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Optimization of Process Variables for the Production of Virgin Coconut Oil from Selected *Cocos Nucifera* Varieties under Fresh-Dry Method

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***Abstract*:** Virgin Coconut Oil (VCO) was prepared from four coconut varieties viz., West Coast Tall, Arasampatti Tall, Deejay and Tiptur Tall. The Fresh-Dry methodology was optimized by three common variable parameters like temperature viz., 30±1ºC, 35±1ºC, 40±1º C, 45±1ºC, Drying intervals viz., 24hrs, 36hrs, 48 hrs, 60hrs and fruit maturity like 10, 11, 12 and 13 month old coconuts was taken to estimate the yielding efficiency of VCO .The yielding efficiencies are calculated from the four Coconut varieties by comparing the total percentage of Oil extracted from Soxhlet method. Among the four, the maximum yielding efficiency 95.33% was obtained in WCT Coconuts drying with 45º C. In the second process variable, where the maximum yield efficiency was showed that is 93.06% with 48 hrs drying. The third process variable showed the same maximum value of 93.06% as in second process variable by employing 12 month old coconuts The coconut varieties are taken in this research study, showed different yield composition of fatty acid profile especially the lauric acid percentage, which was registered maximum that is 51.20% at "WCT Coconuts" and in other coconut varieties such as AT, DJ and TT Coconuts were noted as 50.10%, 49.23% and 48.55% respectively.

***Keywords*:** VCO, yielding efficiency, Fresh-dry method, WCT, AT, DJ, TT.

I. INTRODUCTION

Coconut oil is commonly extracted from the kernel or meat of mature coconut harvested from the coconut palm. It has nourished millions of people throughout the world for generations. Those populations that use it as their primary source of dietary fat are remarkably free of cardiovascular disease and other common degenerative conditions (1).

In Worldwide it is mainly cultivated in Philippines, Indonesia, India, SriLanka, Papua New Guinea, Thailand, Malaysia and Fiji (2). India occupies a predominant position of coconut production in the world. It is grown in 1.94 million ha in 19 states and 3 Union Territories of our country producing 15730 million nuts with an average productivity of 8303 nuts per ha or 44.27 nuts/palm/year (3).It is mainly grown in the southern part of India (4).

The four southern states especially Tamil Nadu, Kerala, Karnataka and Andhra Pradesh occupies more than 90% area for coconut production (5).This Horticulture crop has gained national importance as food, oil seed, beverage crop and it is a major source of raw material for large numbers of agro– based Industrial units.

Its yielding percentage will be varied in each phase and intervals (6).

There are 50 more value-added products are obtained from coconut tree, which are used in domestic purposes as well as importing quality products (7). Coconut oil is utilized for various purposes including skin care, hair care, stress relief, weight loss, cholesterol level maintenance, immunomodulatory effects and cardiovascular uses (8). It is one of the primary sources of energy, in tropical countries like India, SriLanka, Philippines and Indonesia (9). Virgin Coconut Oil (VCO) is defined as "Oil, one which is produced through with or without the use of heat and without undergoing chemical refining (10). Codex gave a general definition for "Virgin Oils", which states that such oils are suitable for human consumption (11). It provides an alternative inexpensive source of energy to neurons of humans in the case of Alzheimer's disease; this was reported by (12). Also it is noticed that various fractions of coconut oil are used as drugs because, it contains many valuable components like vitamin A, E, anti-cancer polyphenols (ferulic acid, catechin, caffeic acid) and Phytosterols (13). Almost 50% of the fatty acid in VCO is in the form of lauric acid. This fatty acid has wide application as wide spectrum of antimicrobial substances against fungi, bacteria and viruses. Moreover, the fatty acid profile of coconut oil shares

the similar characteristic with breast milk (14 & 15*)*. VCO is directly converted to energy in the liver and is not stored in adipose tissue, which is useful in weight management treatment (16).The study on anticancer activity of VCO reveals that the presences of polyphenol fractions have the potential to prevent the cancer progression (17).

Coconuts are obtained in two forms based on their moisture content namely; wet and dry coconuts (18). Commonly VCO produced in both wet and dry methods. In dry method, the grated kernel was kept under controlled temperature up to remove all moisture content from the kernel and finally oil recovered through grinding method (19).Wet methods are commonly divided into chilling and thawing, fermentation, enzymatic and pH method or any of these in combination (20).

Even though, VCO is growing in popularity as functional food, cosmetic and pharmaceutical oil, the high cost value is due to its low recovery from the existing wet methodologies. So pretreatments like slicing, pulverizing and blanching of coconuts along with hot treatment are employed to enhance the VCO recovery in dry processes (21).

Temperature is a prime factor in VCO production both in wet and fresh-dry process. The 95% of VCO was extracted from coconut cream by the mixing ratio of 1:1 coconut cream and 70ºC hot water (22). A research report revealed that the temperature 90ºC at which "Class A" VCO was separated from coconut milk cream using VCO Cooker (23).

Like that other methods, Fresh-dry process yields high quality water-clear colour VCO with permissible moisture content (0.07-0.1%), which determined the longer shelf-life of the product. Also, this method yields around 30 % of VCO from 100kg fresh grated meat (24).

A research study on fatty acid profiles of 60 Talls, 14 Dwarfs, and 34 hybrid coconut varieties was showed that the quality and quantity of coconut oil is not only determined by the external factors but also the variety of coconut(25). Also like that, a report stated that, the quality of VCO is determined by different maturity level of coconut (26 &27).

The western zone of Tamilnadu districts (Coimbatore, Tirupur and Erode), where 91% of coconut plantations are tall variety and 9% are dwarf variety (28). One of the major varieties occupied in southern states of India is West Coast Tall (WCT) (29& 30). The WCT coconut yields around 68% of oil (31).

Arasampatti Tall (AT) is a kind of Tall coconut variety released by the Tamil Nadu Agricultural University in the name of Aliyar Nagar Tall (ALRI) and it is recommended for cultivate in Tamil Nadu region (32**)**. It has a capacity to yield around 115.3 g of copra from a nut (33). A Seventeen years studies from fifteen genotypes of coconuts showed that, Arasampatti Tall continued to record the maximum nut yield that is 187.5g nut yields/palm /year followed by Tiptur Tall tree yields 169.6 g of nut yields/palm /year (34).

Tiptur Tall (TT) is a Tall variety (commonly known as Kalpatharu) grown up to 4.6 meter in height. The mean copra production in this palm was estimated around 165.3g per nut and the maximum oil content registered was 68.6 %(35). Even though TT showed constant production and resistance to leaf spot diseases, its vegetative growth especially number of functional leaves produced per palm/year was estimated around 29.25 numbers (36). Since its productivity is reduced when compared to other Tall coconuts (37).An evaluation trail conducted over 30 years on coconut hybrid combinations reported that Tall x Tall hybrids produced superior yield than other combinations (38).

A comparison study showed that, West Coast Tall (WCT) is a predominant cultivar in the West Coast region than other Tall coconut varieties of India yields around 190.83 g copra content per nut (39). WCT coconuts yield more quantity of oil than other tall coconut varieties (40).

In India Deejay coconut consultancy service is a biggest organization supplying high quality commercial (Hybrid) coconut seedlings to the farming community (41). Deejay coconut (DJ) is one of the high oil yielding (68%) hybrid variety crossed from selected parents (42). Coimbatore is one of the district comes under the western Zone of Tamilnadu includes 12 Blocks, where coconut is the major cultivating crop. In Coimbatore district, Pollachi is known major coconut cultivation area occupies 67.71% of land for coconut cultivation (43 & 44). The three Tall varieties viz. West Coast Tall Arasampatti Tall, Tiptur Tall and dwarf variety such as Deejay coconuts are majorly cultivating in Pollachi region. In this present research the four coconut varieties are collected from both Pollachi and Anaimalai Taluk for the production of VCO.

II. MATERIALS AND METHODS

Coconut samples

The selected coconut varieties such as WCT, AT , DJ Vishwas and TT of four uniformly sized 10, 11, 12 & 13 month old matured brown in colour coconuts, which have high oil content are taken in this research study(45,46 &47). The coconuts were collected from South farm of Vanavarayar Institute of Agriculture (VIA), Manakkadavu and are transferred to Plant biotechnology laboratory without any break.

Process variables in comparative study

There are three different process variables like Drying Temperature, Drying interval and Fruit maturity are take in

account for to estimate the yielding efficiency of VCO of four coconut varieties under this methodology.

Variety of coconuts

The quality of VCO is not only determined by the variety but also extraction procedure (48 & 49). In this study four coconut varieties viz., West Coast Tall, Arasampatti Tall, Deejay Vishwas and Tiptur Tall are used to produce VCO by fresh- dry method.

a. West Coast Tall (WCT):

It is a predominant cultivar in West Coast region of India. The average weight of fruit was around 570g, endosperm thickness is around 1.10 cm and the thickness of shell was found that around 0.44cm (50). This variety has inherent capability to resist against the root wilt disease (51).

b. Arasampatti Tall (AT):

It is an Indian origin planted in the year 1988 commonly called as "Aliyarnagar Tall". It has a characteristic nature of superior yielding capacity. So, it takes a prominent place for local cultivar of west coast region. The palm height is around 14.43 meters and the copra weight is around 115.3-119.0g /nut from the whole nut weight of 742.5 g - 835.0g (52& 53).

c.Deejay Vishwas (DJ):

Deejay Vishwas is an Indian origin based from Karnataka, Bangalore. It is a hybrid variety cultivated since 1983 onwards. It has specially developed to meet the quality seedlings requirement of sub-optimal management conditions etc (54). It produces 250 nuts per annum per tree and high copra and oil.

d.Tiptur Tall (TT):

It is one of the Tall Cultivar commonly known as "Kalpatharu" of Indian Origin especially cultivated for Ball Copra Production (55). It has a characteristic nature against Leaf spot disease. The copra yield per palm per year is around 19.96kg (56).

Drying Temperature

As per the previous study, four low drying temperatures like 30±1ºC, 35±1ºC, 40±1º C and 45±1ºC are selected for dry the coconut flakes under hot air dryer (57&58).

Drying Interval

$$Efficiency = \frac{\text{Yield \% on dry basis}}{\text{Soxhlet estimated oil \%}} \times 100$$

Physico-chemical characteristics

The moisture content, acid value, free fatty acid, Iodine number, peroxide value and Saponification number are calculated from the fresh-dry recovered coconut oil.

A slight modification from earlier study, four drying intervals viz., 24hrs, 36hrs, 48 hrs and 60hrs are chosen for dry the coconut flakes in this Process (59).

Fruit Maturity

The 12 month old coconut is considered as matured one. It contains 28% meat as a solid endosperm (60).In this research study fruit maturity like 10, 11, 12 and 13 month old coconuts was taken to estimate the yielding efficiency of VCO.

Preparation of coconut flakes

The intermediate aged matured brown coconuts of WCT, AT, DJ &TT are selected for the production of VCO (61). Initially the nuts are split into half cups using manual cutter followed by the white kernel was shredded or made in to small pieces (app.1 cm^2) up to 1.5 kg by using stainless steel knife (62). Then it was dried in an aerated oven after that the oil was expelled out using Hydraulic expellers (Piston and cylinder arrangement). The collected oil was filtered by using Whatman filter paper (no. 1) to remove the unnecessary residues, which may escape into the oil make unfavorable odour and color. The process was repeated in triplicate and the oil was kept in a refrigerator condition until further investigation.

Estimation of initial oil content - Soxhlet extraction

The total initial oil content of four coconut varieties was estimated by AOAC Soxhlet method (63). As per the methodology, each ten grams of dry grated coconut pieces are weighed along with extraction thimble and then it was covered with wool. The pre- weighted dried boiling flask was filled with n-hexane. Then the extraction was carried out in triplicate manner for 30 hours. Finally the recovered oil was dried in an oven at 103 ± 1°C for 2 hours to remove the remaining solvent and cooled in a desiccator before reweighing.

Calculation of Oil recovery & Process efficiency

The oil recovery was determined according to the initial oil content in the coconut to the oil extracted from the four coconut varieties by fresh dry methodology (64). The below formulas are applied to calculate the oil recovery and the efficiency of the process (65):

$$Oil\ yield\ (\%) = \frac{\text{Wt. of VCO obtained}}{\text{Wt. of Coconut taken}} \times 100$$

Moisture content

A 20 g of VCO sample was taken in a pre- weighted Petridish and then it was heated up to 110±5°C for 2hrs in a closed air ventilated oven and cooled it down in a desiccator for approximately 15 min and weighted again. The Moisture content was determined by the below mentioned formulae (66):

$$\text{Moisture content (\%)} = \frac{\text{Initial Wt-Final W}}{\text{Initial Wt}} \text{x100}$$

Acid value & free fatty acids

Initially 25 ml alcohol- benzene (1:1, v/v) was pre-heated on a water bath at 70° C for 10 minutes. After cooled 3 drops of phenolphthalein indicator was added and it was titrated with 0.01N NaOH up to slight red color end point. Then the above titration solution was mixed with 2.5 g of VCO sample and heated for 5 min followed by titrated again with 0.01 N NaOH for 10 min to get the slight red solution. Then the consumed NaOH reading was noted for the calculation of both acid value and free fatty acids by using the below formulas (67).

$$Acid\ value = \frac{\text{A} \times \text{N} \times 40}{\text{Sample Wt (g)}}$$

A-Quantity of NaOH
N-Normality of NaOH

40- Molecular Wt of NaOH

$$Free\ fatty\ acids\ \% = \frac{\text{A} \times \text{N} \times \text{M}}{\text{Sample Wt (g)}}$$

A = Quantity of NaOH
N = Normality of NaOH
M = MW of lauric acid (214 g)

Iodine number

Primarily a 250ml cleaned conical flask was taken and the following solutions are added one by one like 3.0 g of VCO , 20 ml cyclohexane (for dissolve the fat) followed by 25 ml of Wijs solution. The flask was completely closed by parafilm or by cork and this mixer was continuously shaken for about 30 min in a shaker. After that, 20 ml of 15% potassium iodide solution (KI) and 100 ml of de-ionized water were added into the same mixture. Then the solution was titrated against with 0.1 N Sodium thiosulfate solution ($Na_2S_2O_3$) until to the disappearance of yellow colour. Subsequently, 2-3 drops of starch solution were added to the same mixer and titration was continued until the blue colour vanished. Volume of $Na_2S_2O_3$ is represented as 'S'. The titration step was repeated with blank sample and the volume of $Na_2S_2O_3$ consumed is represented as "B'. The Iodine number was calculated using the below Equation (68):

$$Iodine\ Number = \frac{(\text{B} - \text{S})\text{N of Na2S2O3} \times 12.69}{\text{Wt of sample (g)}}$$

B= Vol. of $Na_2S_2O_3$ titrated for blank
S = Vol. of $Na_2S_2O_3$ titrated for sample
N = Normality of $Na_2S_2O_3$

Peroxide value

A 5g of VCO was added with 30 ml of acetic acid-chloroform mixture (3:2) and the solution was stirred until the oil has been completely dissolved. Then, 0.5 ml of saturated potassium iodine was added and stirred for about one minute. After that the solution was titrated against with 0.01 N Na_2SO_3 until its colour changed to light yellow. The step of titrating can be skipped by adding 0.5 ml of 1% soluble starch as an indicator that gives a light blue colour, followed by titration with 0.01N Na_2SO_3 until the colour disappear. The volume used for titration was noted and peroxide value (PV) was calculated by using the below formulae (69):

$$PV = \frac{\text{N} \times \text{V}}{\text{W}}$$

V is the titer volume of Na_2SO_3 solution
W is the weight of coconut oil (kg)
N is the normality of Na_2SO_3 solution

Saponification number

At first 1.5 to 2.0 gm of dried filtered sample was taken in a 250 ml conical flask. Then 25 ml of alcoholic potassium hydroxide solution was added into the same flask. As like above, blank determination process also conducted along with sample. For that, both sample and blank flasks are connected to air condensers and boiled constantly under water bath until Saponification process was completed. The completion of reaction is indicated by the absence of oily matter and the appearance of a clear solution. After that the flask and condenser have cooled, wash down inside of the condenser with about 10 ml of hot ethyl alcohol. The excess potassium hydroxide is determined by titration with 0.5N Hydro Chloric Acid (HCL), using about 1.0 ml phenolphthalein as an indicator. The below formulae is used to calculate the Saponification value (70).

$$Saponification\ value = \frac{56.1(\text{B} - \text{S})\text{N}}{\text{W}}$$

B = Vol. of standard HCL required for blank.
S = Vol. of standard HCL required for sample
N = Normality of standard HCL
W = Weight of the oil/fat taken for the test

GC-MS analysis of fatty acid composition

The extracted oil from four coconut varieties under fresh-dry method was analyzed to find out its fatty acid compositions.

GC Programme

A 50mg of oil sample was mixed with 0.95 ml of hexane in a 1.5 ml vial, and then shaken vigorously to dissolve the oil. After that, 0.05 ml of sodium methoxide was added to the same and mixed vigorously for 5seconds.The clear upper layer of 2µl of methyl ester was pipetted off and injected into a Gas Chromatography (GC) column using external

standard method (71). The detector used in this programme is TQ Quadrupole Mass Spectrometer with Carrier gas 1 ml per minute, given as split like 10:1. Software MS Work station 8 was used to analyze the sample. The GC column was 30 m in length, with a 0.25 µm film coating, 0.25 mm ID, and 436-GC Brucker phase (non-polar). Primarily the column temperature was maintained at 110°C for the first 3.5 min, then increased up to 200°C at the rate of 10ºC/ min without hold and finally increased to 280ºC at the rate of 5ºC/min–12min with hold. The rate of temperature was increased at 5°C/min. The injection temperature and detector temperature were maintained at 200°C and 280 °C, respectively. The total running time was 40.5 min.

MS Programme

The software NST Version-11 library was used to analyze the fatty acid composition. The temperature for inlet was 290ºC and source temperature was 250º C. Solvent delay time maintained between 0-3.5 min. Total running time was 40.5 min.

Statistical analysis

All experimental values were carried out in triplicate, and the mean values were presented (table1). Significant differences between the means were determined by Duncan's multiple range tests at a 95 % confidence level (72).

III. RESULTS AND DISCUSSION

Coconut oil is available in the wet flakes as oil in water emulsion, which is stabilized by proteins bonds present in it. Since, in this process the flakes are initially dried under slow heating to coagulate the protein bonds to release the oil (73). Also, the shelf life of coconut kernel is short (74). So, slow and constant heat was applied immediately after grated the coconut. The VCO produced from this heat procedure offer long shelf-life period that is more than one year (75). In this research study three Tall coconut cultivars especially West Coast Tall, Arasampatti Tall, Tiptur Tall and one Dwarf variety such as Dee jay Vishwas (hybrid) was taken for VCO Production. Among the four varieties, WCT yields around 68% of oil (76). More over other coconut varieties like Deejay, Arasampatti Tall and also Tiptur Tall has the ability to yield similar quantity of oil (77, 78, 79, 80).

Soxhlet extraction of Coconut Oil

The initial oil content of the four coconut varieties were evaluated by Soxhlet method (81). The calculated total oil content of WCT, AT, DJ and TT was 67.5%, 63.5%, 61.5 and 58.5% respectively. The results obtained from Soxhlet method was take in account for the estimation of yield efficiencies of three variable parameters used in this fresh-dry method (82).

Effect of drying temperature on VCO yield

The VCO Production from four coconut varieties in respect with drying temperature was presented in table.2. Temperature is a chief factor, which determines the VCO yield in matured brown coconuts with the assisting temperature 50 °C (83). In this present study, the maximum yield efficiency (95.33%) was registered in WCT Coconuts by the exposure of 45°C drying temperature.

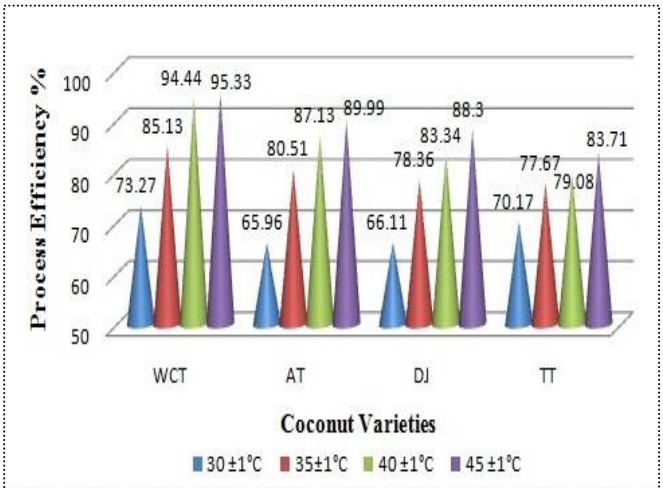

Fig.1.Effect of Drying Temperature on VCO yield efficiency

At the same temperature level the other yielding efficiencies was observed like 89.99%, 88.30% and 83.71% in AT, DJ and TT coconuts vice versa. The results of VCO yield is represented in fig.1. In statistical view observed in SPSS 16.0 at $P \leq 0.05$ level in both temperature and coconut variety (WCT) are showed significant effect on VCO yield efficiency in all four coconut varieties. But interaction of coconut with temperature was not showing significance of yield efficiencies.

Effect of drying interval on VCO yield

The fully matured coconuts (11-12 month old) were used in this study (84). Initially coconuts are made in to 1cm ^{2} size pieces and dried at constant temperature for various intervals (85, 86, 87). The high temperature with constant drying interval is favor for good quality VCO recovery with antioxidant potential (88). In this experimental study, four constant drying intervals are employed. Among them, the maximum VCO yield efficiency (93.06%) was obtained in WCT Coconuts with 48 hrs drying interval. Similarly in AT ,where the second maximum VCO efficiency was obtained (88.66%) at 48 hrs whereas in DJ and TT the higher yield efficiencies obtained as 85.12% and 84.58% vice versa under 60 hrs drying intervals. The above results are given in fig.2.

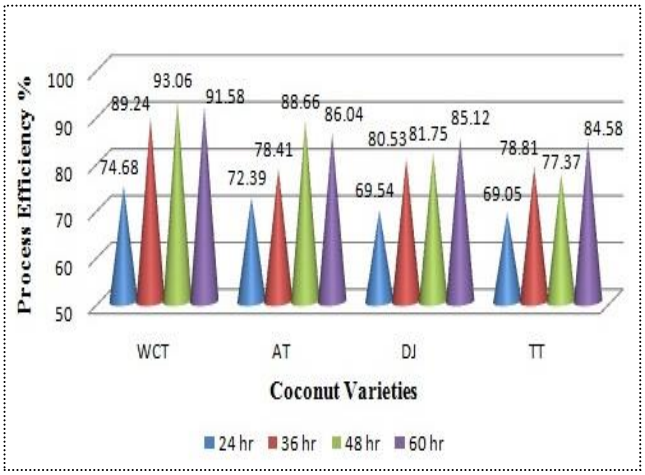

Fig.2.Effect of Drying Interval on VCO yield efficiency

The statistical view revealed that, the drying interval showed significant effect on VCO yield efficiency of the process. But the coconut and interaction not showed any significant effects on yielding. This is furnished in table.2 with 0.05 level.

Effect of fruit maturity on VCO yield

The 10, 11, 12 and 13 month old matured coconuts are taken in this study. The coconut with more than 12 month old maturity was dried under controlled temperature yields highest oil recovery with predominant fatty acid content (89). In this present study, the 12 month aged matured WCT coconutshowed maximum yield efficiency that is 93.06% as such the previous study (90).

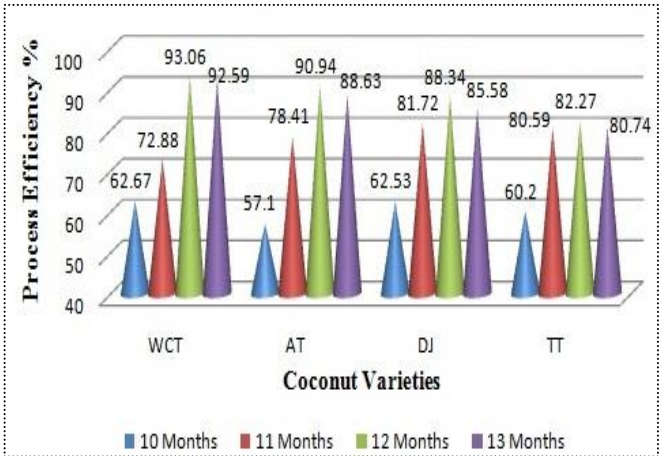

Fig.3.Effect of fruit maturity on VCO yield efficiency

In other coconut varieties, where at the same matured stages proved that, 90.94%, 88.34% and 82.27 % efficiencies obtained from AT, DJ and TT vice versa. The yield efficiencies are represented in fig. 3. The statistical view proved that, 12 month matured coconuts showed significant effect on VCO yield .But coconut and their interactions are not showed any significant. This is given in table.2 with 0.05 level.

Physio-Chemical Properties

Moisture is an important factor that determines the quality especially shelf life of oil (91). The moisture level should be come in between 0.1-0.5%, otherwise high moisture make uncontrollable rancidity (92). The values of moisture content estimated in this study were registered within the range of APCC. This is presented in table.1.

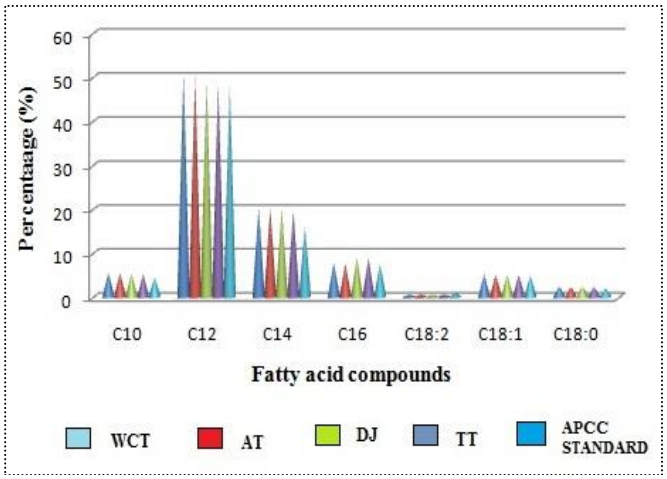

Fig 4. Fatty acid profile of four coconut varieties

Fatty acid Profile of VCO

The prepared VCO was taken for GC-MS analysis of fatty acid methyl esters. It is showed that there are nine numbers of saturated fatty acids namely; C6-Caproic

Table.1 Physio-Chemical Properties of four coconut varieties

Parameters	Physio-chemical properties VCO from four Coconut varieties				APCC Standard
	WCT	**AT**	**DJ**	**TT**	
Moisture (%)	0.27	0.31	0.32	0.30	0.1-0.5
Acid value (mg/KOH/g)	2.254	2.214	2.514	2.544	6max
FFA (%)	0.42	0.45	0.49	0.47	0.5
Iodine Num. (gm/100gm)	5.5	5.8	5.9	5.7	4.1-11.0
Peroxide value (meq O_2/kg)	2.1	2.2	2.3	1.745	< 3
Saponification Num. (mg KOH/g)	256.4	248.9	245.5	254.7	250-260

Fatty acid Profile of VCO

Fatty acid composition varies according to the source plant or it depends on the technology process during their production (93). It is showed that there are nine numbers of saturated fatty acids namely; C6-Caproic acid, C8-Caprylic acid, C10-Capric acid, C12-Lauric acid, C14Myristic acid, C16-Palmiticacid, C18:2-Linoleic acid, C18:1-Oleic acid

and C18:0-Stearic acid were identified in this method. Among them lauric acid is occupied a major proportion in the fatty medium (94 & 95). It has estimated in the range of 48.55 – 51.20% from the four coconut varieties (fig.4). According to the Philippine Coconut Authority (PCA) the fatty acid profile of VCO is greatly dependent on the coconut variety (96). The notable fatty acid such as Lauric acid was registered maximum in WCT coconuts (51.20%) and minimum was estimated from TT coconuts (48.55%). In the remaining varieties were quantified like 50.10%, 49.23% in AT and DJ vice versa.

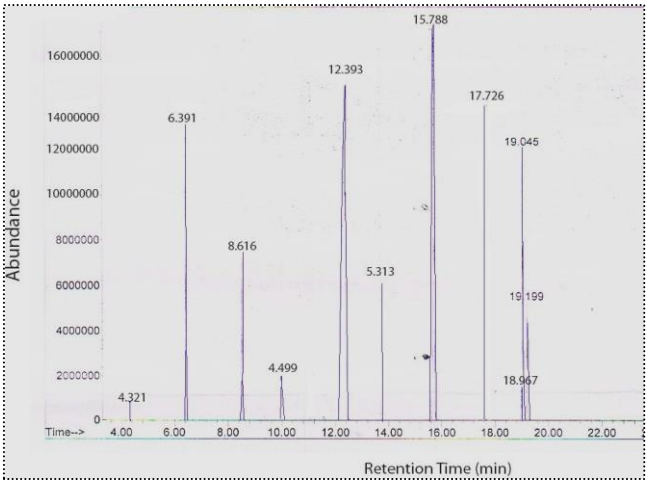

Fig 6. GC-MS Chromatogram of VCO produced from AT

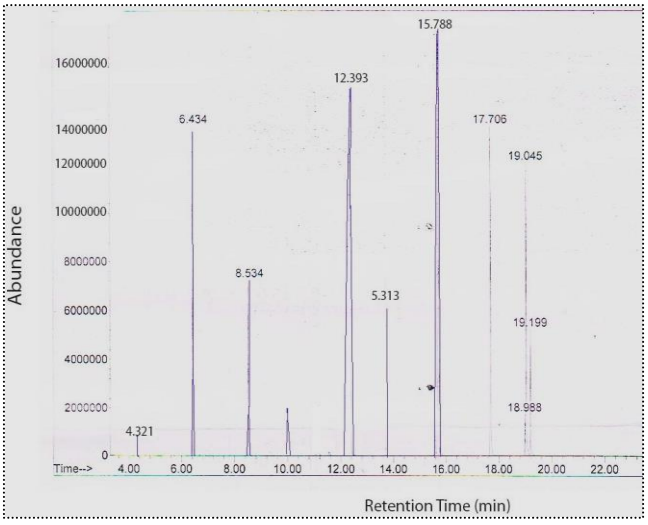

Fig 5. GC-MS Chromatogram of VCO produced from WCT

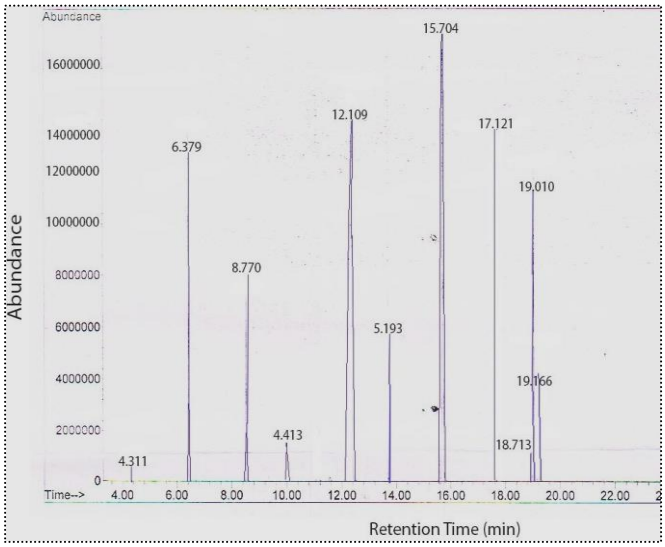

Fig 7.GC-MS Chromatogram of VCO produced from DJ

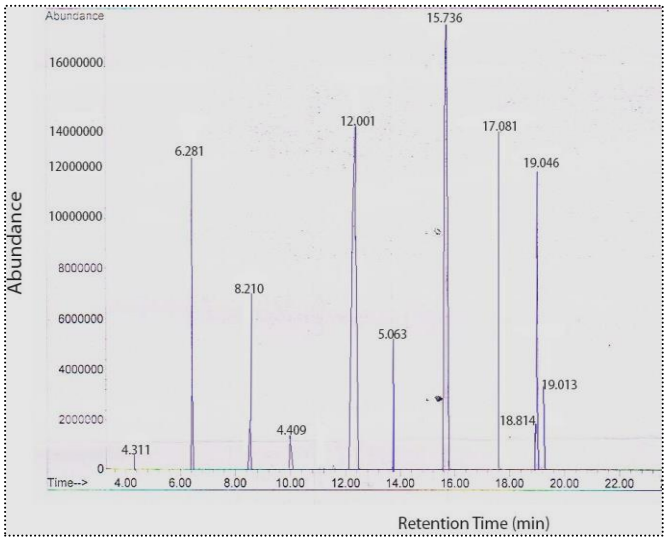

Fig 8.GC-MS Chromatogram of VCO produced from TT

Table 2: Effect of process variables on the production of VCO in four Coconut varieties
(*Values given with superscript mentioned that significantly difference from each other at P≤ 0.05, SPSS)*

Parameters		**VCO yield efficiency (%) for four Coconut varieties**			
		WCT	**AT**	**DJ**	**TT**
Drying Temperature (°C)	30±1	73.27^{a}	65.96^{d}	66.11^{c}	70.17^{b}
	35±1	85.13^{a}	80.51^{b}	78.37^{c}	77.67^{d}
	40±1	94.44^{a}	87.13^{b}	83.34^{c}	79.08^{d}
	45±1	95.33^{ab}	89.99^{cd}	88.30^{ef}	83.71^{gh}
Drying Interval (hours)	24	74.68^{a}	72.39^{b}	69.54^{c}	69.05^{d}
	36	89.24^{a}	78.41^{d}	80.53^{b}	78.81^{c}
	48	93.06^{ab}	88.66^{cd}	81.75^{a}	77.37^{b}
	60	91.58^{a}	86.04^{b}	85.12^{ef}	84.58^{gh}
Fruit Maturity (months)	10	62.67^{a}	57.10^{d}	62.53^{b}	60.20^{c}
	11	72.88^{d}	78.41^{c}	81.72^{a}	80.59^{b}
	12	93.06^{ab}	90.94^{cd}	88.34^{ef}	82.27^{gh}
	13	92.59^{a}	88.63^{b}	85.58^{c}	80.74^{d}

The fatty acid profile of four coconut varieties is furnished in fig.5,6,7 &8.The other fatty acid (excluding Caproic and Linoleic acid) proportions are similar and came within the range of APCC Standards. This result are correlated with the status of previous study showed that, the fatty acids estimated from different processes are similar in proportions and there is no notable changes in the profile (97). The fruit maturity is an important process variable, which determined the VCO profile and the other micro constituents (98). This fresh dry method is showed positive note on the oil quality, which was retained by the dry heat application on the kernel thereby deactivation of lipase enzyme and also unwanted microbial entry was reduced efficiently (99).

IV. CONCLUSION

The fresh dry method was chosen for easy and quick recovery of oil from dried coconut flakes. So, the time of production is reduced when compared to other wet processing methods. In this research study 12 month old matured coconut, highest temperature and lengthy drying interval showed positive effect in the yield efficiencies.

The three process variables had impact on the yield efficiency of VCO in this fresh-dry process. Among the process variables the maximum yield efficiency (95.33%) was registered in WCT Coconuts dried at 45°C drying temperature. At the same temperature the other yielding efficiencies was noted like 89.99%, 88.30% and 83.71% in AT, DJ and TT coconuts respectively. The lowest record (65.96%) was noted in AT. The second process variable that is drying interval confirmed that the maximum yield efficiency (93.06%) was obtained with 48 hrs of drying. Likewise, the second maximum yielding efficiency (88.66%) was observed in AT coconuts at 48 hrs whereas in DJ and TT the higher yield efficiencies as 85.12% and 84.58% vice versa under 60 hrs drying intervals. The lowest efficiency (69.05%) was registered in TT coconuts. The third process variable proved that, the maximum value that is 93.06% efficiency achieved by employing 12 month old matured coconuts. The other efficiencies are obtained as 90.94%, 88.34% and 82.27 % from AT, DJ and TT respectively.

Lauric acid is a notable fatty acid present in VCO from 48-51%. The coconut varieties are taken in this research showed different composition of fatty acid profile especially the lauric acid, which was registered maximum that is 51.20% at “WCT Coconuts” and in other coconut varieties such as AT, DJ and TT Coconuts were noted as 50.10%, 49.23% and 48.55% respectively.

Commonly VCO is produced from wet and dry process. Even though the colour of the product is watery white from the wet method, the quality of the product is dependent upon the moisture reduction percentage from the product. Since, the shelf life of the product is improved in this method than the wet method product. Also, this method ensures that, the microbial contamination and lipase enzyme activity deduction due to permissible heat application in this process. So this research study clearly illustrated that the fresh drying process not only reduces the contamination in VCO but also increase the oil recovery from the above four coconut varieties evidently.

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