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Seasonal Variation in the Fatty Acid Composition of Oil from *Mohachao narel,* a Sweet Endosperm Coconut (*Cocos nucifera* L.) Population from Maharashtra

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ABSTRACT

Coconut palm (*Cocos nucifera* L.) is one of nature's greatest gifts to mankind, belonging to Arecaceae. Practically all parts of the plants are useful in one way or the other but the dried kernel (copra) and the oil extracted from it are the most important product of the coconut palm. *'Mohachao Narel',* a coconut variant characterized by sweet and soft endosperm with less fibre content, has been reported from Guhagar taluk of Ratnagiri district of Maharashtra State in India. Farmers of the area get a premium price for sweet endosperm nuts and the sweet kernel is mainly used for raw consumption. Two types of nuts (sweet and normal) were developed in these palms. An experiment was conducted with an objective to analyze the fatty acid composition of oil from sweet and normal endosperm type nut of these palms at various seasons. Saturated and unsaturated fatty acids, ratio of saturated to unsaturated fatty acids were estimated. Short and medium chain saturated fatty acids (SMCSFAs) and long chain saturated fatty acids (LCSFAs) and their ratio was worked out. Profile of mono and poly unsaturated fatty acids were also studied, during three different seasons. Variation in the composition of fatty acid of coconut oil was noticed between these two types. The concentration of SMCSFAs was lower in sweet type. Ratio of SMCSFAs to LCSFAs was also lower in sweet type. Unsaturated fatty acid was higher in sweet type. Composition of Unsaturated fatty acid was also varied between these types. Concentration of Linoleic acid, an essential fatty acid and Oleic acid was much higher in sweet type. Mono unsaturated fatty acids and poly unsaturated fatty acids were higher in sweet type. The ratio of saturated fatty acid to unsaturated fatty acid was much lower in sweet type, compared to that of the normal type. Significant seasonal variations were also observed in both the types of nuts for all these parameters. The results indicate that oil from the sweet type coconut is very unique in terms of fatty acid composition.

Key words *Sweet kernel coconut; fatty acids; GLC; lauric acid; oleic acid; linoleic acid.*

Due to its multifarious uses, coconut (*Cocos nucifera* L.) symbolizes an important plant for the rural communities in developing tropical countries since it provides the basis for food production and by-product utilization in addition to its uses in industrial processing (Persley, 1992). Every part of this 'tree of life' is beneficial to mankind in one manner or other, the most extensively used part being the endosperm and its derivatives. Coconut endosperm, which is hard and white in colour, is rich in proteins, amino acids, sugars, vitamins, minerals and growth factors. The endosperm is mostly used for extraction of coconut oil and culinary purposes.

Certain coconut palms produce nuts containing soft, jelly-like endosperm, called *Makapuno* in Philippines (Torres, 1937), which has been commercially exploited for product diversification especially in confectionary industries. Mutants similar to *Makapuno*-type have also been reported from other coconut-growing regions: Coco Gra (Seychelles), Kopyor (Indonesia), *Thairu* or *Nei Thengai* (India), Dikiri Pol (Sri Lanka), Mapharao Khati (Thailand), Sap (Vietnam), Niu Garuk (Papua New Guinea) and Pia (Polynesia) (Arunachalam and Rajesh, 2008). This *Makapuno* trait results in abortion of embryo and is known to occur because of the effect of lethal recessive gene (Zuniga, 1953). Similar types have been sporadically reported from India (Arunachalam and Rajesh, 2008).

Recently, another variant with sweet and soft endosperm, named *'Mohachao Narel'* has been reported from Guhaghar taluk of Ratnagiri district of Maharashtra State in India (Anitha Karun *et al*., 2010; Samsudeen *et al*., 2010). Studies on fruit component traits of sweet and normal nuts of this population revealed that endosperm thickness was similar in both sweet and normal types, but the endosperm weight was more in normal types. Copra weight and copra recovery was more in normal nuts compared to sweet endosperm types. Oil content of sweet endosperm nuts was significantly lower than normal endosperm. Total soluble sugars (Brix values) were same in both type of nuts, but organoleptic test showed that water in sweet endosperm nuts was poor in taste. Sweet endosperm nuts get a premium price and are mainly used for raw consumption (Samsudeen *et al*., 2010).

Twenty seven palms of *'Mohachao Narel'* were located in Guhaghar taluk of Ratnagiri district (N17° 28'55'' to N17° 29'50'' and E73° 11'03'' to E73°

Table 1. Area percentage of fatty acids in normal and sweet nuts in all seasons

Fatty acid	Area percentage			
	Normal		Sweet	
	Mean	SD	Mean	SD
C6(caproic acid)	0.43	0.07	0.24	0.02
C8(Caprylic acid)	7.60	1.26	4.00	0.33
C10(capric acid)	5.49	0.82	2.66	0.34
C12(lauric acid)	47.99	1.12	34.78	2.70
C14(myristic acid)	18.93	2.11	21.02	0.22
C16(Palmitic acid)	7.28	0.47	13.92	0.99
C18(Stearic acid)	2.20	0.27	2.25	0.40
C18:1(Oleic acid)	4.98	1.04	15.66	0.81
C18:2(Linoleic acid)	1.30	0.24	4.50	0.75
C24(Lignoceric acid)	0.13	0.01	0.00	0.00

19'50''). The number of nuts with sweet endosperm per bunch varied from 10 to 77 percent in different palms (Samsudeen *et al*., 2010).

Coconut oil is the most important product of the coconut palm. Fatty acids are long chain organic acids having usually from 4 to 30 carbon atoms; they have single carboxyl group and a long, non polar hydrocarbon tail; which gives most lipids their hydrophobic and oily or greasy nature. Fatty acids are the basic components of triglycerides (stored fat) and Phospholipids (cell membranes). Three fatty acids esterified in glycerol is triglyceride. Fat is triglyceride in solid form, and oil is triglyceride in liquid form. Fatty acids are classified as saturated (containing only single bonds) and unsaturated fatty acids (containing one or more double bonds). Compound with one double bond is mono unsaturated fatty acid and those with more than one double bond are polyunsaturated fatty acids. Most of the polyunsaturated fatty acids are also essential fatty acids as human body cannot synthesis them. Fatty acids are also classified based on its size or length of carbon chains. Accordingly there are short chain fatty acids(less than 8 carbon atoms), medium chain fatty acids(MCFAs) with8 to 12 carbon atoms and long chain fatty acids(LCFAs) with >12 carbon atoms. MCFAs are quickly and directly absorbed by the human body without getting deposited as fat. Hence they are considered superior to LCFAs in dietary. (Jain *et al.,* 2005) Present study concentrated on a comparative analysis of fatty acid profile of oil from both the sweet type and the normal type nuts in *'Mohachao Narel*', at various seasons.

MATERIALS AND METHODS

A field survey was conducted during summer season in the initial stage of the study, at Guhagar taluk in Ratnagiri district of Maharashtra. A total of 27 mother palms possessing nuts with sweet kernel ('NSD') have been identified in this area. The identified palms were marked for further studies. In this study, as many mature nuts as possible from each of the 27 palms were harvested during three seasons- pre monsoon , monsoon and post monsoon. The collected nuts were transported to CPCRI, Kasaragod.

Nuts were dehusked, broken and categorized

Table 2 Area percentage of fatty acid components of oil from normal and sweet type nuts at various seasons

Fatty acid	Area Percentage							
	Normal				Sweet			
	Premonsoon	Monsoon	Post monsoon	CD	Premonsoon	Monsoon	Post monsoon	CD
C6 (caproic acid)	0.36	0.40	0.51	0.02	0.25	0.23	0.22	ns
C8 (Caprylic acid)	6.52	7.06	9.23	0.43	4.15	3.57	4.27	0.16
C10 (capric acid)	4.60	5.51	6.38	0.66	2.64	2.30	3.05	0.12
C12 (lauric acid)	47.72	46.89	49.34	0.76	33.64	32.43	38.28	0.83
C14 (myristic acid)	21.60	18.23	16.97	0.90	20.95	21.17	20.95	ns
C16 (Palmitic acid)	7.45	7.61	6.79	0.68	14.51	14.58	12.67	0.78
C18 (Stearic acid)	2.32	2.37	1.90	0.35	2.66	1.88	2.21	0.49
C18:1 (Oleic acid)	4.14	6.31	4.49	0.63	15.78	16.45	14.73	0.74
C18:2 (Linoleic acid)	1.08	1.60	1.23	0.15	5.09	4.88	3.52	0.39
C24 (Lignoceric acid)	0.13	0.14	0.12	0.01	--	--	--	--

them as sweet or normal types, on the basis of organoleptic test. Two nuts collected from the individual experimental palms processed to copra for oil extraction. Oil was extracted from the copra, using petroleum ether, in socs plus extractor (Sadasivam and Manikam, 1996). Clear oil was obtained after the evaporation of solvent .Oil from ten nuts, each of both types (sweet and normal) were bulked together for three different seasons and were separately analyzed for fatty acid profile. The analysis was replicated thrice for each type per season and the mean values were reported. The oil samples (200mg) were used for methyl esterification and the gas liquid chromatography (GLC) performed, following the method of Padua Resurrection and Banzon (1979). The identification of the peaks was carried out by retention times. The concentration of each fatty acid was calculated by dividing the area of the fatty acid by the sum of all peak areas of fatty acids.

RESULT AND DISCUSSION

Individual fatty acid concentration was worked out and presented here. Fatty acid compositions were discussed in terms of saturated, unsaturated, mono-unsaturated, poly-unsaturated, short and medium chain saturated fatty acids (SMCSFAs) and long chain saturated fatty acids (LCSFAs). Significant variations in concentration of individual fatty acids between these two types of nuts (fig.1 & 2) and seasons were observed. The data on fatty acid composition of oil from both types of nuts in all three seasons together and those in three seasons separately is presented in table-1and table-2 respectively.

Saturated fatty acids (SFAs)

The data on different fatty acids of the two types showed that, there was significant variation in the area percentage of fatty acids in oils from both. It was clear from the result that coconut oil contained mostly saturated fatty acids. Among the saturated fatty acids, lauric acid (C12) was present in maximum concentration. Myristic acid (C14) and Palmitic acid (C16) were also present in appreciable concentrations. Other saturated fatty acids present were caproic acid (C6), Caprylic acid (C8), Capric acid (C10), stearic acid (C18), and Lignoceric acid (C24). The concentration of all the SMCSFAs (C6 to C12) was significantly higher in the normal type compared to those in the sweet type (Table-1). But the concentration of LCSFAs (C14, C16 and C18) was significantly higher in sweet type than those in the normal type. Concentration of palmitic acid was almost double (13.92%) in sweet type (Table-1). The data showed that Lignoceric acid was present only in normal type. Concentration of lauric acid was the highest (47.99%) in normal type, while it was only 34.78% in sweet type (Table 1). The result of normal nut is in line with Gregorio (2005) and Gopala *et al*. (2010), they reported that coconut oil is rich source of lauric acid. Lauric acid has been reported to have antimicrobial properties (Hoffman *et al.*, 2001; Ouattar *et al*., 2000; Dawson *et al.*, 2002; Alexey Ruzin and Richard, 2000). In addition, Lauric acid has been found to increase high-density lipoprotein (HDL) or good cholesterol and has a more favorable effect on lowering the total to HDL cholesterol ratio than any other fatty acid (Mensink *et al.,* 2003; Thijssen and Mensink, 2005). Lauric acid comprises about half of the fatty acid content in coconut oil. Only other plant source of lauric acid is palm kernel oil. Otherwise it is found in human breast milk, cow's milk and goat's milk.

Concentration of C6, C8 and C10, in normal nut, showed a steady and significant increase from pre monsoon to post monsoon, through the monsoon season. But in sweet type the variation in C6 was not significant; while C8 and C10 showed the highest concentration during post monsoon, followed by pre monsoon and monsoon (Table-2). Concentration of lauric acid, in both type of nuts were highest during post monsoon and the least during monsoon season (Table-2). Concentration of C14 was significantly higher (21.6%) during pre monsoon, compared to monsoon and post monsoon seasons, in normal nuts; while, in sweet type there was no significant variation (Table-2). Concentration of palmitic acid was higher during monsoon season, in both types of nuts, followed by pre monsoon and post monsoon seasons (Table-2). Stearic acid concentration was higher and on par during pre monsoon and monsoon seasons, in normal nut. But in sweet type it showed higher value (2.66%) during pre monsoon and the least (1.88%) during monsoon season (Table-2).

Unsaturated fatty acids (USFAs)

Two USFAs were recorded in both types of nuts. They were oleic acid (C18:1) and linoleic acid (C18:2). Concentration of oleic acid (15.66%) and linoleic acid (4.50%) was higher in sweet type, compared to normal type (4.98% and 1.30% respectively) (Table-1). Compared to the saturated fatty acids, both types showed lower concentration of unsaturated fatty acids. Higher amount (20.16%) of unsaturated fatty

acids was in sweet type, while the normal type had 6.28% only (Table-3). Oil with higher content of unsaturated fatty acids is more vulnerable to lipid peroxidation or rancidity. On the other hand, the unsaturated fatty acids increase the levels of good cholesterol (HDL) by taking the LDL to the liver to be broken down and removed from the body (Mensink R. P., and Katan M. B. 1989). Hence from dietary angle sweet type is desirable. Amount of oleic acid (6.31%) and linoleic acid (1.60%) was significantly higher during monsoon season, in normal nut; while in sweet nut, concentration of oleic acid and linoleic acid was significantly higher and on par during pre monsoon and monsoon seasons (Table-2).

Table 3. Area percentage and ratio of SFAs and USFAs (all seasons)

Nut type	SFAs	USFAs	SFAs/USFAs
Normal	90.05	6.28	14.34
Sweet	78.87	20.16	3.91

Saturated fatty acids to unsaturated fatty acids ratio

Total saturated fatty acids is higher in normal type (90.05%) compared to the sweet type (78.87%). But the sweet type showed higher value of total unsaturated fatty acids (20.16%) compared to the normal type (6.28%) (Table-3). The ratio of saturated fatty acid to unsaturated fatty acid was 14.34% in normal type, while it was only 3.91% in sweet type (Table-3). Amount of total SFAs was higher during post monsoon season, in both types of nuts, followed by pre monsoon and monsoon seasons (Table-6). Concentration of total USFAs was significantly higher during monsoon, in both types of nuts (Table-6). The ratio of saturated fatty acid to unsaturated fatty acid was significantly higher during pre monsoon (17.38), followed by post monsoon (15.92)and monsoon (11.15),in normal type; while it was higher during post monsoon (4.47), followed by pre monsoon (3.78) and monsoon (3.57) seasons (Table-6). Oil with lower ratio of saturated fatty acid to unsaturated fatty acid favorably influence the LDL/HDL cholesterol ratio and is desirable in the diet (Muller *et al.,* 2003). The present study showed lower ratio of saturated fatty acid to unsaturated fatty acid in sweet type and hence desirable for dietary purposes.

Table 4. Area percentage and ratio of SMCSFAs and LCSFAs (all seasons)

Nut type	SMCSFAS	LCSFAS	SMCSFAS /LCSFAS RATIO
Normal	61.51	28.54	2.16
Sweet	41.68	37.19	1.30

Table 5. Area percentage of Mono and Poly Unsaturated fatty acids (all seasons)

Nut type	MUSFAs	PUSFAs	Total
Normal	4.93	1.30	6.23
Sweet	15.66	4.50	20.16

Ratio of SMCSFAs and LCSFAs

The content of SMCSFAs (C12 and less) and LCSFAS (>C12) and the ratio of SMCSFAs to LCSFAS varied in these two types. The area percentage of short and medium chain saturated fatty acids (SMCSFAs) and long chain saturated fatty acids (LCSFAs) and their ratio are presented in the Table-4.The result indicated that short and medium chain saturated fatty acids (SMCSFAs) was higher (61.51%) in normal type and lower (41.68%) in sweet type. Long chain saturated fatty acids (LCSFAs) were higher (37.19%) in sweet type, while it was lower (28.54%) in normal type. The ratio of SMCSFAs/ LCSFAS was higher (2.16) in normal. It was lower (1.30) in sweet type. Amount of SMCSFAs was significantly higher during post monsoon season, in both types of nuts; while those during pre monsoon and monsoon seasons were on par (Table-7). Concentration of LCSFAs was higher during pre monsoon, followed by monsoon and post monsoon seasons, in both types of nuts (Table-7). The ratio of SMCSFAs/LCSFAS was higher during post monsoon, and it was almost similar during the other seasons, in both types of nuts (Table-7). Saturated fatty acids are considered undesirable in the diet mainly because of the presence of LCSFAS. The SMCSFAs are directly absorbed and not deposited as fat and hence are not harmful for human consumption, on the contrary there are some benefits of including medium chain fatty acids in the diet (Temme *et al.*, 1997; Mensink *et al*., 2003). A high ratio of SMCSFAs/ LCSFAS in the diet has health benefits (Hoffman, 2001; Mensink and Katan, 1992). The high ratio of SMCSFAs/LCSFAS in normal type compared to the sweet type is desirable.

Table 6. Area percentage and ratio of SFAs and USFAs during various seasons

Nut type	Season	Saturated Fatty acid (SFAs)	Unsaturated Fatty acid (USFAs)	SFAs/ USFAs
Normal	Pre monsoon	90.71	5.22	17.38
	Monsoon	88.21	7.91	11.15
	Post monsoon	91.23	5.73	15.92
Sweet	Pre monsoon	78.81	20.87	3.78
	Monsoon	76.15	21.34	3.57
	Post monsoon	81.66	18.25	4.47

Mono and poly unsaturated fatty acids

The area percentage of monounsaturated fatty acids (MUSFAs) and polyunsaturated fatty acids(PUSFAs) are presented in table-5. From the analysis it was observed that both MUSFAs and PUSFAs were higher in sweet type. The analysis showed that oleic acid (18:1) was the only monounsaturated fatty acid present in both the types and the polyunsaturated fatty acid present was linoleic acid (18:2). The area percentage of monounsaturated fatty acid (oleic acid) was 15.66% in sweet type and 4.93% only in normal type. The area percentage of polyunsaturated fatty acid (linoleic acid) was 4.50% in sweet type and 1.30% in normal type (Table-5). Concentration of MUSFAs was significantly higher during monsoon (6.31%), followed by pre monsoon

Table 7. Area percentage and ratio of SMCSFAs and LCSFAs during various seasons

Nut type	Season	SMCSFAs	LCSFAs	SMCSFAs/ LCSFAs
Normal	Pre monsoon	59.20	31.50	1.88
	Monsoon	59.86	28.35	2.00
	Post monsoon	65.46	25.78	2.54
Sweet	Pre monsoon	40.69	38.12	1.07
	Monsoon	38.53	37.62	1.02
	Post monsoon	45.83	35.84	1.28

Table 8. Area percentage of mono and poly unsaturated fatty acids during various seasons

Nut type	Season	MUSFAs	PUSFAs	Total
Normal	Pre monsoon	4.14	1.08	5.22
	Monsoon	6.31	1.60	7.91
	Post monsoon	4.49	1.23	5.72
Sweet	Pre monsoon	15.78	5.09	20.87
	Monsoon	16.45	4.88	21.33
	Post monsoon	14.73	3.52	18.25

(15.78%) and post monsoon (14.73%), in sweet type; while in normal type it was higher during monsoon (6.31%), followed by post monsoon (4.49%) and pre monsoon (4.14%) (Table-8). Amount of PUSFAs was higher during pre monsoon (5.09%), followed by monsoon (4.88%) and post monsoon (3.52%), in sweet type. It was higher during monsoon (1.60%), followed by post monsoon (1.23%) and premonsoon (1.08%) in normal type nut (Table-8).The high content of MUSFAs, especially oleic acid is associated with a low incidence of coronary heart disease (CHD) because it decreases total cholesterol (10%) and low-density lipoprotein cholesterol (Dennys *et al*., 2006; Mensink and Katan, 1989; Rickman, 2004). It was reported earlier that oleic acid blocks the action of a cancer-causing oncogene, called HER-2/neu, which is found in about 30% of breast cancer patients (Menendez *et al*., 2005). Present study showed that total concentration of MUSFAs and PUSFAs was almost three times higher in sweet type compared to that in normal type , during all seasons (Table-5 and 8) and hence the sweet type is desirable for dietary purposes.

The results of the present study showed that the coconut oil profile in terms of saturated, unsaturated, mono-unsaturated, poly-unsaturated, short and medium chain saturated fatty acids (SMCSFAs) and long chain saturated fatty acids (LCSFAs) were different in sweet type nut and normal type nut, during all seasons. It was observed that percentage of short and medium chain saturated fatty acids (SMCSFAs) was more in normal type compared to sweet type. Higher percentage of SMCSFAs found in normal type was due to presence of more lauric acid, caprylic acid and caproic acid. Coconut oil is used for human

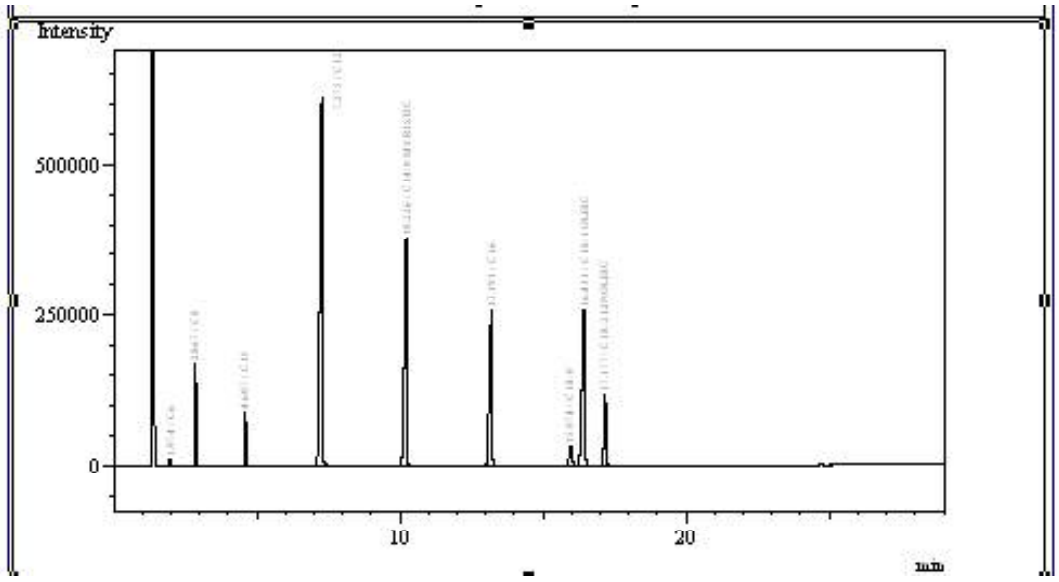

Fig. 1. Chromatogram of oil from sweet kernel

consumption, cosmetic and industrial purposes. Quality required for human consumption is different from that of other uses. Healthy dietary requirement is the major factor deciding the selection of oil for consumption. Coconut oil quality from health angle has been under scrutiny for some time now. It was considered unhealthy because of high saturated fatty acid content around 90% in the coconut oil. But, recent studies have shown that the medium chain fatty acids which constitute more than 65% of saturated fatty acids in coconut oil are good for health (Dayrit, 1995). According to Rajan (2006), coconut oil is the healthiest oil on earth because it contains higher content of short and medium chain saturated fatty acids (SMCSFAs). SMCSFAs are directly absorbed from the intestine to portal veins and transferred to liver for utilization as ready source of energy (B-oxidation in the mitochondria). They are not usually circulated or stored, nor they undergo oxidative stress, and hence SMCSFAs prove to be most protective and safe for human consumption. He also revealed that coconut oil is Cardio protective and prevents degenerative diseases including cancers. The importance of SMCSFAs was also reported by Blackburn *et al*.,(2001) and Enig (2001). According to them SMCSFAs do not contribute to the low- density

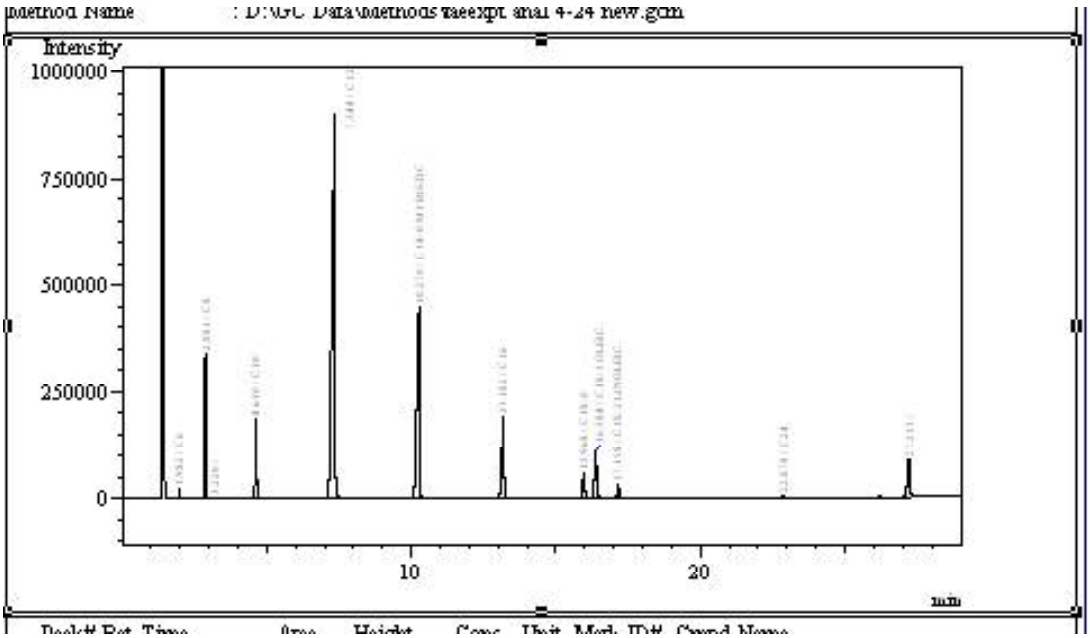

Fig. 2. Chromatogram of oil from normal kernel

lipoprotein (bad cholesterol) in the body. Moreover, Lauric acid content in coconut oil which is approximately 50% lead to increase in high-density lipoprotein (HDL) and has favorable effect on lowering the total to HDL cholesterol ratio than any other fatty acid (Mensink *et al.,* 2003; Thijssen and Mensink, 2005). The result of present study revealed that oil from normal type nut is better in giving health benefit compared to the sweet type. The higher concentration of lauric acid, SMCSFAs and the higher ratio of SMCSFAs/LCSFAS in the oil of normal type nuts makes them more suitable for human consumption.

On the other hand oil from sweet type nuts had lower level of saturated fatty acids, lower ratio of saturated fatty acid to unsaturated fatty acid, higher level of unsaturated, mono and polyunsaturated fatty acids in the oil of sweet nuts, compared to that from the normal nut. Oil with lower ratio of saturated fatty acid to unsaturated fatty acid favorably influence the LDL/HDL cholesterol ratio and is desirable in the diet (Muller *et al.*,2003). This study showed lower ratio of saturated fatty acid to unsaturated fatty acid in sweet type and hence desirable for dietary purposes. The high content of MUSFAs, especially oleic acid is associated with a low incidence of coronary heart disease (CHD) because it decreases total cholesterol (10%) and low-density lipoprotein cholesterol (Dennys *et al*., 2006; Rickman, 2004). It was reported earlier that oleic acid blocks the action of a cancer-causing oncogene, called HER-2/neu, which is found in about 30% of breast cancer patients (Menendez *et al.*, 2005). Present study showed that concentration of MUSFAs and PUSFAs was three times higher (20.16%) in sweet type compared to that in normal type (6.23%). The present study revealed that the fatty acid composition of oil from sweet type nuts contains a healthy mixture of all the types of fatty acids. So coconut palms with sweet nuts, *'Mohachao Narel'* should be efficiently exploited for further breeding programme.

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