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Experiment analysis for efficient virgin coconut oil extraction technique for small scale industries

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Abstract

Coconut palm trees offer a wealth of beneficial products, including coconut oil, copra, and fresh coconuts, all of which are widely used in cooking, medicine, and therapeutic applications. Among them, coconut oil is the most popular. Virgin coconut oil (VCO) is extracted from the kernels of mature coconuts, a process utilized across various cultures and industries. Several methods are available for extracting VCO, such as the traditional method, the cold pressing method, and the method used in small-scale industries by adding jaggery. The cold pressing method is more time efficient, but the yield is lower because a lower temperature prevails during the process. However, in small-scale industries, jaggery is added to increase the yield. The addition of jaggery reduces the quality of the oil. To address this reduction in quality, the proposed method produced high-quality virgin coconut oil. The quality of the oil was confirmed through microbiological laboratory tests using a spectrometer and a redwood viscometer.

Keywords: Virgin coconut oil, Small-scale industries, Cold press, Traditional Oil Extraction, Modern Oil Extraction, Effective Extraction Method.

1. Introduction

In today's fast-paced world, prioritizing good health is more crucial than ever, yet busy lifestyles often lead to neglect. Nutrition is essential for maintaining health and, providing the vital vitamins, proteins, and nutrients necessary for survival. Among the various nutritional sources, edible oils significantly influence the overall well-being. Commonly used edible oils include coconut, peanut, palm, sunflower, and olive oils. Coconut oil, extracted from the coconut palm fruit, offers numerous health benefits. It is widely used not only for cooking but also for weight management, skin and hair care, and for improving digestion and energy levels. Comprising

87% saturated fat, 6% monounsaturated fat, and 4% polyunsaturated fat, coconut oil is an excellent source of medium-chain fatty acids, which are crucial for energy production and metabolism. The main challenge is to efficiently extract high-quality pure virgin coconut oil while maximizing the yield. Several techniques have been used for this purpose. This study explores a new method aimed at enhancing extraction efficiency by comparing it with two existing methods. The first is the traditional extraction technique, which relies on thick coconut milk but is time-consuming. The second method, commonly used by small-scale producers, is cold press extraction. To improve the oil yield and reduce production time, jaggery was added during the extraction process. Microbiological laboratory tests were conducted to evaluate the quality of virgin coconut oil obtained using the new method and comparative techniques. By analyzing and comparing the results of these tests, we draw conclusions regarding the effectiveness of the different extraction methods.

2. Literature review

Millions of people in tropical places rely on coconuts as food and shelter. It is cultivated across more than 93 countries, spanning 11.95 million hectares, and yields approximately 57,510 million coconuts per year [1]. By the end of the 20th century, virgin coconut oil (VCO) had become a prominent product. recognized for its value as an edible product derived from coconuts [2]. VCO's adaptability and extensive use of VCO in food, medicine, cosmetics, and hair care items have made it well-known in nations that produce coconuts [3].

VCO is a transparent, valuable oil that can be produced mechanically or naturally from young, mature coconut kernels [4]. It is widely recognized for its therapeutic qualities, which include immune system support, low glycaemic index, antifungal, antioxidant, antibacterial, and antiviral actions, as well as hepatoprotective effects [5]. Comprising 90–95% saturated fatty acids [6], coconut oil differs from plant-based oils, which contain long-chain fatty acids. Smaller medium-chain fatty acids in coconut oil enhance cell permeability, leading to immediate energy conversion rather than fat storage. In addition to their antibacterial and antifungal properties, these medium-chain fatty acids are simpler to digest than the long-chain fatty acids present in plant-based oils [7].

Virgin coconut oil (VCO) offers several health advantages over other fats while having 2.6% fewer calories [8]. The primary saturated triglycerides in coconut oil are medium-chain fatty acids, particularly lauric and myristic acids [9]. The contents of a 100 g sample of coconut oil are as follows: 6.80 g of C8-caprylic acid, 41.84 g of C12-lauric acid, 8.64 g of C16-palmitic acid, 16.65 g of C14-myristic acid, and 2.52 g of C18-stearic acid [10]. However, the cold extraction method, results in a lower yield than other techniques [11]. The hot extraction method employs heat to disrupt the water-oil emulsion and destabilize it by denaturing the stabilize proteins [12].

An alternate process entails chilling or freezing of coconut milk after hydrolysis it using a partly purified seabass protease [13]. A 65.5% yield can be obtained by combining enzymes such α-amylase, hemicellulose, protease, cellulase, and pectinase [14]. Furthermore, adding 2% hemicellulose, pectinase, cellulase, and β-galactosidase to desiccated coconut kernels can increase coconut oil output to 84% [15]. When shredded coconut kernel was treated with a blend of 1% (w/w) cellulose, α-amylase, polygalacturonase, and protease at 60°C and pH 7, the yield reached 73.8% [16]. Additionally, without purification, incorporation α-amylase, polygalacturonase, and protease into diluted coconut paste resulted in an 80% yield of coconut oil [17].

In 2016 [18], Senphan and Benja Kul developed an extraction method for coconut oil that only requires proteases from the hepatopancreas of Pacific white prawns. This process may also be useful for processing coconut meat. However, Ghosh et al. [19] observed that coconut oil extracted using this method may have a rancid odor. To combat the COVID-19 pandemic, research has been conducted on the antibacterial properties of coconut oils. [20]. Its strong antibacterial properties make it suitable as a natural deodorant, which can be formulated by combining coconut oil with organic ingredients such as arrowroot powder, corn starch, baking soda, and essential oils [21].

Medium-chain triglycerides, a key component of coconut oil [22], where further extracted from virgin coconut oil. According to a recent study by Lugoda, a strain sensor used in soft robotics, health monitoring, and activity recognition can be achieved by mixing coconut oil and carbon black[23]. Additionally, coconut oil is used in the industry as a lubricant and cutting fluid, although its use is limited by its poor thermal stability [24]. Ongoing research is aimed at improving its thermal stability to expand its applications as an industrial lubricant [25].

The efficiency and yield of new extraction techniques compared to small-scale companies and old techniques represent a significant research gap in the field of virgin coconut oil extraction. A lack of comprehensive studies that methodically analyze the efficiency, oil quality, and yield of various extraction processes, such as cold press and conventional approaches, has resulted in the use of different methodologies. The environmental effects and profitability of new extraction technologies have also not been studied, especially for to small-scale industries and traditional techniques. In addition to the lack of established microbiological testing techniques for determining oil purity, the impact of additives such as jaggery on oil yield and quality is still poorly understood. By filling these loopholes, extraction procedures can be greatly improved, and oil quality can be increased, which is addressed in this paper.

3. Methodology

3.1 Traditional Oil Extraction method

In traditional methods, a wooden cold-press machine, driven by a bull is used. The wooden press was fixed in place and the bull moved in a circular motion. As the bull turned, the coconut inside the machine was crushed and the oil from the virgin coconuts was extracted.

FIG 1: Collection of coconuts for extracting virgin coconut oil

The collection of coconuts in a container intended for oil extraction is illustrated in Fig. 1. Choosing mature brown coconuts, husking them, and cracking them open to reveal the meat are the steps in this process. The coconut is then finely broken down by the grating or shredding process of the meat, which is housed in a specially designed vessel. We ensured that the coconut meat was thoroughly processed.

This strategy does not use any external variables. Its main drawback is that it takes a much longer time than the alternative approaches. The machine runs at a modest pace, which produces very little heat and maintains the temperature at almost ambient temperature. The coconut oil cake was simple to remove from the machine at this temperature. Nevertheless, the oil output decreased because of the lower temperature. To continue the extraction process, fresh coconuts were introduced into the machine once the oil cake had been removed.

3.2 Small-scale industries

The next method used in small-scale industries involves producing coconut oil using an iron cold press machine, replacing the traditional wooden press, and utilizing a motor instead of a bull. The motor increased the speed of the machine, which in turn increased the temperature. This iron cold press features a cavity with a sharp-threaded crusher rod, resulting in significantly lower processing times compared with traditional methods. During extraction, a specific amount of jaggery was added. The purpose of adding jaggery is to enhance the oil yield and provide a pleasant aroma. Additionally, jaggery helps maintain machine's operation. After oil extraction, some residual oil cake remained in the cavity of the machine.

The motor must be turned off to remove the oil cake from the machine. Subsequent extractions were performed if jaggery was not introduced during the extraction procedure. The oil cake in the cavity absorbs more oil in the absence of jaggery, making extraction more challenging. When jaggery is added, the oil turns light brown avoiding such issues.

FIG. 2: Oil that extracted from the method used in small scale industries

The oil produced with the addition of jaggery is shown in **Fig. 2**, which has a notable brown color. This coloring indicates that the jaggery has affected the appearance of the oil because of the sugars that have been caramelized and other components from the jaggery.

FIG 3: Package of the oil extracted from small scale industries.

It is evident that the oil was brown in color as shown in **Fig. 3**, where it was kept in a transparent bottle. Because the bottle is transparent, the color of the oil can be seen clearly, and it turned brown because of jaggery.

3.3 Effective method

The proposed method is the most effective and is comparable to small-scale industry and traditional methods with the primary distinction being that jaggery is not used. The pure and colorless coconut oil generated without jaggery may have influenced the subsequent extraction procedures. The issue can be resolved by turning off the motor, cleaning and removing the oil cake from the machine, and then initiating extraction following the conventional procedure.

The ideal temperature for maximizing oil output is critical. The machine initially operates at a low temperature, eventually rising to an ideal level with time. More oil can be produced with coconut oil at higher temperatures. Low-quality coconut oil can be processed via the machine to reach the required temperature, after which it is rated based on its appearance. To maintain its purity, the oil was left undisturbed for one-two days following extraction.

FIG .4: Comparison of oil cake and oil extracted from effective vs method used in small-scale methods.

The physical changes that occur during the oil extraction process are highlighted in Fig. 6, which shows the oilcake after oil extraction. The oilcake, which was once thick and wet, became much thinner and more compact, indicating that a large amount of oil had been removed. After settling for a couple of days, Fig. 5 depicts the oilcake that was extracted without the addition of jaggery, with a clear white color. The natural state of the oilcake is emphasized by this coloring, which mirrors the pure, unadulterated appearance of the coconut material once the extraction process is finished.

4. Results and discussions

The samples were collected using three methods; the traditional method, small-scale industrial method, and effective method. These samples were tested using two methods for their quality: a spectrophotometer and a redwood viscometer.

4.1 Spectrometer

In the spectrometer, the samples were analyzed by passing light across the visible spectrum, ranging from 200 to 700 nm. In this study, a UV 1800 spectrometer was employed to determine the absorption peaks at specific wavelengths. Three oil samples extracted using various techniques were evaluated. The absorption rates were recorded at wavelengths of 279 nm, 321.5 nm, and 338 nm. The results were plotted for the analysis.

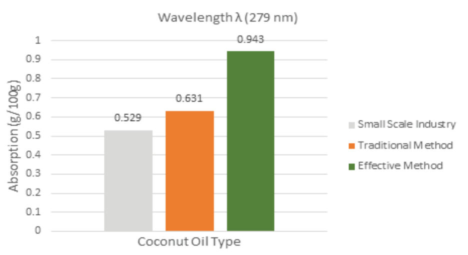

FIG 5: Absorption vs extraction methods at 279 nm

Fig. 5. indicates that at a wavelength of 279 nm, the most effective method achieves the highest absorption rate, reaching its peak. In contrast, the traditional method shows an absorption rate of approximately 66.9 %, whereas the small-scale industry method displays a notably lower rate of approximately 56.0 %.

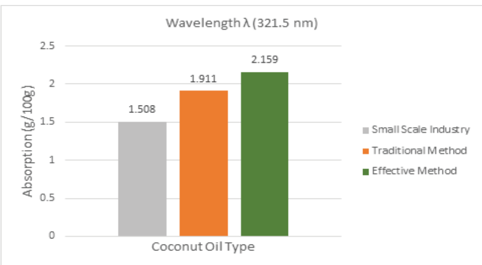

FIG 6: Absorption vs extraction methods at 321.5 nm

Fig. 6. indicates that at a wavelength of 321.5 nm, the most effective method exhibits the highest absorption rate, reaching its maximum value. In comparison, the traditional method shows an absorption rate of approximately 70.9 %, whereas the small-scale industry method has a significantly lower rate of approximately 55.9 %.

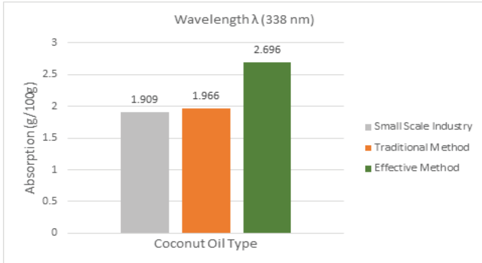

FIG. 7: Absorption vs extraction methods at 338 nm

Fig. 7. indicates that at a wavelength of 338 nm, the most effective method achieves the highest absorption rate, reaching its maximum value. In comparison, the traditional method shows an absorption rate of approximately 91.1 %, whereas the small-scale industry method has a lower absorption rate of approximately 88.5 %.

4.2 Redwood viscometer

The Redwood viscometer had a vertical, cylindrical oil cup with a ball-sealed central opening at the base. The cup has a hook that acts as a filling guide for the oil. The water bath in which the cylindrical cup was immersed maintained the oil at a steady temperature. For example, fuel oils are typically evaluated at 50 or 70°C, whereas lubricating oils are usually evaluated at 100°C. The water bath was heated using an immersed electric heater and included stirring provisions to ensure a uniform temperature. A thermometer was used to monitor the temperature of both the oil and the water bath. The cylinder is 47.625 mm in diameter and 88.90 mm in depth. Its aperture was 1.70 mm in diameter and 12 mm long. This viscometer was used to measure the kinematic viscosity of the oil, which was then used to calculate its dynamic viscosity.

A particular viscometer used to gauge the viscosity of fluids, particularly petroleum compounds, is the redwood viscometer. It has a tiny oil reservoir on the top and a cylindrical container with an opening at the bottom. The amount of time it takes for a certain volume of oil to flow is determined by allowing the oil to flow out of the aperture under the influence of gravity. To use the redwood viscometer, the liquid to be evaluated must first be heated to a specified temperature, which depends on the kind of liquid being evaluated. For instance, fuel oils are normally evaluated at 50 or 70°C, whereas lubricating oils are typically evaluated at 100°C.

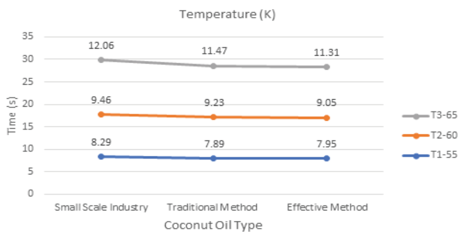

FIG. 8: Flow time for 50 cc vs temperature at different levels

Fig.8. shows the time taken for oil to flow through the orifice at temperatures of: 55°, 60°, and 65°. The time taken for the oil to flow is shorter for the effective method compared to other methods such as small-scale industry and traditional methods, and is regarded as one of the key elements influencing virgin coconut oil quality.

5. Conclusions

To analyze the quality of coconut oils extracted using different methods—traditional techniques, small-scale industries, and effective methods a spectrometer and Redwood viscometer were employed. The spectrometer measured the oil absorption rate, indicating that the oil became whiter with higher absorption. The effective method demonstrated a higher absorption rate than both traditional and small-scale industry methods. Using an effective method to enhance oil quality can improve the purity of virgin coconut oil in small-scale ventures, leading to improved quality and increased profitability.

For high-quality coconut oil, a lower viscosity is advantageous as it allows the oil to spread more easily, pour smoothly, and be absorbed more effectively. This property is particularly beneficial in culinary applications, skincare, and haircare, where rapid absorption and ease of application are crucial for optimal results. The Redwood viscometer measured the viscosity of the oils, revealing that the effective method produced oil with a lower viscosity than other methods. Lower viscosity is preferable for high-quality coconut oil.

The proposed method relies on enhancing existing processes to produce a purer product without increasing the operational complexity or costs associated with high-tech equipment. Although the production rate may be lower, the absence of jaggery and focus on traditional, efficient techniques enhance the quality of oil. This allows the product to be marketed as premium virgin coconut oil that can be sold at a higher price. Premium pricing compensates for reduced production volume, potentially leading to increased profit margins. By maintaining cost-effective production practices and improving product quality, manufacturers can effectively boost profitability and gain a competitive edge in the market.

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