*International Journal of Engineering Research and Development*
*e- ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com*
*Volume 21, Issue 6 (June 2025), PP 93-97*

# Optimizing Virgin Coconut Oil Production: A Comparative Study of Extraction Methods and Quality Parameters

[1*]Vasu Gajendiran,[2]DoaaSalim Musallam SamhanAlkathiri, [3]Alyamamah Ali Salim Jashaool, [4] Haifa Badar Salim Alkathiri.[5]MarimuthuChellakannu.
[1, 2, 3, 4, 5] *College of Engineering and Technology, University of Technology and Applied Sciences, Salalah, Oman*
[6]*University of Technology and Applied Sciences, Muscat, Oman*
[*]*Corresponding Author: Vasu Gajendiran*

***Abstract***
*Virgin coconut oil (VCO) is a natural, unrefined oil extracted from fresh and mature coconut kernels using mechanical or natural processes without the application of heat or chemical refining. Its high content of bioactive compounds, such as lauric acid, polyphenols, and antioxidants, contributes to its wide-ranging applications in the food, pharmaceutical, and cosmetic industries. The demand for VCO has risen significantly due to increasing consumer preference for organic and functional products. This study aims to investigate the production processes of VCO, compare traditional and modern extraction methods, and evaluate the quality parameters associated with each technique. Emphasis is placed on the cold-press and fermentation methods, assessing their impact on oil yield, purity, and nutrient retention. The findings highlight the importance of controlled processing conditions and hygienic handling in achieving premium-grade VCO. Additionally, the study underscores the need for standardized procedures to ensure consistency, safety, and international market competitiveness of the final product.*

---

Date of Submission: 06-06-2025 Date of acceptance: 16-06-2025

---

## I. Introduction

Virgin coconut oil (VCO) is a premium edible oil extracted from fresh and mature coconuts through natural, non-chemical processes. It retains high levels of bioactive compounds, including lauric acid, polyphenols, and antioxidants, due to minimal processing. The increasing global demand for natural, functional, and organic products has elevated the significance of VCO. Unlike refined coconut oil, VCO is produced using cold-pressing, fermentation, or centrifugation techniques without heat or additives.

These methods preserve the oil's natural aroma, flavor, and nutritional integrity. The process begins with the careful selection and preparation of mature coconuts, followed by kernel extraction and milk pressing. Oil is then separated from the aqueous phase through controlled biological or mechanical processes. Maintaining low temperature and strict hygiene is essential to ensure quality and extend shelf life.

VCO is widely utilized in the food, cosmetic, and pharmaceutical industries due to its therapeutic and nutritional properties. Its antimicrobial, antioxidant, and skin-conditioning activities make it a versatile ingredient. Sustainable production practices have further enhanced its appeal in eco-conscious markets.

Research and development continue to optimize extraction efficiency and product quality. Standardization and quality assessment remain critical for international market acceptance. This manuscript provides a comprehensive overview of VCO production methods, quality parameters, and commercial potential. Understanding these aspects is vital for advancing technology and meeting global demand for high-quality VCO.

Virgin coconut oil (VCO) has become a highly sought-after product due to its functional health benefits and natural composition. Unlike refined coconut oil, VCO is extracted from fresh and mature coconut meat without chemical refining or high-heat processes, which helps preserve its natural bioactive compounds, including lauric acid, tocopherols, and polyphenols (Marina et al., 2009). These compounds contribute to its antimicrobial, antioxidant, and anti-inflammatory properties, making VCO attractive to the food, pharmaceutical, and cosmetic industries (DebMandal& Mandal, 2011).

Several extraction methods are employed in VCO production, each affecting the final oil's quality, yield, and nutritional value. Traditional methods such as fermentation and boiling are widely used in rural and small-scale setups due to their simplicity and low cost. However, these methods are often associated with variable oil quality, lower yields, and increased risk of microbial contamination when not properly managed

(Bawalan& Chapman, 2006; Dia et al., 2015). Fermentation, while cost-effective, typically requires longer processing times and is sensitive to environmental factors such as temperature and pH, which can affect the stability and clarity of the oil (Seneviratne et al., 2009).

Modern techniques such as cold pressing and centrifugation have been developed to overcome the limitations of traditional methods. Cold-press extraction, in particular, is recognized for maintaining the integrity of heat-sensitive nutrients and producing high-purity oil with minimal oxidative damage (Man et al., 2017). This method has gained popularity among health-conscious consumers and premium markets. Studies have shown that cold-pressed VCO exhibits better antioxidant properties and retains more polyphenols compared to oil obtained through heat-based methods (Marina et al., 2009).

Comparative studies underscore the importance of balancing oil yield with quality parameters such as moisture content, free fatty acid levels, peroxide value, and sensory characteristics. For instance, while fermentation may yield oil with higher natural aroma, it may also present higher levels of impurities if not carefully monitored (Dia et al., 2015). On the other hand, cold-pressed oil generally has a longer shelf life due to its lower moisture and peroxide values, highlighting its industrial advantages (Seneviratne et al., 2009).

Standardization of VCO production is increasingly emphasized to ensure product consistency, safety, and regulatory compliance. Quality standards developed by organizations such as the Asian and Pacific Coconut Community (APCC) serve as benchmarks for acceptable physicochemical characteristics in the global market. These standards aid in harmonizing production practices and enable producers to meet the rising demand for certified organic and high-quality VCO products (Bawalan& Chapman, 2006).

Nevin and Rajamohan (2004) emphasized that cold-pressed VCO retains significantly higher antioxidant capacity due to the preservation of unrefined phenolic compounds and vitamin E. Pakarinen et al. (2010) highlighted how microbial profiles during spontaneous fermentation significantly affect oil stability, supporting the need for controlled fermentation environments. Raghavendra and Raghavarao (2006) demonstrated that moisture content critically influences VCO shelf life, reinforcing the role of drying efficiency in production.

Economic analyses by Nambiar et al. (2014) showed that while cold press and centrifugation involve higher initial investment, they result in more consistent, market-ready products. Raghavendra and Raghavarao (2010) further revealed that natural coagulants such as moringa extract can improve oil recovery and shorten fermentation time. Sensory analyses by Zakaria et al. (2012) supported consumer preferences for cold-pressed oil, citing superior aroma and clarity.

The nutritional profile and health benefits of VCO were further validated by Arunima and Rajamohan (2012), who linked its high lauric acid content to lipid-lowering effects. Siong et al. (2018) assessed storage stability, confirming the longer shelf life of cold-pressed VCO due to its low moisture and peroxide values. Tangsuphoom and Coupland (2008) emphasized that emulsion breakdown is a critical step affecting both clarity and yield in fermentation-based extraction. Lastly, Prasertsan and Srisuwan (2020) explored enzymatic-assisted extraction as an innovation to enhance yield while preserving oil quality, suggesting potential for industrial adoption with proper control.

Together, these studies highlight the importance of optimizing extraction techniques and standardizing processing parameters to produce high-quality VCO that meets both nutritional and commercial benchmarks.

## II. Materials and Methods

***Raw Material Selection***

Mature coconuts (10–12 months old) were sourced from local farms, ensuring uniformity in maturity and freshness. All coconuts were visually inspected for signs of spoilage or microbial contamination.

***Pre-processing***

Coconuts were dehusked, deshelled, and the brown testa was removed to obtain the white kernel. The kernel was washed thoroughly with potable water to remove dirt and surface impurities.

***Grating and Milk Extraction***

The cleaned kernel was grated using a stainless-steel mechanical grater. The grated coconut was then pressed using a cold press expeller to extract coconut milk.

***Oil Separation Methods***

Two different methods were employed to extract VCO from the coconut milk:

Fermentation Method: The coconut milk was left undisturbed in a sterilized container at room temperature (30–32°C) for 24–36 hours. Natural fermentation caused phase separation, after which the top oil layer was collected, filtered, and stored.

Centrifugation Method: Fresh coconut milk was subjected to high-speed centrifugation (8000 rpm for 20 minutes). The oil layer was separated, filtered, and stored.

**Filtration and Storage**
The extracted oil was passed through a muslin cloth to remove any residual solids and then filtered using a 0.45 µm membrane. VCO was stored in amber-colored glass bottles at room temperature (25°C) to prevent light-induced oxidation.
**Quality Analysis**
VCO samples from each method were analyzed for:
Physicochemical Properties: Moisture content, free fatty acid (FFA) level, peroxide value (PV), and iodine value.
Sensory Evaluation: Color, clarity, aroma, and taste.
Nutritional Analysis: Lauric acid concentration and antioxidant activity (DPPH assay).

## III. Results and Discussion

The virgin coconut oil (VCO) samples extracted through fermentation and centrifugation were analyzed for their physicochemical properties, yield, and nutritional quality. The results are presented in the following tables:

**Table 1: Physicochemical Properties of VCO Extracted by Two Methods**

| Parameter | Fermentation Method | Centrifugation Method | Standard Limit* |
|---|---|---|---|
| Moisture Content (%) | 0.15 | 0.08 | ≤ 0.1 |
| Free Fatty Acid (%) | 0.2 | 0.08 | ≤ 0.2 |
| Peroxide Value (meq/kg) | 2.8 | 1.2 | ≤ 3.0 |
| Iodine Value (g $I_2$/100g) | 6.4 | 6.2 | 4.1–11.0 |
| Saponification Value (mg KOH/g) | 260 | 262 | 250–265 |
| Refractive Index (40°C) | 1.448 | 1.448 | 1.448–1.449 |
| Color (Lovibond Scale, R/Y) | 1.2 / 10.0 | 0.5 / 6.0 | Clear to pale yellow |
| Odor | Mild coconut aroma | Fresh, clean coconut aroma | Characteristic coconut odor |
| Clarity | Slight turbidity | Clear | Clear, free from sediments |

Table 1 presents a comparative analysis of the physicochemical properties of virgin coconut oil (VCO) extracted using the fermentation and centrifugation methods. The table outlines various quality parameters of VCO, comparing them against standard limits set for optimal oil quality.Moisture content is one of the most crucial parameters for determining the stability and shelf life of VCO. The fermentation method yielded a slightly higher moisture content (0.15%) compared to centrifugation (0.08%). This discrepancy exceeds the recommended standard limit of ≤ 0.1%, indicating that the fermentation method may result in a higher risk of microbial contamination and spoilage, which could affect the oil's storage stability.The free fatty acid (FFA) levels, an indicator of hydrolytic rancidity, also vary between the two methods. Fermentation results in a higher FFA content (0.20%) compared to centrifugation (0.08%). The standard limit for FFA is ≤ 0.2%, suggesting that centrifugation provides oil with a lower degree of degradation, which would be beneficial for both flavor and shelf life.

The peroxide value, which measures the extent of primary oxidation, is notably lower in the centrifugation method (1.2 meq/kg) compared to fermentation (2.8 meq/kg). The peroxide value for both oils is within the acceptable standard limit of ≤ 3.0 meq/kg, indicating that both methods produce oil with acceptable oxidative stability, though centrifugation results in a more stable product.In terms of iodine value, which is a measure of unsaturation, the two methods show nearly identical results (6.4 for fermentation and 6.2 for centrifugation), both of which fall within the recommended range of 4.1–11.0 g $I_2$/100g. This indicates that both extraction methods produce oils with similar levels of unsaturation, which is a desirable characteristic for various applications in the food and cosmetic industries.The saponification value, which relates to the oil's ability to form soaps, is also similar between the two methods (260 for fermentation and 262 for centrifugation), with both values falling within the standard range of 250–265 mg KOH/g. This suggests that both methods produce oils with comparable fat content, which is essential for emulsification and cosmetic formulations.The refractive index is consistent at 1.448 for both methods, matching the standard range of 1.448–1.449 at 40°C. This indicates that both oils have similar purity and light transmission properties, which is essential for their appearance in cosmetic products.When it comes to color, measured on the Lovibond scale, the centrifugation method produces a lighter oil (0.5 red / 6.0 yellow) compared to the fermentation method (1.2 red / 10.0 yellow). This suggests that centrifugation results in oil that is clearer and more visually appealing, which is a critical factor for consumer acceptance in high-end markets.The odor of both oils is described as typical of coconut oil, with the fermentation method yielding a milder coconut aroma, while the centrifugation method produces a fresher, cleaner coconut scent. This difference in aroma could be influenced by the processing conditions, with the more refined centrifuged oil offering a cleaner sensory profile that may be preferred in cosmetic and food applications.

Finally, clarity is another important quality parameter. The oil produced by the fermentation method exhibits slight turbidity, indicating the presence of fine particles or impurities, while the centrifugation method yields clear oil, free from sediments. This visual difference could impact the marketability of the oil, with clearer oils often being perceived as of higher quality and more suitable for cosmetic formulations.In summary, the table shows that while both fermentation and centrifugation methods produce VCO that meets the standard limits in most quality parameters, the centrifugation method generally results in oil with superior stability, clarity, and sensory qualities. This makes centrifugation the preferred method for producing high-quality VCO suitable for premium markets, where consistency and aesthetics are key factors.

## IV. Conclusion

This study provides a comparative analysis of the physicochemical properties of virgin coconut oil (VCO) extracted using two different methods—fermentation and centrifugation. The results presented in Table 1 highlight key differences in the quality parameters of the oils produced by each method.The fermentation method, while producing VCO with acceptable properties, generally shows higher moisture content and free fatty acid (FFA) levels compared to the centrifugation method. These factors indicate a higher risk of microbial contamination and a greater degree of degradation in the fermented oil, which could negatively affect its stability and shelf life. In contrast, centrifugation yields oil with lower moisture content, FFA levels, and peroxide value, contributing to better oxidative stability and extended shelf life.Both methods produce VCO with similar iodine and saponification values, indicating comparable levels of unsaturation and fat content, which are important for food and cosmetic applications. The refractive index for both oils is also consistent, suggesting similar purity. However, centrifugation excels in other sensory and aesthetic qualities, producing oil that is clearer, lighter in color, and fresher in aroma. These characteristics enhance the appeal of the centrifuged oil, making it more attractive to premium markets, especially in the cosmetic industry.The clarity of the oil, which is an important factor for consumer perception, is notably superior in centrifuged VCO, with the oil being free from sediments and exhibiting a cleaner, more refined appearance. This aspect is crucial for high-end product formulations, where visual appeal and consumer expectations are significant drivers of product choice.In conclusion, while both fermentation and centrifugation methods produce VCO that meets the standard quality limits in most parameters, the centrifugation method consistently outperforms fermentation in terms of oxidative stability, sensory properties, and visual appeal. As a result, centrifugation emerges as the preferred method for producing high-quality VCO that is suitable for premium markets where consistency, aesthetics, and product stability are essential.

### Reference

[1]. Nevin&Rajamohan (2004) found that VCO extracted via cold press retains significantly higher antioxidant capacity compared to refined coconut oil, attributing the effect to the presence of unrefined phenolic compounds and vitamin E, which are sensitive to heat and chemicaltreatment.*Nevin, K. G., &Rajamohan, T. (2004). Beneficial effects of virgin coconut oil on lipid parameters and in vitro LDL oxidation. Clinical Biochemistry, 37(9), 830-835.*

[2]. Pakarinen et al. (2010) explored microbial activity during natural fermentation and found that the lactic acid bacteria profile significantly affects oil stability and quality, suggesting the need for microbial control to reduce peroxide levels and improve shelf life. *Pakarinen, O. M., et al. (2010). Microbial dynamics in spontaneous fermentation of coconut milk. Journal of Applied Microbiology, 108(3), 926-934.*

[3]. Raghavendra et al. (2006) analyzed the impact of moisture content on VCO stability, showing that high moisture levels in extracted oil accelerate rancidity, underscoring the importance of drying and hygienic handling in both fermentation and cold-press techniques. *Raghavendra, S. N., &Raghavarao, K. S. M. S. (2006). Effect of different treatments for the destabilization of coconut milk emulsion on the quality of virgin coconut oil. Food Chemistry, 99(2), 260-266.*

[4]. Nambiar et al. (2014) highlighted the economic feasibility of cold press and centrifugation for small to medium enterprises, concluding that while these methods require higher capital, they result in a more consistent and export-ready product. *Nambiar, V. S., et al. (2014). A cost-benefit analysis of different virgin coconut oil production systems. International Journal of Agricultural Economics, 2(1), 18-25.*

[5]. Raghavendra&Raghavarao (2010) studied the phase separation in fermentation and concluded that adding natural coagulants like moringa leaf extract can improve oil recovery, yield, and reduce fermentation time. *Raghavendra, S. N., &Raghavarao, K. S. M. S. (2010). Extraction of virgin coconut oil using natural coagulants. Innovative Food Science & Emerging Technologies, 11(3), 599-603.*

[6]. Zakaria et al. (2012) conducted sensory evaluations on oils obtained via cold press, fermentation, and heat-based methods and found that cold-pressed oil scored highest in terms of aroma, clarity, and overall acceptability among consumers. *Zakaria, A., et al. (2012). Sensory attributes and physicochemical properties of virgin coconut oil extracted by different methods. International Food Research Journal, 19(3), 1005-1010.*

[7]. Arunima&Rajamohan (2012) linked the high lauric acid content in cold-pressed VCO to cholesterol-lowering effects in animal studies, reaffirming the significance of preserving fatty acid composition during extraction.*Arunima, S., &Rajamohan, T. (2012). Virgin coconut*

*oil improves hepatic lipid metabolism in rats compared with copra oil, sunflower oil and olive oil. Indian Journal of Experimental Biology, 50(11), 802-809.*

[8]. Siong et al. (2018) examined the oxidative stability of VCO under storage conditions and found that cold-pressed VCO maintained its stability longer than fermented VCO, likely due to lower initial moisture content and better packaging compatibility. *Siong, H. J., et al. (2018). Evaluation of the storage stability of virgin coconut oil produced by different extraction techniques. Journal of Food Quality, 2018, Article ID 9290526.*

[9]. Tangsuphoom&Coupland (2008) studied the emulsion stability of coconut milk as a precursor step to VCO extraction and emphasized that controlling emulsion breakdown significantly influences oil clarity and yield, especially in fermentation. *Tangsuphoom, N., &Coupland, J. N. (2008). Effect of processing conditions on the stability of coconut milk emulsions. Food Hydrocolloids, 22(7), 1233-1242.*

[10]. Prasertsan&Srisuwan (2020) investigated innovations in enzymatic-assisted extraction and reported that enzymes can enhance oil recovery from coconut meat by breaking down cell walls, but require precise control to avoid protein denaturation affecting oil flavor. *Prasertsan, P., &Srisuwan, S. (2020). Enzymatic extraction of virgin coconut oil: Optimization and quality assessment. Food and Bioproducts Processing, 119, 1-10.*