Cryptostegia grandiflora — a potential multi-use crop

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Abstract

Cryptostegia grandiflora, a member of Asclepiadaceae, was evaluated as a potential multi-use crop. The plant contained 14.0% protein, 6.5% oil, 6.9% polyphenol, and 2.13% hydrocarbon. The gross heat value of the species was 3878.0 cal/g, while the oil fraction was 7350.1 cal/g, and the hydrocarbon fraction was 9300.0 cal/g. The NMR spectra of the hydrocarbon fraction reveals the presence of cis-polyisoprene (natural rubber). The oil fraction contains both saturated and unsaturated fatty acids including: lauric acid (trace), myristic acid (15.24%), palmitic acid (25.90%), stearic acid (3.8%), oleic acid (8.0%), linoleic acid (24.76%), and arachidic acid (22.28%). The high proportion of saturated fatty acids and the high oil content (> 5.0%) make C. grandiflora a potential source for industrial raw material and alternative for conventional oil. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Cryptostegia grandiflora; Gross heat value; Fatty acid; Hydrocarbon; Polyphenol; Protein; Oil

1. Introduction

Currently there is a renewed interest in developing alternate crops to meet the everlasting demand for fuels, chemicals, and industrial feedstocks. New crops evaluated for these characteristics could be grown in underutilized areas providing needed raw materials, and subsequently stimulate economic growth. This has promoted the need to identify and evaluate potential plant species with multi-uses.

Cryptostegia grandiflora R.Br. (Asclepiadaceae), is a laticiferous woody climbing shrub. It grows profusely without any agronomic management and survives well under extreme environmental conditions such as high temperature and limited water supply. It could be cultivated as an intercrop with other trees especially in teak farms, or along with neem, Jatropha curcas planted as hedge plants. During World War II, C. grandiflora was used as a source of natural rubber (Bagby et al., 1981). The objective of the present study was to analyse the phytochemicals of the plant parts of C. grandiflora as an intermediate energy source.
2. Material and methods

2.1. Extraction of chemical constituents

Plant samples were randomly collected in and around the V.H.N.S.N. college campus from healthy plants belonging to more or less of same age group with almost similar height, circumference growing in same agro-climatic zones from a minimum of 15 populations, each containing 10–20 plants with a total fresh weight of 2000–2500 g and composited into one sample for chemical analyses. Each sample was subsampled twice. *C. grandiflora* was clipped at ground level including the leaves and flowers, allowed to dry, and then ground in a Wiley mill equipped with a 1-mm diameter sieve. Extractable fractions were removed from the plant debris using acetone followed by hexane in a soxhlet apparatus for a minimum of 24 h per solvent. The acetone extract was allowed to dry and partitioned between hexane and aqueous ethanol (water:ethanol, 1:7) to obtain fractions of ‘oil’ and ‘polyphenol’, which were oven dried and weighed gravimetrically for yield. The ‘hydrocarbon’ fraction was also oven

dried and gravimetrically weighed for yield after removal of the hexane (Buchanan et al., 1978a,b).

2.2. Analytical analysis

Ground subsamples were analysed for ash content using the method of Goering and Van Soest (1970). Protein content was determined by the Kjeldahl method (AOAC, 1980) and the oil fraction was saponified by conventional procedure (Allen et al., 1982).

NMR spectra of hydrocarbon fractions were recorded using a Bruker AC 300F NMR spectrometer (300 MHZ) with tetramethylsilane (TMS) as the internal standard and (deuterochloroform) CDCl₃ as the solvent.

Gross heat values of plant subsamples, oil fraction, and hydrocarbon fraction were determined using a Toshniwal, Model cc.O.1, Bomb calorimeter (Anon., 1966).

Fatty acid composition of the oil fraction was analysed using methyl esters of the fatty acids and a GLC equipped with a SE 30 column (Metcalfe and Wang, 1981).

2.3. Statistical analysis

Three replications of each subsample were evaluated for extraction of chemical constituents, protein, ash content and gross heat value. Values in Table 1 are the means of three replications, ± S.D.

3. Results and discussion

3.1. Chemical composition of constituents

*C. grandiflora* is a stout woody climbing shrub suitable for annual pollarding. Calvin (1984) reported that latex of *Euphorbia* spp. and *Calotropis procera* is an emulsion of oil and water similar in terms of composition to that of natural latex rubber. The hydrocarbon can be a smaller molecule with low molecular weight. Plant materials of *C. grandiflora* have an oil content of 6.5%, polyphenols of 6.9%, hydrocarbons of 2.13%, and a protein concentration of 14%. The appearance

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**Table 1**

<table>
<thead>
<tr>
<th>Source</th>
<th>Gross heat value (dry) (cal/g)</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant sample</td>
<td>3878.0 ± 18.7</td>
<td>0.18 ± 0.04</td>
</tr>
<tr>
<td>Oil fraction</td>
<td>7350.1 ± 20.6</td>
<td></td>
</tr>
<tr>
<td>Hydrocarbon fraction</td>
<td>9300.0 ± 12.1</td>
<td></td>
</tr>
<tr>
<td>Rice straw hulls</td>
<td>3333.0 b</td>
<td></td>
</tr>
<tr>
<td>Lignite coal</td>
<td>3888.0 b</td>
<td></td>
</tr>
<tr>
<td>Cattle manure</td>
<td>4111.0 b</td>
<td></td>
</tr>
<tr>
<td>Corn cobs</td>
<td>5167.0 b</td>
<td></td>
</tr>
<tr>
<td>Municipal refuse</td>
<td>5278.0 b</td>
<td></td>
</tr>
<tr>
<td>Methanol</td>
<td>5353.0 b</td>
<td></td>
</tr>
<tr>
<td>Anthracite coal</td>
<td>7111.0 b</td>
<td></td>
</tr>
<tr>
<td>Fuel oil (Mexico)</td>
<td>10,308.0 b</td>
<td></td>
</tr>
<tr>
<td>Crude oil</td>
<td>10,531.0 b</td>
<td></td>
</tr>
<tr>
<td>Gasoline</td>
<td>11,256.0 b</td>
<td></td>
</tr>
</tbody>
</table>

* Values are means of three replicates, ± S.D.

of the plant oil fraction was dark with a property of melting at slightly above room temperature (20°C) into a low viscosity fluid. According to Hopkins (1999), the same plant yielded 13% of oil, which clearly indicates that the difference in the agro-climate/environmental condition have a role on the quantity of phytocontents. Generally solvent extraction or cold pressing would be more efficient to extract oil in minimal quantities. Polyphenol fractions can be a mixture of phytochemicals including a variety of lipids, tannins, and phlobaphenes (Carr, 1985). In the future, these types of constituents may contribute substantially to the manufacturing of various adhesives, phenolic resins and antioxidants. Potential uses of oils and polyphenols have been reported by Buchanan et al. (1978a) and Wang and Huffman (1981). The saponification value for C. grandiflora plant extract was 245.7 which is higher than that of mango seed oil with 212.8. This indicates the presence of low molecular weight triglycerides and low molecular weight acids (Raman et al., 1997).

3.2. Gross heat value

The gross heat values of the plant sample, oil fraction, and hydrocarbon fraction indicates that it might potentially be useful as an intermediate energy source (Table 1). The gross heat value of the plant sample was 3878.0 cal/g which is higher than that of rice straw hulls with 3333.0 cal/g. The very low ash content of the plant (0.18%) may be a positive attribute as a fuel source. High ash content has a negative influence on the gross heat value (Van Emon and Seiber, 1985). The gross heat value of the oil fraction was 7350.1 cal/g. The low gross heat value of oil fraction compared to crude oil (Table 1) might be due to the presence of unsaturated fatty acids. This agrees with the work of Goering et al. (1982) on fuel properties of vegetable oils which indicates that with fewer hydrogen atoms, there is a greater unsaturation which decreases the gross heat value. The gross heat value of the hydrocarbon fraction was 9300.0 cal/g. The value is dependent on the composition of the substances such as rubber, gutta, waxes and their molecular weights. The gross heat value of oil fraction and hydrocarbon fraction are significantly higher in C. grandiflora than that of anthracite coal with 7111.0 cal/g. The gross heat value of the hydrocarbon fraction is also comparable with that of crude oil with 10531.0 cal/g.

3.3. NMR analysis

The NMR spectra of hydrocarbon fraction revealed the presence of natural rubber, (cis-polyisoprene) by producing a peak at 1.68 ppm (Chen, 1962). Some plant species produce low molecular weight natural rubbers which can be used as plasticizing additive (processing aids) for rubber mixes, for liquid rubber processing methods, or for making adhesive cements (Buchanan et al., 1980).

3.4. Fatty acid composition

The oil fraction of C. grandiflora contained saturated fatty acids with trace amounts of lauric acid (12:0), 15.24% myristic acid (14:0), 25.90% palmitic acid (16:0), 3.80% stearic acid (18:0) and 22.28% arachidic acid (20:0). The unsaturated fatty acids observed were oleic acid (18:1) with 8.0%, linoleic acid (18:2) with 24.76%. The fatty acid composition of oil is one of the key factors that determines the potential use of oils as an alternate fuel source such as diesel fuel for engines. The larger size of vegetable oil molecules (three or more times larger than hydrocarbon fuel molecules) and the presence of oxygen in the molecule suggest that some fuel properties of vegetable oils would differ from hydrocarbon fuels. Viscosity increases with an increase in chain length and decreases with an increase in number of double bonds (Goering et al., 1982). Cetane number which is one of the prime indicators of the quality of a fuel increases with increasing saturation as well as with increasing size of the ester group (Knothe et al., 1996). Normally, plants have C16 and C18 as the chief fatty acids, but the latex bearing plants have long chain fatty acids, such as C20–C30 (Nemethy et al., 1979). Oil with a high percentage of palmitic acid could be used in the preparation of palmitates of vitamin A and chloramphenicol (Balaji, 1995).
4. Conclusions

Diesel fuel contain both saturated and straight or unbranched chain unsaturated hydrocarbons. The presence of latter in minimal quantity will not present a problem for fuel oxidation. The straight chain structure is preferred for better ignition (Goering et al., 1982). In the present investigation, the proportion of the saturated fatty acids in oil from C. grandiflora, is higher than that of the unsaturated fatty acids. Moreover, C. grandiflora has an oil content of >5% showing promise as potential new crop sources for industrial raw material and an alternative source for conventional oil. C. grandiflora need to be established only once as it is suitable for annual pollarding. The annual yields/ha are unknown, however, their yield will be comparable with the high biomass producing crops because of the former’s fast growth rates. It grows profusely without agronomic management which will reduce production costs. Furthermore, its ability to flourish on marginal arid and semi arid soil is an added advantage since its commercial development will not compete with other conventional agricultural crops or crop lands.

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References