daniel Dawson
Nov. 15, 2023 13:44 UTC

How do you know if extra-virgin olive oil is really extra-virgin? Australia to start quality monitoring program

ABC Rural / By Elsie Adamo and Faith Tabalujan
Posted Tue 9 Apr 2024 at 8:54pm, updated Yesterday at 3:11pm

AI-generated image

CALIFORNIA DEPARTMENT OF
FOOD & AGRICULTURE

Grade and Labeling Standards for Olive Oil, Refined-Olive Oil and Olive-Pomace Oil

Effective September 26, 2014

				Physico-chemical quality parameters								Sensory evaluation	
				FFAs	PV	K_{232}	K_{268} or K_{270}	Δ K	FAEEs	PPPs	1,2-DAGs	MeD	MeF
Olive oils	Virgin olive oils	EVOO	IOC	≤ 0.8	≤ 20.0	≤ 2.50	≤ 0.22	≤ /0.01/	≤ 35	N/C		0	> 0.0
			Codex						N/C				
			EU						≤ 35				
			USDA										
			AUS						N/C	≤ 17	≥ 35		
			CAF	< 0.5	< 15.0	< 2.40							
		VOO	IOC	≤ 2.0	≤ 20.0	≤ 2.60	≤ 0.25	≤ /0.01/	N/A	N/C		0 < Me ≤ 3.5	> 0.0
			Codex									0 < Me ≤ 2.5	
			EU						N/A			0 < Me ≤ 3.5	
			USDA						N/C	N/A		0 < Me ≤ 2.5	
			AUS										
			CAF	≤ 1.0									
		OVOO	IOC	≤ 3.3	≤ 20.0	N/A	≤ 0.30	≤ /0.01/	N/A	N/C		3.5 <Med ≤ 6.0	N/A
			Codex						N/C			2.5 < Me ≤ 6.0	
		LVOO	IOC	> 3.3	N/A				N/A	N/C		Me > 6.0	N/A
			EU	> 2.0								Me > 3.5	
			USDA									Me > 2.5	
			AUS		> 20.0	>2.60	>0.25	>/0.01/	N/C	N/A		Me > 2.5	
			CAF	> 1.0				≤ /0.01/					
	ROO		IOC	≤ 0.3	≤ 5.0	N/A	≤ 1.10	≤ /0.16/	N/A	N/C		N/A	N/A
			Codex						N/C				
			EU						N/A				
			USDA										
			AUS						N/C	N/A		≤ 2.5	
			CAF										
	OO		IOC	≤ 1.0	≤ 15.0	N/A	≤ 0.90	≤ /0.15/	N/A	N/C		N/A	N/A
			Codex						N/C				
			EU						N/A				
			USDA										
			AUS						N/C	N/A		≤ 2.5	> 0.0
			CAF	≤ 0.8									

AUS (Australian standards): 2011
CAF (California standards): 2014

Bajoub, A., Bendini, A., Fernández-gutiérrez, A., & Carrasco-pancorbo, A. (2018). Olive oil authentication: A comparative analysis of regulatory frameworks with especial emphasis on quality and authenticity indices, and recent analytical techniques developed for their assessment. A review. *Critical Reviews in Food Science and Nutrition*, *58*(5), 832-857.

EVOO shelf-life prediction & determination

mandated by the Olive Oil Commission of California since HY2019

The Guillaume - Ravetti (2016) Use-by-date Prediction Model:

The use-by-date is determined by the *lowest* of the following three estimations:

1) Hours of **induction time** at 110°C x 1 = expected shelf-life (in months).
2) (17.0% - **PPP**)/0.6% = expected shelf-life (in months).
3) (**DAGs** – 35.0%)/**FFA factor** = expected shelf-life (in months).

- FFA factor = 1.7% (if FFA < 0.4%); 2.1% (if 0.4% < FFA < 0.6%); or 2.5% (if FFA > 0.6%).

Non EVOO:

- **Expected shelf-life is a negative value**
- **Sensory evaluation: MeD > 0 (sensory defect(s) present)**

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*(1), 6393962.

INTERNATIONAL OLIVE COUNCIL

COI/T.15/NC No 3/Rev. 20
November 2024

ENGLISH
Original: FRENCH

- Myristic acid	≤ 0.03
- Palmitic acid	7.00 - 20.00
- Palmitoleic acid	0.30 - 3.50
- Heptadecanoic acid	≤ 0.40
- Heptadecenoic acid	≤ 0.60
- Stearic acid	0.50 - 5.00
- Oleic acid	55.00 - 85.00
- Linoleic acid	2.50 - 21.00
- Linolenic acid	≤ 1.00 [3]
- Arachidic acid	≤ 0.60
- Gadoleic acid (eicosenoic)	≤ 0.50
- Behenic acid	≤ 0.20*
- Lignoceric acid	≤ 0.20

- Cholesterol	≤ 0.5
- Brassicasterol	≤ 0.1*
- Campesterol	≤ 4.0**
- Stigmasterol	< campesterol in edible oils
- Delta-7-stigmastenol	≤ 0.5***
- Apparent beta-sitosterol: beta-sitosterol + delta-5-avenasterol + delta-5-23-stigmastadienol + clerosterol + sitostanol + delta 5-24-stigmastadienol	≥ 93.0

FATTY ACID COMPOSITION (Expressed as % m/m Methyl Esters)		
Myristic acid	(C 14:0)	≤0.05
Heptadecanoic acid	(C17:0)	≤0.3
Stearic acid	(C 18:0)	0.5-5.0
Arachidic acid	(C20:0)	≤0.6
Behenic acid	(C22:0)	≤0.2[1]
Lignoceric acid	(C24:0)	≤0.2

STEROL AND TRITERPENE DIALCOHOLS COMPOSITION (Expressed as % of Total Sterols)	
Brassicasterol	≤0.1
Stigmasterol	≤1.9

Crushing

Malaxing

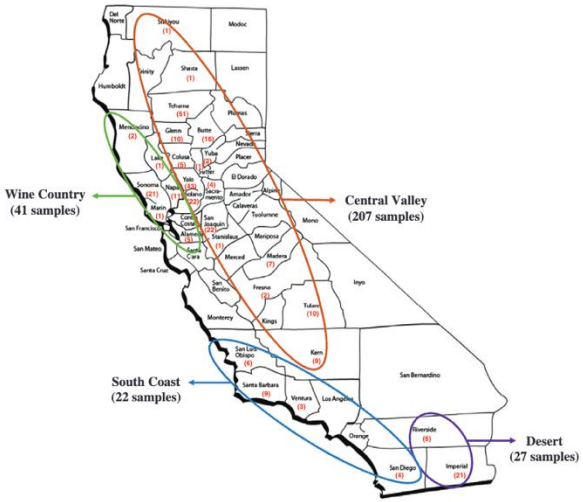
Centrifuging

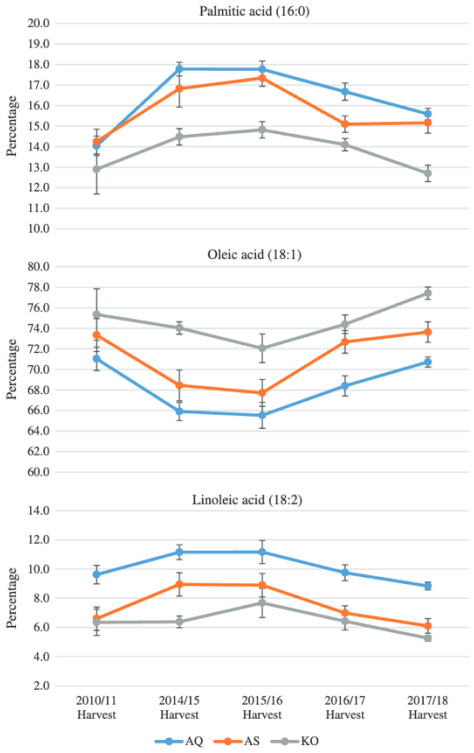
J Am Oil Chem Soc (2019) **96:** 215–230
DOI 10.1002/aocs.12192

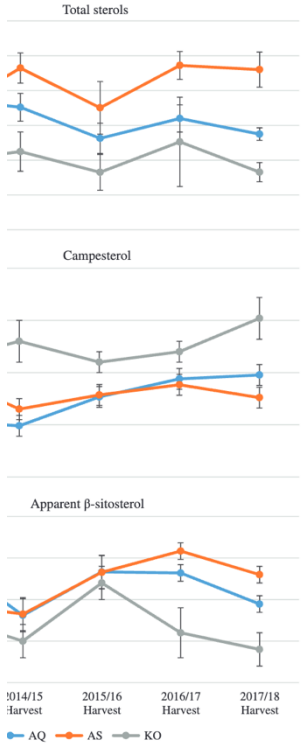
ORIGINAL ARTICLE

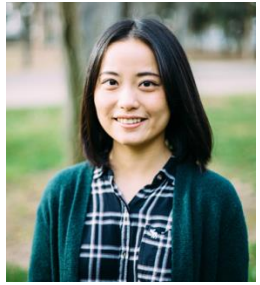
The Effects of Variety, Growing Region, and Drought Stress on Fatty Acid and Sterol Compositions of California Olive Oil

Xueqi Li[1] · Jon D. Flynn[1] · Selina C. Wang[1,2]









Xueqi (Shirley) Li MS

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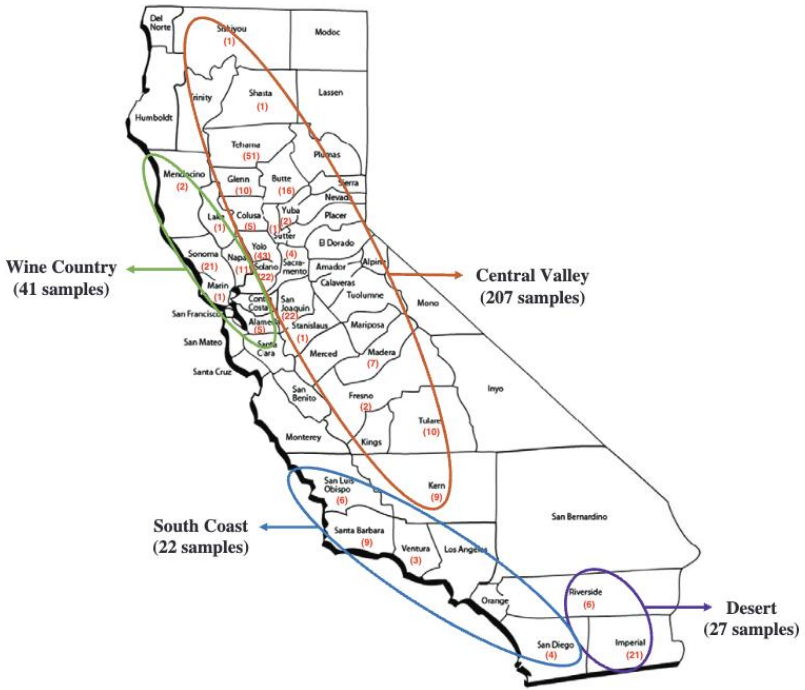
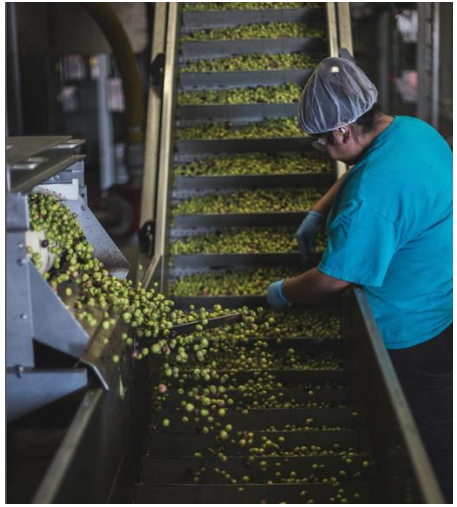


- **Arbequina and Arbosana (Desert)**
  - ↑ palmitic acid (C16:0)
  - ↑ palmitoleic acid (C16:1)
  - ↑linoleic acid (C18:2)
  - ↓ oleic acid (C18:1)
  - ↑ campesterol
  - ↓ apparent β-sitosterol
- **Koroneiki (Central Valley & Desert)**
  - ↑ campesterol
  - ↓ apparent β-sitosterol
  - ↓ total sterols
- **Arbequina, Arbosana, Picual, and Leccino (Desert)**
  - ↑ total sterols
- **SHD varieties (Central Valley)**
  - ↑ heptadecenoic acid (C17:1)
- **SHD varieties (Desert)**
  - ↑ campesterol
  - ↓ apparent β-sitosterol
  - ↑ delta-7-stigmastenol
  - ↑ stigmasterol




Agri-food industry is responsible for the generation of high volumes of organic wastes (biomasses), reaching up to 140 billion tons per year.

Received: 12 June 2021 | Revised: 31 August 2021 | Accepted: 3 September 2021

DOI: 10.1111/1750-3841.15925

Journal of Food Science WILEY

INTEGRATED FOOD SCIENCE

Health benefits of first and second extraction drum-dried pitted olive pomace

Marce Inzunza-Soto[1] | **Sandy Thai**[2] | **Amanda J. G. Sinrod**[3] | **Donald A. Olson**[2] | **Roberto J. Avena-Bustillos**[2] | **Xueqi Li**[4] | **Matthew R. Rolston**[5] | **Selina C. Wang**[3] | **Eli Teran-Cabanillas**[1] | **Wallace Yokoyama**[2] | **Tara H. McHugh**[2]

Contents lists available at ScienceDirect

LWT

journal homepage: www.elsevier.com/locate/lwt

Integrated microwave- and enzyme-assisted extraction of phenolic compounds from olive pomace

Gabriela A. Macedo[a,c], Ádina L. Santana[a,b], Lauren M. Crawford[c], Selina C. Wang[c,d], Fernanda F.G. Dias[c], Juliana M.L.N. de Moura Bell[c,e,*]

[a] Bioprocesses Laboratory, DEPAN/FEA (School of Food Engineering), Unicamp (University of Campinas), R. Monteiro Lobato, 80, 13083970, Campinas, Brazil
[b] 264 Food Innovation Center, University of Nebraska-Lincoln, 1901 N 21st Street, Lincoln, NE, 68588, United States
[c] Department of Food Science and Technology, University of California, Davis, One Shields Avenue, Davis, CA, 95616, United States
[d] Olive Center, Robert Mondavi Institute for Wine and Food Science, University of California, Davis, One Shields Avenue, Davis, CA, 95616, United States
[e] Biological and Agricultural Engineering, University of California, Davis, One Shields Avenue, Davis, CA, 95616, United States

Contents lists available at ScienceDirect

LWT

journal homepage: www.elsevier.com/locate/lwt

Characterization of California olive pomace fractions and their *in vitro* antioxidant and antimicrobial activities

Hefei Zhao[a], Yoonbin Kim[a], Roberto J. Avena-Bustillos[b], Nitin Nitin[a,c], Selina C. Wang[a,*]

[a] Department of Food Science and Technology, University of California, Davis, One Shields Ave, Davis, CA, 95616, USA
[b] Western Regional Research Center, Healthy Processed Foods Research, Albany, CA, 94710, USA
[c] Department of Biological and Agricultural Engineering, University of California, Davis, One Shields Ave, Davis, CA, 95616, USA

Construction and Building Materials 330 (2022) 127217

Contents lists available at ScienceDirect

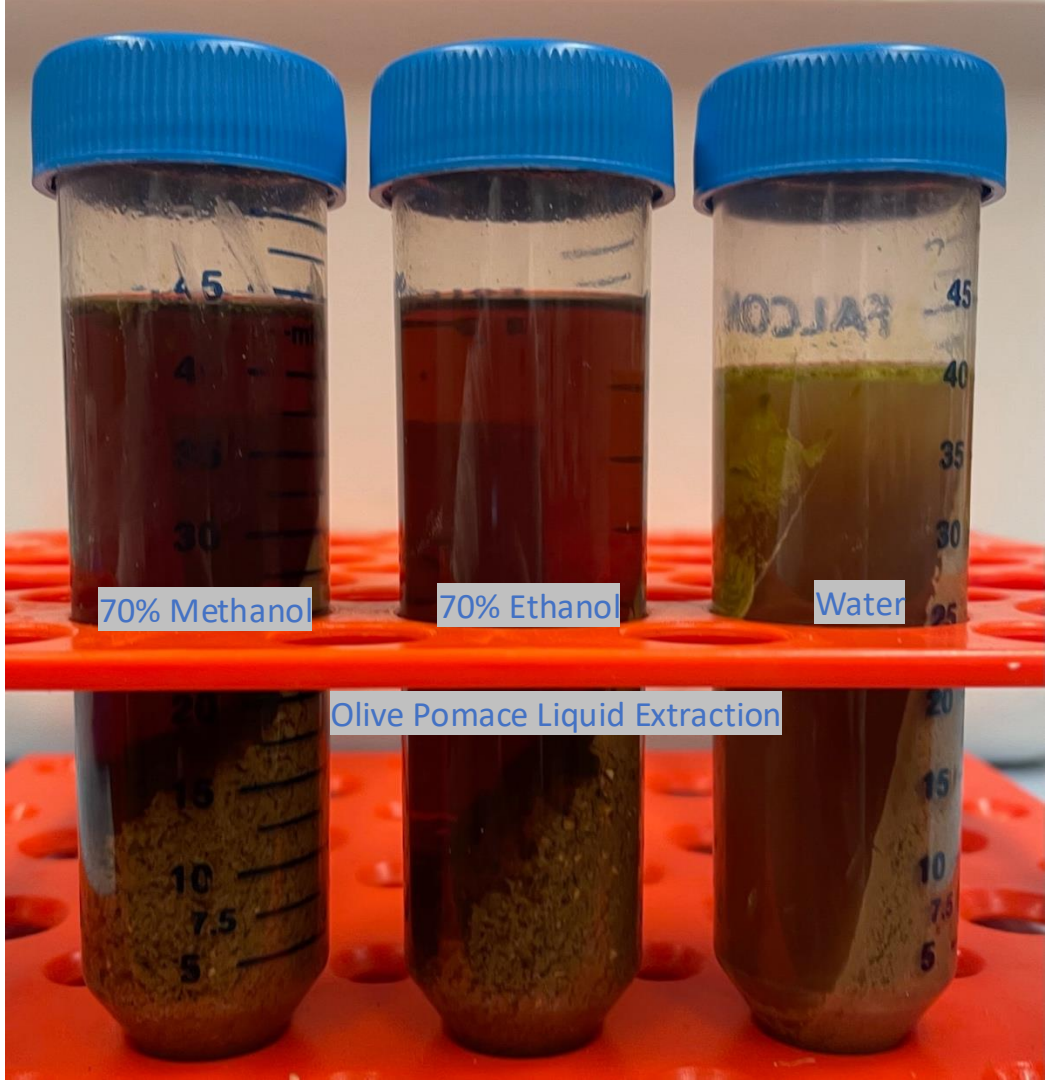
Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Upcycle olive pomace as antioxidant and recycling agent in asphalt paving materials

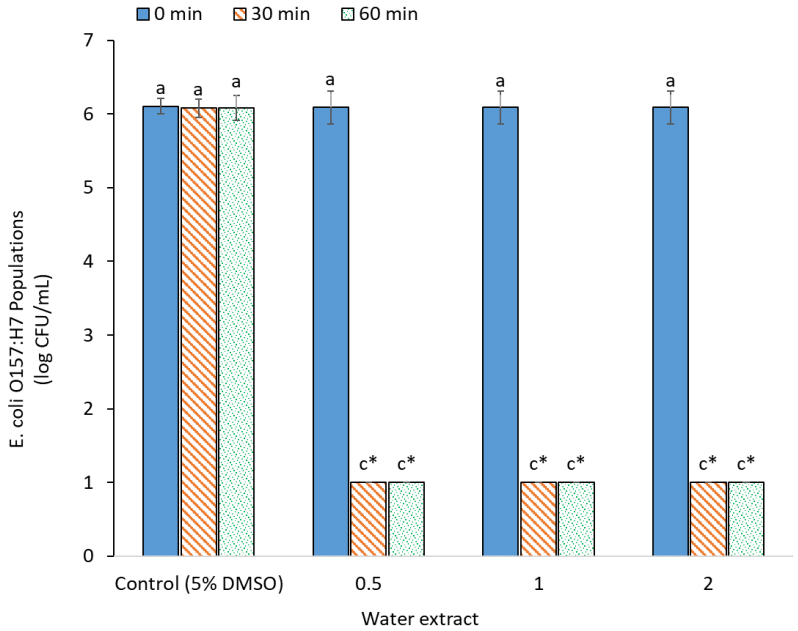
Kun Zhang[a,*], Hefei Zhao[b], Selina C. Wang[b]

[a] Department of Civil Engineering, California State University, Chico CA95929, USA
[b] Department of Food Science and Technology, University of California, Davis, CA 95616, USA

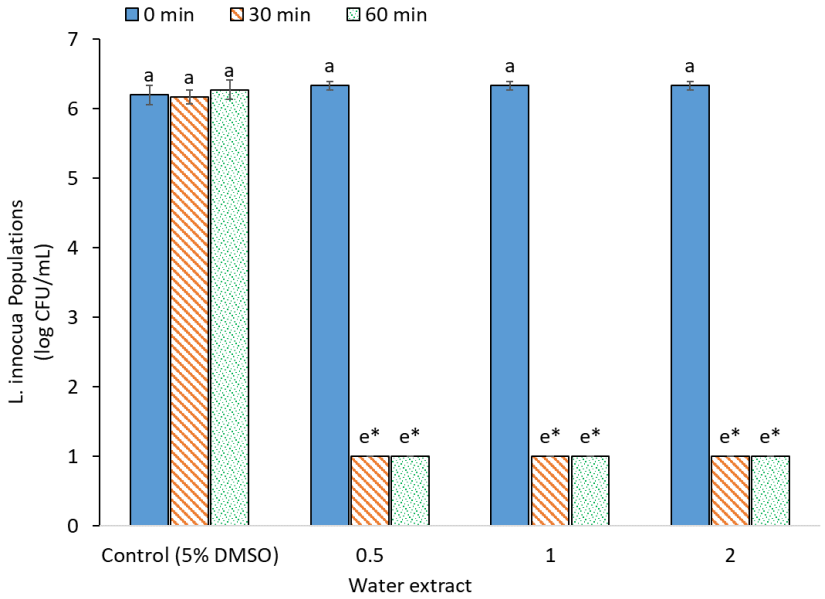

70% Methanol
70% Ethanol
Water
Olive Pomace Liquid Extraction

Antimicrobial treatment activities of water extracts 0.5, 1.0, and 2.0 mg GAE/mL) against *E. coli* O157:H7 and *L. innocua*.

- *E. coli* O157:H7



- *L. innocua.*



Leading olive oil research in the US

Call to action – quality and purity

Regulations and standards

Method development

Processing – yield, quality, and nutrient density

Byproducts

Avocado oil gaining popularity

Should You Be Using Avocado Oil Instead of Olive Oil?

We taste tested and cooked with avocado oil to see if it beats out olive oil for a spot in our pantry.

Sample Collection

22 samples, representative of avocado oils available in the US, were collected from in stores (14) and online (8).

Samples were grouped according to their label: Extra virgin (EV), refined (R), unspecified (U).

Price/ fl oz varied from $0.25-$2.35 across all samples ($8.45-79.4/Liter).

Quality

Free fatty acidity

Peroxide value

UV absorbance

Purity

Fatty acids

Sterols

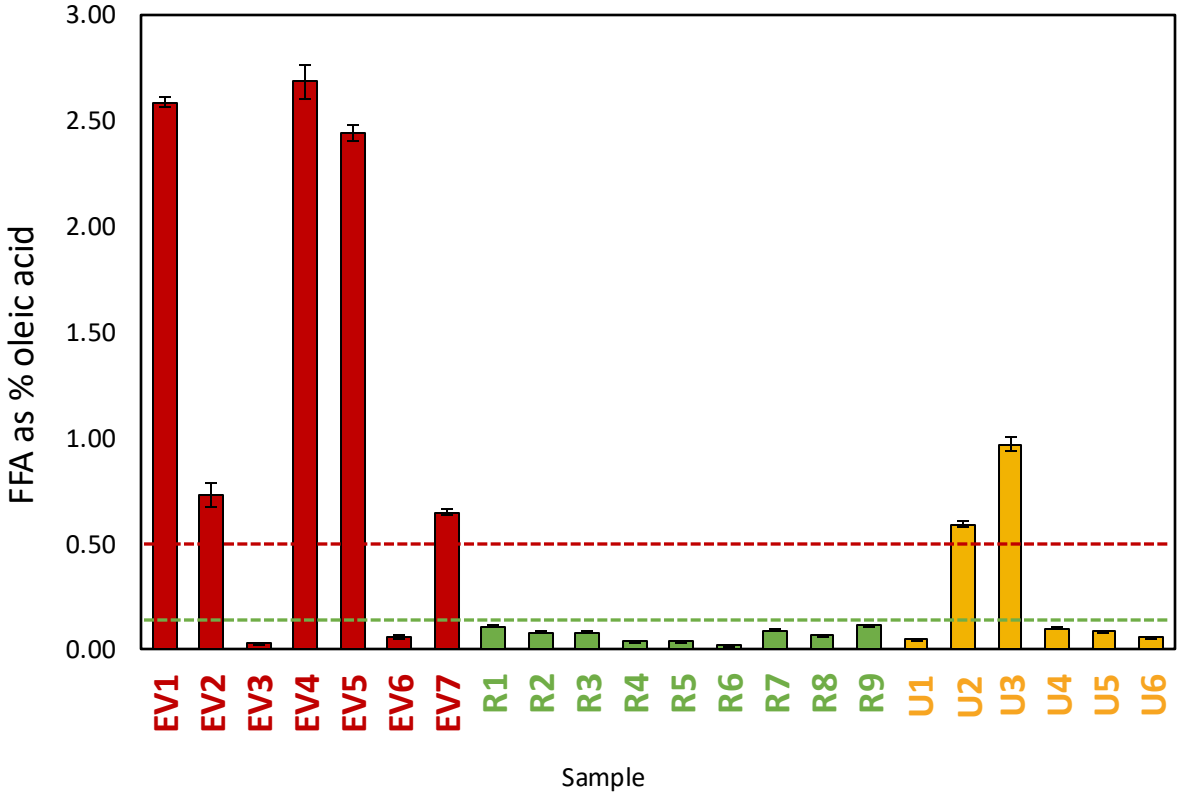
Triacylglycerols

Minor Components

Tocopherols

Chlorophylls

Free fatty acid content



Dashed lines indicate proposed limits for extra virgin and refined avocado oils.

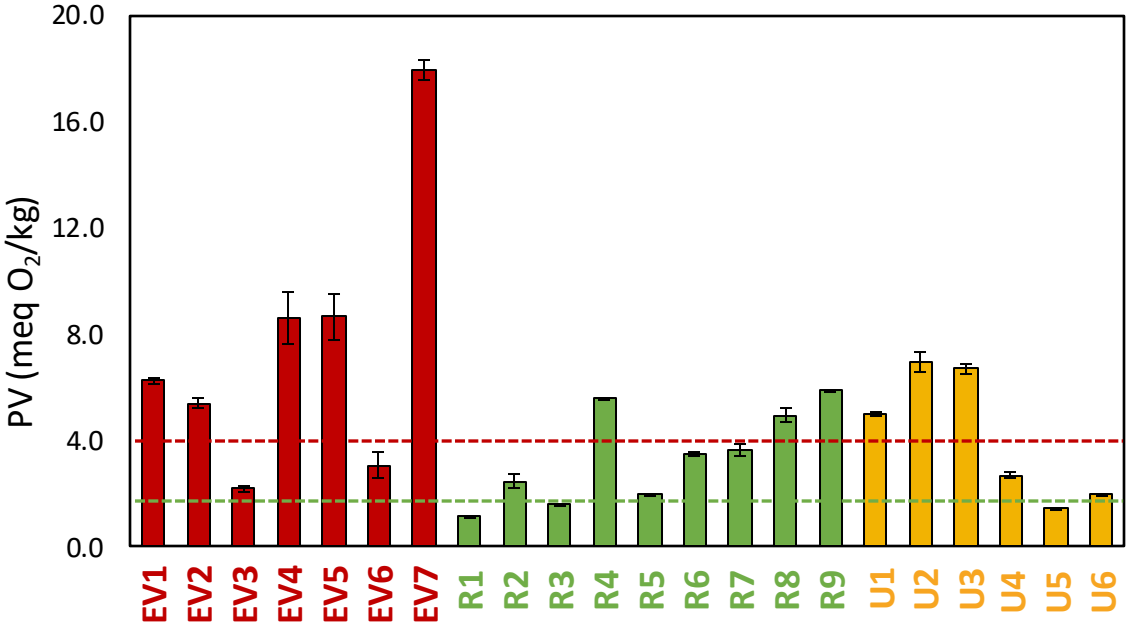
[1]Refined: ≤ 0.1 % (green)

[2]Extra Virgin: <0.5% (red)

[1]CODEX proposed standards, 2019.

[2]Woolf (2009). Avocado Oil. *Gourmet and Health-Promoting Specialty Oils*.

Peroxide value: Indicator of oxidation



Dashed lines indicate proposed limits for extra virgin and refined avocado oils.

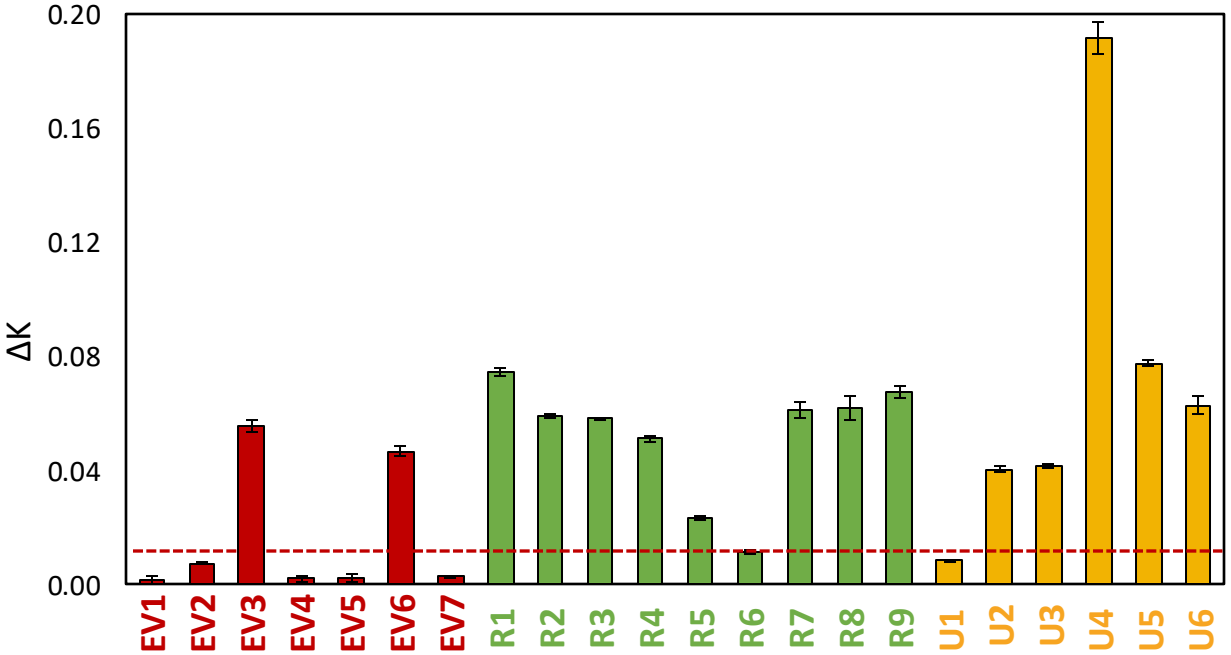
[1]Refined: ≤ 2.0 meq O_2/kg oil

[2]Extra Virgin: ≤ 4.0 meq O_2/kg oil

[1]CODEX proposed standards, 2019.

[2]Woolf (2009). Avocado Oil. *Gourmet and Health-Promoting Specialty Oils*.

Delta K: Indicator of refining



Dashed line shows standard for ***extra virgin olive oil***, ΔK: ≤ 0.01.

There is no proposed standard or literature available for ΔK in avocado oil.

Fatty acid profile: Purity Parameter

	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3
EV1	16.5±0.12	6.9±0.01	0.5±0	55.6±0.13	19.2±0.12	1.2±0.01
EV2	15.6±0.01	6.5±0	0.5±0	61±0	15.2±0	1±0
EV3	10.9±0.01	0.1±0.02	4±0.02	21.4±0.15	54.4±0.15	8.2±0.03
EV4	15.5±0	6.4±0.01	0.5±0.01	59.3±0.12	17±0.11	1.1±0.02
EV5	15.6±0.01	6.4±0	0.5±0	58.6±0	17.5±0	1.1±0
EV6	10.4±0.03	0.1±0	3.8±0.01	19.7±0.5	55.4±0.4	9.8±0.05
EV7	16±0.01	6.6±0	0.5±0	62.4±0.01	13.4±0	0.9±0
R1	10±0.02	1.7±0	2.3±0	69.1±0.02	15.2±0	0.5±0
R2	14.7±0.01	5.8±0	1.4±0	64.4±0.07	12.2±0.03	0.7±0.01
R3	13.2±0.03	4.2±0.01	1.4±0	63.8±0.09	16±0.12	0.7±0
R4	15.8±0.01	6.8±0	0.5±0	63.8±0.01	12±0	0.8±0
R5	15±0	6.5±0	0.8±0	63.6±0	12.8±0	0.8±0
R6	17.8±0.03	8.6±0.02	0.6±0	61±0.07	10.9±0.02	0.8±0
R7	14.4±0.01	5.2±0	1.4±0	64.8±0.02	13±0	0.7±0
R8	13.4±0	5.1±0	1.6±0	67.5±0.02	10.9±0.01	0.6±0
R9	14.1±0.01	5.2±0.01	1±0	63.2±0.02	15±0	0.8±0
U1	16.5±0.01	7.4±0.01	1.3±0	63.9±0.01	9.8±0	0.7±0
U2	16.4±0	7.2±0.01	0.6±0	60±0.05	14.7±0.03	0.9±0.01
U3	16.5±0.02	7.4±0	0.6±0	60.4±0.02	13.9±0.01	0.8±0
U4	10.4±0.01	2±0	2.1±0	66.5±0.02	17.4±0.01	0.5±0
U5	11.2±0.02	0.6±0	2.8±0	68.3±0.02	15.4±0	0.5±0
U6	10.9±0	0.1±0	4±0	21±0	54.7±0.01	8.2±0

ELSEVIER

Food Control

Volume 116, October 2020, 107328

First report on quality and purity evaluations of avocado oil sold in the US

Hilary S. Green [a], Selina C. Wang [a, b]

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https://doi.org/10.1016/j.foodcont.2020.107328

Highlights

- Avocado oils on the market labeled extra virgin and refined are of poor quality.
- Adulteration of avocado oils on the market was confirmed.
- There is an urgent need to develop standards for avocado oil to protect consumers.
- Standard are also needed to protect genuine producers and the industry as a whole.

Key Findings

- 82% of the samples were of poor quality or adulterated.
- Adulteration with 100% soybean oil was confirmed in three samples (two labelled as EV).
- More research is needed to understand how chemical compositions change with climate and growing region.

Capital Press

UC-Davis study scrutinizes quality of avocado oils

Most avocado oils sold in the U.S. are stale or impure, researchers say. Some of them contain hardly any avocado at all, they say. Avocado oil ...

1 week ago

The New Food Economy

Avocado oil is booming. Most of it is rancid.

... at the University of California, Davis, researchers tested 22 commercially available samples of extra virgin, virgin, and refined avocado oil for ...

Jun 17, 2020

UC Davis

Study Finds 82 Percent of Avocado Oil Rancid or Mixed With ...

But according to new research from food science experts at the University of California, Davis, the vast majority of avocado oil sold in the U.S. is ...

Jun 15, 2020

SciTechDaily

Warning on Avocado Oil Sold in the U.S.: 82% Tested Rancid or Mixed With Other Oils

In first extensive study of commercial avocado oil quality and purity, UC Davis researchers find majority impure or stale. Food scientist says ...

Jun 17, 2020

Woodland Daily Democrat

Study finds most avocado oil is rancid

A UC Davis study has found that most avocado oil sold in the United States is of poor quality or mislabeled. ASSOCIATED PRESS ARCHIVES.

Jun 15, 2020

Olive Oil Times

82 Percent of Avocado Oil Adulterated, Mislabeled or Poor Quality, Study Finds

The UC Davis study confirmed findings from avocado oil producers' own independent surveys of the market. Hannam explained his company's ...

Jun 22, 2020

MinnPost

Most avocado oil sold in US is either rancid or contains other oils, study finds

... scientist at the University of California, Davis, in a released statement. “But because there are no standards to determine if an avocado oil is ...

Jun 24, 2020

National Post

Avofraudo: 'Vast majority' of avocado oil is either rancid or ...

... a new study conducted at the University of California, Davis (UC Davis) found that “the vast majority” of avocado oils sold in the U.S. fall short.

Jun 23, 2020

New Food

Shocking number of avocado oils sold in US are rancid or ...

In what is said to be the country's first extensive study of commercial avocado oil quality and purity, the UC Davis team report that as much as ...

Jun 18, 2020

Foodprocessing

US study: 82% of avocado oil either rancid or adulterated

In the study, UC Davis researchers reported that at least 82% of test samples were either stale before expiration date or mixed with other oils. In ...

Jun 22, 2020

Food Control
Volume 152, October 2023, 109837

Purity and quality of private labelled avocado oil

Hilary S. Green, Selina C. Wang

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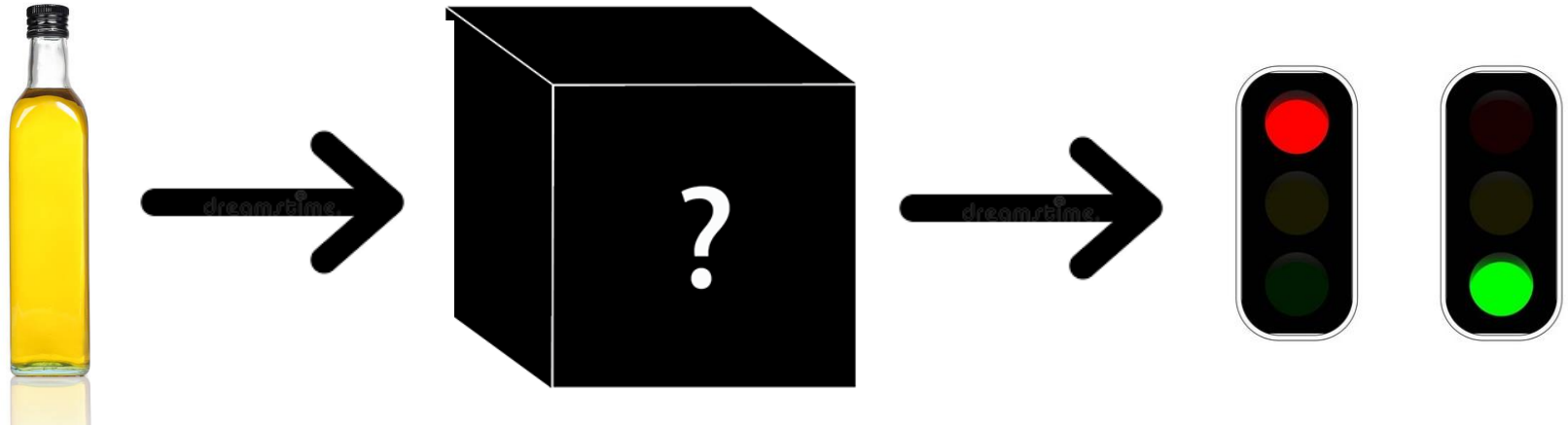
https://doi.org/10.1016/j.foodcont.2023.109837

Highlights

- Of 36 private labeled avocado oils 31% were pure and 36% of advertised quality.
- Three refined samples and one extra virgin met both quality and purity standards.
- Stearic fatty acid and delta-7-stigmastenol may be useful adulteration indicators.
- Professional buyers can use common markers to make confident supplier choices.
- Extremely low-priced oils were more likely to be adulterated.

Key Findings

- 70% of the samples were of poor quality or adulterated.
- Adulterants and ratios were different from the first study.
- Extremely low-priced oil were more likely to be adulterated, but high price didn't guarantee quality or purity



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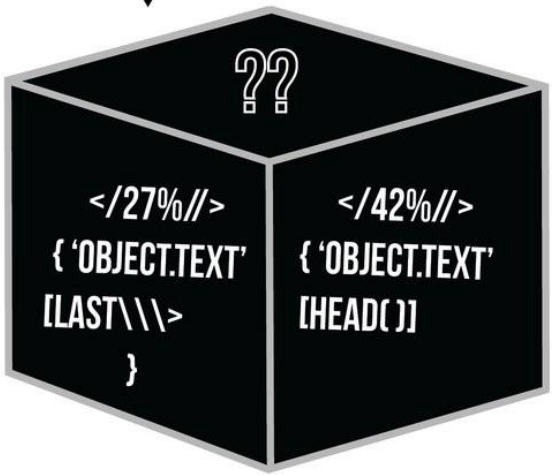

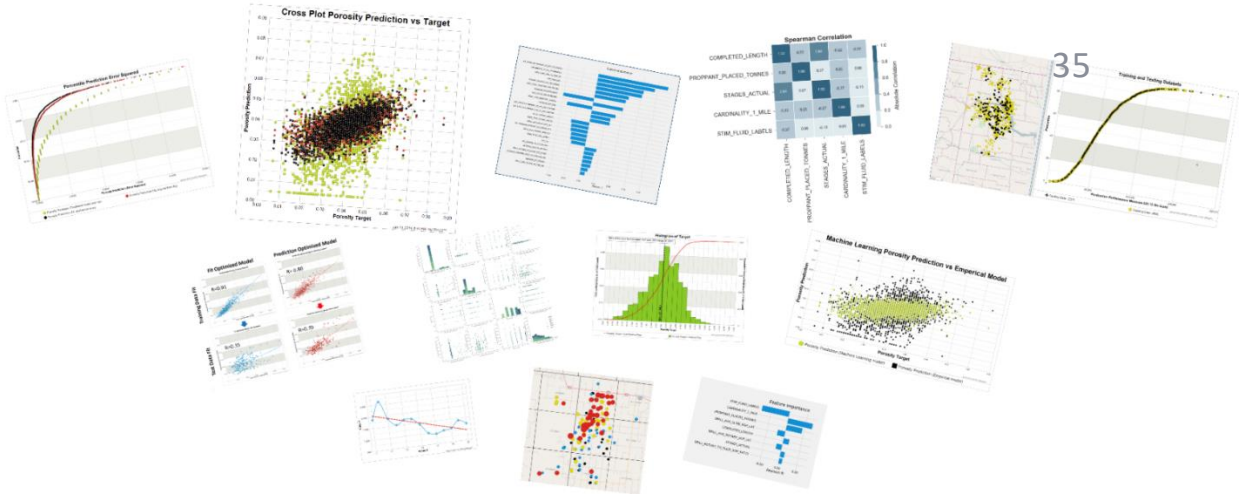

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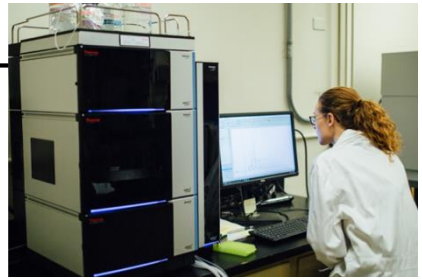
Food Analytical Methods (2023) 16:850–856
https://doi.org/10.1007/s12161-023-02468-7



Tandem Triacylglycerol (TAG) and PCA Adulteration Detection Approach for Avocado Oil

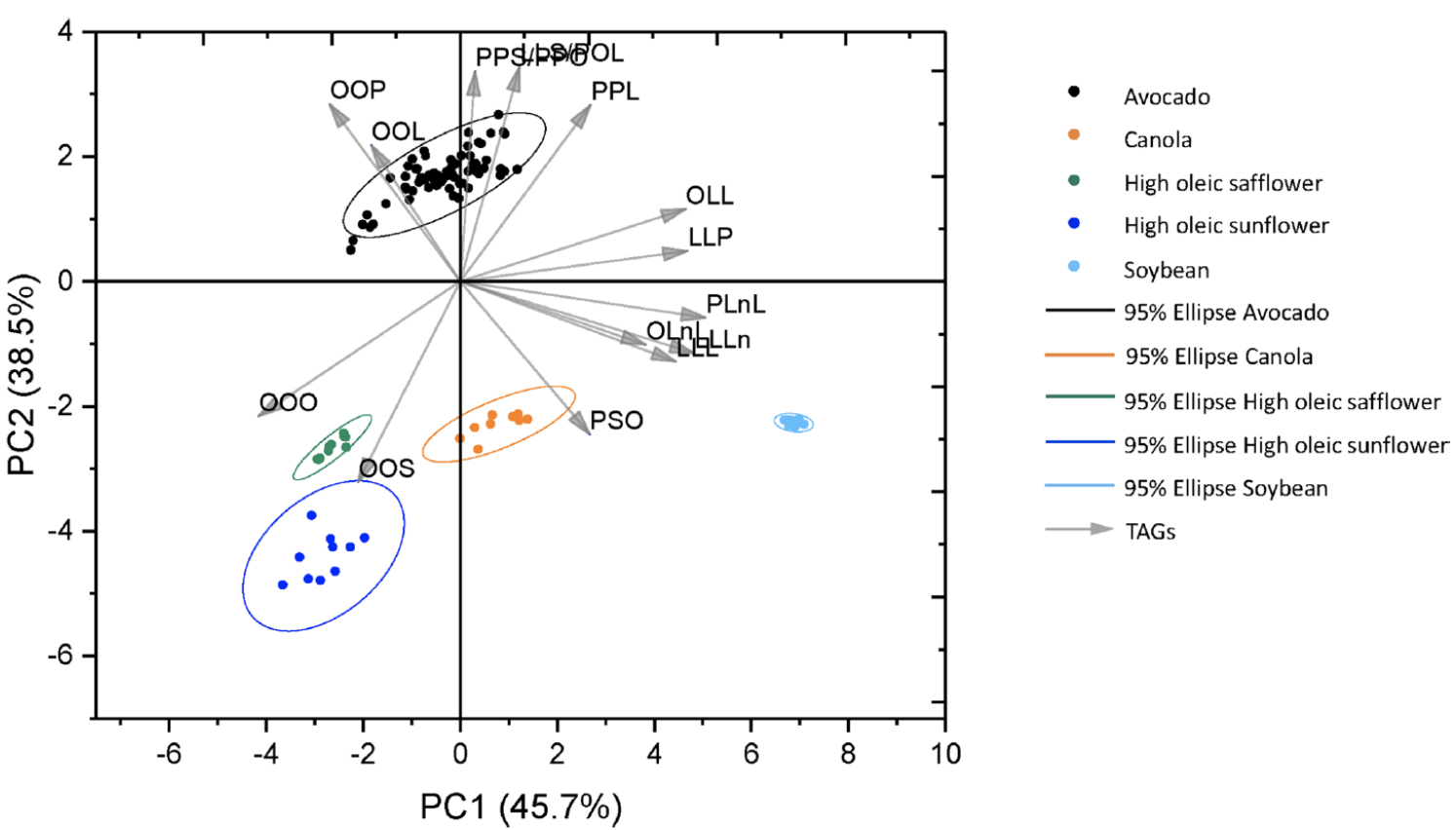
Hilary S. Green[1] · Selina C. Wang[1]

Received: 17 July 2022 / Accepted: 2 March 2023 / Published online: 14 March 2023

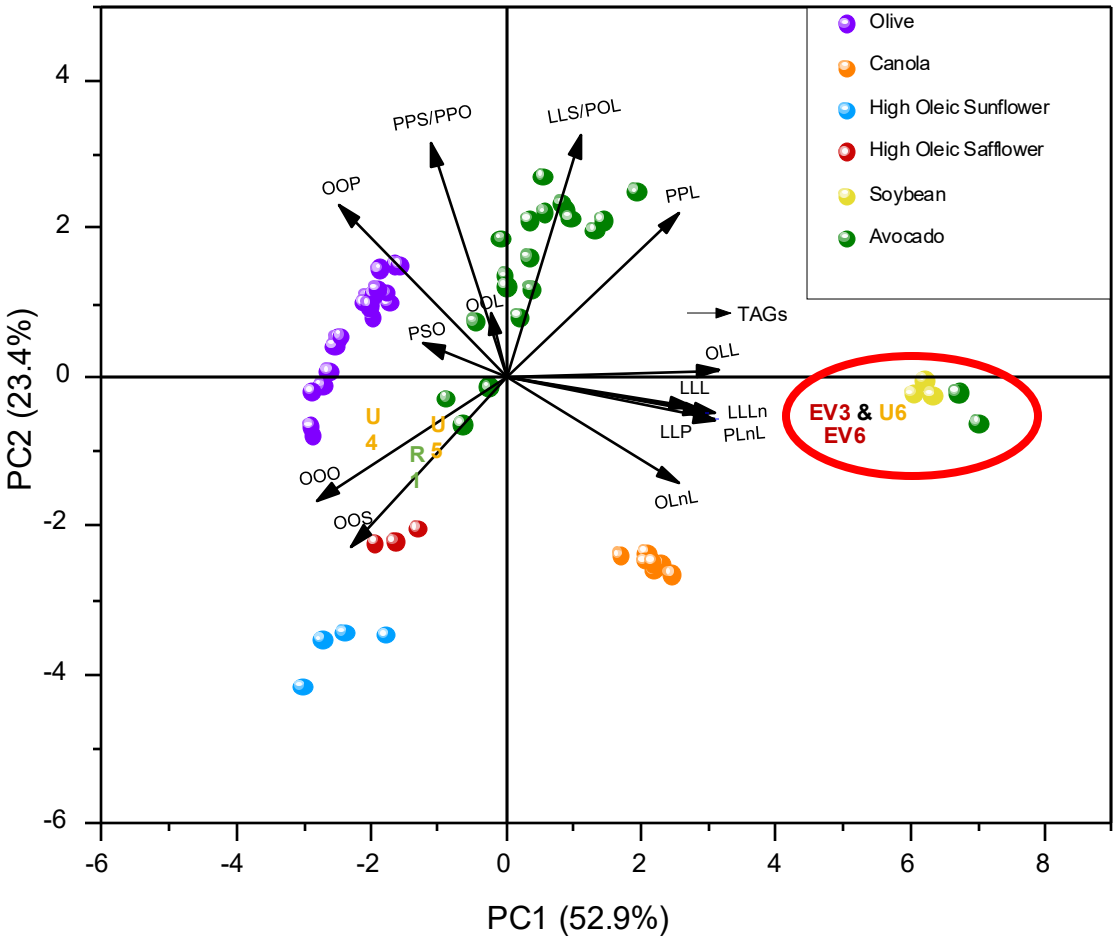
Abstract

Traditional methods used to determine oil purity like fatty acids and sterols are time consuming and chemically wasteful; standards that utilize these methods require a large set of samples to cover natural variables to establish upper and/or lower limits for each compound. Due to this, it can be challenging to determine the purity of newer products on the market, like avocado oil, when standards have not yet been fully developed. Triacylglycerol analysis in tandem with principal component analysis (PCA) differs from these tradition methods; standard ranges for each triacylglycerol are not needed to determine purity. This study built on our earlier work on olive oil but used laboratory-made avocado oils accounting for a wide range of natural variables to measure avocado oil triacylglycerols and apply PCA to detect adulteration in avocado oil. This method had the same purity determination accuracy as traditional fatty acid and sterol methods, while being less time consuming, producing less chemical waste, easier to perform than the original methods with the added advantage that it can be utilized immediately by industry while official standards are still being developed.

Principal component analysis using TAGs as variables showing avocado oil compared to potential adulterant oils



TAG analysis



Key Takeaways

- Food fraud compromises consumers trust, reduce livelihood of honest producers, and undermines the credibility of industry and government over the quality and safety of food
- Standards need to be accommodating of natural variables but robust to differentiate quality and authenticity
- Climate is changing – food processing needs to be more sustainable and better for human and planetary health
- Collaboration and cooperation are imperative.

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Contact us:

ucfoodquality.ucdavis.edu

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