

A Portable Steam Distillation Unit for Essential Oil Crops

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Summary. An experimental steam distillation unit has been designed, built, and tested for the extraction of essential oils from peppermint and spearmint. The unit, using a 130-gal (510-liter) distillation tank, is intermediate in size between laboratory-scale extractors and commercial-sized distilleries, yet provides oil in sufficient quantity for industrial evaluation. The entire apparatus—a diesel-fuel-fired boiler, extraction vessel, condenser, and oil collector—is trailer-mounted, making it transportable to commercial farms or research stations. Percentage yields of oil per dry weight from the unit were slightly less than from laboratory hydrodistillations, but oil quality and terpene composition were similar.

Aromatic crops such as peppermint and spearmint require specialized steam distillation equipment to extract the naturally occurring essential oils. The production of mint oil in the United States has a rich history (Landing, 1969), and has become the most mechanized system of essential oil production in the world. In the United States, peppermint and spearmint are the most important essential oil crops grown, valued at more than \$100 million annually (Simon, 1990). The increased interest in new crops and the potential of growing other plant species as sources of essential oils or specific raw aroma chemicals for the fragrance and flavor industries has stimulated interest in examining the potential to commercialize many other aromatic plants (Simon, 1990).

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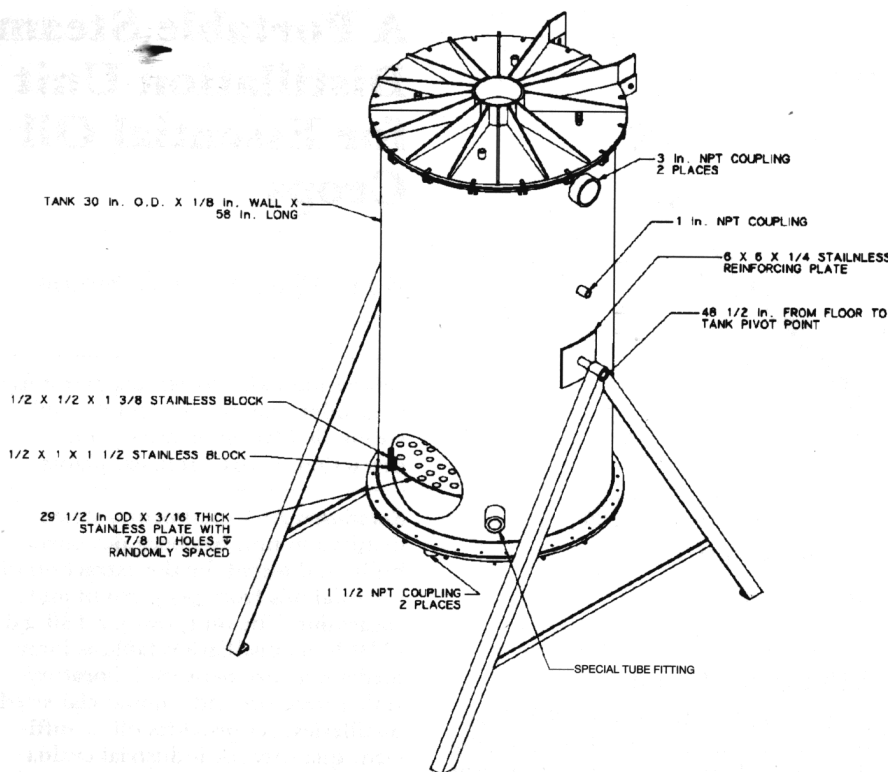


Fig. 1. Assembly drawing of the stainless steel 135-gal (510-liter) steam extraction vessel.

A major problem hindering such new crop development in aromatic plants is the lack of appropriately sized distillation units to extract oils from experimental field plots and variety trials, and to procure essential oil samples in sufficient quantity for industrial evaluation. Commercial distillation units designed for large-scale mint oil extraction are expensive and too large for most developmental research applications, while laboratory units yield oil in amounts too small (only 1- to 2 ml of oil per hydrodistillation) for such preliminary evaluations. Non-portable intermediate-scale research distillation units have been constructed in Australia (Denny, 1989); in Alberta, Canada (R Gaudiel, personal communication); and in Quebec, Canada (La Chance, 1980). A 322-liter (85-gallon) portable unit without an on-board steam source was used for optimization studies of commercial steam distillation methods in Oregon peppermint (Hughes, 1952).

The design objective was to manufacture a machine that would extract essential oil from large field plots of aromatic plants (i.e., 20 m²) to estimate area oil yield and to procure samples for industrial evaluation. Such a unit also could be used to evaluate new cultivars, chemotypes, and pesticide residues in herbs and mint. To

achieve these objectives, we needed to construct a steam distillation unit that would yield about 100 ml of essential oil per distillation; could be used for low- or high-pressure extractions; would yield high-quality essential oils comparable to those sold on commercial markets; and could be operated by a single individual. As mint is grown over a large area in northern Indiana, and our herb research plots often are located in different areas of the state, we decided to construct a transportable still that would require only a water source and electricity at the site of use.

Design of the experimental steam distillation unit. A 135-gal (510-li-

ter) stainless steel distillation vessel was constructed by the physical plant personnel of Purdue Univ. in 1990 according to designs provided (Fig. 1) and hydrostatically tested at 90 psi. Steam is supplied through a manifold pipe into the bottom of the vessel from a high-pressure boiler (Model D 450-S, Bryan Boiler Co., Peru, Ind.) and routed upward through a false-bottom perforated plate to the plant material being extracted. The steam, water vapor, and entrained volatiles exit the tank near the top via a 3-inch (7.6-cm)-diameter flexible pipe and are carried to a water-cooled, parallel-piped multitubular aluminum condenser (Fig. 2) that is mounted vertically (manufactured by Campnell Bros. Welding, Pardeeville, Wis.). The oil and water condensate then is separated in a 10-liter Pyrex florentine flask (designed by R. Gaudiel, Alberta Agriculture, personal communication), or in a specially designed miniature mint oil separator. Care was taken to ensure that the extracted oils and volatiles would contact only stainless steel, aluminum, galvanized metal, or glass, as iron and copper would discolor the oil (Virmani and Datta, 1970). The entire apparatus, including the steam generator, is mounted on a trailer, making it transportable to commercial farms and research stations (Fig. 3).

The lid of the extraction vessel is removed before and after each distillation by a cable linked to a hand winch and boom mounted alongside and above the unit. Plant material is loaded and removed by tilting the tank on side-mounted swivels to a horizontal position. To facilitate loading and removal of spent plant material, quick-connecting couplers permit rapid disconnection of the flexible metal steam

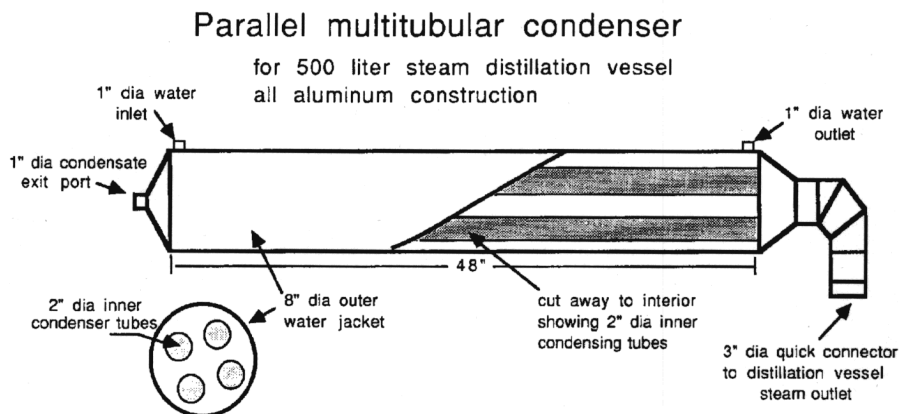


Fig. 2. Design of the aluminum multitubular condenser for the distillation unit, which is mounted vertically on the wailer, adjacent to the steam vessel.



Fig. 3. A side view of the trailer-mounted portable steam distillation unit.

feed hose and the cold-water condenser hook-up from the vessel.

The 10-horsepower boiler weighs 1400 lb (635 kg), and is rated to deliver 125 psi maximum pressure, using about 1.5 gal (6 liters) of home-heating fuel oil or tractor diesel fuel oil per distillation. The 135-gal (510-liter) extraction vessel dimensions are 30 inches (diameter) × 58 inches (height) [76 cm (diameter) × 147 cm (height)], and weighs ≈700 lb (320 kg). The aluminum condenser has four 2-inch (5.1-cm) inner condensing tubes in a parallel arrangement totaling 600 inch² (1530 cm²) in surface area. The two-axle trailer has a weight limit of 2 tons (1800 kg) with a usable space platform of 6.5 × 12 ft (2 × 3.7 m).

Evaluation of oil quality and yield from the portable steam distillation unit. To test the quality of oil extracted from the portable experimental unit, field-grown samples of peppermint and spearmint were harvested and dried under low temperature (35°C) in a forced-air oven. Essential oil yields were 0.95% for peppermint and 0.50% for spearmint (as percentage of total dry weight) from the portable steam distillation unit when steam-extracted for 75 min at 8 psi pressure. Yield from 10 lb (4.5 kg) of dried, uncompressed peppermint leaves (tilling about one-third of the volume of the extraction vessel) was 48 ml. We now can estimate that a full vessel of dried leaves should yield more than 100 ml of peppermint oil per distillation. These yields were lower

than those obtained from the same plant material extracted in our laboratory bench-top scale hydrodistillation units (Table 1), with the procedures for hydrodistillation described previously (Simon and Quinn, 1988). Yield differences may have been due to the inclusion of coarse stems and soil debris in the distillation unit, whereas in the laboratory hydrodistillations, rough materials are sieved and separated out before extraction.

The composition of essential oils extracted by the steam distillation unit were compared to oils from the same plant materials extracted by hydrodistillations. Essential oils were analyzed with a Varian 3700 Gas Chromatograph, equipped with a FID and a Varian electronic 4270 integrator (Varian, Walnut Creek, Calif.), as described previously (Charles and Simon, 1990). In each case, peppermint and spearmint terpene profiles and percentages were similar (Fig. 4 A and B). Whether this is true for other essential oils from other aromatic plants awaits study. The color of the mint oil extracted using the portable distillation

Table 1. Comparison of essential oil yield from peppermint and spearmint using a portable experimental steam extraction unit and laboratory hydrodistillation.

Extraction method	Peppermint oil (% dry wt.)	Spearmint oil (% dry wt.)
Portable steam distillation unit	0.95	0.50
Hydrodistillation	1.25	0.84

unit also compared favorably with those of commercially distilled mint oils.

There are many features that make this distillation unit a practical research tool. Aromatic plants grown in large research plots could be harvested and extracted for oil, providing a more accurate estimate of oil yield than the typical small bench-top units, which reflect yields of individual plants or a limited number of plants from a small area. Essential oil samples of sufficient size for industrial evaluation now can be obtained by a single extraction, with a quality comparable to oil obtained from commercial steam distilleries. The ability to transport the entire distillation unit, including the steam generator, provides great flexibility when several locations are being used to evaluate aromatic plants. This unit can be operated by a single technician, and can be operated to extract at either high or low pressures. Under low pressure, the experimental unit has worked successfully in the extraction of fresh and dried peppermint and spearmint foliage. The unit's high-pressure capability, although not tested in this study, could be useful in the extraction of essential oils from seeds. The distillation unit requires only a water hose, 115 VAC, and tractor diesel fuel or

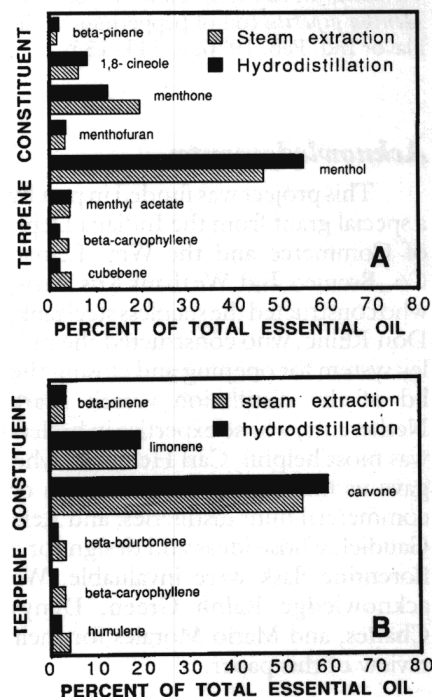


Fig. 4. Comparison of (A) peppermint oil contents and (B) spearmint oil contents of laboratory hydrodistillation extraction vs. oil extracted from the portable experimental steam distillation unit.

home-heating oil to operate for use at any site.

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