STUDIES ON THE EXTRACTION AND CHARACTERISATION OF MICROALGAL OIL.

Shaleesha A.Stanley[1] Ananadhi Padmanabhan M.R.[2] and Anitha A.S.[3]

[1]HOD, Department of Biotechnology, Jeppiaar Engineering College, Jeppiaar Nagar, Chennai – 119.
[2]Research Scholar, Department of Biotechnology, Sathyabama University, Jeppiaar Nagar, Chennai – 119.
[3]Department of Chemical Engineering, Sathyabama University, Jeppiaar Nagar, Chennai – 119
Email: [2]mr_anandhi@yahoo.com

Abstract

High oil species of microalgae cultured in growth optimized conditions have the potential to yield 5,000 – 15,000 gallons of microalgal oil per acre per year. As with any biological lipid, this is a potential feedstock for making the renewable fuel biodiesel. The main objectives of the project is to make use of the algae present in the water bodies and to extract the useful algal oil meant for Biodiesel production to meet the challenges of fuel requirement in the present scenario. Microalgal Oil was extracted from *Chaetoceros* sp. and the physico-chemical properties were determined. The Density, Viscosity, Acid value, Saponification value and free fatty acids were recorded as 1.305 gm/ml, 6.2 mm^2/s, 2.5339 mg/gm of oil, 173.56 mg/gm of oil and 0.71 gm/100 gm of algae (Oleic acid). The fatty acid profile showed Pentadecanoic acid (17.56%), 1. Nonadecenoic acid (20.1%), methyl palmitate (2.91%), methyl linoleate (12.07%), palmitic acid (1.97%) as major fatty acids.

Key Words: *Chaetoceros* sp., Algal Oil, solvent extraction, Oil analysis, Algal Oil yield, fatty acids.

I. INTRODUCTION

Algae are more promising feed stock to their widespread availability and higher oil yields. Micro algae can build a global oil supply chain that is sustainable and delivers fuel. It will be the supplier to the biodiesel business. Marine algae contain lipids and fatty acids as membrane components, storage products, metabolites and source of energy. Algae contain about 2% lipid and 40% fatty oils by weight. Today Algae are used by humans in many ways; for example, as fertilizers, soil conditioners and livestock feed.

The current oil crisis and fast depleting fossil oil reserves have made the countries to invest more time and efforts into research on algae to biodiesel. They can double their mass several times a day and produce at least 15 times more oil per acre than alternatives such as rapeseed, palms, soybeans, or jatropha. Moreover, algae-growing facilities can be built on coastal land unsuitable for conventional agriculture. They can grow 20 to 30 times faster than food crops. The hard part about algae production is growing the algae in a controlled way and harvesting it efficiently.

The basic concept behind algal biofuels is deceptively simple. Microalgae naturally produce and store lipids similar to those found in most vegetable oils. If scientists can genetically jigger the oil-storing tendencies of algae into becoming more efficient than they are in nature, commercially viable levels of transportation fuels may result. The key challenges include selecting the most suitable algae strains, growing these algal cells at optimal rates, engineering the metabolic pathways that control oil production to create cells pregnant with desirable oil products, and extracting the oil in an efficient and economic manner.

The present research work was designed to extract and study different physico-chemical parameters of microalgal oil so as to explore a source to produce biodiesel in India. *Chaetoceros* species are marine microalgae. They are pelagic diatom cultures to be one of the best algal groups to culture and as a food source, unparallel. It is a medium size diatom (microscopic unicellular marine alga having cell walls

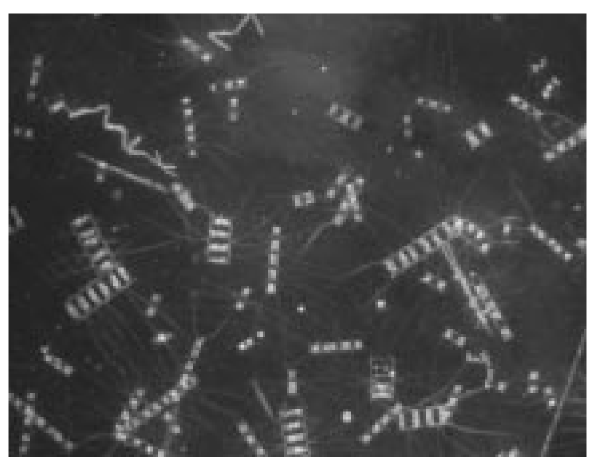

Fig. 1. Microscopic view of *Chaetoceros* sp.

impregnated with silica) that is extensively used in the aqua culture industry, primarily for bivalve shell fish and shrimp. It has high reproductive potential characteristic.

II. MATERIALS AND METHODS

A. Culture Conditions

Chaetoceros species was obtained from Centre for Advanced studies, Madras University, Chennai, Tamil Nadu. The algae were grown in 1 L volumes in 2 L Erlenmeyer flasks. The inoculums for the strain was 5 ml, containing about 5×10^4 cells/ml. The strains were cultivated at 24°C with a light: dark photoperiod of 14:10 h, with a light intensity of 115 μ mol $m^{-2} s^{-1}$ and were continuously stirred for aeration. The Marine microalgae were grown in F/2 Medium. pH was maintained as 7.9 throughout the growth study.

B. Algal Oil Extraction

Algae were ground with motor and pestle as much as possible. The ground algae were dried for 20 min at 80°C in an incubator for removal of moisture. The oil was extracted through solvent extraction process. To 0.5 gm of dry algae, ethanol and con HCL added and it is heated well in water bath at 90°C for 45 min and stirred well often. Then the mixture was extracted with petroleum ether and anhydrous sodium sulphate. At last the oil & petroleum ether mixture is heated in water bath at 50°C and placed in a desicator for removal of moisture. The oil percentage was calculated on the basis of following formula:-

$$\text{Percent oil in rice bran} = \frac{\text{Weight of oil (g)}}{\text{Weight of sample (g)}} \times 100$$

C. Algal Oil Analysis

The extracted oil was analysed for density, viscosity, acid value, saponification value and free fatty acids. The fatty acid composition of oil was determined through Gas Chromatograph. The fatty acids were identified by chromatographic retention time by comparison with standards.

III. RESULTS AND DISCUSSION

On average basis 40 percent oil was recovered from marine microalgae. Saunders also reported similar results of oil recovery from rice bran for different rice varieties. The results on physico-chemical characteristics of marine microalgae indicated that the Density, Viscosity, Acid value, Saponification value and free fatty acids were recorded as 1.305 gm/ml, 6.2 mm^2/s, 2.5339 mg/gm of oil, 173.56 mg/gm of oil and 0.71 gm/100 gm of algae (Oleic acid) (Table 1).

Table 1. Physico–chemical characteristics of microalgal oil.

S.No	Parameters	Values
1	Density	1.305gm/ml
2	Viscosity	6.2 mm^2/s
3	Acid Value	2.5339 mg/gm of oil.
4	Saponification value	173.56 mg/gm of oil
5	Free fatty acid value	0.71 gm/100 gm of algae (Oleic acid)

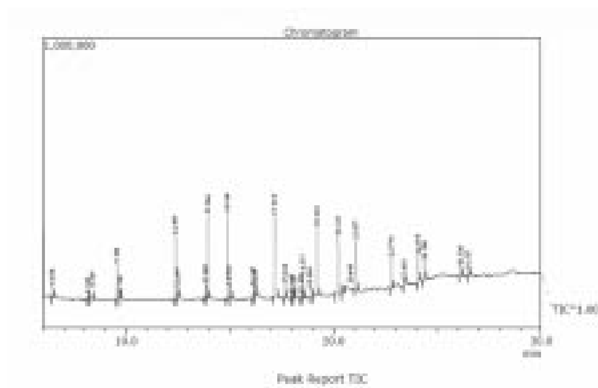

Fig: 2. GC chromatogram and fatty acid composition of C_ALGAL OIL

The fatty acid profile of marine microalgal oil indicated that Pentadecanoic acid (17.56%), 1. Nonadecenoic acid (20.1%), methyl palmitate (2.91%), methyl linoleate (12.07%), palmitic acid (1.97%) as major fatty acids. The extracted microalgal oil consists of major fatty acids which is similar to rice bran oil in fatty acid composition as shown in Table 2..

Table 2. Fatty acid composition of c_algal oil

Peak#	R.time	Area	Area%	Name
1	6.454	162931	1.39	1-Decene
2	8.185	76984	0.66	Undecane
3	8.387	65229	0.56	Dimethoxymethylbenzene
4	9.581	511307	4.35	1-Dodecene
5	9.704	87068	0.74	Tetradecane
6	12.397	888039	7.56	1-Pentadecene
7	12.499	128692	1.10	pentadecane
8	13.862	186411	1.59	N,N-Dimethyl-Heptylamine
9	13.944	1193140	10.16	2,4-Di-tert-butylphenol
10	14.908	1207835	10.28	1-Pentadecene
11	14.992	172113	1.47	1-Bromo-2-methyldecane
12	16.147	154971	1.32	Nanodecane
13	16.253	125003	1.06	Di-methyldodecylamine
14	17.165	1187709	10.11	1-Nonadecene
15	17.668	181214	1.54	Neophytadiene
16	18.007	53194	0.45	Isobutyl phthalate
17	18.117	53446	0.46	(2E)-3,7,11,15-Tetramethyl-2-hexadecen-1-ol
18	18.458	64183	0.55	(2r,4r)-3-benzoyl-4-benzyl-2-(tert-butyl)-4-isopropyl-1
19	18.537	341957	2.91	Methyl Palmitate
20	18.894	231863	1.97	Palmitic acid
21	19.210	1030913	8.78	1-Nonadecene
22	20.213	1418071	12.07	Methyl linoleate
23	20.448	161043	1.37	Methyl behenate
24	21.077	700517	5.96	1-Nanodecene
25	22.794	446299	3.80	9-Hexacosene
26	23.410	52885	0.45	rac-1,3,4,6-tetraphenylhexane
27	24.075	357880	3.05	Monoethylhexyl phthalate
28	24.384	276854	2.36	9-Hexacosene
29	26.104	153689	1.31	1-Eicosanol
30	26.517	74850	0.64	Squalene
		11746290	100.00	

IV. CONCLUSION

Algae are more promising feed stocks to their wide spread availability and higher oil yields. The experimental oil yield obtained from *Chaetoceros* species was about 40%. Algal oil is highly used for Biodiesel production which is eco-friendly. Once the oil is extracted from the algae the residue left is used for feed animals. The Density, Viscosity, Acid value, Saponification value and free fatty acids were recorded as 1.305 gm/ml, 6.2 mm^2/s, 2.5339 mg/gm of oil, 173.56 mg/gm of oil and 0.71 gm/100 gm of algae (Oleic acid). The obtained algal oil was analyzed by using Gas Chromatography. The fatty acid profile showed Pentadecanoic acid (17.56%), 1. Nonadecenoic acid (20.1%), methyl palmitate (2.91%), methyl linoleate (12.07%), palmitic acid (1.97%) as major fatty acids. In view of the physico-chemical parameters of microalgal oil extracted from *Chaetoceros* species can be efficiently used for biodiesel production.

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