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

Abstract

Virgin coconut oil is a finestedible oil having immense health benefits. Several methods are adopted for the extraction of virgin coconut oil. This experiment aims to provide a cost-effective and efficient method for small-scale production of high-quality virgin coconut oil.The objective of this 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 that the 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.

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 there are versatile processed products of coconut, Virgin Coconut oil (VCO) is known for its therapeutic and antioxidant properties (Carandang, 2008).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. Presence of lauric acid in VCO, contributes to immunity enhancement and protects newborns against various infections (Nasir *et al.*, 2018).VCO is acquiring global acceptancebecause of its applications in food, medicine, cosmetics and hair care(Varma *et al*., 2019).It has antifungal, antioxidant, antibacterial, antiviral, hepatoprotective and immune system stimulatingproperties. Apart from these, VCO exhibits low glycemic index and cosmetic uses (Konar *et al*., 2020).

Virgin coconut oil (VCO) is made from the ripe and fresh kernels of the coconut (*Cocos nucifera* L.), either naturally or mechanically, by using or not using 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 and Chapman (2006) discussed different methods like modified kitchen method, modified natural fermentation method, low pressure oil extraction method, high pressure expeller method etc. for VCO separation. The choice of extraction technique can significantly influence the composition, purity, and applications of virgin coconut oil.

Centrifugation is an excellent method which can be utilised for the extraction of VCO. 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).Christine (2012) observed the effect of different combinations of centrifugation speed and time to the coconut milk emulsion after it had been subjected to various chilling temperatures.

Investigating afeasible and effective coconut oil extraction process is essential for advancing extraction technology, for downstream processing, and driving innovation in the coconut oil industry. Hence the study wascarried out by me at Department of Plantation Spices, Medicinal and Aromatic Crops, College 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 methods used for the standardisation of revolutions per minute (rpm) and time period were detailed and designed to evaluate both the effectivness of the extraction process and the quality of the recovered 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. Different rpm like 6000, 8000, 10000, 12000 and time period 5, 10, 15, 20, 25, 30 minutes were tried for the VCO extraction. On the basis of oil yield, for further experiment,refrigerated coconut milk was centrifuged at 8000, 10000 and 12000 rpm at a time period of 10, 15 and 20 minutes. The model used for the study was HERMLE Z 383K (radius of rotation – 7.5cm). Unit of rpm was expressed as G force.

G force (Newton) = $1.12 \times r \times (rpm/1000)^2$ Where, r = radius of rotation and rpm = revolutions per minute

The experiment was laid out in Completely Randomised Design with 27 treatments and three replications. The treatments included

1. T_1 (CG+CW 1:1 -8000rpm- 10 minutes) 5376 N
2. T_2 (CG+CW 1:1 -8000rpm- 15 minutes) 5376 N
3. T_3 (CG+CW 1:1 -8000rpm- 20 minutes) 5376 N
4. T_4 (CG+W 1:1- 8000rpm- 10 minutes) 5376 N
5. T_5 (CG+W 1:1- 8000rpm- 15 minutes) 5376 N
6. T_6 (CG+W 1:1- 8000rpm- 20 minutes) 5376 N
7. T_7 (CG+W 1:2- 8000rpm- 10 minutes) 5376 N
8. T_8 (CG+W 1:2- 8000rpm- 15 minutes) 5376 N
9. T_9 (CG+W 1:2- 8000rpm- 20 minutes) 5376 N
10. T_{10} (CG+CW 1:1 - 10000rpm- 10 minutes) 8400 N
11. T_{11} (CG+CW 1:1- 10000rpm- 15 minutes) 8400 N
12. T_{12} (CG+CW 1:1- 10000rpm- 20 minutes) 8400 N
13. T_{13} (CG+W 1:1 - 10000rpm- 10 minutes) 8400 N
14. T_{14} (CG+W 1:1 - 10000rpm- 15 minutes) 8400 N
15. T_{15} (CG+W 1:1 - 10000rpm- 20 minutes) 8400 N
16. T_{16} (CG+W 1:2 - 10000rpm- 10 minutes) 8400 N
17. T_{17} (CG+W 1:2 - 10000rpm- 15 minutes) 8400 N
18. T_{18} (CG+W 1:2 - 10000rpm- 20 minutes) 8400 N
19. T_{19} (CG+CW1:1 - 12000rpm- 10 minutes) 12096 N
20. T_{20} (CG+CW1:1 - 12000rpm- 15 minutes) 12096 N
21. T_{21} (CG+CW1:1 - 12000rpm- 20 minutes) 12096 N
22. T_{22} (CG+W1:1 - 12000rpm- 10 minutes) 12096 N
23. T_{23} (CG+W1:1 - 12000rpm- 15 minutes) 12096 N
24. T_{24} (CG+W1:1 - 12000rpm- 20 minutes) 12096 N
25. T_{25} (CG+W1:2 - 12000rpm- 10 minutes) 12096 N
26. T_{26} (CG+W1:2 - 12000rpm- 15 minutes) 12096 N
27. T_{27} (CM+W1:2 - 12000rpm- 20 minutes) 12096 N

Oil Recovery : The oil recovery was found out using the following formula.

$$\text{Oil Recovery (in percentage)} = \frac{\text{Weight of oil extracted}}{\text{Weight of coconut milk used}} \times 100$$

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 Acid: It was analysed by titrating the recovered oil dissolved in equal proportion of diethyl ether and ethanol against potassium hydroxide.Phenolphthalein was used as indicator.Free fatty acid content was expressed as mg KOH per g oil.

$$\text{Acid value (mg KOH/g of oil)} = \frac{\text{Titre value} \times \text{Normality of KOH} \times 56.1}{\text{Weight of the sample (g)}}$$

Total phenolic content: Total phenolic content was determined using Folin - Ciocalteureagent. Catechin was taken as standard and all the samples were read at 760nm. Results were expressed as mg catechin equivalent per kg of oil.

Moisture content: Moisture content was found out using the hot air-oven method. Samples were dried at at 50°C till a constant weight was obtained.

$$\text{Moisture Percentage} = \frac{W1}{W} \times 100$$

Where, W1 = Loss in g of the sample on drying; W = Weight in g of the sample taken for test

Sensory test for colour, odour and taste: 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 (out of 10), and statistical analysis utilized the Kruskal-Wallis one-way analysis of variance technique for evaluation.

Like extremely –9; Like very much –8; Like moderately – 7; Like slightly – 6; Neither like nor dislike – 5; Dislike slightly –4; Dislike moderately – 3; Dislike very much – 2; Dislike extremely -1

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 may be because of close contact between large droplets and prolonged centrifugation time period causes emulsion instability, leading to phase separation (Chiewchan and Tansakul, 2004).Nour *et al*. (2009) emphasized that the rate of sedimentation and the emulsion separation of two non-miscible liquids increased as a result of faster centrifugation. Wong and Hartina (2014) found that virgin coconut oil production by centrifugation method at 12000 rpm for 120 minutes yield more oil (13.53%). At 12000 rpm, there is sufficient centrifugal force for the extraction process. Higher centrifugation speeds were associated with increased oil recovery which were in line with Kamila and Broto's (2022) report. It reveals that the time period affect the quantity of recovered oil.Whenrotation time increases,oil yield also increases.Based on the oil recovery, centrifugation speed, time period and gravitational force were fixed as 12000 rpm, 15 minutesand 12096 Nrespectively.

Quality parameters of recovered oil

Free fatty acid, total phenolic content and moisture content: The effect of centrifugation on the free fatty acid content, total phenolic content and moisture content of VCO obtained using various ratios of coconut gratings, water and coconut water were examined.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 after centrifugation did not show anysignificant difference between the treatments. High percentage of moisture leads to higher free fatty acid content. Since the moisture content of recovered oil possess not much variation and under the standard range of APCC, less chance in the variation of free fatty acid content. The variations in rpm and time period may not be large enough to produce a significant difference for the quality parameters. It can be concluded that the oil quality was unaffected by various centrifugation techniques employed. Wong and Hartina (2014) analysed the moisture contentof virgin coconut oil obtained through centrifugation method at different speed (rpm), time (minutes) and temperature ranged from 0.88% to 1.03% and did not come under theacceptable range of APCC standards (0.1 to 0.5%).

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 obtained from chilled coconut milk extracted using different ratios of coconut gratings, water and coconut water. Maximum oil recovery was achieved with treatment T1 (CG+ CW 1:1) (28.087) and treatment T2 (CG+ W 1:1) (22.474 percent).According toRosenthal *et al*. (1996), for effective oil recovery using centrifugation, significant percentages of particles in the oil seed dispersion have to be removed. 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). Wong (2010) conducted a study using various rpm and time period for VCO extraction and

obtained37.3% of oil yield at 12000 rpm and 105 minutes. 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.

Centrifugation of coconut milk after chilling can substantially reduce the time period.After a few hours of chilling, 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).VCOrecovery from chilled coconut milk extracted using equal quantity of coconut gratings and coconut water and centrifuged at 12000rpm for 15 minutes is more compared to other treatments.

Sensory parameters: When centrifuged at 12,000 rpm for 15 minutes and dried at 50°C, the virgin coconut oil obtained from coconut milk extracted using 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.

Conclusion

In conclusion, the present study highlight the effectiveness of a specific method for coconut milk extraction in optimizing oil recovery.

1) The coconut milk extracted with equal quantity of coconut water, refrigerated at 5-7^{o}C for 10 hours followed by centrifugation at 12000rpm for 15 minutes showed higher (28.087 percent) oil recovery.
2) 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.
3) The range of the total phenolic content in oil was 56.8–62 mg catechin equivalent/kg.
4) 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.

Acknowledgement

We are thankful to Kerala Agricultural University for providing all the required facilities from the university. We gratefully acknowledge Dr. Meena Kumari for the valuable advice throughout the work.

References

1. APCC [Asian and Pacific Coconut Community]. 2003. *APCC Standards for virgin coconut oil* [on-line]. Available: http://www.apccsec.org/standards.htm. [08 Nov. 2013].
2. Bawalan, D.D. and K.R. Chapman, 2006. *Virgin Coconut Oil- Production Manual for Micro- and Village-Scale Processing*. Food and Agricultural Organisation, United Nations, 80p.
3. Carandang, E.V. 2008. Health benefits of virgin coconut oil. *Indian coconut journal-Cochin*, 38(9): 8-12.
4. Chiewchan and A.N. Tansakul, 2004. Effect of fat content and temperature on the apparent viscosity of coconut milk. *J. Food Eng.*,64: 193-197.
5. Christine, L.T.W. 2012. Study of virgin coconut oil via combination of chilling and centrifugation method. B.Sc thesis, School of Food Science and Nutrition, University Malaysia Sabah, 50p.
6. Dia, V.P., V.V. Garcia., R.C. Mabes. andM.E.M.Tecson, 2005.Comparative physicochemical characteristics of virgin coconut oil produced by different methods.*Philipp. Agric. Sci.*, 88: 462-475.
7. Kamila, N.P. and W. Broto, 2022. The Effect of Mixing Red Coconut and Green Coconut on The Manufacture of VCO Using The Centrifugation Method. *J. Appl. Food Technol.*, 9 (2): 30-33.
8. Konar M.C., K. Islam., A. Roy.and T. Ghosh. 2020. Efect of virgin coconut oil application
9. Nevin, K.G. and T. Rajamohan, 2004. Beneficial effects of virgin coconut oil on lipid parameters and in vitro LDL oxidation.*Clin.Biochem.*, 37: 830-835.
10. Nour, A.H., F.S. Mohammed., R.M. Yunus. and A. Arman, 2009.Demulsification of virgin coconut oil by centrifugation method: afeasibility study. *Int. J. Chem. Technol.*, 1(2): 59-64.
11. Raghavendra, S.N.andK.S.M.S. Raghavarao, 2010.Effect of different treatments for the destabilization of coconut milk emulsion.*J. Food Eng.*,97: 341-347.
12. Rosenthal, A., Pyle, D. L. and Niranjan, K. 1996. Aqueous and enzymatic processes for edible oil extraction. *Enzyme Microbial Technol*. 19: 402- 420.
13. Seneviratne, K.N., C.D. Hapuarachchl. And S. Ekanayake, 2009. Comparison of the phenolic-dependent antioxidant properties of coconut oil extracted under cold and hot conditions.*Food Chem.*, 114: 1444-1449.

14. Seow, C.C.andC.N. Gwee, 1997. Review, coconut milk: chemistry and technology. *Int. J. Sci. Technol*., 32: 189-201.
15. Varma, S.R., T.O. Sivaprakasam., I. Arumugam., N. Dilip., M. Raghuraman., K. Pavan., M. Rafq.and R. Paramesh, 2019.*In vitro* anti-infammatory and skin protective properties of Virgin coconut oil. *J Tradit. Complement. Med.,* 9:5–14.
16. Wong, P.W.2010. Production of virgin coconut oil (VCO) via combination of microwave and centrifugation method.*Faculty of Chemical & Natural Resources Engineering University Malaysia Pahang.*1-16.
17. Wong, Y.C. and H. Hartina, 2014. Virgin coconut oil production by centrifugation method.*Orient. J. Chem.,* 30(1): 237-245.

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 (%).

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

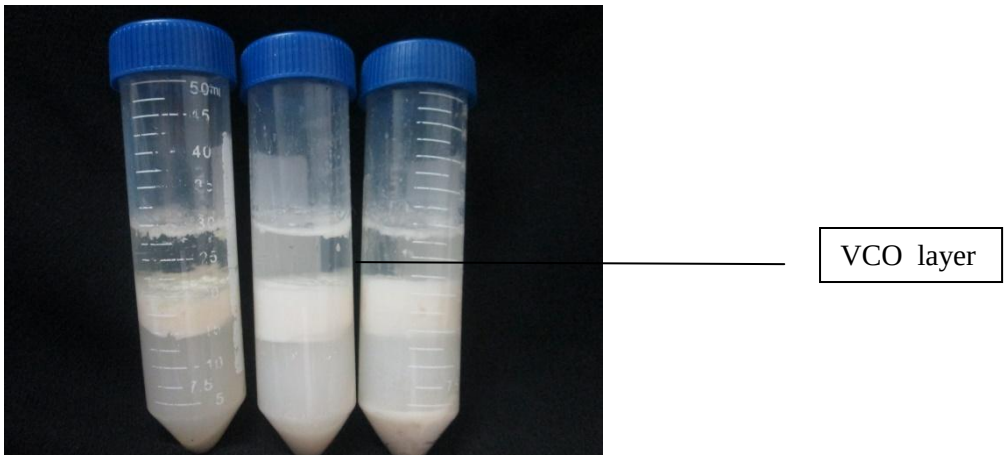

Fig. 1. Photograph of separated virgin coconut oil by centrifugation method

Fig.2 Model of Centrifuge

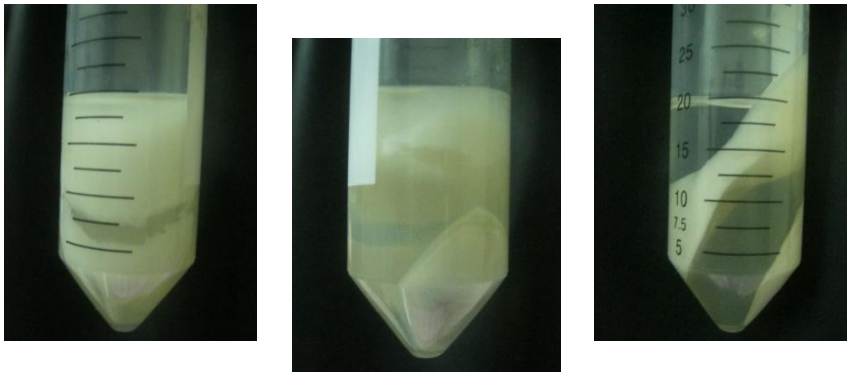

Fig.3: Different stages of oil separation