JEAS

Journal of Engineering and Applied Sciences 6 (2010) 47-51

JOURNAL OF ENGINEERING AND APPLIED SCIENCES

The effect of process variables on the physico-chemical properties and oil yield of rubber seed

J.T. Nwabanne, M.H. Omoniyi

Department of Chemical Engineering, Nnamdi Azikiwe University, P.M.B. 5025, Awka, Nigeria

Abstract

The effect of process variables on the physico-chemical properties and oil yield of rubber seed was investigated. Mechanical expression and solvent extraction methods were used for the extraction of oil from rubber seed. For mechanical expression, it was found that oil yield increased from 16.80 to 24.72% as temperature increased from 40 to 80^{o}C at a fixed pressure of 5N/m^2, while varying the pressure from 5 to 8N/m^2 showed no significant effect on oil yield. Oil yield increased from 15.80 to 35.80% as time of extraction increase from 5 to 35min during solvent extraction. Maximum oil yield of 25.24% and 35.80% were obtained during mechanical expression and solvent extraction respectively. Physico-chemical analysis of the oil obtained during mechanical expression showed that it has iodine value of 120.1 g I_2/100g, acid value of 49.65mg KOH/g, free fatty acid of 24.97% and specific gravity of 0.917. Iodine value of the oil decreased as temperature increased while the acid value, percentage free fatty acid and specific gravity increased with increase in temperature. The oil is semi-drying oil and is similar to linseed oil and can partly replace it in industrial processes.

Keywords: Extraction; physico-chemical; oil yield; rubber seed oil

1. Introduction

Many seeds, nuts and kernels contain oil that can be extracted and used in the manufacture of a wide range of industrial and house-hold products. Until recently, little or no attention has been paid to the seeds produced by the rubber tree (Hevea brasiliensis) unknown that it contains valuable oil which has potential industrial applications (Hosen et al., 1981).

Chemical analysis of the seed showed that the seed without shell contains 43% oil, 22.30% protein, 23.39% carbohydrates, 43.1% fibre and 3.5% minerals (Uzu et al., 1986; Nwokolo et al., 1988). The oil is a semi-drying, yellowish oil which consists of 17-22% saturated fatty acids and 17-82% unsaturated fatty acids (George and Kuruvilla, 2000). Among the non edible oils available, rubber seed oil has characteristics that are similar to that of linseed oil and as such it could be adopted as a total or partial replacement for edible oil such as linseed oil in industrial processes (Iyayi et al., 2007).

Research findings have shown that rubber seed oil (RSO) has many areas of potential applications which include lubricant (Njoku and Ononogbu, 1995), printing ink and foaming agent in latex foam (Reethamma et al., 2005), fatice (Vijayagopalan, 1997; Fernando, 1971), biodiesel (Perera and Dunn, 1990; Ikwuagwu et al., 2000; Ramadhas et al., 2005), paints, alkyd resin, soap making and coatings (Aigbodion et al., 2003; Chin et al., 1997; Ghandi et al., 1990), possible use in the manufacture of fatty acids (Chin et al., 1977), production of water reducible alkyds (Ikhuoria et al., 2005) and others (Iyayi et al., 2007).

Two methods of extraction of oil from rubber seed are mechanical expression and solvent extraction. Mechanical expression may involve decortications and crushing of the seeds and finally, the oil is pressure expelled, filtered and refined. It is safer, initial capital investment is low and does not require skilled personnel to operate. On the other hand solvent method of extraction uses a solvent such as hexane. It is highly inflammable and as such it is susceptible to fire-out break during its use. It also requires highly skilled personnel to operate the process and the initial capital investment is high (Iyayi et al., 2007). The purpose of this study is to investigate the effects of process variables on mechanical expression and solvent extraction of rubber seed and to characterize the oil produced for its physicochemical properties.

2. Materials and methods

2.1. Seed collection and preparation

Rubber seeds were collected from Rubber Research Institute of Nigeria, Benin City in Edo State. The collected seeds were cleaned to remove any adhering dirt and oven dried at 60^oC for 24hours to reduce the moisture content. The seeds were shelled to obtain the kernels, and the kernels were then milled and stored for oil extraction and analysis.

2.2. Oil extraction

2.2.1. Mechanical expression

500g of the dried milled rubber seeds were weighed into mesh bags and placed on a receptor tray, which was then placed on the tower platen of a hydraulic press. The temperature of the press platens were then set to 40^oC and then closed by applying a fixed pressure of $5N/m^2$. As the platen closed, oil exuded from the seeds into a fabricated receptor tray, passing through the spout into a collection beaker. The electrical power to the press was turned off, and the amount of oil extracted was obtained by weighing using a weighing balance. The above process was repeated for temperatures of 50, 60, 70 and 80^oC and pressure of 6, 7 and $8N/m^2$ and for each case the percentage oil yield was calculated as follows:

$$\text{Percentage oil yield} = (W_o/W_s) \text{ X } 100$$

Where W_o = amount of oil obtained after extraction
W_S = weight of sample before extraction

2.2.2. Solvent extraction

This was carried out in a 500ml soxhlet extractor using n-hexane. 150ml of n-hexane was poured into a round bottom flask. 20g of the milled kernels was placed in the thimble and was inserted in the centre of the extractor. The soxhlet was heated at 60^oC. As the solvent starts boiling, the vapour rose through the vertical tube into the condenser at the top. The liquid condensate dripped into the filter paper thimble in the centre which contained the solid sample to be extracted. The extract seeped through the pores of thimble and filled the siphon tube, where it flowed back down into the round bottom flask. This was allowed to continue for 5min. At the end the solvent was distilled and the percentage oil extracted determined. The experiment was repeated at a fixed temperature of 60^oC but at different time of extraction of 10, 15, 20, 25, 30, 35min.

2.3. Analysis of rubber seed oil

2.3.1. Determination of iodine value

The method specified by ISO 3961 (1989) was used as reported by (Kyari, 2008). 0.13g of oil was weighed within 0.001g in a glass weighing scoop and placed in a 250ml conical flask. 15ml of carbon tetrachloride was added to dissolve the oil followed by the addition of 25ml wijs reagent. A stopper was then inserted and the content of the flask was shaken gently. The flask was then placed in the dark for 30minutes. At the end of this period, 20ml of 10% aqueous potassium iodide and 150ml of distilled water were added using a measuring cylinder. The content was titrated with 0.1M sodium thiosulphate solution until the yellow color almost disappeared. A few drops of starch indicator were added and the titration continued by adding sodium thiosulphate drop-wise until blue coloration disappeared after vigorous shaking. The above process was repeated with a blank under the same conditions. The iodine value (IV) is given by the expression:

$$IV = 12.69 \times T \times (V_1 - V_2)/m$$

Where V_1 = Volume of sodium thiosulphate used for the blank,
V_2 = Volume of sodium thiosulphate used for the test portion,
T = Normality of sodium thiosulphate used,
m = Mass, in g, of the test portion.

2.3.2. Determination of acid value

The acid value of the rubber seed oil was determined according to AOCS 5a-40 (1989) as reported by (Bashar and Jumat, 2009). 2g of the oil sample was dissolved in 25ml of a mixture of toluene and ethanol (1:1 ratio). The mixture was titrated with 0.1N potassium hydroxide using a phenolphthalein indicator to end point with constant shaking for which a permanent pink colour was observed and the volume of 0.1N potassium hydroxide was noted. The acid value is given by the expression:

$$\text{Acid value} = 56.1 \times V \times M/W_s$$

Where W_s = weight of sample,
V = volume of potassium hydroxide solution titrated,
M = molarity of potassium hydroxide.

2.3.3. Determination of free fatty acid

The acid value is equivalent to the percent free fatty acid multiplied by the factor of 1.986, when the percent free fatty acid is based upon oleic acid as reported by (Adefarati, 1986).

2.3.4. Determination of specific gravity

The density bottle was used in this determination. The density bottle was weighed and recorded as Y. the bottle was filled with water, weighed and recorded as X. The water was poured out and the bottle dried. After drying and cooling, it was then filled with the oil sample and recorded as Z. The specific gravity of the oil was calculated as:

Specific gravity = weight of oil/weight of water = Z-Y/X-Y

Where Y = weight of empty density bottle,

X = Weight of density bottle with water,

Z =Weight of density bottle with oil.

3. Results and discussion

3.1. Oil yield

Table 1 shows the effect of temperature and pressure on oil yield for mechanical expression. It can be seen that there was little change in percentage oil yield (16.8-16.94%) as extraction pressure increased from 5 to 8N/m^2 at 40^{o}C. Gikuru and Lamech (2007) studied the yield characteristics during mechanical oil extraction of preheated and ground soybeans. They reported a significant increase in oil yield as pressure increase from 50 to 70kgf/m^2. However, for the effect of temperature, there was an increase in percentage oil yield from 16.8 to 24.72% as temperature increased from 40^{o}C to 80^{o}C at 5N/m^2. Suparno et al., (2006) investigated the optimization of rubber seed (Hevea brasiliensis) drying in rubber seed oil extraction for chamois leather and tanning and obtained maximum oil yield of 20.52% while Aigbodion and Bakare (2005) reported maximum oil yield of 23% from rubber seed. The cause of the increase yield with temperature is not definitely known but is often attributed to reduced viscosity of the oil in the capillaries of the vegetable matter (Fasina and Ajibola, 1989).

Table 1
Effect of temperature and pressure on percentage oil yield for mechanical expression

Pressure(N/m^2)	% Oil yield				
	40^{o}C	50^{o}C	60^{o}C	70^{o}C	80^{o}C
5	16.80	18.83	20.92	23.02	24.72
6	16.84	18.84	20.96	23.36	24.92
7	16.88	18.88	21.28	23.44	25.17
8	16.94	19.54	21.32	23.68	26.24

For solvent extraction, there is significant increase in percentage oil yield (15.8-35.80%) as time of extraction increase from 5 to 35min at a fixed temperature of 60^{o}C as shown in Fig. 1. A maximum oil yield of 35.80% was obtained in this study. Nwokolo et al (1988) and Uzu et al (1986) in their separate work on extraction of oil from rubber seed obtained a maximum oil yield of 43%. Kyari (2008) studied extraction and characterization of seed oils and obtained a maximum oil yield of 34% for Butyrospermum parkii, 33% for Sterculia setegeraa, 40% for Lophira lanceolata and 42% for Schorocarya birrea. The percentage oil yield obtained from solvent extraction was higher than the yield obtained from mechanical expression. Uzu et al (1986) obtained the same result.

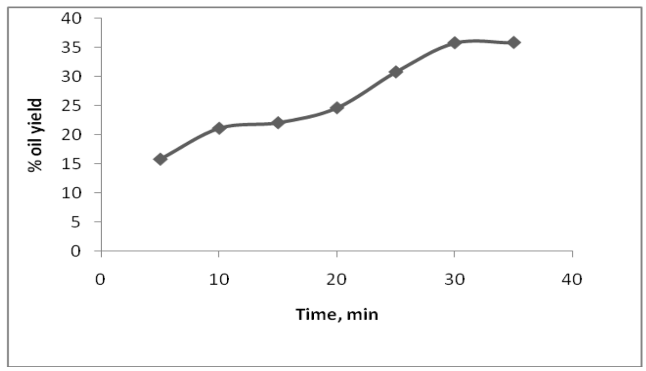

Fig.1. Effect of extraction time on percentage oil yield.

3.2. Physico-chemical analysis

The effect of temperature on iodine value of RSO is shown in Fig. 2. It can be seen that the iodine value decreased with increase in temperature indicating a decrease in unsaturation of the oil which may be due to the polymerization of the oil molecules. The maximum iodine value obtained in this study was 120.1 g I_2/100g. Aigbodion and Bakare (2005) in their study on rubber seed oil quality assessment and authentication obtained a maximum iodine value of 136 while Suparno et al (2006) in their study on rubber seed oil reported a maximum iodine value of 146. The iodine value for other seed oils were 52 for palm oil (Onyeike and Achoru, 2002), 106 for perah seed oil (Yong and Jumat, 2006), (99-119) for cotton seed oil and (103-128) for corn seed oil (Gunstone et al., 1994). The iodine value falls within the range of 100-140 which confirms that rubber seed oil is a semi-drying oil and can be used in the preparation of alkyd resin for production of paint (Aigbodion and Bakare, 2005).

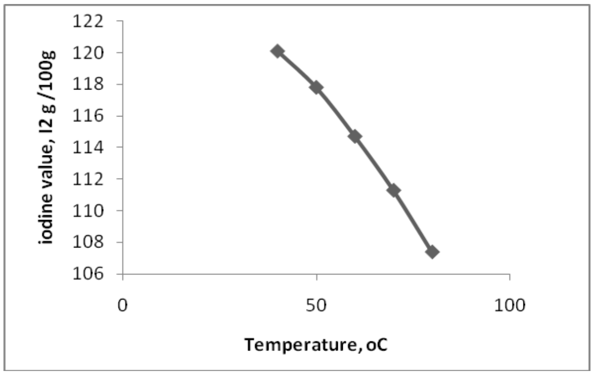

Fig. 2. Effect of temperature on iodine value.

Fig. 3 and 4 depict the effect of temperature on the acid value and percentage free fatty acid of RSO respectively. It can be seen that acid value and % FFA increased with increase in temperature. This is due to the splitting of the oil molecules into fatty acids and glycerol as temperature increased. The maximum values of percent FFA and acid value was obtained were 24.97% as oleic and 49.65mg KOH/g respectively, which shows that rubber seed oil is highly acidic, implying that larger amounts of polyol will be required in the transesterification reaction leading to the formation of alkyds. Aigbodion and Bakare (2005) obtained maximum percent FFA (as oleic) of 21.40% and acid value of 43.62mg KOH/g, while Suparno et al (2006) obtained maximum acid number of 2.08mg KOH/g and FFA of 1.04%. Bashir and Jumat, (2009) carried out physico-chemical properties of Malaysian and Nigerian rubber seed oils and reported % FFA values of 7.55 and 21.40 for Malaysian and Nigerian RSO and acid values of 15.03 and 43.62 for Malaysian and Nigerian RSO respectively .

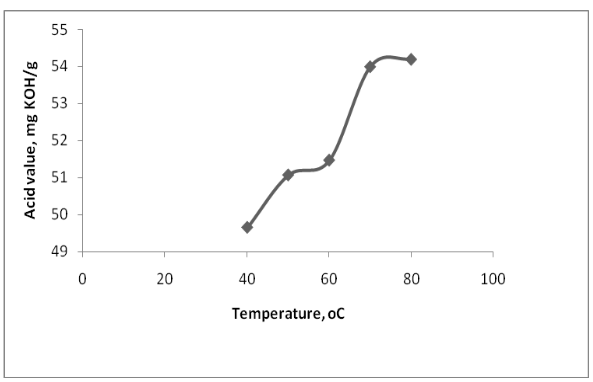

Fig. 3. Effect on temperature on acid value.

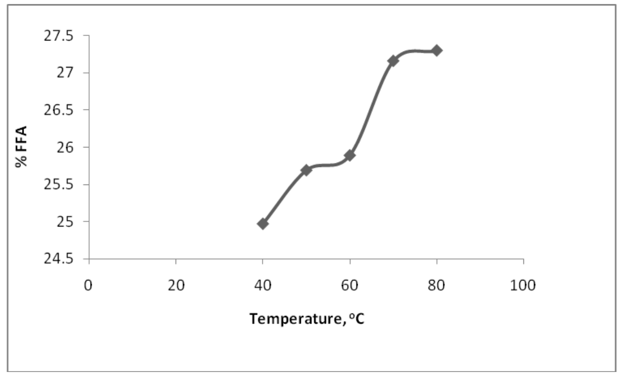

Fig. 4. Effect of temperature on percentage free fatty acid.

The effect of temperature on specific gravity of RSO is shown in Fig.5. The specific gravity increased slightly as temperature increased. The specific gravity obtained in this work is comparable to those of known vegetable oils and seems to indicate that no heavy element is present in the oil (Adefarati, 1986). Aigbodion and Bakare (2005) reported 0.916 for specific gravity of rubber seed oil at 30^{o}C.

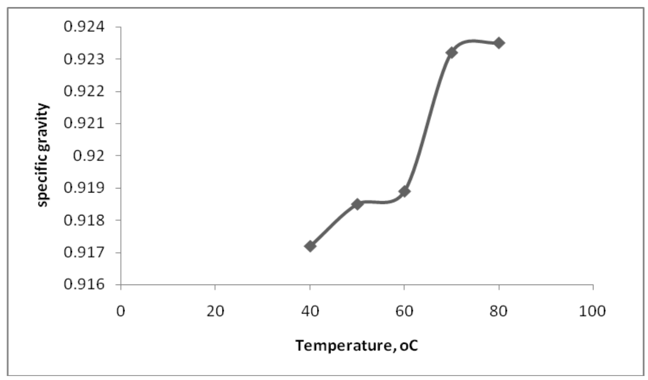

Fig. 5. Effect of temperature on specific gravity.

4. Conclusion

The effect of process variables on the physico-chemical properties and oil yield of rubber seed was studied. For mechanical expression oil yield was found to be dependent on temperature but independent of pressure. Oil yield increased with increase in time for solvent extraction. Physico-chemical analysis of the oil shows that it is semi-drying oil and has properties similar to that of linseed oil which means that it can partly replace linseed oil in industrial processes.

References

Adefarati, F.B., 1986. Development of non- edible oils for use in the Nigerian surface coating industry with particular reference to rubber (Hevea brasiliensis) seed oil for manufacture of air-drying oil modified alkyds. In: E.E Enabor (ed). In: Industrial utilization of natural rubber (Hevea brasiliensis) seed, latex and wood, RRIN Benin city.27-38.

Aigbodion, A. I., Bakare, I.O., 2005. Rubber seed oil quality assessment and authentication. Journal of American Oil Chemical Society, 82, 465-469.

Aigbodion, A.I., Okieimen, F.E., Ikhuoria, E.U., Bakare, I.O., Obazee, E.O., 2003. Rubber seed oil modified with maleic anhydride and fumaric acid and their alkyd resins as binders in water-reducible coatings. J.Polym. Sci., 89, 3256 – 3259.

Basher, M.A., Jumat, S., 2009. Physicochemical characteristics of Malaysian rubber (Hevea brasiliensis) seed oil. European Journal of Scientific Research, 1(3), 437-445.

Chin, H.F., Enoch, I.C., Rajaharun, R.M., 1977. Seed Technology in the Tropics. Faculty of Agriculture, University Putra Malaysia Publishing, Kuala Lumpur, Malaysia.

Fasina, O.O., Ajibola, O.O., 1990. Mechanical expression of oil from conophor nut (Tetracarpidium conophorum). Journal of Agric. Engr. Res., 44, 275-287.

Gandhi, V.M., Cheriank, M., Mulky, M.J., 1990. Nutritional and toxicological evaluation of rubber seed oil. Journal of American Oil Chemical Society, 67, 883-886.

George, K.T., Reghu C.P., Nehru, C.R., 2000. By products and ancillary source of income. In: Natural Rubber Agromanagement and Crop Processing (Ed. PJ George and C. Kuruvilla Jacob), Rubber Research Institute of India, Kottayam. 509-520.

Gikuru, M., Lamech, M., 2007. A study of yield characteristics during mechanical oil extraction of preheated and ground soybeans. Journal of Applied Sciences Research, 3(10), 1146-1151.

Gunstone, F.D., John, L.H., Fred, B.P., 1994. The Lipid Hand Book, Second ed. Chapman & Hall Publishing, United States of America, New York.

Hosen, S.B.M., Chin, H.F., Hor, Y.L., 1981. Fruit and seed development in *Hevea* (clone RRIM600) in Malaysia. Journal of Rubber Research Institute of Malaysia, 32(1), 101 – 110.

Ikhuoria, E.U., Aigbodion, A.I., Okieimen, F.E., 2005. Preparation and characterization of water-reducible alkyds with fumarized rubber seed oil. Progress in Organic Coatings, 52, 238-240.

Ikwuagwu, O.E., Ononogbu, O.U., Njoku, O.U., 2000. Production of biodiesel using rubber seed oil. Ind. Crops Products, 12, 57 -62.

Iyayi, A.F., Akpaka, P.O., Ukpeoyibo. U., Balogun, F.E., Momodu, I.O., 2007.Rubber seed oil: An oil with great potentials; Chemtech J., 3, 507 –516.

Kyari, M.Z., 2008. Extraction and characterization of seed oils. Int. Agrophysics. 22, 139-142.

Njoku, O.U., Ononogbu, I. C., 1995. Preliminary studies on preparation of lubricating greases from bleached rubber seed oil. Ind. J.N.R Res, 8(2), 140 – 141.

Nwokolo, E., Kitts, D.D., Kanhai, J., 1988. Serum and liver lipids of rats fed rubber seed oil. Plant Foods for Human Nutrition, 38, 145-153.

Onyeike, E.N., Acheru, G.N., 2002. Chemical composition of selected Nigerian oil seeds and physicochemical properties of the oil extracts. Food Chemistry, 77, 431-437.

Perera, Edi H., Dunn, P.D., 1990. Rubber seed oil for diesel engines in Sri-lanka. J. Rubb. Inst. Sri-Lanka, 70, 11- 25.

Ramadhas, A.S., Muraleedharan, C., Jayaraj, C., 2005. Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil. Renewable energy, 30, 1789-1800.

Suparno, O., Ika, K., Muslich, Gita, N.A., Dan, K.S., 2006. Optimization of rubber seed (Hevea brasiliensis) drying in rubber seed oil extraction for chamois leather tanning. J. Tek. Ind. Pert., 19(2), 107-114.

Uzu, F.O., Ihenyen, G.A., Imoebe, S.O., 1986. Processing, analysis and industrial utilization of natural rubber (Hevea brasiliensis) seed and cake. In: E.E Enabor (ed). In: Industrial utilization of natural rubber(Hevea brasiliensis) seed, latex and wood. RRIN Benin City. 19 –26.

Vijayagopalan, K., 1971. Factice from rubber seed oil. Rubber Board Bulletin, 11(2), 48 -51.

Yong, O.Y., Jumat, S., 2006. Characteristics of Elateriospermum tapos seed oil as a new source of oilseed. Industrial Crops and Products, 24, 146-151.