Analysis of Quantity and Quality Features of Virgin Coconut Oil Produced in Selected Coconut varieties under Fresh-Dry Method N. Muthukkannan^{1*}, T. Balasaravanan²

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ABSTRACT: In this research study, Virgin Coconut Oil (VCO) was produced in four selected varieties of coconuts like West Coast Tall, Arasampatti Tall, Deejay Vishwas and Tiptur Tall. The Present method was optimized with three common parameters especially temperature viz., $30\pm1^{\circ}$ C, $35\pm1^{\circ}$ C, $40\pm1^{\circ}$ C, $45\pm1^{\circ}$ C, Drying intervals viz., 24hrs, 36hrs, 48 hrs, 60hrs and fruit maturity like 10, 11, 12 and 13 month old coconuts was taken to study the yielding efficiency of VCO from four varieties . In this quantity analysis with temperature variable, the maximum yield efficiency 95.33% was obtained in WCT Coconuts at 45° C. The Drying interval analysis showed, the maximum yield efficiency that is 93.06% with 48 hrs drying. The fruit maturity level analysis showed the same maximum value of 93.06% as in the drying interval analysis. 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 rest of varieties such as AT, DJ and TT Coconuts were noted as 50.10%, 49.23% and 48.55% respectively.

Keywords: VCO, Temperature, Drying Interval, Fruit maturity, yielding efficiency.

1. INTRODUCTION

Coconut is cultivated largely in Philippines, Indonesia, India, SriLanka, Papua New Guinea, Thailand, Malaysia and Fiji (1). India occupies a leading position of coconut production in the world. It have 1.94 million ha in 19 states and including 3 Union Territories covers 15730 million nuts production with an average productivity of 8303 nuts per ha or 44.27 nuts/palm/year (2).It is for the most part grown in the southern part of India (3).Southern states particularly Tamil Nadu, Kerala, Karnataka and Andhra Pradesh occupies more than 90% area for coconut production (4).

VCO is defined as "Oil, one which is produced through with or without the use of heat and without undergoing chemical refining (5). The fractions of coconut oil are utilized as drugs because; it contains many key components like vitamin A, E, anti-cancer polyphenols (ferulic acid, catechin, caffeic acid) and Phytosterols (6). Nearly 50% of the fatty acid in VCO is in the form of lauric acid, which is act as an antimicrobial substance against fungi, bacteria and viruses. Additionally, the fatty acid profile of coconut oil shares the similar characteristic of breast milk (7 & 8).

Based on their moisture content coconuts are classified as wet and dry coconuts (9). Commonly VCO produced in both wet and dry methods. In dry method, the grated kernel was dried under controlled temperature up to complete moisture removed. Finally oil is extracted through grinding process (10).Wet methods are commonly classified into chilling-thawing, fermentation, enzymatic and pH methods or the combinations of the above (11). The existing wet methodology

offers low oil recovery also higher market price.

Fresh-dry process yields high quality water-clear VCO with acceptable moisture content (0.07-0.1%), which determined the longer shelf-life of the product. Also, this method offers around 30 % of VCO from 100kg fresh grated meat (12).

A research study on fatty acid profiles from 60 Talls, 14 Dwarfs, and 34 hybrid coconut varieties was confirmed that the quality and quantity of coconut oil is determined by both external factors and variety of coconut (13). Also like that, a report stated that, the quality of VCO is determined by different maturity level of coconut (14 &15). A research study on tree height at Coimbatore, Tirupur and Erode, showed that 91% of coconut plantations are tall and 9% are dwarf variety (16). One of the major varieties occupied in southern states of India is West Coast Tall (WCT) (17& 18). The WCT coconut yields around 68% of oil (19).

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 (20). It has a capacity to yield around 115.3 g of copra from a nut.

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 %(21).

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 (22). WCT coconuts yield more quantity of oil than other tall coconut varieties (23).

In India Deejay coconut consultancy service is a biggest organization producing hybrid commercial seedlings to coconut farmers (24). Deejay coconut (DJ) is one of the high oil yielding (68%) hybrid variety crossed from selected parents (25). 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 (26 & 27). The three Tall varieties viz. WCT, AT, TT and one dwarf variety such as DJ are majorly cultivating in Pollachi region. In this present research the all four coconut varieties are collected from both Pollachi and Anaimalai Taluk for VCO production.

2. MATERIALS & METHODS

2.1 Coconuts in the Study

Selected varieties such as WCT, AT, DJ Vishwas and TT of four uniformly sized 10, 11, 12 & 13 month old matured brown in colour coconuts are taken in this research study. The VCO quality is determined by both variety and extraction procedures. 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 the region of West Coastal part of India. The average fruit weight was around 570g, endosperm thickness is around 1.10 cm and the thickness of shell was found that around 0.44cm (28). This variety has inherent capability to resist against the root wilt disease (29).

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 (30)

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 (31). 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 (32). It has a characteristic nature against Leaf spot disease. The copra yield per palm per year is around 19.96kg (33).

2.2 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.

a) Drying Temperature

As per the previous study, four low drying temperatures like $30\pm1^{\circ}$ C, $35\pm1^{\circ}$ C, $40\pm1^{\circ}$ C and $45\pm1^{\circ}$ C are selected for dry the coconut flakes under hot air dryer (34)

b) Drying Interval

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 (35).

c) Fruit Maturity

The 12 month old coconut is considered as matured one. It contains 28% meat as a solid endosperm (36). In this research study fruit maturity like 10, 11, 12 and 13 month old coconuts was taken to estimate the yielding efficiency of VCO.

2.3 Preparation of coconut flakes

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 cm²) up to 1.5 kg by using stainless steel knife (37). Then it was dried in an aerated oven after that the oil was expelled out using Hydraulic expellers (Piston and cylinder arrangement). The extracted oil was filtered through Whatman No.1 filter paper for the removal of 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.

2.4 Estimation of initial oil content - Soxhlet extraction

The total initial oil content of four coconut varieties was estimated by AOAC Soxhlet method (38). 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 inside the oven at $103 \pm 1^{\circ}$ C for 2 hours for the removal of remaining solvent and cooled in a desiccator before reweighing.

2.4.1 Calculation of Oil recovery & Process efficiency

The oil yield was determined from the initial oil content in the coconut to the VCO extracted from the four coconut varieties in the present methodology. The below formulas are applied to calculate the oil recovery and the efficiency of the process (39):

Wt. of VCO Obtained Oil yield (%) = ------ x 100 Wt. of Coconut Taken

Soxhlet estimated oil %

2.5 Physico-chemical characteristics

a) Moisture content

Initially 20 g weighted VCO sample was taken in a pre- weighted Beaker and kept at $110\pm5^{\circ}$ C for 2hrs in a closed air ventilated oven followed by immediately put inside the desiccator for 15 min and weighted again. The value was determined by the below formulae (40):

Initial Wt – Final Wt Moisture content (%) = ----- x 100 Initial Wt

b)Acid value & free fatty acids

Initially 25 ml volume of alcohol- benzene (1:1, v/v) was heated in a water bath for 10 mins at 70° C. After cooled 3 drops of indicator (phenolphthalein) was added into the flask and 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 and heated for 5 min followed by titrated against 0.01 N NaOH for 10 min to get the slight red solution. Then the consumed NaOH reading was noted for calculations (41).

A * N * 40 Acid Value = ------Sample Wt in g

A- NaOH Quantity*N*- NaOH Normality40- Molecular Wt of NaOH

A * N * M

Free fatty acids (%) = -----

Sample Wt in g

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

c)Iodine number

Primarily a 250ml cleaned conical flask was taken and the following solutions are added one by one like of VCO (3.0 g), cyclohexane (20 ml) followed by Wijs solution(25 ml). 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% KI solution and de-ionized water (100ml) were added into the same mixture. Then the mixture solution was titrated against 0.1 N Sodium thiosulfate solution (Na₂S₂O₃) until to the yellow colour disappearance. Subsequently, starch solution (2-3 drops) was added to the same mixer and titration was

continued until the blue colour vanished. The Iodine number was calculated by the below Equation (42):

(B-S)* N of Na₂S₂O₃ *12.69

Iodine Number = -----

Wt of Sample (g)

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

d)Peroxide value

VCO (5 g) was added to the 30 ml of acetic acid-chloroform mixture (3:2) and mix it thoroughly. Then, 0.5 ml of saturated potassium iodine was added and mixed well for one minute. After that the solution was titrated against 0.01 N Na₂SO₃ until its colour changed to light yellow. The step of titrating can be skipped by the addition of 1% soluble starch (0.5ml) as an indicator that gives a light blue colour, followed by titration with 0.01N Na₂SO₃ until the colour disappear. The volume used for titration was noted and peroxide value (PV) was calculated by using the below formulae (43):

$$PV = ------ W$$

V = volume of Na₂SO₃ solution W = weight of coconut oil (kg) N = normality of Na₂SO₃ solution

e)Saponification number

Initially 1.5 to 2.0 gm sample was taken in conical flask. Then 25 ml of alcoholic potassium hydroxide solution was added. Similarly blank also conducted along with sample. Both sample and blank flasks are connected to air condensers and boiled constantly in a water bath until the process completed. The completion of reaction is noted by the absence of oily matter and the appearance of a clear solution. Then the flask and condenser was cooled and washed with hot ethyl alcohol. The excess potassium hydroxide in the flask is determined by titration against 0.5N Hydro Chloric Acid (HCL), with phenolphthalein indicator. The below formulae is used to calculate the Saponification value (44).

56.1 (B-S) N

Saponification Value = -----

W

B = Vol. of standard HCL(for blank)
S = Vol. of standard HCL (for sample)
N = Normality of HCL
W = Weight of the oil/fat

2.6 Analysis of fatty acid composition (GC-MS)

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

2.6.1 GC Programme

A 50mg of oil sample was mixed with 0.95 ml of hexane in a 1.5 ml vial, followed by 0.05 ml of sodium methoxide was added and mixed well. 2μ l of methyl ester was taken from the mixer and injected into a Gas Chromatography (GC) column as external standard method (45). 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 10°C/ min without hold and finally increased to 280°C at the rate of 5°C/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.

2.6.2 MS Programme

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

2.7 Statistical analysis

The present experimental values were carried out in triplicate, and the mean values were furnished (table1). Significant differences between the mean values were determined by Duncan's multiple range tests in a 95 % confidence level (46).

3. RESULTS & DISCUSSION

Coconut oil in the wet flakes available as oil in water emulsion. It is stabilized by proteins bonds

present in it. Since, in this process the flakes are dried in slow heating for long duration to coagulate the protein bonds to release the oil (47). Also, the shelf life of coconut kernel is short (48). 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 (49). In this research study three Tall coconut cultivars especially WCT,AT,TT and Dee jay Vishwas (hybrid) was taken for VCO Production. Among the four varieties, WCT yields around 68% of oil (50). More over other coconut varieties like Deejay, Arasampatti Tall and also Tiptur Tall has the ability to yield similar quantity of oil.

3.1 Coconut Oil Extraction (Soxhlet method)

Initial oil content of the four coconut varieties were evaluated by Soxhlet method (51). 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 (52).

3.2 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 (53). In this present study, the maximum yield efficiency (95.33%) was registered in WCT Coconuts by the exposure of 45°C drying temperature.



Figure 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.

3.3 Effect of drying interval on VCO yield

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 presented at Fig.2.



Figure 2. 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.

3.4 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 (54). In this present study, the 12 month aged matured WCT coconut showed maximum yield efficiency that is 93.06%.



Figure 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.

3.5 Physio-Chemical Properties

The moisture level should be come in between 0.1-0.5%, otherwise high moisture make uncontrollable rancidity (55). The values of moisture content estimated in this study were registered within the range of APCC. This is given in table.1.

Parameters	Physio-	APCC Standard			
	WCT	AT	DJ	TT	
Moisture (%)	0.27	0.31	0.32	0.3	0.1-0.5
Acid value (mg/KOH/g)	2.254	2.214	2.514	2.544	бтах
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

 Table 1:Physio-Chemical Properties of four coconut varieties

3.6 Fatty acid Profile of VCO

It is showed that there are nine numbers of saturated fatty acids namely; C6, C8, C10, C12, C14, C16, C18:2, C18:1 and C18:0 were identified in this method. Among them lauric acid (C12) is occupied a major proportion in the fatty medium (56). It has estimated in the range of 48.55 - 51.20% from the four coconut varieties (fig.4). 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. The fatty acid profile of the 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.



Figure 4. Fatty acid profile of four coconut varieties

The fruit maturity is an important process variable, which determined the VCO profile and the other micro constituents (57). 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 (58).



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



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



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



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

Table 2:Efdfect of process variables on the production of VCO in four coconut varieties

(values given with superscript mentioned that significantly difference from each other at

Parameters		VCO yield efficiency (%) for four Coconut varieties				
		WCT	AT	DJ	TT	
Drying	30±1	73.27 ^a	65.96 ^d	66.11 ^c	70.17 ^b	
Temperature	35±1					
		85.13 ^a	80.51 ^b	78.37 ^c	77.67 ^d	
(°C)	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	24	74.68 ^a	72.39 ^b	69.54 [°]	69.05 ^d	
Interval	36	89.24 ^a	78.41 ^d	80.53 ^b	78.81 [°]	
(hours)	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	10	62.67 ^a	57.10 ^d	62.53 ^b	60.20 ^c	

 $\leq 0.05, SPSS$)

Maturity (months)	11	72.88 ^d	78.41 [°]	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

4. 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 12month 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.

83./1% 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 obtained 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

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