Plants Species Evaluated for New Crop Potential

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About 500 plant species from various regions of the United States have been screened previously at the USDA Northern Regional Research Center for their multipurpose, energy-producing potential. Most collections have been from the rich flora of central Illinois. For this report, 92 additional species were collected from southern Illinois and evaluated by criteria previously established at this Center. Plant samples were analyzed for "oil," "polyphenol," "hydrocarbon," and protein. Oil fractions of selected species were analyzed for classes of lipid constituents and were saponified to determine yields of unsaponifiable matter and fatty acids. Hydrocarbon fractions of selected species were analyzed for rubber, gutta, and waxes. Average molecular weight and molecular weight distribution of rubber and gutta were determined. Of the 92 species, complete analytical data are presented for 16 selected species. Substantial quantities of oil were obtained from Philadelphus coronarius (5.0%; dry, ash-free sample basis), Cacalia muhlenbergii (4.1%), Lindera benzoin (4.1%), and Koelreuteria paniculata (4.0%). High yields of polyphenol were obtained from Acer ginnala (33.1%), Cornus obliqua (20.8%), and Salix caprea (20.0%). Maximum yields of hydrocarbon and protein were from Elymus virginicus (0.6%) and Lindera benzoin (11.1%), respectively. Data are discussed with respect to species previously analyzed at this Center.

In recent years, there has been considerable interest in developing alternate crops for supplementing our needs for fuels, chemicals, and feeds (Buchanan and Duke, 1981; Princen, 1983; Calvin, 1983). Interest became increasingly widespread immediately following the 1973 oil embargo, but later diminished to some extent as petroleum again became more available (Calvin, 1983; Bungay, 1982). An increasing number of agricultural and industrial concerns are impressed with the need for alternate crops. New crops grown in underused land areas could provide essential materials and stimulate industrial and economic growth.

Since 1974, our Center has screened 508 plant species in efforts to identify oil- and hydrocarbon-producing species with potential as multipurpose crops (Buchanan et al., 1978a,b; Bagby et al., 1980; Roth et al., 1982, 1984; Rawls, 1983). We have extended this screening program until at least another 500 new species are screened. Generally, information has been published on selected species using analytical and botanical criteria established at this Center as the primary basis for selection (Buchanan et al., 1978a).

This report discusses our evaluation of 92 additional species, bringing the total to 600 in 88 families. Complete analytical data are presented for 16 selected species.

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2 Northern Regional Research Center, Agricultural Research Service, USDA, Peoria, IL 61604. The mention of firm names or trade products does not imply that they are endorsed or recommended by the USDA over other firms or similar products not mentioned.

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A brief overview of previous data, including some information not in other reports is included in this report.

EXPERIMENTAL

Procedures used in this work have been partially reported by others (Buchanan et al., 1978a,b,c; Swanson et al., 1979) and updated as follows: Herbaceous species were collected as mature plants with seeds, clipped at ground level. Small shrubs were clipped at ground level, but large shrubs and trees were sampled by cutting the latest year's growth. Plant materials were collected from Jackson County, southern Illinois, between August and December of 1982 in quantities of about 1,000 g (dry basis) for each collection. Voucher specimens of all species are kept at the Northern Regional Research Center herbarium. Plant materials were allowed to dry in a sheltered area at temperatures ranging from about 60–90°F and then ground in a Wiley mill equipped with a sieve having 1-mm-diameter holes.

Milled samples were analyzed for moisture, ash (ignition at 600 ± 25°C), protein (Kjeldahl nitrogen × 6.25) and extractables.

Extractables were removed from a 50-g sample of each species with acetone and then with hexane in a Soxhlet apparatus for 48 h per solvent. Previously, cyclohexane was used, but hexane was found to give less variation in yields among replicate extractions and is now used routinely in single sample extractions. Care in completely removing acetone from the marc before hexane extraction has also improved reliability in yield of hexane extractables.

Acetone extracts were allowed to air dry in a fume hood and, then, partitioned between hexane and aqueous ethanol (water : ethanol, 1:7) to obtain fractions referred to as “oil” and “polyphenol,” respectively (Buchanan et al., 1980). After solvent removal, these fractions were oven dried (105°C, 2 h), weighed, and reported on a dry, ash-free basis.

After solvent removal, the “hydrocarbon” fractions from the second 48-h extractions were oven dried (105°C, 2 h), weighed, and examined by infrared (IR) spectroscopy for the presence of rubber, gutta, and waxes. Hydrocarbon fractions were redissolved in cyclohexane and then frozen until molecular weight (MW) and molecular weight distribution (MWD) of those containing polyisoprenes were determined by gel permeation chromatography (GPC). Previously, the hydrocarbon was not stored under conditions that would preclude MW deterioration. Recent work indicates that MW of rubber and gutta remains constant when kept frozen with exclusion of oxygen.

MW of rubber and gutta in hydrocarbon fractions were determined in tetrahydrofuran solution on a Waters Model ALC/GPC 244 Liquid Chromatograph with use of polystyrene standards. Five Waters M-Styrogel columns were used (10^6, 10^5, 10^4, 10^3 and 500 Å) at room temperatures (25–27°C) with an injection volume of 200 μL and a flow rate of 1 mL/min. A “Q” factor of 60.4 was used to convert chain length data to weight average molecular weight (Mw).

For thin-layer chromatography (TLC) and saponification of oil, pigments and polar materials were removed from each plant oil by warming a mixture of the oil, Darco S-51 activated carbon, Cellite (1 g each, w/w), and hexane (200 mL) over a steam bath for 10 min, and then filtering the mixture through Whatman no. 2 filter paper. The treated oils were spotted on TLC plates (Silica Gel 60, 0.25-mm-layer thickness, MCB Mfg. Chemicals, Inc.) with a 5-μL pipette. A standard mixture of sitosterol, oleyl alcohol, oleic acid, triolein, oleyl laurate, and squalene was spotted beside each oil. Chromatographs were developed with a mixture of hexane, diethyl ether and acetic acid (80:20:1). The plates were then dried, sprayed with aqueous 40% sulfuric acid-5% potassium dichromate and charred at 200°C for 5 min.

Oils were saponified by conventional procedures (Cocks and van Rede, 1966) and partitioned between aqueous ethanol (1:1) and hexane to yield primarily soaps (sodium salts of organic acids) and unsaponifiable matter, respectively. Soaps were acidified and then partitioned between aqueous ethanol (1:1) and hexane to yield polar materials (e.g., glycerol and salt) and free organic acids, respectively. Fractions containing polar materials were discarded, and the organic acid fractions were dried and weighed. TLC procedures described above were applied to unsaponifiable matter and organic acid fractions.

Infrared (IR) spectra of hydrocarbon films on sodium chloride discs were obtained with a Perkin Elmer Model 137 Spectrophotometer.