World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

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A comprehensive review on applications of artificial intelligence and spectroscopy for coconut oil

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World Journal of Advanced Research and Reviews, 2024, 21(02), 518–532

Publication history: Received on 27 December 2023; revised on 03 February 2024; accepted on 05 February 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.21.2.0447

Abstract

Extracted from the kernels, meat, and milk of the coconut palm fruit, coconut oil is a consumable oil with diverse applications. Numerous researchers have integrated Artificial Intelligence (AI) and Spectroscopy into several processes involving Coconut Oil. This literature review explores the applications of artificial intelligence and spectroscopy in the context of analyzing coconut oil, a vital component in various industries ranging from food to cosmetics. Moreover, the research delves into several uses of this integrated strategy, including authentication, detection, and quality control of coconut oil.

Keywords: Artificial Intelligence; Coconut Oil; Literature Review; Spectroscopy

1. Introduction

Coconut (*Cocos nucifera*) is one of the highly nutritious and most popular export fruits from numerous countries [1]. It is a member of the palm tree that utilizes the leaf, fruit, and almost all parts of its tree[3]. Several applications are used in human consumption, fuel, cosmetics, folk medicine, and building materials that are widely used universally. Coconut oil is an edible oil derived from the coconut palm fruit's kernels, meat, and milk. With the advancement of technologies, the quality of coconut oils in the agricultural sector has improved in some ways.

The creation of computer systems that are capable of carrying out activities that normally require human intelligence is known as artificial intelligence or AI. These include problem-solving, pattern recognition, comprehension of spoken language, experience-based learning, and decision-making. Artificial intelligence (AI) systems are made to emulate human cognitive processes and change with the times[2].

Artificial Intelligence is an important component of the growing field of data science[3]. Through the use of statistical methods, algorithms are trained to make classifications or predictions and to uncover key insights in data mining projects.

Spectroscopy is a scientific method for examining how matter and electromagnetic waves interact. It is employed in the analysis and characterization of materials according to their electromagnetic radiation (EM) interactions with light or other sources[4]. Spectroscopy measures the absorption, emission, or scattering of electromagnetic radiation to determine the content, structure, and properties of substances. Numerous scientific fields, including chemistry, physics, biology, and environmental research, use different forms of spectroscopy, such as nuclear magnetic resonance, ultraviolet-visible, and infrared spectroscopy. In the context of coconut oil, spectroscopy plays a crucial role in analyzing and characterizing the composition of this valuable substance. Various spectroscopic techniques are employed to study the molecular structure, chemical properties, and overall quality of coconut oil.

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The most commonly used Spectroscopy in the context of coconut oil is the Infrared Spectroscopy (IR). This technique involves measuring the absorption of infrared light by the coconut oil sample. It provides information about functional groups present in the molecules, aiding in the identification of specific components and potential contaminants.

Coconut oil examination becomes more accurate and efficient when various spectroscopic techniques are used, especially when they are combined with artificial intelligence and sophisticated data analysis tools. Spectrophotometry is used by researchers to evaluate the consistency, quality, and possibility of adulteration of coconut oil, which helps to enhance production procedures and guarantee its use in food, cosmetics, and medicinal products.

Numerous researchers have integrated Artificial Intelligence and Spectroscopy into several processes involving Coconut Oil. This process includes determining coconut oil adulteration, coconut oil processing, classification of adulterated particles found in oil, and classifying coconut oil to other variations of oil.

In the context of coconut oil, adulteration is the unapproved addition of contaminants, inferior materials, or impurities that compromise the oil's quality and authenticity[5]. Adulteration can happen at many points in the production and supply chain, putting customers in danger and harming the coconut oil industry's reputation[6]. The following are typical ways that coconut oil is adulterated:

1.1. Mixing with other Oils

To boost volume and cut expenses, some dishonest producers could mix cheaper vegetable oils with coconut oil. The nutritional value and health advantages of pure coconut oil are diminished by this dilution, which also runs the risk of introducing allergies or unwanted fatty acids.

1.2. Dilution with Water

Underhanded methods could include diluting coconut oil with water to make it more volumetric, which would lower the oil's content and compromise its purity.

1.3. Addition of Artificial Flavorings or Fragrances

The addition of adulterants, such as artificial flavorings or scents, might cover up the changes in flavor or aroma that come from using subpar coconuts, processing them incorrectly, or combining them with other oils

1.4. Presence of Contaminants

During the process of growing, harvesting, or processing coconut oil, contaminants such pesticides, heavy metals, or microbiological contaminants may enter. These impurities contaminate the oil's safety and present health hazards.

In order to detect adulteration in coconut oil complex analytical methods, such as mass spectrometry, chromatography, and spectroscopy. Certain indicators and chemical compositions that are indicative of pure coconut oil can be identified using these techniques. The establishment and enforcement of standards to prevent adulteration are vital functions of regulatory agencies and industry groups, guaranteeing that consumers obtain genuine and superior coconut oil goods. Consistent testing, certification schemes, and open supply chains all help to preserve coconut oil's reputation in the marketplace.

2. Methodology

2.1. Aims

With an emphasis on resources found in a specific database, the study's main goal is to perform an extensive review of the literature. In the context of coconut oil, the main focus of this review is on examining and summarizing the literature on machine learning and related fields' applications. Through an examination of the extensive collection of academic papers and publications in the database, the research seeks to shed light on the state of technological integration in the coconut oil industry on a current basis. Examining how machine learning ideas and methods are currently being used or could be used in conjunction with coconut oil, is the review's main objective. The background of this study suggests a deep curiosity about how technology—in particular, machine learning—intersects with the extraction, refining, or application of coconut oil. The study may investigate various domains such as quality control procedures, extraction method optimization, predictive modeling for coconut oil production, and potential health applications of coconut oil. The study's conclusions may have ramifications for several parties, such as the coconut oil industry, policymakers, and researchers in technology, agriculture, and food science. In the end, the research aims to provide insightful information that closes the gap between technological developments and real-world applications in the coconut oil industry.

2.2. Selection of Studies

The goal of the systematic literature review that is being examined is to thoroughly examine research that explores the use of spectroscopy and artificial intelligence (AI) in coconut oil. Studies from any nation are included in this review as long as they are published in reputable journals and written in English. The inclusion criteria emphasize a multidisciplinary approach that combines cutting-edge technological methodologies with the study of this particular agricultural product, underscoring the significance of studies exploring the intersection of AI and Spectroscopy with coconut oil.

The review used a thorough search approach across several reliable databases, such as IEEE Xplore, Scopus, Web of Science, and Google Scholar, to find pertinent studies. By carefully crafting the search query to target relevant literature, particular keywords from published study titles and abstracts were included. 'AI,' 'Artificial Intelligence,' 'Spectroscopy,' and 'Coconut Oil' are among the keywords that are used. Boolean operators, specifically 'AND,' guarantee that the studies that are retrieved must contain all of these key terms, which narrows the search to studies that specifically discuss the combination of AI and Spectroscopy about coconut oil.

In addition to ensuring that studies directly relevant to the research question are included, this methodical and selective approach to literature search also aligns with the intention to provide a thorough and insightful synthesis of existing knowledge on the subject. The goal of the review is to provide a high-caliber analysis of the state of research at the connection of artificial intelligence, spectroscopy, and coconut oil by concentrating on English-language publications in credible journals and utilizing important databases in the field.

3. Results and discussion

The results are presented in this section, followed by a discussion that summarizes the main conclusions drawn from the systematic literature review on the use of spectroscopy and artificial intelligence (AI) in the context of coconut oil. The review was restricted to research that had been published in English-language journals and that had been retrieved from reputable databases like Google Scholar, IEEE Xplore, Scopus, and Web of Science.

A total of 37 pertinent studies that satisfied the predetermined inclusion criteria were found during the literature search. Together, these studies offer insightful information about the various uses and consequences of combining spectroscopy and artificial intelligence with coconut oil research. Below are the studies included together with their Author, Title, Number of literature, objectives, process, and findings:

Table 1 Literature Reviews for Artificial Intelligence (AI)

Lead Author and Year	Title	No. of Literature	Objectives	Process	Findings
Saibaba, 2012 [7]	Application of Artificial Neural Networks and Statistical Methods in Coconut Oil Processing	23	To optimize the pretreatment conditions for coconut nut kernels to maximize oil yield efficiently and cost-effectively within oil-producing industries.	Artificial Neural Network (ANN) Central Composite Design (CCD)	The study uses Artificial Neural Networks (ANN) and a predictive model to optimize coconut oil yield during extraction processes. Strong agreement between predicted and experimental values highlights the significance of both linear and quadratic terms in the model. The outcomes demonstrate how important carefully selected parameters are to effective oil extraction.
Palananda, 2022 [8]	Classification of Adulterated Particle Images in Coconut Oil Using Deep Learning Approaches	33	Improve the detection of impurities in coconut oil	Deep Learning Convolutional Neural Network	The study demonstrates how MobileNetV2 efficiently and quickly detects impurities in coconut oil after training on two datasets. It draws attention to how altering training time affects accuracy and emphasizes the need for a balanced approach. To achieve the best balance between accuracy and training time, the study recommends modifying a dropout parameter.
Kanchymalay. 2017 [9]	Multivariate Time Series Forecasting of Crude Palm Oil Price Using Machine Learning Techniques	32	Investigate the correlation between crude palm oil (CPO) prices and various vegetable oil prices, crude oil prices, and monthly exchange rates.	Machine Learning Techniques, Multi-layer perception, Support vector regression, and Holt Winter exponential smoothing techniques	The study used a variety of techniques to forecast the price of crude palm oil (CPO), with support vector regression proving to be more accurate. The efficacy of support vector regression in CPO price forecasting is emphasized, and it is suggested that by employing feature selection techniques and adding more pertinent attributes, future research can improve accuracy.
Zhao, 2022 [10]	The application of machine-learning and Raman spectroscopy for the rapid detection of edible oils type and adulteration	19	Rapid detection of edible oils type and adulteration.	Machine learning, Raman spectroscopy	The study combined nine machine learning algorithms with Raman spectroscopy to improve the detection of oil quality. The ML model outperformed other techniques in classifying oils by fatty acid composition with 100% accuracy, achieved 96.7% accuracy in detecting oil types, and predicted adulteration with an R2 of 0.984. This method offers a quick and accurate way to analyze food, especially when determining different types of oil.
Sajeeb, 2020 [11]	Assessment of Viscosity of Coconut-	22	Create hybrid nano-lubricants based on	Artificial Neural Network	The research used artificial neural networks (ANN), correlation analysis, and experiments to compare the

	Oil-Based CeO2/CuO Hybrid Nano-lubricant Using Artificial Neural Network		coconut oil and different ratios of CeO2 and CuO nanoparticles.		viscosity ratios of hybrid nano-lubricants. The ANN predictions outperformed the correlation method (2% deviation) and were closer to the experimental values (1% deviation).
George, 2017 [12]	Artificial Neural Network Based Ultrasonic Sensor System for Detection of Adulteration in Edible Oil	21	Design, develop, and experimentally validate an ultrasonic sensor system to detect adulteration in edible oil.	Artificial Neural Network	The study investigates using ultrasonic methods and artificial neural networks (ANN) to identify adulteration in coconut oil with high accuracy (99.53% for sunflower oil and 98.82% for palm oil). The results raise the possibility of developing a basic handheld sensor system for monitoring adulterated edible oil.
Sajeeb, 2022 [13]	Experimental Investigation and Machine Learning Techniques on Tribological Characteristics of Blend of Coconut and Mustard Oil Based Nano-lubricant	23	Develop a nano-lubricant.	Machine Learning Techniques	The study created an environmentally friendly nano-lubricant by mixing mustard and coconut oils with additional particles. It successfully lowers wear and friction, according to testing and computer models. The quantity of particles is the crucial element. This work advances the development of environmentally friendly and reasonably priced lubricants.
Mondal, 2022 [14]	Cookies Formulated with Gamma-Irradiated Virgin Coconut Oil are Less Rancid: Analysis By Metal Oxide-Based Electronic Nose and Support Vector Machines	31	Hydrogenated vegetable fat in cookies with gamma-irradiationn-induced deodorized virgin coconut oil (VCO).	Gamma-irradiated deodorized VCO	To create cookies with antioxidants that taste good for 150 days, this study swapped out unhealthy fat for a unique kind of coconut oil. They contrasted these cookies with typical ones. By using a special nose machine, they discovered that the new cookies can be stored for up to 150 days. Hence, these updated cookies are a longer-lasting and healthier choice.
Samson, 2016 [15]	An Artificial Neural Network Based Analysis of Factors Controlling Particle Size in a Virgin Coconut Oil-Based Nanoemulsion System Containing Copper Peptide	40	To develop a predictive model for a virgin coconut oil (VCO) nanoemulsion system intended for the topical delivery of copper peptide, an anti-aging compound.	Artificial Neural Network (ANN)	This study used a neural network with a genetic algorithm to predict the size of the particles in VCO nanoemulsions. The main factor affecting size was the amount of xanthan gum. Even with copper peptide, the model functioned well, with very little variation between actual and predicted sizes. The formulations demonstrated remarkable stability, suggesting their potential application in the cosmeceutical sector.

Samuel, 2018 [16]	Comparison of Response Surface Methodology (RSM) and Artificial Neural Network (ANN) in modelling of waste coconut oil ethyl esters production	40	To model the yield of coconut oil ethyl ester (CNOEE) through transesterificationn.	Response Surface Methodology (RSM) and Artificial Neural Network (ANN)	The study used RSM and ANN to convert low-free fatty acid coconut oil into biodiesel. The ANN model worked more effectively. The resulting ethyl ester of coconut oil satisfied the requirements for fossil diesel. Additional fuel properties and engine testing can be investigated in future research.
Ong, 2021 [17]	Modeling and Optimization of Microwave-Based Bio-Jet Fuel from Coconut Oil: Investigation of Response Surface Methodology (RSM) and Artificial Neural Network Methodology (ANN)	55	To transesterify coconut oils with ethanol using microwave technology, followed by fractional distillation to collect bio-kerosene or bio-jet fuel.	Response Surface Methodology (RSM) and Artificial Neural Network (ANN)	This study investigates the ideal circumstances for producing ethanol and coconut oil-based bio-jet fuel, which is crucial for environmentally friendly aviation. Key parameters are identified by ANN-ACO modeling, yielding a 74.45% yield that satisfies ASTM D1655 requirements. It is advised to use an aromatic additive to raise the freezing point. Future studies will concentrate on deoxygenation and catalyst techniques to improve the characteristics of bio-jet fuel.
Surya, 2022 [18]	Identification of oil authenticity and adulteration using deep long short-term memory-based neural network with seagull optimization algorithm	56	To address the issue of adulteration in edible oils, which poses health risks and financial concerns.	Deep Long Short-Term Memory (LSTM) neural network with a Seagull Optimization Algorithm (SOA)	The experimental results address issues like data imbalance, overfitting, computational complexity, and cost, and demonstrate better performance than current approaches. The suggested method provides a practical way to identify adulteration and guarantee the genuineness of edible oils.
Ranasinghe, 2022 [19]	Transmittance Multispectral Imaging for Reheated Coconut Oil Differentiation	88	To address the impact of oil reheating on global health.	Multispectral Imaging Systems (MISs)	To detect changes in chemical properties during the repetitive heating of frying coconut oil, this paper suggests using multispectral imaging systems (MISs) to estimate reheat cycle count classes. The study demonstrates MIS's superiority over RGB images and demonstrates how a novel spectral clustering (SC) algorithm can produce accurate results. The application that is being proposed improves oil reheating health and safety procedures. In the future, MIS will be used to expand the application to other oils and fryable foods.

Arora, 2011 [20]	Artificial Neural Network Modeling & Standardization of HPTLC Method for the Estimation of Cholesterol in Edible Oils	7	To design an Artificial Neural Network (ANN) model for predicting optimum Rf values obtained from high-performance thin-layer chromatography of cholesterol in various market-available edible oils.	Artificial Neural Network (ANN)	The study finds that the most effective backpropagation algorithm is the Levenberg-Marquardt algorithm, which has minimal mean squared error values. As a helpful supplement to traditional experiments, the suggested Artificial Neural Network model is beneficial for insightful Rf value predictions and provides the possibility of predicting ideal conditions in edibles without requiring lab testing.
Afzal, 2023 [21]	Characterization of biodiesel based on plastic pyrolysis oil (PPO) and coconut oil: Performance and emission analysis using RSM-ANN	68	To conduct a comparative study on the production and characterization of sustainable biodiesel fuel, derived from waste plastics and virgin coconut oil.	RSM (response surface method) and ANN (artificial neural network)	The study used FTIR, TGA, and GCMS for characterization to compare the production of biodiesel from waste plastics and virgin coconut oil. RSM and ANN were used to evaluate the performance and emissions of diesel engines that were not modified. At 75% load, a 20% diesel/hybrid blend showed excellent efficiency (33%) and low CO emissions (0.12%). RSM and ANN models fit the data with 90–93.5% accuracy. When it came to predicting brake thermal efficiency, ANN performed marginally better ($R2 = 0.9978$ vs. $R2 = 0.960$).
Neelamegam, 2011 [22]	Estimation of liquid viscosities of oils using associative neural networks	17	To determine the dynamic viscosities of various vegetable oils and lubricant oils over a temperature range of 30°C to 90°C.	Associative Neural Network	A Ubbelohde viscometer was used in the study to determine the oils' dynamic viscosities. To unknown temperatures, an associative neural network predicted viscosities with high accuracy, demonstrating a strong correlation ($R2 = 0.99$) with experimental results.
Afzal, 2020 [23]	Human thermal comfort in passenger vehicles using an organic phase change material– an experimental investigation, neural network modelling, and optimization	56	To enhance human thermal comfort in automobile cabins by using coconut oil-impregnated phase change material (PCM).	Artificial neural network modeling using multiple feed-forward back propagation (MBP) for regression and Response Surface Methodology (RSM)	According to the study, using coconut oil as a phase change material indoor spaces and beneath car roofs raised humidity by 8.6% and lowered the interior temperature by 13 °C. This easy fix increases parked cars' comfort and energy efficiency in the sun. The developed neural network model highlights the strong relationship between cabin conditions and ambient temperature by predicting thermal comfort.

Bhaumik, S., 2019 [24]	Computational intelligence-based design of lubricant with vegetable oil blend and various nano friction modifiers	46	Develop an intelligence-based design with vegetable oil	Artificial Neural Network	The study used computational intelligence, artificial neural network models, and experimental testing to design and analyze a biodegradable lubricant based on a blend of vegetable oils and various nano friction modifiers, with a focus on optimizing anti-wear properties.
Herath S., 2020 [25]	Quantitative Assessment of Adulteration and Reuse of Coconut Oil Using Transmittance Multispectral Imaging	38	Develop an imaging system hardware and image processing-based algorithm for adulteration of Coconut Oil	Image Processing	Significantly, this study presented a technique that classifies coconut oil as adulterated and not. The study constructed a hardware as well as an algorithm to detect adulterated coconut oil with palm oil.
Lugoda, P., 2020 [26]	Coco Stretch: Strain Sensors Based on Natural Coconut Oil and Carbon Black Filled Elastomers	66	Build a sensor based on Coconut Oil	Strain Sensors	Presented here is a cost-effective strain sensor that is biocompatible, composed of an elastomer-filled with a mixture of natural Coconut Oil and Carbon Black. This research showcases the ability of Coconut Oil to establish a conductive percolation network within elastomers, eliminating the need for harmful chemicals or expensive machinery.
Gagliardi, G., 2022 [27]	A Decision Support System for Sustainable Agriculture: The Case Study of Coconut Oil Extraction Process	28	Develop a Decision support system to aid in Coconut Oil Industry	Decision Support System	This paper introduces a novel decision support system as a solution to the challenges encountered by coconut oil producers when making strategic decisions, specifically in comparing various methods of oil extraction. The adopted methodology provides insights into addressing issues related to coconut oil extraction, aiming to reduce both processing time and costs while achieving energy savings.
Bose, A., 2018 [28]	Development of a new equation in fuzzy logic analysis for ascertaining appropriate dose of gamma irradiation of virgin coconut oil	7	Creating a new fuzzy logic equation.	Fuzzy Logic Analysis	The study's findings contain the new equation, an evaluation of the defuzzified scores, and descriptions. It suggested that IVCO 3 was thought to be "the best" in terms of fragrance. This fresh Equation that has been established can be extensively used to quickly, clearly, and consistently, without interference from e-nose techniques or similarity values. It avoids the intricacy in comparing the application of similarity values to the evaluation of sample defuzzified scores.

Palananda, A., 2021 [29]	Turbidity of Coconut Oil Determination Using the MAMoH Method in Image Processing	31	Assess clarity of Coconut Oil using Image Processing	Image Processing	The study suggested that among the several techniques for figuring out coconut oil turbidity, the above techniques may aid in the creation of the coconut oil industry's procedure. It can be applied to the measuring of coconut oil's transparency in each manufacturing cycle, enhancing the manufacturing process' efficiency procedure. Within the suggested procedure, the MAMoH algorithm had the most favorable classification outcome in the experiment. of turbidity in coconut oil at 99%.
Brantson, E. T., 2022 [30]	Coconut oil and fermented palm wine biodiesel production for oil spill cleanup: experimental, numerical, and hybrid metaheuristic modeling approaches	94	Create an innovative biodiesel using experimental methods.	Adaptive neuro-fuzzy inference system (ANFIS) hybridized with invasive weed optimization (IWO)	The best model was found to be ANFIS-IWO based on the test results. Furthermore, ANFIS-IWO was tested with additional coconut biodiesel data from the literature, and it performed better than both the artificial neural network models and response surface methodology. The generated biodiesel served as an affordable and environmentally acceptable substitute for shoreline bioremediation, and the hybridized models demonstrated their resilience for biodiesel yield modeling.
Sheeba, M., 2005 [31]	Fibre optic sensor for the detection of adulterant traces in coconut oil	15	The design and development of a fibre optic sensor for the detection of trace amounts of paraffin oil and palm oil in coconut oil.	Sensor	Concluding that Intelligent and adaptable evanescent wave detection systems showcasing sensor concepts based on polished plastic optical fiber have been created to detect minute quantities of adulterants in a sample of coconut oil. The created sensor is easy to use, and reusable, making it possible to determine the proportion of adulterants present in a sample of coconut oil.
Marina, A. M., 2009 [32]	Use of the SAW Sensor Electronic Nose for Detecting the Adulteration of Virgin Coconut Oil with RBD Palm Kernel Olein	31	An electronic nose was applied to the detection of adulteration of virgin coconut oil	Electric Nose	The created sensor was utilized to create a pattern of the volatile compounds found in the samples. It is based on a surface acoustic wave sensor. Palm kernel olein that has been purified, bleached, and deodorized was combined with virgin coconut oil. A PCA was employed to distinguish between samples that were pure and those that were tampered with. The PCA effectively distinguished between the samples.
Libish, T. M., 2011 [33]	Detection and analysis of paraffin oil adulteration in coconut oil using fiber	18	Analysis and detection of paraffin oil adulteration in coconut oil	Fiber Optic Sensor	The created sensor can instantly determine the percentage concentration of adulterant in a sample of coconut oil and is reusable. The recently created sensor demonstrated strong repeatability and reversibility as well. This study

	optic long period grating sensor				could be a significant step toward regulating the quality of food and industry-related uses.
Libish, T. M., 2010 [34]	Fiber Optic Long Period Grating Based Sensor for Coconut Oil Adulteration Detection	24	Detection of palm oil adulteration in coconut oil	Fiber Optic Sensor	This study have significantly created a basic fiber optic sensor that may be used to detect if coconut oil has been adulterated with with palm oil. This kind of grating sensor has the advantages of being straightforward to fabricate, simple to interrogate, and free of hazardous chemicals or solvents.
Anbalagan, T., 2022 [35]	Coconut Oil Adulteration Monitoring System Using Plastic Optic Fiber Sensor with IoT	4	Build an optical-based cost-effective monitoring of coconut oil adulteration	Fiber Optic Sensor	Coconut oil and paraffin oil were the oil samples used in this study. The study's sustainability and it effects on the social, cultural, and environmental fields. Because it uses less energy and doesn't manufacture any chemicals or dangerous materials, optical fiber is better for the environment than conventional electronic sensors.

Table 2 Literature Reviews for Spectroscopy

Lead Author and Year	Title	No. of Literature	Objectives	Process	Findings
Amit, 2020 [36]	Utilizing ATR-FTIR spectroscopy combined with multivariate chemometric modelling for the swift detection of mustard oil adulteration in virgin coconut oil	30	Adulteration Detection	Fourier Transform Infrared Spectroscopy	The study successfully employed an extraordinary technique such as the ATR-FTIR Spectroscopy on detecting adulterated Virgin Coconut Oil and Coconut Oil mixed in another type of oil which is the Mustard Oil. Having an immense accuracy and precision proving excellence on the said technique
Amit, 2020 [37]	Application of ATR-FTIR spectroscopy along with regression modelling for the detection of adulteration of virgin coconut oil with paraffin oil	41	Adulteration Detection	Fourier Transform Infrared Spectroscopy	Concluding that the ATR-FTIR Spectroscopy is an effective way of detecting adulteration of Coconut Oil with another type of oil which is Paraffin Oil. Exhibiting high precision and accuracy leaving new opportunities for future research.
Amit, 2020 [38]	Rapid detection of pure coconut oil adulteration with fried coconut oil using ATR-	32	Adulteration Detection	Fourier Transform	The study found a way of detecting Pure Coconut Oil with Fried Coconut Oil which is harmful. The effectiveness of the study significantly help the oil-producing industries and the regulatory

	FTIR spectroscopy coupled with multivariate regression modelling			Infrared Spectroscopy	authorities to build standard guidelines for the detection of FCO adulteration.
Tachie C. Y. E, 2024 [39]	Classification of oils and margarines by FTIR spectroscopy in tandem with machine learning	42	Oil Classification	Fourier Transform Infrared Spectroscopy and Machine Learning	This study reveals the integration of Machine Learning and Fourier Transform Infrared Spectroscopy as a way of classifying variation of oils including Coconut Oil. Among the models used, KNN was the most effective in classifying the oils.
Usha Rani D., 2020 [40]	Artificial neural networks to authenticate Virgin Coconut Oil adulterants using FTIR spectral data	4	Adulteration Detection	Fourier Transform Infrared Spectroscopy	The study utilizes FTIR Spectroscopy of Coconut oil as well as adulterated virgin coconut oil with palm oil and mustard oil. Demonstrating excellent ways of detecting adulteration, opening up new study avenues.
Neves, D. G. E., 2020 [41]	Authentication and identification of adulterants in virgin coconut oil using ATR/FTIR in tandem with DD-SIMCA one class modeling	34	Adulteration Detection	Fourier Transform Infrared Spectroscopy	Providing a fast, clean and satisfactory technique, this study proved that FTIR Spectroscopy is an efficient way to detect adulteration of Coconut Oil exhibiting a high accuracy.
Natarajan, 2022 [42]	A Review on Machine Learning Based Oil Adulteration Determination Techniques	36	To address the global issue of adulteration in edible oils, which poses health risks to consumers.	Fourier Transform Infrared Spectroscopy	The review emphasizes the worldwide problem of adulterating edible oil to increase profit, underscoring the necessity of sensitive and quick detection techniques. The article discusses several methods for qualitative analysis to guarantee oil purity, such as Attenuation Total Reflectance-Fourier Transform Infrared spectroscopy and Gas Chromatography.

3.1. Applications of Artificial Intelligence (AI) in Coconut Oil Analysis

The literature review indicates a significant focus on utilizing Artificial Intelligence (AI) in different aspects of coconut oil analysis, signifying a revolutionary change in the way the industry handles its procedures. Integrating AI into quality control processes is one important application that stood out from the research. Researchers have successfully used artificial intelligence (AI) to evaluate crucial coconut oil quality parameters like acidity levels, moisture content, and the presence of impurities. These algorithms include machine learning and deep learning models. AI ensures a higher level of accuracy in assessments and speeds up the entire evaluation process by automating these quality control procedures. This allows for quick decision-making in the production and distribution of premium-grade coconut oil.

Furthermore, research in the literature shows a notable use of AI in coconut oil industry predictive modeling. AI-driven predictive models have proven to be able to predict yields for the production of coconut oil by analyzing historical data and adding variables like weather, soil quality, and agricultural practices. Predictive modeling allows for more efficient resource allocation and inventory management in addition to helping farmers and producers optimize their cultivation techniques. AI plays a major role in improving the efficiency of coconut oil supply chains, mitigating production risks, and strengthening the industry's resilience by offering data-driven insights.

All things considered, these uses highlight how AI can transform operations involving coconut oil while improving accuracy and efficiency. The adoption of AI technologies by the coconut oil industry marks a turning point in its adoption of creative and sustainable practices, as it fits in with larger trends in agricultural technology. The ramifications of these AI applications go beyond the lab and into the larger coconut oil supply chain, offering breakthroughs that support the expansion and sustainability of the sector. In addition to demonstrating the present level of technological integration in coconut oil analysis, the results of these studies open up new avenues for investigation and advancement, fostering ongoing innovation at this dynamic nexus of artificial intelligence and coconut oil.

3.2. Integration of Spectroscopy Techniques

Integration of spectroscopy techniques in coconut oil analysis is a noteworthy theme that emerged from the reviewed literature, indicating a major advancement in the industry's analytical methodologies. Particularly, research highlighted the effectiveness of sophisticated spectroscopy methods, such as Near-Infrared Spectroscopy (NIRS), in describing different aspects of coconut oil. A detailed analysis of elements like purity, molecular makeup, and even possible impurities in coconut oil samples is made possible by this technological integration. For instance, using Near-Infrared Spectroscopy to analyze the chemical composition of coconut oil has shown to be a particularly useful method for obtaining detailed information without requiring harmful procedures. Due to its ability to maintain sample integrity and facilitate quick, real-time analysis, this non-destructive quality is crucial.

These studies demonstrate how the integration of spectroscopy techniques has the potential to revolutionize analytical methods used in the coconut oil industry. A break from laborious, traditional methods is indicated by the high degree of efficiency and precision with which key properties can be characterized. Additionally, because spectroscopy techniques are non-destructive, they provide opportunities for ongoing quality control and monitoring during the production and processing stages. Reducing sample waste, not only optimizes the analytical workflow but also advances sustainable practices. Therefore, the use of sophisticated spectroscopy techniques becomes essential in the search for quick and non-destructive analysis methods, highlighting its potential to change the face of coconut oil analysis and open the door for further developments in the area.

4. Conclusion

In conclusion, this literature review's conclusion offers a thorough overview of the state of current research at the nexus of spectroscopy, coconut oil, and artificial intelligence (AI). A clear picture of the current advancements and innovations in this multidisciplinary field is produced by synthesizing the various findings gleaned from the combination of studies. A vital foundation for steering future research efforts in the dynamic convergence of AI, Spectroscopy, and coconut oil, the reviewed literature not only summarizes the current state of knowledge but also provides invaluable insights. Future developments in technology will have ever more significant effects on the coconut oil sector. The summary of these results highlights the revolutionary potential of utilizing state-of-the-art technologies, highlighting the ability of AI and Spectroscopy to transform analytical techniques and improve precision in the coconut oil industry. In addition to adding to the scholarly conversation, this thorough review has real-world application, highlighting the necessity of ongoing research and application of cutting-edge technologies to have a substantial influence on and progress the coconut oil sector in the years to come.

Compliance with ethical standards

Acknowledgements

The authors give their utmost thanks and deepest gratitude to their professor Dr. Edwin R. Arboleda, for his guidance throughout the whole process of the study. His insights and feedback deeply impact and inspire us for completing this study.

Disclosure of Conflict of interest

No conflict of interest to be disclosed

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