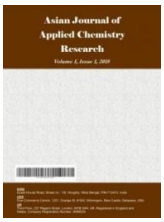

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Determination of the Quality of Coconut Oils (Unrefined Grade) and (Refined Grade) Produced from Three Survey Regions of East Godavari District, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author GVPK designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors NVVSSL, VCS and CD managed the analyses of the study. All authors provided literature searches, read and approved the final manuscript.

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ABSTRACT

Aim: The study sought to assess the quality of coconut oil extracted from fresh copra milk by Traditional fermentation(FWCE) and from dry copra balls by continuous processing using expellers(TDCE,DMCE) method with respect to moisture content (MC), free fatty acid (FFA) content, Acid value (AV) and Saponification value in comparison with Food safety and standards authority of India.

Methodology: Three samples of coconut oil were taken from major processing centers in east Godavari district (AMP, SML, KRG) for quality determination. Similarly three samples of coconut oil were prepared from fresh grated coconut milk in the Medicinal chemistry laboratory at Korangi College of pharmacy and three samples were prepared from dry coconut cups. Replicate titer

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values of each of the nine (09) oil samples obtained were compared with brand double refined oil and the averages were taken into consideration. The AOAC and AOCS methods were used in the analyses and the results compared with Standards provided by Food safety and standards authority of India, Coconut Development Board, Kochi.

Results: The results showed that 50% of the total fermented oil sample had high moisture content than standard and expected to undergo oxidative rancidity. According to the standards, 100% of the oil samples had free fatty acids and acid value within acceptable range indicating no signs of rancidity.

Conclusion: There was a significant difference in saponification value, free fatty acid profile and moisture content of Traditional fermented (FWCE) and dry copra balls by continuous processing expellers (TDCE, DMCE) method. The ANOVA ($P<0.05$) showed that there were significant differences in the MC, FFA, AV of oils produced among the processing centers and that produced in laboratory. The processes involved in all the extraction centers vary and might have accounted for that. The results indicate that the coconut oils produced in both the cases meet the standards however new technologies in processing should be adopted to improve the quality to meet the standards.

Keywords: Virgin coconut oil; moisture content; free fatty acids; acid value; Indian standards.

ABBREVIATIONS

FWCE : Fermented Wet Copra Extracted Virgin Coconut Oil
TDCE : Traditional Dry Copra-Lab-milled Oil
DMCE : Processed Dry Copra -milled Trade Oil
BSEO : Brand Solvent Extracted Oil

1. INTRODUCTION

The coconut palm *Cocus nucifera* is a member of the family Arecaceae (palm family) which grows well in humid areas in the region of the equator. The name coconut often refers to the entire plant, the seed or fruit (botanically drupe not nut). The freshly harvested coconut flesh has 50% moisture 34% oil, 2.2% ash, 3.0% fibre, 3.5% protein and 7.3% carbohydrate. Coconut has many uses which are of domestic, commercial and industrial importance. Fresh coconut kernel is used as snack and in pastries. Dried coconut flesh, copra, contains about 60-65% of oil which is produced by crushing the copra. Coconut oil contains 92% of saturated fatty acids and naturally has a very good flavor [1-5]. Coconut is used in domestic cooking, food processing industries particularly baking, pharmaceuticals, soaps, cosmetics and hair oil [6].The moisture content of the oil is of great importance for many scientific, technical and economic reasons (Food Standards Committee, 1978). Low moisture content is a requirement for long storage life [7]. The maximum limit of moisture in edible oils according to Indian standards should be 0.1%-0.5%. Levels of acidity in fats and oils normally reflect the amount of fatty acids hydrolysed from triacylglycerols. In addition to free fatty acids, acid phosphates and amino acids can also contribute to acidity. Acid value is defined as the milligram (mg) of KOH or NaOH necessary to neutralize the free acids present in 1g of fat or oil. High levels of free fatty acids are unwanted in crude oils since they end up in huge losses of neutral oil during refining. Acid value or FFA is often used to approximate the quantity of oil that will be vanished during refining steps intended to get rid of fatty acids in crude fats [8]. Free fatty acids are also undesirable in finished oils because they can cause off-flavors and shorten the shelf life of the oil.

According to standards the free fatty acids for edible virgin oil should not be more than 4mg KOH/g oil whilst 0.5 mg KOH/g oil is recommended by APCC. FFAs' influence the period of division of distinct cells which results in an inhibitory end product compared to the control medium's longer period of divisions [9-15]. A lot of reviews have been done on the quality of coconut oil internationally but little in Godavari region. Coconut is a major and a principal cash crop in Godavari district found particularly in the East Godavari District of Andhra Pradesh with a 520,000 metric tons output in 2015 (MOFA, 2015). East Godavari District – Konaseema region the largest area in coconut production, which is already popular in the country, is finding ready market in the Asian region, particularly in China, Japan, Dubai and Pakistan. The coconut variety is the most preferred in both Telangana and Ap because of less price, big size and high percentage of oil. Most of the coconut trees cultivated in this zone belongs to three popular varieties commonly Tall varieties (*Cocos nucifera*

L. Var. typica (Tall) Lakshadweep ordinary (LCT) 64 per cent oil, Copra content: 125 gram / nut, the range between 100 and 140 gram); Dwarf Varieties (*Cocos nucifera* L. Var nana (Dwarf) Chowghat Orange Dwarf (COD) Copra content: 150 gram / nut, Oil content: 66 per cent); Hybrid Varieties (Kerasankara (WCT x COD) Copra content: 187 gram / nut Oil content: 68 per cent).

Small scale oil extraction forms a greater part of the coconut industry in the area. However, the quality of the oil is not known since no laboratory tests are conducted to determine the quality and nutritional characteristics such as free-fatty acid (FFA) content, moisture content and acid value. It is therefore necessary to determine the quality of oil produced in the area. Furthermore, the producers and marketers face the problem of off-flavors and aromas which are the major signs of rancidity and deterioration as high rate of deterioration in the rainy season is experienced by some oil sellers [16].

This study seeks to assess the quality (moisture content, free fatty acid content and acid value) of coconut oil produced in different processing centers in the East Godavari District of Andhra Pradesh and to compare the out comes with standards.

2. MATERIALS AND METHODS

2.1 Sample Collection

Three different samples of coconut oil (500 cm^3 per sample) were collected in hermetically sealed plastic containers from each of the three major coconut oil processing centers which have been randomly selected. The oil samples were kept at room temperature in the laboratory for analysis. The total numbers of samples analyzed were nine (09). The collection was done between july and September 2018. These processing centers include: (AMP) Amalapuram, (SML) Samalkota, (KRG) Korangi Village of east Godavari district.

2.2 Preparation of Virgin Coconut Oil

Coconuts were collected from the three provinces, a voucher specimen, KP/ASK/2018/ 01, was deposited at Korangi College of pharmacy, Dept. of Pharmacognosy, Kakinada. Virgin coconut oil (VCO) was separated from the coconut as follows. The fresh coconut meat was shredded and then cold-pressed to make coconut milk. The coconut milk was fermented for 48 h**,** where upon centrifuge, boiling the milk for 1 hr at a temperature of 40˚C leaves behind the crude oil and it is separated out by filtering. This unique process means that the pure oil does not have a coconut taste or odor. The virgin coconut oil was stored in air tight container for further investigations [17].

2.3 Analysis of Quality Parameters

The parameters determined were moisture content, free fatty acids and acid value, saponification value. Three replicate titer values of each of the Nine (09) oil samples were obtained and the averages found. The average values found were designated as AMP, SML, and KRG for each of the centers. These indices were chosen because bulk fats and oils can vary markedly in these parameters due to differences in source, composition and susceptibility to deterioration.

2.4 Moisture Content Determination

Oven Method: Moisture content of oils and fats is the loss in mass of the sample on heating at 105±1˚C under operating conditions specified. Metal dishes 7 – 8 cm diameter and 2 - 3 cm deep provided with tight fitting slip on covers. Weigh in a previously dried and tarred dish about 5 – 10 g of oil or fat which has been thoroughly mixed by stirring. Loosen the lid of the dish and heat, in an oven at 105±1˚C for 1 hour. Remove the dish from the oven and close the lid. Cool in a desiccator containing phosphorus pentoxide or equivalent dessicant and weigh. Heat in the oven for a further period of 1 hour, cool and weigh. Repeat this process until change in weight between two successive observations does not exceed 1 mg. Carry out the determination in duplicate [18].

$$\text{Moisture and volatile matter Percent by weight} = \frac{W_2}{W_1} X100$$

Where,

W_2 = Loss in gm of the material after drying
W_1 = Weight in gm of the material taken for test.

Determination of Saponification Value: The saponification value is the number of mg of potassium hydroxide required to saponify 1 gram of oil/fat. The oil sample is saponified by refluxing with a known excess of alcoholic potassium

hydroxide solution. The alkali required for saponification is determined by titration of the excess potassium hydroxide with standard hydrochloric acid. The saponification value is an index of mean molecular weight of the fatty acids of glycerides comprising a fat. Lower the saponification value, larger the molecular weight of fatty acids in the glycerides and vice-versa [19].

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

Where,

B = Volume in ml of standard hydrochloric acid required for the blank.

S = Volume in ml of standard hydrochloric acid required for the sample

N = Normality of the standard hydrochloric acid and

W = Weight in gm of the oil/fat taken for the test.

Determination of Acid Value: The acid value is defined as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of oil glycerides. The value is also expressed as per cent of free fatty acids calculated as oleic acid. The acid value is determined by directly titrating the oil/fat in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution [20-21].

$$\text{Acid value} = \frac{(56.1)\ VN}{W}$$

Where,

V = Volume in ml of standard potassium hydroxide or sodium hydroxide used

N = Normality of the potassium hydroxide solution or Sodium hydroxide solution; and

W = Weight in g of the test sample

The acidity is frequently expressed as free fatty acid for which calculation shall be

$$\text{Free fatty acids as oleic acid} = \frac{28.2}{W} \text{xVN per cent by weight}$$

W Acid value = Percent fatty acid (as oleic) x 1.99

2.5 Statistical Analysis

Data were analyzed using Graph pad prism version 5.0, one way ANOVA followed by Dunnets test for multiple comparisons The Prism was used to run Analysis of Variance and the means compared using the least significant difference (LSD) to determine the significance levels of the parameters. Results obtained were compared with standards. The analysis was made to determine differences between and within the communities.

3. RESULTS

Saponification value, Acid value and moisture content are summarized in Tables 1, 2, 3 which showed significant change in MC, SV, FFA & AV. In the present study, the saponification value obtained for the VCO samples in a range of 248-265 (mg KOH/g) oil which is in agreement with APCC standard. The similar results were applicable for moisture content in the range of 0.1-1.1(%). The saponification value is a measure of the average molecular weight of all the fatty acids present. The higher the saponification value, the shorter the fatty acids on the glycerol backbone. Fatty acid profile of the VCO as well as other coconut oil samples showed little difference and this could be the reason for similar saponification values.

4. DISCUSSION

The moisture contents (MC) of the oil from the AMP region were significantly ($p < 0.05$) lower than those of KRG and SML (Fig. 1). Also SML was significantly lower than KRG. The Moisture content values of oil in KRG and SML constituting >50% within the recommended range of 0.2 - 0.5%. The high moisture contents shown in KRG may be due to limited drying periods. However the improper drying process will have some water component in the oil. The low moisture content is a requirement for a long storage life (Food Standards Committee, 1978).

The result shows that the free fatty acid (FFA) contents of oil in all the three centres (AMP, KRG, SML) were significantly higher ($p >0.05$) than the standard (Fig. 2). This indicates that the FFA content from the entire centers dis satisfies the Indian requirement. The maximum limit of free fatty acid content is 0.5 mg KOH/g oil, according to the Asian and Pacific Coconut Community (APCC) standard. However,

compared to the APCC, the FFA content were significantly higher in all (100%) the centers. It indicates that the oil will show sign of rancidity and this confirms the findings. The differences among the communities might be due to variation in the processing of oil extraction.

Table 1. Determination of study parameters – AMP survey region

S. no	Study design	Participant zone	MC	SV	FFA	AV
1	Fermented Wet – Lab-extracted oil (FWCE)	AMP	1.11±0.01[a]	253.89±1.02[a]	1.68±0.01[a]	2.37±0.01[a]
2	Traditional Dry-Lab-Milled oil (TDCE)		1.04±0.01[a]	252.16±1.01[a]	0.95±0.01[a]	2.21±0.01[a]
3	Processed Dry milled Traded oil(DMCE)		0.37±0.01[a]	251.62±1.04[a]	0.50±0.01[a]	2.01±0.01[a]
4	Branded solvent extracted oil(BSEO)	Parachute	0.1±0.01[a]	248.01±1.01[a]	0.31±0.01[a]	1.98±0.01[a]

Notes: Mean± SD (n = 3); Mean values within the same superscript letters in the same column do not differ significantly (p ≤ 0.05)

Table 2. Determination of study parameters – KRG survey region

S. no	Study design	Participant zone	MC	SV	FFA	AV
1	Fermented Wet – Lab-extracted oil (FWCE)	KRG	2.18±0.01[a]	265.89±1.02[a]	2.66±0.01[a]	2.94±0.01[a]
2	Traditional Dry-Lab-Milled oil (TDCE)		1.53±0.01[a]	259.16±1.01[a]	2.03±0.01[a]	2.33±0.01[a]
3	Processed Dry milled Traded oil(DMCE)		0.96±0.01[a]	253.62±1.04[a]	1.81±0.01[a]	2.19±0.01[a]
4	Brand solvent extracted oil(BSEO)	Parachute	0.1±0.01[a]	248.01±1.01[a]	0.31±0.01[a]	1.98±0.01[a]

Notes: Mean± SD (n = 3); Mean values within the same superscript letters in the same column do not differ significantly (p ≤ 0.05).

Table 3. Determination of study parameters – SML survey region

S. no	Study design	Participant zone	MC	SV	FFA	AV
1	Fermented Wet – Lab-extracted oil (FWCE)	SML	1.69±0.01[a]	260.89±1.02[a]	1.99±0.01[a]	2.58±0.01[a]
2	Traditional Dry-Lab-Milled oil (TDCE)		1.32±0.01[a]	256.16±1.01[a]	1.27±0.01[a]	2.29±0.01[a]
3	Processed Dry milled Traded oil(DMCE)		0.25±0.01[a]	251.62±1.04[a]	0.94±0.01[a]	2.17±0.01[a]
4	Brand solvent extracted oil(BSEO)	Parachute	0.1±0.01[a]	248.01±1.01[a]	0.31±0.01[a]	1.98±0.01[a]

Notes: Mean± SD (n = 3); Mean values within the same superscript letters in the same column do not differ significantly (p ≤ 0.05)

Table 4. Physico-chemical characteristics of coconut oil as per standards

S. no	Study design	Process, expressed first grade refined oil			
		APCC	Codex	Indian	AOCS
1	Moisture at 105°C (%)	<0.1	0.1	0.25	0.1
2	Saponification value(mg KOH/g)	248-265	245-255	245-255	250-255
3	Fatty acid composition (relative %)	0.3	0.3	0.5	0.3
4	Acid value (max)	0.5	1.0	2.0	0.5

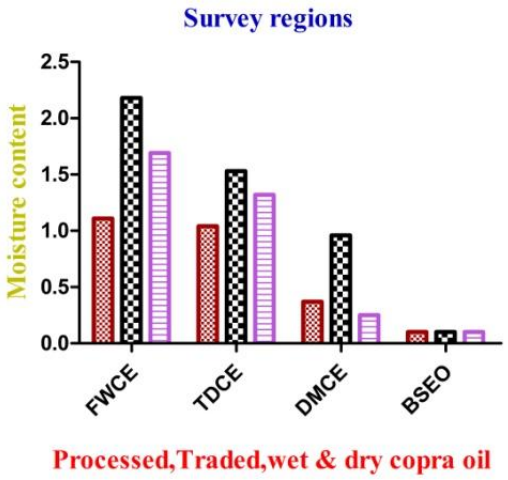

Fig. 1. Graph indicating moisture content

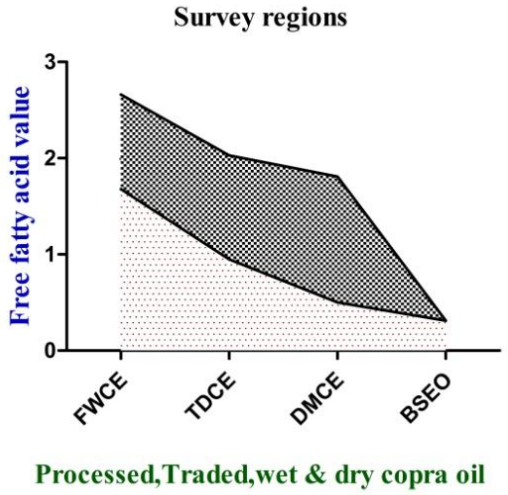

Fig. 2. Graph indicating free fatty acid values

The acid values indicate that the oil prepared and collected in all the centers was insignificant. ($p>0.05$) The values were greater than the requirement (Fig. 3) indicating moderate quality. The reference maximum level of 4 mg KOH/g oil does not produce off-flavors and are also desirable for consumption. Acid values are dependent on FFA. According to literature, Acid value =1.99FFA. This means that the higher the FFA content the higher the acid value and vice versa. Therefore, higher acid values in finished oils are undesirable. All the oil samples (100%) did not meet the APCC standard range of 0.5 mg KOH/g oil. This means that based on the APCC standard, the oils will go rancid with time, become undesirable for consumption and may require further refining. The Acid value (AV) content of the traded oil sample from the AMP zone was significantly ($p<0.05$) lower than those of KRG, SML.

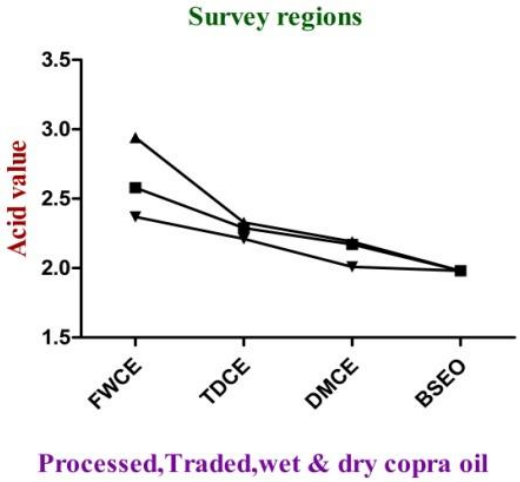

Fig. 3. Graph indicating acid values

The saponification values clearly indicate an index of mean molecular weight of the fatty acids of glycerides comprising a fat. Lower the saponification value, larger the molecular weight of fatty acids in the glycerides and vice-versa. The saponification value (SV) of the lab processed wet copra derived oil from AMP zone was found excellent to meet the Indian standard requirements and the values are within the range. The rest of oils considered to be edible only for the short storage time and prolonged stocking of oils may lead to inedible (Fig. 4). The saponification value (SV) content of the traded oil sample from the AMP zone was significantly ($p<0.05$) lower than those of KRG, SML.

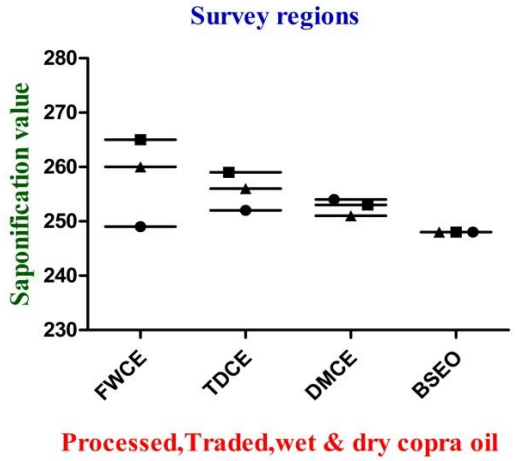

Fig. 4. Graph indicating saponification values

5. CONCLUSIONS

Among the two VCO (hot and cold extraction process) and traded samples, there was a significant difference in saponification value, fatty acid profile, Acid value and moisture content.

In comparison to all the three oils Fermented wet copra derived oil from Amalapuram (AMP) found to be better in terms of rancidity and almost similar with the traded first grade coconut oil. The good quality content gives a significant trade value which is most widely exported from Andhra Pradesh to foreign countries and this commodity is having a good export value as well as medicinal value in terms of diabetes and hyperlipidemia. 100% Pure Cold-Pressed Coconut oil from the finest quality of copra (Free from Sulphur) is generally extracted using VAAGAI wooden churner. Cold pressing ensures the nutritional value and higher content of unsaturated fat. Therefore, VCO has a wide future scope as functional oil. It can be incorporated in various products for fortification.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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