VEGETABLE OIL FROM FRUITS OF FOREST SPECIES

M. A. Razzaque
M. Sayeed
S. C. Das

Studies were conducted to assess the possibility of commercial exploitation of fruits and seeds of forest species to meet the shortfall in industrial and edible vegetable oils in the country. Seeds from 15 forest species were collected from various forests of Bangladesh. In cases where the seed coat could be detached, the weight ratio of seed-coat to kernel was worked out. Oil content of kernel, pulp or whole seed was determined by solvent extraction process, depending on the ease or otherwise of separation of the coat. The free fatty acid content, saponification value and iodine value of the extracted oil samples were determined. High percentages of oils were obtained from most of the species under investigation. Slightly lower yield is likely to be obtained when oil is extracted by expression process.

Comparative lower yield of oil obtained from *Shorea robusta, Pongamea Pinnata, Aleurites montana* and *Garcinia cowa* than that obtained in other countries is thought to be due to various degrees of deterioration set in the seeds collected from the forest bed. Acceptable grades of edible oils may be produced from several species.

INTRODUCTION

Bangladesh is deficient in vegetable oils. Indigenous sources of vegetable oils are the agricultural oil crops. Soyabean, coconut, sunflower and other vegetable oils are imported to supplement the quantity produced in the country. Because of acute shortage of agricultural land, the possibility of increasing oil production by bringing more agriculrural land under cultivation of oil crops is remote.

Under the conditions prevailing in Bangladesh, the oil seeds of forest species may become important as sources of vegetable oils and fats which may be used as human food or as raw material in industries for the production of commodities such as paint, varnish and soap. In many countries oil bearing seeds of forest trees have been established as important sources of vegetable oil. In Bangladesh, some oil-bearing seeds of forest trees are available in abundant quantities containing enough oil to be exploited commercially.

Seeds of some species may be found to be rich in oil content but may not be available in sufficient quantity for commercial exploitation. In that case, oil content of the seeds may be considered as an additional quality of the species for future afforestation.

MATERIALS AND METHODS

The seeds were collected through two different agencies of Forest Research Institute, Chittagong. Some of the seeds were found deteriorated when received. The general use characteristics of oils extracted from seeds of 14 forest species are given in Table 1 and described below :

1. **Aleurites montana** (Tung)

Tung oil is a quick drying oil (double the rapidity of linseed oil) and dries at a uniform rate instead of forming a skin like linseed oil. The oil does not need any alkali refining, as the acid number is ordinarily very low. When heated, it sets into a gel, the gelation time varying from 8 to 10 minutes (Manjunath 1948). It is an excellent material for manufacture of varnish of a high degree of water resistance, gloss and durability.

2. **Amoora spectabilis** (Rata) and **Amoora spp.** (Okyang)

Amoora oil, commonly known as Pitraj or Pittaraj, is suitable for manufacture of soap. There is some confusion about its proper botanical identity. Previously known as *Amoora ruhituka,* it is believed to be the synonym of *Aphanamixis polystachya.*

3. **Aphanamixis polystachya** (Pitraj)

The seeds contain 78% of kernel which yield 47% of a reddish-brown, semidrying oil (Manjunath 1948). The oil is used as a liniment in rheumatism and as illuminant. The oil has also been found suitable for manufacture of soap.

4. **Calophyllum inophyllum** (Sultana Champa, Ponyal)

The seeds contain 43–52% of kernel which yield 50–73% of a dark green viscous oil (Sastri 1950). Both the extracted and expressed oils possess a disagreeable odour and taste. The oil is excellent for soap manufacturing but unsuitable for edible purposes, because of the presence of toxic non-fatty constituents. It is used as an illuminant and in medicine. It can also be used in the manufacture of varnishes.

5. **Elaeis guineensis** (Oil palm)

There are various types of oil palm grown in different countries of the world. The percentage of shell varies from type to type (Eckey and Miller 1954). Macrocarya (Congotype), Dura (Deli type), Tenera (Liscombe type) and Pisifera type have 50, 30, 10 and 0 per cent of shell respectively. Oil percentage also varies from

Table 1. Characteristics of oils of forest seeds under investigation (Collected from Wealth of India, Raw Materials, Vols. I, II, V, VI, VIII and IX)

Species	Local name	Specific gravity	Major Acids and other Components (%)					
			Acid value	Palmitic	Oleic	Stearic	Linoleic	Others
1. *Aleurites montana*	Tung	0.92	3.4	51.5	4	–	–	–
2. *Amoora spectabilis, Amoora* spp.	Rata, Okyang	–	–	–	–	–	–	–
3. *Aphanamixis Polystachya*	Pitraj	0.93	13.7	–	–	–	–	–
4. *Calophyllum inophyllum*	Sultana Champa, Ponyal	0.94	27–28	17	50	10	11	–
5. *Elaeis guineensis*	Oil palm Pulp Kernel	0.90 0.90–0.91	– –	40–46 16–19	39–45 13–19	3–5 1	7–11 –	Lauric 46–52, Myristic 14–17
6. *Garcinia cowa*	Kau	–	–	–	–	–	–	–
7. *Hydnocarpus Kurzii*	Chaulmoogra	0.93–0.97	20–30	–	6.5	–	–	Hydnocarpic 49, Chaulmoogric 27, Gorlic 12
8. *Mallotus Philippinensis*	Sinduri, Kamala	0.94	5–11	9	13	–	12	Kamlolenic 59, Elaeostearic 38
9. *Mesua ferrea*	Nageswar	0.96	6–31	8	55-66	10–16	10–20	–
10. *Mimusops elengi*	Bakul	0.95	2.2	11	64	10	15	–
11. *Pongamia pinnata*	Karanja	0.93	6.3	4–8	44-71	2–9	11–18	Arachidic 2–5, Eicosenoic 10-12
12. *Schleichera oleosa*	Kusum, Jaina	0.86–0.92	13.1–19.2	2	52	10	–	Arachidic 20, Gadoleic 9
13. *Shorea robusta*	Sal	0.92	6.0	5	42	44	3	Arachidic 6
14. *Zanthoxyllum budrunga*	Bajna	0.90	36.1	–	–	–	–	l–sabinene 36, l–pinene 18, b–pinene 12, Carene 16

type to type. The oil is generally extracted by roller mills. The mesocarp is broken down sufficiently to rupture a high proportion of the oil-containing cells (Hartley 1977). Two types of oil are obtained from the fleshy mesocarp and the seed kernel. The Deli type yields 29% oil from the mesocarp while the seed kernel yields 44–53% of oil. The kernel is 6% of the total weight of the fruit (Eckey and Miller 1954). Good quality palm oil has a characteristic odour and taste and a pale yellow to deep orange colour. The orange colour is due to the presence of carotene (0.05–2%). The carotene is a precursor to Vitamin A. Palm oil is extensively used in cooking and the manufacture of margarine and soap. Other uses include ice cream manufacture, cocoa, butter substitute, confectionery and bakery.

6. **Garcinia cowa** (Kau)

The fruits of the Kau plant are edible, though not very palatable due to their acid taste. They can be made into Jam or preserve. In Assam the dried fruit is considered useful in dysentery (Bor 1953). The seeds are supposed to contain some oil, but no reference is available in the literature.

7. **Hydnocarpus Kurzii** (Chaulmoogra)

The seeds contain 73–85% kernel which yields 48–55% yellow or brownish yellow oil with a characteristic odour of rancid butter. Chaulmoogra oil has been in use in the treatment of skin diseases and leprosy for many centuries (Sastri 1959). Ayurvedic system of medicine and British pharmacopoeia have praised this oil for this use. Indian pharmacopoeia has officially recommended this oil for external application. The ethyl ester of the oil is also used in therapy.

8. **Mallotus Philippinensis** (Sinduri, Kamala)

The pale white seed kernels (60% of seed weight) yield on solvent extraction 35–36% of a viscous dark brown to pale yellow oil or semisolid fat. Owing to its high viscosity the oil cannot be extracted by expression. The oil is of dark colour due to the presence of kamala dye (Sastri 1962). Because of its rapid drying characteristics it is used as substitute of Tung oil in varnish and paint industries. It may also be used in formulations of hair fixers and ointment.

9. **Mesua ferrea** (Nageswar)

Mesua ferrea seeds, 300–400/kg, has 53–73% kernel and yield 67–77% of a viscous, reddish or dark-brown oil with disagreeable odour and a bitter taste (Sastri 1962). Physico-chemical characteristics vary greatly for seeds collected from different localities. The oil is suitable for soap making when the colour is improved by caustic treatment followed by bleaching with activated carbon.

10. **Mimusops elengi** (Bakul)

The seed kernel of the fruit of Bakul yields 16–20% of a fatty oil used for edible and lighting purposes. The crude oil is tasteless, but has a reddish brown colour with an unpleasant odour. The refined oil is odourless and colourless, but acquires a yellow tint on exposure to air (Sastri 1962).

11. **Pongamia pinnata** (Karanja)

Karanja seeds contain 29–39% of a fatty oil which is used for leather dressing, soap making, lubrication, illumination and for medical purposes (Krishnamurthi 1969). The yield, however, from expellers and village crushers is much lower (18–27.5%). Crude pongamia oil has a yellowish orange to brown colour which darkens on storage. It possesses a disagreeable odour and a bitter taste.

12. **Schleichera oleosa** (Kusum, Jaina)

Kusum seeds yield an oil commercially known as Macassar oil. The kernels constitute 60–65% of the seeds. The fat content of the kernel varies from 59–72%. Oil yield from the bullock ghani is from 25–27% (Chadha 1972). The Kusum oil is a yellowish brown semisolid with faint odour of bitter almonds. Kusum oil has long been used for hair dressing. It is used in cooking and for lighting purposes. Other uses include lubrication for machinery and skin liniment for itch, acne and burns. It is also reported to be useful in rheumatism. For cooking purposes it must be properly refined to remove cyanogenetic glucosides. It is a common adulterant of mustard oil. It could as well be used for soap manufacture.

13. **Shorea robusta** (Sal)

The oil from Sal seeds is similar to that obtained from Kusum seeds. The oil, known as Borneo tallow in the trade circle, is used in the chocolate trade. The kernel is 72% of the total seed weight. Oil yield is 19–20% (Chadha 1972). The oil is greenish white to whitish in colour. The fat is obtained by boiling husked seeds in water and skimming off the oil, which solidifies to a buttery consistency (M. P. 37°C). The oil is locally used for cooking, lighting and as adulterant in ghee. This is suitable for manufacturing soap.

14. **Zanthoxyllum budrunga** (Bajna)

The fruits yield an essential oil called Mullilum oil which is obtained by steam distillation of the dried ripe fruits. The oil has a pleasant odour resembling that of sweet orange. It is used in the indigenous system of medicine for the treatment of Cholera. The oil is used as an antiseptic and disinfectant. Reportedly the oil has local anaesthetic action. The seeds yield c 30% of a non-drying fatty oil which is suitable for soap making and for edible purposes after refining.

EXPERIMENTAL

The oil content of the seeds was determined by solvent extraction process as described in the manual of American Oil Chemists' Society (Mehlenbacher and Hopper 1946). The following characteristics of the fruits/seeds and oils were determined :

1. Ratio of seed coat to kernel in possible cases
2. Oil content of pulp or kernel
3. Acid value of the oil
4. Saponification value of the oil
5. Iodine value of the oil

For extraction, petroleum ether in the boiling range of 60° to 80°C was used.

RESULTS AND DISCUSSION

Data pertaining to the characteristics of fruits/seeds and oils obtained therefrom are given in Table 2. The oil has been extracted from various parts of the fruits of the forest species. It can be seen from the Table that there is a wide variation in the ratio of seed coat to kernel in the

Table 2. Yield and chemical properties of oils and fats of forest seeds

Species	Seed coat/ kernel ratio	Oil content of kernel(%)	Acid value	Saponification value	Iodine value
1. Tung	0.86	12.96	0.7	198	159.40
2. Rata	–	43.88	0.8	192	53.60
Okyang	–	1.77	–	–	–
3. Pitraj	0.18	36.53	1.0	184	32.30
4. Sultana Champa, Ponyal	–	58.38	15.2	192	20.80
5. Oil palm	2.78	60.22* 35.22	22.5	204	8.50
6. Kau	0.63	12.47	9.6	–	–
7. Chaulmoogra	0.40	46.30	0.4	180	47.60
8. Sinduri, Kamala	–	28.43	11.6	–	–
9. Nageswar	0.39	65.26	1.0	195	25.30
10. Bakul	0.89	45.31	8.7	–	–
11. Karanja	2.10	8.38	2.6	198	–
12. Kusum, Jaina	0.23	68.05	24.4	177	14.60
13. Sal	0.43	9.18	9.8	202	19.20
14. Bajna	0.89	28.33	10.2	128	–

*From pulp

seeds. The oil is generally stored in the kernel. When the seedcoat could not be easily peeled off, the whole seed was ground and used for extraction of oil. In cases where the whole fruit was used, the oil was extracted from the pericarp and mesocarp (pulp). In some cases, as with oil palm, the oil was extracted both from the pulp and the kernel.

When the oil was extracted from the kernel, the results have been expressed as percentage of the kernel weight and not of the whole seed or the fruit. In case of oil palm, the percentage of oil from the pulp has been expressed as that of the combined weight of pericarp and mesocarp. It can be seen from Table 2 that nine out of the 14 species under study have over 28% of oil in the kernel. Oil palm has a very high percentage of oil in the pulp. It may, however, be mentioned here that oil yield from the mechanical expellers may not be as high as obtained here by solvent extraction process. Complete removal of oils from oil-cakes cannot be ensured by any mechanical process of expression. Moreover, during solvent extraction, certain amounts of extraneous matters are always obtained along with the oil. In commercial exploitation, hot water floatation process may yield better results than bullock expellers.

It may be seen from Table 2 that oil contents of some of the species are rather low. This lower yield, compared to that obtained in India and elsewhere, especially in the cases of *Shorea robusta*, *Pongamia pinnata*, *Aleurites montana* and *Garcinia cowa* may be due to the defects in the process of collecting research materials through different agencies. Some of the seeds supplied, for example, were not fully mature and some were received at various degrees of deterioration. Under better condition of collection, higher yields of oil are expected. It seems that promptness in collection and processing will be an important factor in commercial exploitation of forest seeds.

Free fatty acid contents of the extracted oils expressed as Acid values roughly indicate the degree of edibility of the oil concerned. A high free fatty acid content makes the oil disagreeable to the stomach. This value for oils of some of the known edible oils under investigation, such as *Elaeis guineensis*, *Schleichera oleosa*, *Zanthoxyllum budrunga*, *Shorea robusta* and *Calophyllum inophyllum* is higher than those of most other species under investigation. These values are somewhat higher than those obtained in other countries. This minor variation may be due to differences in climatic and soil conditions. The chemical nature of the oils may also somewhat change with the process of extraction. The solvent extraction process used in the present work is likely to leave some colouring matter, waxes and unsaponifiable matters. The presence of these extraneous matters in the oils may somewhat change the quantities of free fatty acids in the oils. Oils obtained by hot water floatation process or by expression of oil from the seeds in mechanical expellers, are likely to contain lower quntities of free fatty acids.

The saponification and iodine values of most of the species indicate the suitability of these species for use in the manufacture of soap, paint, varnish and other industrial products. Some of the oils, especially Chaulmoogra, Pitraj, Kau and Kusum have good medicinal values. The kernel oil from oil palm has good percentages of lauric and myristic acids. Specialized use of these oils could be made in industry. It is interesting to note that Bajna oil has a number of alkaloids as its constituents, which might make it suitable for the manufacture of medicine.

REFERENCES

Bor, N. L. 1953. Manual of Indian Forest Botany, Oxford University Press, London : 201–202

Chadha, Y. R. (Chief Ed.) 1972. The wealth of India (Raw materials), Vol IX : 253 pp

Eckey, E. W. and Miller, L. P. 1954. Vegetable fats and oils, Reinhold Publishing Corporation, New York : 322–334

Hartley, C. W. S. 1977. The oil palm., Longman, London, New York. 693 pp

Krishnamurthi, A. (Chief Ed.) 1969. The Wealth of India (Raw materials), Vol : VIII. 206 pp

Manjunath, B. L. (Chief Ed.) 1948. The Wealth of India (Raw materials), Vol 1 : 46–47 and 253

Mehlenbacher, V. C. and Hopper, T. H. 1946. Official Tentative Methods of American Oil Chemists' Society, Illinois, U. S. A.

Sastri, B. N. (Chief Ed.) 1950. The Wealth of India (Raw materials), Vol II : 19 pp

————————1959. The Wealth of India (Raw materials), Vol V. 141 pp

————————1962. The Wealth of India (Raw materials), Vol VI. 232, 352 and 384

M. A. Razzaque, Divisional Officer, M. Sayeed and S. C. Das, Field Investigators, Forest Research Institute, Chittagong, Bangladesh