International Journal of Current Engineering and Technology

ISSN 2277 – 4106

Available at http://inpressco.com/category/ijcet

Research Article

Comparative Extraction of Castor seed Oil Using Polar and Non polar Solvents

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Abstract

Extraction of oil from castor seeds was carried out by Soxhlet apparatus using hexane at 1:3, 1:6, 1:9 solid to solvent ratios and different extraction time periods of 8, 10, 12 and 14h. The highest oil yields of 43.9, 42.8 and 45.8% were obtained at 1:3 (14h), 1:6 (14h) and 1:9 (12h) respectively. The optimum condition for the extraction using hexane as solvent was found to be solid to solvent ratio, 1:9 and time period of 12h... The same optimum condition was applied to extract the oil using different solvents (i.e. polar and non-polar) such as ethyl acetate, isopropanol, methanol, pentane, petroleum ether and cyclohexane. The result reveals highest oil yield of 49.1% with ethyl acetate at solid to solvent ratio, 1:9 and time period of 12h and the next highest yield 46.9% was obtained using methanol as solvent. Nevertheless, other solvents also gave appreciable yield in the range 42-45%. The physic-chemical properties of castor oil extracted using all the solvents were estimated and compared. The iodine value of oil indicates that it is a non-drying oil. High acid value of oil shows that it needs pre-treatment before being utilised for transesterification process.

Keywords: *Castor oil, Extraction, Solvent, Oil yield, Oil properties.*

1. Introduction

Castor (*Ricinus communis)* plant is belongs to the Euphorbiaceae family and it is also called palma christi. This plant is well-adapted to drought conditions for longer periods [L.B.F Carmen, 2001]. Castor seeds are poisonous to human and animals due to presence of ricin and other compounds which are toxic. This castor seeds are life threat to the children (inhalation) and also risky to the farmers during harvesting [Ogunniyi, 2006]. The seeds contain about 45-60% oil [Olaniyan, 2010]. Castor oil contains 91-95% ricinoleic acid, 4-5% linoleic acid and 1-2% palmitic and stearic acids [L. B. F Carmen, 2001].

Castor oil is non-edible oil which can be used as a replacement of edible oils in many industrial applications. It has a good shelf life compared to other vegetable oils if it is not subjected to excess heat [D.S. Ogunniyi, 2006]. Castor oil has been used in paints, coatings and inks for several years [A.S. Trevino et al, 2002]. And also used in medical and industrial applications such as purgative, antibiotic, an illuminant, cosmetics, soaps, plastics, resins, dyes and lubricants [A.M. Olaniyan, 2010].

There are several methods to extract oil from seeds such as pressing, solvent extraction and supercritical fluid extraction [W. Radziah et al, 2011]. Soxhlet (solvent) extraction is the standard technique where the fresh solvent contacts the sample frequently [H. Wu et al, 2011]. It is widely used technique because it is simple and easy to run. Extraction depends on the nature of the solvent and oil, contact time of sample with solvent, extraction temperature, particle size and solvent ratio. It is required to select a suitable solvent for the extraction of oil. Hexane is widely used solvent in oil extraction due to its low boiling temperature and low corrosiveness [W. Radziah et al, 2011]. Apart from that other polar and non polar solvents used for the oil extraction are petroleum ether [V.I.E. Ajiwe et al, 1994], ethyl ether [H. Wu et al, 2011], pentane, isopropanol, toluene, ethyl acetate, cyclohexane, acetone, chloroform, ethanol [R. Zarnowski et al, 2004 and Z. Hamamre et al, 2012] and methanol [A. Ahmad, 2010].

But no detail data is available in the literature regarding oil extraction from castor seed with different solvents as well as their physico-chemical properties estimation. Therefore, the study has been conducted to compare the efficiency of oil extraction from castor seed by different solvents and their properties estimation. This paper discussed the effects of parameters such as solid to solvent ratio, extraction time on the oil extraction efficiency.

2. Experimental

A. Seed collection and cleaning

Castor seeds were purchased from local market in Andhra Pradesh, India. The collected seeds were cleaned manually from dirt and other unwanted materials before extraction.

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The seeds were analysed for oil content by an exhaustive extraction method using different solvents in a Soxhlet apparatus.

B. Chemicals

All the solvents and other chemicals used were analytical grade and supplied by Merck India Ltd.

C. Oil Extraction

20g of dry ground seeds were used for the extraction of oil with hexane as solvent. The oil was extracted at 1:3, 1:6 and 1:9 solid (sample) to solvent ratios and different extraction periods i.e. 8h, 10h, 12h and 14h. The solvent was then evaporated using rotary evaporator. Oil yield was calculated based on the oil weight. The same method was followed for the extraction with other solvents.

D. Characterization of Oils

The physic0 chemical properties of oil such as density, specific gravity, kinematic viscosity (HAAKE rheometer), acid value (AOCS Te 1a-64, 1997), FFA (Free Fatty Acid) content, iodine value (AOCS Tg 1-64, 1997), saponification value (ISO 3657, 1988) and unsaponifiable matter (U.S pharmacopeia) were determined in accordance with standard method.

3. Results and discussion

A. Extraction with hexane

Table 1 show the oil yield obtained with hexane as solvent. The highest yield of 43.97, 42.85 and 45.83% were obtained at solid to solvent ratio of 1:3 (14h), 1:6 (14h) and 1:9 (12h). From the table it can be observed that oil yield increases with increase in time at 1:3 ratio. Whereas, in the case of 1:6 and 1:9 solvent ratios, oil yield was not consistent with time.

B. Characterization of Oils

The properties of castor oils extracted using different solvents are shown in Table 3. The obtained density values were within the range of 925-949 Kg/m3. The higher density of castor oil was due to the presence of hydroxyl group. This hydroxyl group also adds extra stability to oil and also prevents hydro peroxides formation [D.S. Ogunniyi, 2006]. Density values were higher (949 Kg/m3) for n-hexane extracted castor oil and lower (925 Kg/m^3) for cyclohexane extracted oil compared to other solvents. The obtained kinematic viscosities value were in the range of 122-229Cst. These values are deviating from the values reported in the literature (i.e. 240-300Cst), because in the literature values were estimated using the densities at 15^{o}C [V. Scholz et al, 2008]. Whereas, density value in the present work was estimated at 23^{o}C.

Table1: Castor oil yields obtained with hexane

S. No	Solid/Solvent ratio (wt. /vol.)	Extraction time(h)	Yield (%)
1	1:03	8	42.73
2	1:03	10	42.89
3	1:03	12	42.98
4	1:03	14	43.97
5	1:06	8	42.73
6	1:06	10	42.23
7	1:06	12	41.97
8	1:06	14	42.85
9	1:09	8	43.14
10	1:09	10	42.66
11	1:09	12	45.83
12	1:09	14	43.79

Figure 1: Castor plantation in Andhra Pradesh

Table 2: Castor oil yields with different solvents

S. N.	Solvent	Solid to solvent ratio (wt/vol.)	Extraction time(h)	Yield (%)
1	Hexane	1:03	14	43.9
		1:06	14	42.8
		1:09	12	45.8
2	Petroleum Ether	1:03	14	44
		1:06	14	43.2
		1:09	12	45
3	n-pentane	1:03	14	40.4
		1:06	14	40.4
		1:09	12	44.5
4	Cyclohexane	1:03	14	43.8
		1:06	14	44.3
		1:09	12	43.1
5	Isopropanol	1:03	14	43.7
		1:06	14	45.1
		1:09	12	45.3
6	Ethyl acetate	1:03	14	47.7
		1:06	14	46.3
		1:09	12	49.1
7	Methanol	1:03	14	46.9
		1:06	14	45.5
		1:09	12	46.2

C. Extraction with different solvents

The optimum extraction condition obtained with hexane as solvents were used throughout the study for other solvents such as pentane, cyclohexane, petroleum ether, ethyl

acetate, methanol and isopropanol. 20g of dry ground seeds were used for the extraction Extractions were carried out near the boiling point of the respective solvent and the results are shown in Table 2. The extracted castor oil with

Table 3: Properties of castor oil extracted with different solvents

Extracted Oil Property	Hexane	Petroleum ether	n-pentane	Ethyl acetate	Cyclo hexane	Isopropanol	Methanol
Density	949	927	932	937	925	936	941
(Kg/m^3)							
Specific gravity	0.976	0.953	0.958	0.963	0.951	0.962	0.968
Kinematic viscosity							
(Cst) at 40°C	229	143	140	122	155	182	210
Acid value	84.67	74.05	111.85	109.28	90.51	83.98	73.42
(mg KOH/g)							
FFA	42.33	37.02	55.92	54.64	45.25	41.99	36.71
(mg KOH/g)							
Saponification value	154. 27	161.28	168.3	175.31	168.3	175.31	168.3
(mg KOH/g)							
Un saponifiable matter (wt. %)	0.42	0.6	0.25	1.04	1.23	0.643	0.8
Iodine value	70.35	59.22	77.24	68.42	76.22	59.02	62.13
(gI_2/100g of oil)							

non-polar solvents was pale yellow and with polar solvents the colour was little dark. This dark colour may be due to the colouring matter in oil seeds [O. Akaranta et al, 1996]. Among all the solvents, the highest oil yield of 49.1% was obtained with ethyl acetate at 1:9(12h). However, appreciable oil yield was obtained at 1:9 (12h) with petroleum ether, pentane, isopropanol and ethyl acetate. But for n-pentane no variation in the oil yield was noticed with increase in solid to solvent ratio from 1:3 to 1:6. Similar type of results was observed with other solvents such as isopropanol (1:6, 1:9; ≈ 45%), methanol (1:3, 1:9; ≈ 46%) and cyclohexane (1:3, 1:9; ≈ 43%). In this study increase in the solid to solvent ratio showed insignificant role on the oil yield. The results obtained in the present work on castor oil yield (i.e. 40-49%) agrees well with the values (45-60%) reported by A.M. Olaniyan, 2010.

The acid values of the oil extracted in the present work were found to be higher compared (i.e. 73-111.85 mg KOH/g) to the values reported in the literature [D.S. Ogunniyi, 2006]. The higher acid values of the samples may be due to the poor storage condition of seeds or definite interactions of the hydroxyl and carboxylic acid groups of oil with the hydroxyl groups present in the solvents [O. Akaranta et al, 1996]. The higher acid value and FFA content decreases the shelf life of oil [V.I.E. Ajiwe et al., 1996]. The saponification values of the oil samples were found to be in the range of 154-175 mg KOH/g and the range agrees well with the values 123-185 mg KOH/g reported by V.I.E. Ajiwe et al, 1994 and A. A. Warra et al. The higher saponification values of oil indicate that oil can be used for liquid soap preparation [V.I.E. Ajiwe et al., 1996]. The unsaponifiable matter was found to be 0.2-1.23wt %. The obtained iodine values (59-77 gI_2/100g of oil) were lower compared to the literature values [V.I. E. Ajiwe et al, 1994]. The iodine value range in the present study was below 90 and which placed the oil in non-drying category [C.N. Ibeto et al, 2012].

Conclusion

From the present study it was revealed that nature of solvent and extraction time had influence on the oil yield. Therefore, these process condition need to be controlled during the extraction processes. Ethyl acetate and methanol showed higher castor oil yields in the present study compared to hexane. The results proved that other solvents can be a better alternative to hexane for castor oil extraction. The oil properties reveal that the type of solvent has influence over the oil properties with variance. The acid values of the oil were higher which shows that it needs pre-treatment before being utilised for transesterification process.

References

C.L.B. Forero, Biodiesel from castor oil: a promising fuel for cold weather, Department of Hydraulic, Fluids and Thermal Sciences, Francisco de Paula Santander University, Avenida Gran Colombia No. 12E-96 Cucuta (Colombia).

D.S. Ogunniyi {2006}, Castor oil: A vital industrial raw material, Bioresource Technology, 97, 1086–1091.

A.M. Olaniyan {2010}, Effect of extraction conditions on the yield and quality of oil from castor bean, *Journal of cereals and oil seeds*, 1(2), 24-33.

A.S. Trevino and D.L. Trumbo, {2002}, Aceto acetylated castor oil in coatings applications, *Progress in Organic Coatings*, 44, 49–54.

W. Radziah, M.R. Miradatul, and M.I. Nurfadilah {2011}, Basic study on anti bacterial properties of adenanthera pavonina (saga) seed oil, *IEEE Symposium, Engineering and industrial applications, Malaysia*.

H. Wu, J. Shi, S. Xue, Y. Kakuda, D. Wang, Y. Jiang, X. Ye, Y. Li, J. Subramanian {2011}, Essential oil extracted from peach (Prunus persica) kernel and its physicochemical and antioxidant properties, LWT - Food Science and Technology, 44, 2032-2039.

V.I.E. Ajiwe, S. C. Umerie, C. A. Okeke and V. N. Oburota {1994}, Extraction and utilisation of cassava seed oil, *Bioresource Technology*, 47, 85-86.

R. Zarnowski, Y. Suzuki {2004}, Expedient Soxhlet extraction of resorcinolic lipids from wheat grains. *Journal of Food Composition and Analysis*, 17, 649–663.

Z. Hamamre, S. Foerster, F. Hartmann, M. Kröger, M. Kaltschmitt {2012}, Oil extracted from spent coffee grounds as a renewable source for fatty acid methyl ester manufacturing, *Fuel*, 96, 70–76.

A. Ahmad {2010}, Optimization of soxhlet extraction of herba leonuri using factorial design of experiment, *International Journal of Chemistry*, vol. 2.

O. Akaranta, and A.C.I. Anusiem {1996}, A bioresource solvent for extraction of castor oil, Industrial Crops and products, 5, 273-277.

V. Scholz, and J. N. Silva{2008}, Prospects and risks of the use of castor oil as a fuel, *Biomass and Bioenergy*, 32, 95 – 100.

V.I.E. Ajiwe, C.A. Okeke, H.U Agbo, G.A. Ogunleye, and S.C. Ekwuozor {1996}, Extraction, characterization and industrial uses of velvet-tamarind, physic-nut and nicker-nut seed oils, *Bioresource Technology*; 57, 297-299.

A.A. Warra, I.G. Wawata, S.Y. Gunu, and Aujara K.M, Extraction and Physicochemical Analysis of some selected Northern Nigerian Industrial oils, Scholars Research Library, Available online at www.scholarsresearchlibrary.com.

C.N. Ibeto, C.O.B. Okoye, and A.U. Ofoefule, {2012}, Comparative study of the physicochemical characterization of some oils as potential feedstock for biodiesel production, *International Scholarly Research Network: ISRN Renewable Energy*.