Standardisation of centrifugation method for virgin coconut oil production and comparison of quality parameters of the recovered oil

Abstract

The objective of the study was standardisation of centrifugation method for virgin coconut oil production. Mature coconuts from West Coast Tall variety werecollected and coconut milk was taken out by using coconut gratings with equal quantity of water and coconut water and two fold of water. The coconut milk was then chilled for 10 hours at 5-7^{0}C, followed by centrifugation at different revolutions per minute (rpm) and time. The colour, odour, taste, moisture content, free fatty acid content and total phenolic content of the resulting virgin coconut oil were assessed. The study revealed thatthe optimal conditions for maximum virgin coconut oil yield (28.087 percent)involve extracting coconut milk from coconut gratings with equal quantity of coconut water followed by chilling for 10 hours at 5-7°C, centrifuged at 12000 rpm for 15 minutes and subsequently drying at 50°C. This standardization process aims to provide a cost-effective and efficient method for small-scale production of high-quality virgin coconut oil.

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Key words: *Virgin coconut oil, oil recovery, centrifugation, quality parameters, coconut milk, coconut water.*

Introduction

Coconut palm(*Cocos nucifera* L.)holding a significant role intropical regions, often referred as"Tree of heaven"or "Kalpavriksha" provides a myriad of essential resources for human life. Though all botanical parts of coconut have immense use, among its versatile products, Virgin Coconut oil (VCO) is known for its therapeutic and antioxidant properties. Widely recognized for its applications in food, medicine, cosmetics and hair care, VCO is gaining global popularity(Varma *et al*., 2019).VCO is a high value product marketed for its health benefits due to antifungal, antioxidant, antibacterial, antiviral, hepatoprotective, low glycemic index, and immune system stimulationproperties as well as its cosmetic use (Konar *et al*., 2020). VCO stands out due to its unique composition and numerous health benefits. The distinctive composition of VCO, containing lauric acid, vitamin E, polyphenols, and antioxidants, sets it apart from other vegetable oils. Monolaurin, a monoglyceride form of

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lauric acid, contributes to immunity enhancement and protects newborns against various infections(Nasir *et al.*, 2018).

Virgin coconut oil (VCO) is made from the ripe and fresh kernels of the coconut (*Cocos nucifera* L.), either naturally or mechanically, with or without the application of heat, so long as the oil's composition remains unchanged (APCC, 2003). Various techniques may be employed to extract virgin coconut oil from the mature and fresh kernel of the coconut flesh (Bawalan& Chapman, 2006). The choice of extraction technique can significantly influence the composition, purity, and applications of coconut oil.

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By carefully regulating temperature, cooling, and centrifugal force, centrifugation effectively upsets the coconut milk emulsion, allowing for the separation of virgin coconut oil from water and solids (Raghavendra and Raghavarao, 2010). This process helps to produce high-quality VCO with minimal processing and without the use of harsh chemicals or high temperatures that could degrade the oil's natural properties.Optimal centrifugation speed with varying durations and speeds is crucial for achieving a high yield of VCO, with minor differences in oil quality(Nour *et al*., 2009). Chilling is also employed to break the coconut milk emulsion, followed by the separation of cream through boiling and centrifugation(Nevin and Rajamohan, 2004; Raghavendra and Raghavarao, 2010).

By employing any of these methods including controlled temperature, centrifugation followed by cooling, enzymatic processes, pH adjustment, or a combination of these techniques, it has been explored to enhance the extraction process.After a few hours of freezing, coconut milk goes through a phase called "separation of cream," during which the cream is gently boiled and centrifuged to extract the virgin coconut oil (Seneviratne *et al*., 2009; Raghavendra and Raghavarao, 2010).

Chiewchan and Tansakul (2004) found that the instability of the emulsion and subsequent phase separation and production of oil and aqueous layers were caused by the close contact between big droplets (increased interaction duration) and applied force during centrifugation. Christine (2012) studied by introducing different combinations of centrifugation speed and time to the coconut milk emulsion after it had been subjected to different chilling temperatures.Investigating industrial coconut oil extraction processes is essential for advancing extraction technology, ensuring its feasibility and effectiveness for downstream processing, and driving innovation in the coconut oil industry.Hence the investigation wascarried out at Department of Plantation Spices, Medicinal and Aromatic Crops, College

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of Agriculture, Vellayaniwith the aim of establishing a standardized procedure for centrifugation which is essential for ensuring the optimal utilization of resources of coconut.

Materials and methods

The present investigation on standardisation of centrifugation method for virgin coconut oil productionand evaluation of the quality features of the recoveredoil was carried out at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Agriculture, Vellayani, Kerala, India. The methods used were detailed and designed to evaluate both the efficiency of the extraction process and the quality of the resulting virgin coconut oil.

Twelve month old mature coconuts were collected from West Coast Tall palms, dehusked, shelled and grated. Equal amounts of coconut gratings (CG) and coconut water (CW), as well as equal and double amounts of coconut gratings and water (W), were used to prepare coconut milk. The coconut milk was kept in refrigerator at 5-7°C for 10 hours. The refrigerated coconut milk was centrifuged at 8000, 10000 and 12000 rpm at a time period of 10, 15 and 20 minutes.

The experiment was laid out in Completely Randomised Design with 27 treatments and three replications. The treatments includedT_1: CG+CW (1:1) at 8000 rpm for 10 minutes (5376 N), T_2: CG + CW (1:1) at 8000 rpm for 15 minutes (5376 N), T_3: CG + CW (1:1) at 8000 rpm for 20 minutes (5376 N), T_4: CG+W (1:1) at 8000 rpm for 10 minutes (5376 N), T_5: CG+W (1:1) at 8000 rpm for 15 minutes (5376 N): T_6: CG+W (1:1) at 8000 rpm for 20 minutes (5376 N), T_7: CG+W (1:2) at 8000 rpm for 10 minutes 5376 N, T_8: CG+W (1:2) at 8000 rpm for 15 minutes 5376 N, T_9: CG+W (1:2) at 8000 rpm for 20 minutes 5376 N: T_{10}: CG+CW (1:1) for 10000 rpm for 10 minutes 8400 N, T_{11}: CG+CW (1:1) at 10000 rpm for 15 minutes 8400 N, T_{12}: CG+CW (1:1) at 10000 rpm for 20 minutes 8400 N, $T_{13:}$ CG+W (1:1) at 10000 rpm for 10 minutes 8400 N, T_{14}: CG+W (1:1) at 10000 rpm for 15 minutes 8400 N, T_{15}: CG+W (1:1) at 10000 rpm for 20 minutes 8400 N, T_{16}: CG+W (1:2) at 10000 rpm for 10 minutes 8400 N, T_{17}: CG+W (1:2) – 10000 rpm for 15 minutes 8400 N, T_{18}: CG+W (1:2) for 10000 rpm for 20 minutes 8400 N, T_{19}: CG+CW (1:1) at 12000 rpm for 10 minutes 12096 N, T_{20}: CG+CW (1:1) at 12000 rpm for 15 minutes 12096 N, T_{21}: CG+CW (1:1) at 12000 rpm for 20 minutes 12096 N, $T_{22:}$ CG+W (1:1) at 12000 rpm for 10 minutes 12096 , T_{23}: CG+W (1:1) for 12000rpm for 15 minutes 12096 N, T_{24} CG+W (1:1) for 12000rpm for 20 minutes 12096 N, $T_{25:}$ CG+W (1:2) at 12000rpm for 10 minutes 12096 N, T_{26}: CG+W(1:2) at 12000 rpm for 15 minutes (12096 N), T_{27} : CM+W (1:2) at 12000rpm for 20 minutes (12096 N). Based on the oil recovery, the rpm and time period were standardized.

The assessment included analyzing free fatty acids, total phenolic content, and moisture levels in the virgin coconut oil to determine if the extraction method affected these quality parameters. Free fatty

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acids and total phenolic content were analyzed based on the Sadasivam and Manikam (1992) procedure with adjustments by Ramma *et al*. (2002). Moisture content was determined using the hot air-oven method. Additionally, VCO obtained through different coconut milk extraction methods were assessed for acceptability through sensory tests evaluating aspects such as colour, odour, and taste. A panel of ten semi-trained members scored these sensory attributes, and statistical analysis utilized the Kruskal-Wallis one-way analysis of variance technique (Kruskal and Wallis, 1952) for evaluation.

Results and Discussions

Revolutions per minute and time required: The effect of different revolutions per minute (rpm) on oil recovery from coconut milk extracted using various ratios of water to coconut water was examined in this study. The results are displays in Table 1, showing variations in oil recovery at different rpm and time intervals.There were substantial differences between the treatments at different rpm in the oil recovery. The treatment T21, extracting coconut milk at using equal quantity of coconut gratings and coconut water and centrifuged at 12000 rpm for 20 minutes, exhibited the highest oil recovery (27.806%). This was comparable to T20, which had a 15-minute centrifugation at the same rpm (27.800%). This was followed by the treatment, T12 that is coconut milk extracted using equal quantity of grated coconut and coconut water, centrifuged at 10000 rpm for 20 minutes, showed an oil recovery of 26.933%. When coconut milk was extracted using two fold of water and centrifuged at 8000 rpm for 10 minutes, the oil recovery was at its lowest (6.966%).Centrifugation at 12000 rpm for 15 minutes under a gravitational force of 12096 Nenhanced oil recovery, suggesting the significance of rpm and time in the process.

Chiewchan and Tansakul (2004) highlighted that close contact between large droplets and prolonged centrifugation times caused emulsion instability, leading to phase separation. The rate of sedimentation and the emulsion separation of two immiscible liquids increased as a result of the trend toward faster centrifugation (Nour *et al*., 2009). Wong and Hartina (2014) investigated virgin coconut oil production and found the highest yield (13.53%) at 12000 rpm for 120 minutes. Higher centrifugation speeds were associated with increased oil recovery which were in line with Kamila and Broto's (2022) where it was reported as the length of the rotation time affect the amount of oil produced, the longer the separation process, the more oil droplets separate from the emulsion, and generally the longer the rotation time, the more optimal the oil yield obtained.

Quality parameters of recovered oil

Free fatty acid, total phenolic content and moisture content: Table 2 shows the impact of centrifugation on the free fatty acid content (mg KOH/g of oil), total phenolic content (mg catechin equivalent /kg of oil), and moisture content (percentage) of virgin coconut oil recovered through the

extraction process of coconut milk using coconut gratings as well as different ratios of water and coconut water. The findings demonstrated that, when virgin coconut oil was recovered from coconut milk extracted by different methods followed by centrifugation at 12000 rpm for 15 minutesand was dried at 50°C, there was no discernible difference between the treatments on quality parameters.

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Dia*et al*. (2005) determined the total phenolic content in virgin coconut oiland reported that virgin coconut oil contains higher total phenolic content compared to refined coconut oil.Moisture content is also an important parameter which play an important role in the determination of the quality of the virgin coconut oil samples produced. The study conducted by Wong and Hartina (2014) showed that the moisture contentof centrifuged virgin coconut oil at varying centrifugation speed (rpm), time (minutes) and temperature ranged from 0.88% to 1.03% and did not fall in the range of APCC standards of moisture percentage maximum range between 0.1 to 0.5%.Therefore, it can be concluded from the current experiment that the various centrifugation techniques employed had no effect on the oil's quality.

Oil recovery: Table 2 shows the impact of centrifugation on the recovery percentage of virgin coconut oil. The findings demonstrated a substantial difference in the virgin coconut oil recovered from coconut milk extracted using different ratios of coconut gratings, water and coconut water followed by centrifugation for 15 minutes at 12,000 rpm. Maximum oil recovery was achieved with treatment T1 (CG+ CW 1:1, 12000 rpm – 12096 G force) at 15 minutes (28.087), and treatment T2 (CG+ W 1:1 12000 rpm – 12096 G force) at 15 minutes (22.474 percent).

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For effective oil recovery using centrifugation, significant percentages of particles in the oil seed dispersion have to be removed (Rosenthal *et al*., 1996). By reducing the presence of particles and impurities in the dispersion, the efficiency of centrifugation can be improved, leading to higher oil recovery rates and better overall extraction performance.The coconut cream obtained after centrifugation has been tried to be broken up using methods such as heating and centrifugation, freezing and thawing and chilling and thawing (Seow and Gwee, 1997). According to Wong (2010), 37.3% of the virgin coconut oil produced by centrifugation at 12000 rpm and 105 minutes was the greatest yield. The maximum yield of 46.88 percent virgin coconut oil was achieved using a combination of centrifugation and microwave technology, with 720 watts of microwave power, 12000 rpm, and 105 minutes. According to Wong and Hartina (2014), centrifugation yielded an oil recovery of 13.53 percent at 12000 rpm in 120 minutes.

Sensory parameters: When centrifuged at 12,000 rpm for 15 minutes and dried at 50°C, the virgin coconut oil recovered from coconut milk extracted with coconut gratings, equal quantity of water and coconut water and coconut gratings with two fold of water did not demonstrate any differences between the treatments on sensory parameters such as colour, odour, or taste (Table 3). Thus the sensory parameters of the virgin coconut oil remained consistent regardless of the different processing

conditions applied. It implies that the different coconut milk extraction processes in centrifugation process did not negatively impact the sensory qualities of the virgin coconut oil.

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Conclusion

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In conclusion, the present study highlight the effectiveness of a specific method for coconut milk extraction in optimizing oil recovery. The coconut milk extracted with equal quantity of coconut water, refrigerated at 5-7°C for 10 hours followed by centrifugation at 12000rpm for 15 minutes showed higher (28.087 percent) oil recovery. Moreover, the moisture content and free fatty acid content of the extracted coconut milk were within the recommended range set by the APCC, ensuring the quality of the produced oil. The range of the total phenolic content in oil was 56.8–62 mg catechin equivalent/kg. The colour, flavour, and odour of the coconut milk remained consistent across various coconut milk extraction methods.Based on high oil recovery, the coconut milk extracted with equal quantity of gratings and coconut water and refrigerated at 5-7^0 C for 10 hours, followed by centrifugation at 12000 rpm for 15 minutes, can be recommended as an affordable technology for small-scale virgin coconut oil production.

Future Scope

Investigating different coconut cultivars can provide valuable insights into variations in oil recovery and other relevant parameters.

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Table: 1. Effect of rpm (gravitational force - N) and duration (minutes) on oil recovery (%) under centrifugation

Treatments	Oil recovery (%)
T_1 (CG+CW1:1 -8000rpm- 10 minutes) 5376 N	10.066
T_2 (CG+CW1:1 -8000rpm- 15 minutes) 5376 N	18.133
T_3 (CG+CW1:1 - 8000rpm- 20 minutes) 5376 N	21.533
T_4 (CG+W 1:1- 8000rpm- 10 minutes) 5376 N	7.933
T_5 (CG+W 1:1- 8000rpm- 15 minutes) 5376 N	15.900
T_6 (CG+W 1:1- 8000rpm- 20 minutes) 5376 N	19.866
T_7 (CG+W 1:2- 8000rpm- 10 minutes) 5376 N	6.966
T_8 (CG+W 1:2- 8000rpm- 15 minutes) 5376 N	14.166
T_9 (CG+W 1:2- 8000rpm- 20 minutes) 5376 N	15.466
T_{10} (CG+CW1:1 - 10000rpm- 10 minutes) 8400 N	16.566
T_{11} (CG+CW1:1 - 10000rpm- 15 minutes) 8400 N	23.866

T_{12} (CG+CW1:1 - 10000rpm- 20 minutes) 8400 N	26.933
T_{13} (CG+W 1:1- 10000rpm- 10 minutes) 8400 N	10.200
T_{14} (CG+W 1:1- 10000rpm- 15 minutes) 8400 N	19.566
T_{15} (CG+W 1:1- 10000rpm- 20 minutes) 8400 N	22.500
T_{16} (CG+W 1:2- 10000rpm- 10 minutes) 8400 N	8.000
T_{17} (CG+W 1:2- 10000rpm- 15 minutes) 8400 N	16.966
T_{18} (CG+W 1:2- 10000rpm- 20 minutes) 8400 N	21.366
T_{19} (CG+CW1:1 - 12000rpm- 10 minutes) 12096 N	15.600
T_{20} (CG+CW1:1 - 12000rpm- 15 minutes) 12096 N	27.800
T_{21} (CG+CW1:1 - 12000rpm- 20 minutes) 12096 N	27.806
T_{22} (CG+W 1:1- 12000rpm- 10 minutes) 12096 N	17.666
T_{23} (CG+W 1:1- 12000rpm- 15 minutes) 12096 N	22.400
T_{24} (CG+W 1:1- 12000rpm- 20 minutes) 12096 N	22.433
T_{25} (CG+W 1:2- 12000rpm- 10 minutes) 12096 N	16.766
T_{26} (CG+W 1:2- 12000rpm- 15 minutes) 12096 N	21.133
T_{27} (CG+W 1:2- 12000rpm- 20 minutes) 12096 N	21.133
SE	0.293
CD(0.05)	0.582

CG: Grated Coconut, CW: Coconut water, Water: Water

Table: 2. Effect of centrifugation on free fatty acid content (mg KOH/g of oil), total phenolic content (mg catechin equivalent /kg of oil), moisture content (%) and oil recovery (%).

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Treatments	Free fatty acid (mg KOH/g of oil)	Total Phenolic content (mg catechin equivalent /kg of oil)	Moisture content (%)	Oil recovery (%)
T_1 (CG+ CW 1:1 12000rpm – 12096 G force at 15 minutes)	0.208	56.800	0.065	28.087
T_2 (CG+ W 1:1 12000rpm – 12096 G force at 15 mints)	0.208	62.000	0.072	22.474
T_3 (CG+ W 1:2 12000rpm – 12096 G force at 15 mints)	0.224	59.200	0.072	19.687
SE	0.045	5.850	0.020	0.330
CD(0.05)	NS	NS	NS	0.810

Table: 3. Effect of centrifugation on sensory parameters of virgin coconut oil

Treatments	Mean sensory scores		
	Colour	Odour	Taste
T_1 (CG + CW 1:1)	8.9	8	7.9
T_2 (CG + W 1:1)	8.9	7.8	7.7
T_3 (CG + W 1:2)	8.9	7.8	7.5
Kruskal Wallis H	0.00	0.27	1.46
	NS	NS	NS

Fig. 1. Photograph of separated virgin coconut oil by centrifugation method

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