Table I. Color and Pigmentation Ruby and Star Ruby Juice Blends

sample	date	gardner color a/b	mg % carotene	mg % lycopene
Ruby	12/11/74	0.10	0.11	0.08
10% Star		0.30	0.16	0.15
20% Star		0.46	0.19	0.22
30% Star		0.63	0.24	0.28
Star Ruby		1.21	0.34	0.69
Ruby	1/21/75	0.14	0.13	0.06
10% Star		0.41	0.15	0.16
20% Star		0.48	0.21	0.18
30% Star		0.66	0.24	0.28
40% Star		0.77	0.27	0.32
Star Ruby		1.41	0.53	0.68
Ruby	3/18/75	0.13	0.14	0.05
10% Star		0.26	0.16	0.09
20% Star		0.38	0.20	0.15
30% Star		0.51	0.23	0.21
40% Star		0.63	0.29	0.28
Star Ruby		1.04	0.49	0.60
Ruby	12/8/75	0.18	0.11	0.06
10% Star		0.38	0.16	0.16
20% Star		0.47	0.19	0.22
30% Star		0.61	0.27	0.33
Star Ruby		1.21	0.54	0.74
Ruby	1/30/76	0.03	0.13	0.05
10% Star		0.20	0.16	0.13
20% Star		0.41	0.18	0.19
30% Star		0.46	0.22	0.28
40% Star		0.57	0.29	0.31
Star Ruby		1.07	0.56	0.63
Ruby	3/25/76	0.03	0.10	0.04
10% Star		0.17	0.11	0.07
20% Star		0.28	0.14	0.14
30% Star		0.39	0.17	0.17
40% Star		0.49	0.18	0.28
Star Ruby		0.89	0.31	0.57
Ruby	12/14/76	0.04	0.14	0.05
10% Star		0.26	0.18	0.17
20% Star		0.36	0.21	0.20
30% Star		0.53	0.23	0.24
Star Ruby		1.40	0.54	0.70
Ruby	2/22/77	0.07	0.13	0.05
10% Star		0.32	0.16	0.17
20% Star		0.49	0.18	0.21
30% Star		0.64	0.23	0.24
40% Star		0.75	0.34	0.25
Star Ruby		1.60	0.45	0.72
Ruby	3/23/77	0.03	0.09	0.04
10% Star		0.20	0.13	0.15
20% Star		0.38	0.22	0.19
30% Star		0.43	0.26	0.23
40% Star		0.55	0.29	0.30
Star Ruby		1.01	0.39	0.70

continuous from early October, 1976, until about February 2, 1977; and as a result, the second sample of the 1976–1977 season was harvested over 1 month later than usual.

Previous work on Ruby Red grapefruit pigmentation (Lime et al., 1957) was based on the entire fleshy section. As compared with the juice, the fleshy section has perhaps three times as much pulp (minus the rag) and five times as much pigment since much pigment remains in the reject pulp when juice is machine extracted. Pulp content, to be reported in more detail later, varied from 6–16% in the Ruby Red juice and from 5–12% in the Star Ruby. During the extraction, we noted that the juice sacs of the Star Ruby were significantly thicker than those of the Ruby Red; consequently, more pulp was rejected during juicing of the Star Ruby.

For the three seasons, the color of the Ruby Red grapefruit juice alone was satisfactory, as judged from the readings of the color difference meter [positive a/b ratio, with the LR-1 standard; Lime et al. (1958)]. However, the Texas citrus industry would like a deeper-pink product. Their representatives visually examined the juice blends and indicated that a level of 30% Star Ruby in early season blends were sufficiently colored to be recognized as pink. For comparable color, a 40% level would be necessary in late season blends.

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Essential Leaf Oils of *Parthenium argentatum* A. Gray

The major monoterpenes in the leaf oil of *Parthenium argentatum* A. Gray have been identified by gas chromatography–mass spectroscopy to be α-pinene, camphene, β-pinene, sabinene, β-myrcene, limonene, terpinolene, β-ocimene, and ocimene.

In the foreseeable future, the direct production of hydrocarbons by cultivated plants will become one of the important substitutes for our limited supply of fossil fuel. This development of our agricultural industry would also alleviate our dependence on nondomestic sources of these strategic commodities. The rubber producing potential of guayule has long been known. The early commercial development of guayule began around 1904 with the invention of a practicable extraction process for guayule rubber. The Continental-Mexican Rubber Co. began experiments for growing the shrub under cultivation and initiated a study of the plant (Lloyd, 1911).

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National interest in guayule and other rubber-bearing plants as a source of crude rubber for emergency and defense uses was initiated in 1942, under Public Law 473 of the 77th Congress, with the formation of an Emergency Rubber Project. Further development of the cultivation of guayule became uneconomic with the development of a satisfactory synthetic rubber, GR-S, and the many other types of synthetic rubber that have been produced since. Today, the limited and unpredictable supply of raw material and hydrocarbon fuel warrants an immediate reexamination of the domestic agricultural production of rubber and an investigation of the potential of plants as a general source of hydrocarbons (Calvin, 1976).

Green plants possess the capacity for terpenoid synthesis and carotenoids are essential in the function of chloroplasts. We have been interested in the volatile oils (essential oils) of leaves and have speculated that these volatile terpenoid constituents serve as precursors for higher isoprenoid synthesis (Hopfinger et al., 1978). Many researchers have investigated various chemical groups in the genus *Parthenium*, but only few on the essential leaf oils. Zutschi et al. reported in 1976 on the antimicrobial activity of the essential oil of *Parthenium hysterophorus* L., and Dominguez et al. (1971) had identified limonene and α-pinene in *P. incanum*.

We wish to report on the examination of the essential oil obtained by the steam distillation of the leaves of *P. argentatum* (Tribe Heliantheae, subtribe Ambrosiinae).

EXPERIMENTAL PROCEDURE

Healthy mature leaves were harvested at the University of California, Riverside, Botanical Gardens on May 25, 1978, and immediately ground under a carbon dioxide atmosphere and steams distilled with a Clevenger apparatus using a refrigerated (ethylene glycol solution) cold finger.

A Varian Aerograph Series 1520 equipped with a matrix temperature programmer and thermal conductivity detectors was connected to a Spectra Physics autolab system I integrator and used to determine the composition of the oil. Gas chromatograms were obtained on a Beckman 10-in recorder. Stainless steel column, 304.8 × 0.635 cm o.d., were packed with 20% LAC 446 on 60–80 mesh Chromosorb W, and helium at 63 mL/min was used as the carrier gas. A nonlinear program from 50 to 175 °C was adjusted to optimize the separation of individual components.

A Finnigan 1015 S/L quadrupole mass spectrometer equipped with a Varian Aerograph series 1400 gas chromatograph and controlled with a pdp 8/m system/150 computer was used to obtain the mass spectra for the identification of each component. A stainless steel column, 304.8 × 0.3175 cm o.d. packed with the same stationary phase was used with a 5-μL volume of oil injected. The oven temperature was held isothermally at 50 °C for 50 min and linearly programmed at 1 °C min for 115 min and then kept isothermal until the completion of the run at 200 min. The mass spectra for reference compounds were obtained on the same instrument with the same conditions.

After the extraction, the remaining tissue was dried in a PS forced air oven at 57 °C and 104.2 g dry weight yielded 2.8 mL of essential oil.

RESULTS

The composition of monoterpenes with their elution times are: α-pinene, 16.7%, 1269 s; camphene, 1.2%, 1764 s; β-pinene, 13.6%, 2130 s; sabinene, 6.5%, 2295 s; β-myrcene, 2.5%, 2526 s; limonene, 5.9%, 2775 s; terpinolene, 9.2%, 2853 s; β-ocimene, 2.1%, 3162 s; ocimene, 0.2%, 3477 s; and sesquiterpene components totaling 39.5%.

DISCUSSION

Recent interest in the bioinduction of polyisoprenoid rubber in guayule was reported by Yokoyama et al. (1977). The use of external chemical agents to increase the yield of rubber is a major step toward the feasible economic production of rubber from guayule plants. Another factor involved is the escalation in price of synthetic rubbers and the uncertainty of the long-term supply of raw materials. We can anticipate that the reductions in acreage of traditional Hevea rubber will further limit its supply, so the cultivation of the marginal lands of the southwestern United States with a native plant could offer the promise of the creation of a new industry with its beneficial effects on our economy.

In the processing of guayule, the leaves are discarded as nuisance waste. Any practical utilization of the leaf oil would depend on knowing its composition. We have identified seven additional monoterpene components as well as the α-pinene and limonene found by Dominquez et al. (1971) in *P. incanum*. The sesquiterpene fraction is currently under investigation. The utilization of other byproducts such as waxes, resins, leaf proteins, and stem residues for paper pulp or fuel will also be factors in making the production of guayule rubber economically feasible.

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