Rapid adulteration detection of cold pressed oils with their refined versions by UV–Vis spectroscopy

Subtitle **Chemical Engineering**

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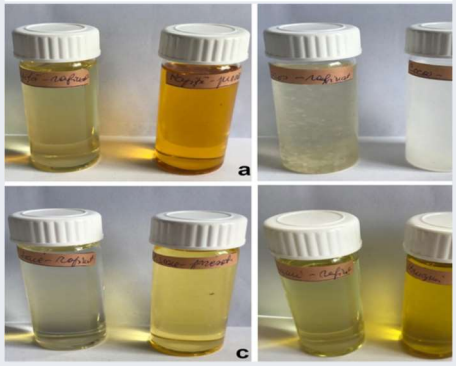
Visual colour difference between refined and cold pressed (right) oils: (a) Canola; (coconut; (c) sunflower; (d) grapeseed

Absorbance spectra of cold pressed oils adulterated with refined ones (percentage cold pressed oil): (a) Canola; (b) coconut; (sunflower; (d) grapeseed



Abstract

The accelerated development of European and national public policies in the field of food safety aims to protect human health and consumer interests as well as a fair relationship between producers and consumers. The aim of this study is the rapid detection of food pressed oils adulteration with their refined versions, using UV–Vis spectroscopy. The study investigates some common oil physicochemical parameters such are: density, viscosity, refractive index, etc., to detect differences between cold pressed oils versus refined ones, for some food-grade oils found on Romanian market, as well as other analytical methods, obtaining similar results to those presented in the literature. Color analysis instead is a very good and rapid method to differentiate a cold pressed oil from a refined one.

KEY TERMS

Oils adulteration – it is the practice to add other oils to pure oils to increase the profit margin.

UV-VIS spectroscopy – has application in analytical chemistry, especially in quantitative analysis. It deals with measuring the absorption of light by a substance or matter to obtain information regarding its structure and properties.

The physicochemical parameters for oil monitoring are determined by characteristics such as: density, viscosity, refractive index, acidity index, etc.

Introduction

Recent developments have expanded food safety objectives. The new approach, which seeks a fair and direct relationship, has been integrated and developed at the European level in the global European Green Pact of 2020, which aims to align healthy and safe food production for consumers with the need to preserve the environment.

Beans and seeds are the most important vegetable oil sources. Some oils are obtained from cold pressing technology, which is environmentally friendly, preserves the nutrients in the oils and is easy to perform. Cold pressed oils contain natural ingredients with numerous health benefits. There are different methods to obtain refined oils in food industry. By refining technologies, undesirable materials may be removed along with some valuable components. Quality differences of cold pressed vs. refined oils were reported. Some physicochemical parameters, such are: density, acid index, peroxide value, viscosity, or GC–MS (gas chromatography mass spectrometry) detection may be used to distinguish a cold pressed oil from a refined one. Fatty acids composition of vegetable oils influences human health, lipids being among fundamental nutrients.

Price of food oils depends on their quality and purity, cold pressed oils being more expensive, that is why labels on oil bottles must mention whether it is crude or a refined oil. Cold pressed oils are frequently subjected to fraud by mixing with different other seeds oils with inferior quality. Standards and rules are introduced by international quality control organizations to detect and prevent food oil falsification.

Some authors proposed methods to investigate these adulterations, such are: three-dimensional fluorescence spectroscopy, UV–IMS and chemometric analysis, fluorescence quenching method with aqueous CTAB-coated quantum dots, confocal X-ray scattering analysis with coherent/incoherent scattered X-rays, near-infrared spectroscopy and chemometric techniques, optical thin-film biosensor chips, or stimulated Brillouin scattering in combination with visible absorption spectroscopy. Oil color is an important property for consumers and a good indicator of oil quality. Yet, this feature was presented only in a few articles.

To the best of our knowledge, there are no reports on detecting adulteration of cold pressed oils with their refined versions, or the use of CIEL*a*b* color space in UV–Vis spectroscopy method for adulteration detection. The purpose of this paper is to highlight that UV–Vis spectroscopy is a rapid and facile method for detecting adulteration of some cold pressed oils with their refined versions in different proportions, comparing to some other known and used methods.

Methods

Four different cold pressed oils and their refined versions were purchased from the Romanian market: coconut oil, sunflower oil, grapeseed oil and Canola oil, for a period of three years. Every year we purchased all oils under the same brand names, to compare the results. Because the properties of the oils were similar, in this paper we only presented one example for each oil purchased in the last year of the research. The chemicals used
in this study were of analytical grade.

Density was determined using pycnometer method. Refraction index was determined using an Abbe-Zeiss refractometer. Acid number was determined according to ISO 660: 2009 method. Peroxide value was determined according to ISO 3960: 2017 method.

Viscosity was determined using a Brookfield CAP 2000+ L viscosimeter. FT-IR spectra were recorded by the film working technique, with KBr pellets, using a Jascow FT-IR-430 spectrophotometer, at a resolution of 4 cm−1. color analysis was conducted using a Cary-Varian 300 Bio UV–VIS colourimeter with integrating sphere, using a Spectralon standard and three illuminants: D65, A and F2. All color data were expressed by *L*, a*, b** coordinates, where *L** corresponds to lightness; *a** corresponds to the transition from green (− *a**) to red (+ *a**); and *b** corresponds to the transition from blue (− *b**) to yellow (+ *b**).

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Women in STEM - Facts about the author.

Simona Popa is Associate Professor Habil. Dr. Engineer at Politehnica University Timişoara, Romania. For more than 25 years, she has been teaching courses on Colorants and Pesticides; Equipment for the ecological industry, Equipment for the food industry; Food policy; Food law and customer protection. In 2021 she presents her habilitation thesis: *Color and color analysis using CIEL*a*b* parameters from UV-Vis spectroscopy*. She has published numerous books and articles on her field of interest and presented the results of research projects implemented at various national and international conferences. The most important research topics concern: The bubble column reactor used in chemical technology to obtain ecological products; Color analysis of organic and food materials, Adsorption of dye traces and other toxic products from wastewater. Every year she is a scientific promoter for MS and BS students, through the coordination of their license and master theses. She is a member of national scientific societies/professional affiliation: Romanian Society of Chemistry, 1993 to present, Romanian Society of Chemical Engineering, 1993 to present, Brainmap Community – UEFISCDI. She has 2 invention patents registered in her field of activity.

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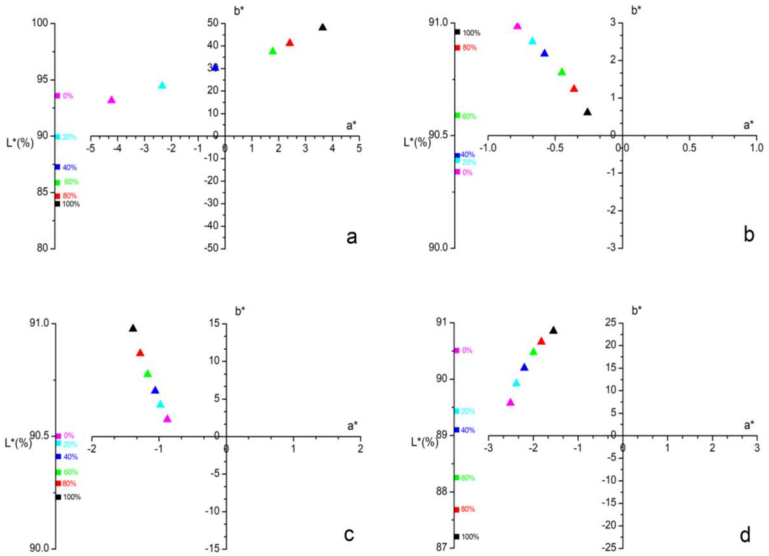
Results

The research on the adulteration of cold-pressed oils with their refined versions demonstrated:

-the usefulness of UV-Vis spectroscopy which is a fast and easy method for detecting the adulteration of some cold-pressed oils with their refined versions in different proportions, compared to other known and used methods.

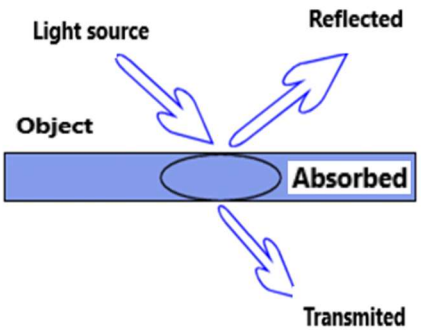
- the usefulness of the proposed method for consumer protection authorities who have a quick method by which they can detect the alteration of the quality of oil products intended for sale.



CIE L*a*b* parameters of cold pressed oils adulterated with refined ones (percentage of cold pressed oil): (**a**) Canola; (**b**) coconut; (**c**) sunflower; (**d**) grapeseed.

Discussion

- What is food adulteration?
-What is the UV-Vis spectroscopy?
-What is the Color analysis?
-How important are the research results of Dr. Simona POPA in everyday life?



Absorption, reflection and transmission of the light

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Conclusion

To verify theory, color analysis was also performed on the same four different cold pressed oils (coconut oil, sunflower oil, grapeseed oil and Canola oil) and their refined versions, which were purchased under different brand names. The proposed equations for the a* and b* parameters being like the previous ones. Classical physicochemical properties present very similar values for the tested cold-pressed oils and their refined versions, so they may not be successfully used for distinguishing a cold pressed oil from a refined one, and for the adulteration detection purposes. Color difference between the cold pressed oils and the refined ones may be visually appreciated and determined by UV–Vis spectroscopy. For this reason, this last investigation technique was proposed as a rapid method for appreciating adulteration of cold pressed oils with refined ones. When adulterating cold pressed oils with refined ones, the maxima in the absorbance spectra fade out as the percentage of refined oil adulteration increases. Regarding CIE L*a*b* parameters, dependence equations for *a** and *b** on cold pressed oil content (mass%) were proposed, that may be used to calculate the amount of cold pressed oil in a product. These results show us how research work can become useful in everyday life, contributing to the reduction of consumer risk in a growing and diversifying market such as the one in Romania.

Resources:

- Reference the original article: https://doi.org/10.1038/s41598-020-72558-7

Publish in *Scientific Reports*, 2020, 10:16100 WOS:000577212800012 (ISI 4.379/2021 – Q1)

Any other resources that will help understanding (articles, videos, podcasts etc):

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Siger, A., Józefiak, M. & Górnaś, P. Cold-pressed and hot-pressed rapeseed oil: the effects of roasting and seed moisture on the antioxidant activity, canolol, and tocopherol level. *Acta Sci. Pol. Technol. Aliment.* **16**(1), 69–81. https ://doi.org/10.17306 /J.AFS.2017.2017.0458 (2017).

Vingering, N., Oseredczuk, M., du Chaffaut, L., Ireland, J. & Ledoux, M. Fatty acid composition of commercial vegetable oils from the French market analysed using a long highly polar column. *Oilseeds Fats Crops Lipids* **17**(3), 185–192. https ://doi.org/10.1051/ocl.2010.0309 (2010).

Shirasawa, S., Sasaki, A., Saida, Y. & Satoh, C. A rapid method for trans-fatty acid determination using a single capillary GC. *J. Oleo Sci.* **56**(2), 53–58. https ://doi.org/10.5650/jos.56.53 (2007).

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Reflection Questions:

1.What is adulteration?

a) the alteration of physicochemical parameters by removing some substances

b) the action of making something poorer in quality by the addition of another substance

c) keeping the existing parameters

Answer: b) the action of making something poorer in quality by the addition of another substance

2. What is the Color analysis?

a) identification and determination of concentrations of substances that absorb light

b) the eye's perception of one or more frequencies (or wavelengths) of light.

c) the monitoring of the light absorption using spectrophotometric devices

Answer: c) the monitoring of the light absorption using spectrophotometric devices.

3. What is UV-Vis spectroscopy?

a) the measure of light absorption by a substance or a matter to obtain information regarding its structure and properties

b) the quantitative determination of the density of a substance

c) the quantitative determination of the viscosity of a substance

Answer: a) the measure of the light absorption by a substance or a matter to obtain information regarding its structure and properties.

4. Which is the visible range, for the human eye, of the spectrum?

a) 380-780nm

b) 180-380nm

c) 780-1080nm

Answer: a) 380-780nm

5. How important are research results in everyday life?

a) it helps us in choosing a product that respects its quality and characteristics

b) helps us buy more

c) helps us buy the worst quality

Answer: a) it helps us in choosing a product that respects its quality and characteristics.

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Lesson Plan Title:

Rapid adulteration detection of cold pressed oils with their refined versions by UV-Vis spectroscopy

Objectives:

- Students will understand the concept of color and how it appears in different conditions.

- Students will learn how to measure the color parameters using a simple experiment.

- To increase students' interest in healthy food choices.

Materials:

- Project handout - communication documents;

- Laptop or computer with internet access;

- Projector for slides;

- Color monitoring device;

- Different colored materials dyed with organic dyes;

- Colored food products;

- Wastewater from dye industry;

Background Information:

The development of Romania's trade in a global market makes the diversity and rapid circulation of food products grow year by year. Under these conditions, checking the quality of these products to protect consumers from the interest of maximizing the profits of producers and sellers in any condition is an objective to which Dr. Simona POPA's research makes a direct contribution.

Introduction (15 minutes): Color

1. Begin by discussing with students what they know about color. Ask questions such as:

-How does the color appear?

- What is the meaning of each color?

2. Introduce the concept of color and of different factors that influence color.

3. Which are the monitoring color devices.

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4. How color influences our choices when it comes to buying food products.

- Maybe the color demonstrates the alteration of a product?

Activity - Measuring Color of different products (30 minutes):

1. Divide the students into small groups.

2. Provide each group with a colored product.

3. Instruct each group how to use the color monitoring device.

4. Instruct each group how to prepare colored water using a well-known dye.

5. Next, instruct the students to use adsorption material to eliminate the dye from this water.

6. Measure the water and the adsorption material color parameters at the beginning and at the end of the adsorption process.

7. After completing the experiment, each group shares their findings with the class using a flipchart or whiteboard to create a visual map of different results.

Discussion (15 minutes):

1. Lead a class discussion on the results of the experiment. Discuss any variations in measurements between groups and reasons for those differences.

2. Emphasize that color is a property of different materials measured in different conditions.

3. Introduce the concept of *metamerism* – that the same object has different colors under different illuminants.

Conclusion (10 minutes):

1. Summarize the key points of the lesson: the concept of color and how to measure it.

2. Discuss real-world applications of measuring color.

3. Assign a simple homework task related to color, such as paying attention to how the color-absorbing sheets used in laundry absorb and traps loose dyes in wash water, protecting clothes against damage from color bleeds.

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Assessment:

- Evaluate group presentations and participation in the hands-on activity. Evaluate student understanding through group participation, the accuracy of measurements, and their ability to measure color parameters.

- Challenge students to explore how color varies under different illuminants, such as food products, by designing additional experiments.

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