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Field Distillation of Cinnamon Leaf Oil

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Abstract : The distillation of cinnamon leaf oil in Sri Lanka is an important industry with a business turnover of at least Rs. 20 million/annum. However, none of the distillation systems employed at present are efficient. This paper deals with field studies made on traditional systems of distillation as well as the CISIRILL Manakoka. It also details the design and testing of a new condensing system which has resulted in a cinnamon leaf oil still (called the CISIRILL Boitaré) that has proved to be far more effective than any other essential oil still now in operation.

1. Introduction

The distillation of cinnamon leaf oil has a long history in this country, covering a period of more than half a century. The industry, which comprises small cottage type stills, is still expanding and as many as 160 stills were in operation in 1978. Put in more meaningful terms, this amounts to 225 still body units each capable of using 250 to 350 kg/leaf. The technology and distribution of stills and availability of raw material (which have been described in detail elsewhere[2]) shows the following salient features. (1) Most of the cinnamon leaf (a by product of the cinnamon bark industry) available is used for the distillation of leaf oil whilst about 20% to 30% of the leaf being either unused or used as fertiliser. (2) There are 4 types of stills in the field which are used for the distillation of cinnamon leaf oil : (*a*) the traditional cinnamon leaf type A still (Negombo), (*b*) the traditional cinnamon leaf type B still (Ambalangoda-Galle), (*c*) the traditional citronella type still (Galle-Matara) and (*d*) the CISIRILL Manakoka. The design of these stills has been described elsewhere.[2]

It was recognized in 1970 that the industry would be greatly benefited by the design of a cheap and efficient still; a situation which led to the design and construction of the CISIRILL Manakoka.[3]

The basic rationale used for the design of the C. Manakoka was threefold. (1) In the dry zone (Hambantota), the distillation of citronella leaf oil was often curtailed due to lack of water therefore a water sparing still would be of tremendous benefit to the country. (2) Reduction of the size of the static water condensor eliminated the need for the costly large ground tanks, which are used for condensation in the

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traditional cinnamon type B and the traditional citronella type and so reduces the cost of construction of the distillation system. (3) Upgrading the technology of the industry by improving still designs and using more suitable materials of construction which would lead to increased yield and a better quality of oil. The system had been applied to all leaf essential oil distillations (cinnamon, lemon grass, citronella and eucalyptus) available in the country.

However, the system did not work as envisaged, due to malfunction of its condensing system resulting in frequent overheating of distillate. In addition, studies done in this laboratory very clearly showed[1] that the rate of distillation plays a very important role in the recovery of cinnamon leaf oil ; good recoveries were possible only with high rates of distillation. Therefore, it was imperative that any new system of distillation should have an efficient condensing system.

This paper describes field studies made on the traditional systems of distillation and the CISIRILL Manakoka which led to the design of the new still, the CISIRILL Boitaré (modified Manakoka). The trials carried out with this new still are also reported.

2. Experimental

2.1. Field Distillations.

In these experiments, the stills were operated by the authors. Measurements taken were : (i) furnace temperature (by a pyrometer), (ii) rate of distillation, (iii) rate of oil recovery, (iv) temperature of distillation, (v) temperature of condensor water and (vi) mass of charge.

2.2. Determination of Yield and Efficiency.

Yield (% V/W) was calculated by measuring total charge of leaf (kg) and total yield of oil (litres). Efficiency of oil extraction was calculated by sampling the leaves used for the distillation[1] and carrying out a laboratory distillation of the leaves and twigs for oil content (after separation and determination of leaf : twig ratio) by the methods described previously.[1] Efficiency was then calculated by the following equation.

$$\text{Efficiency} = \frac{\text{Yield of oil (\% V/W) in field}}{\text{Yield of oil (\% V/W) in laboratory}}$$

3. Results and Discussion

3.1. Field Trials on Traditional systems

Studies on traditional system A (Dalugama still) showed that the condensing system was ineffective and overheating of distillate occurred towards the end of the distillation. Yields of 0.6% to 0.75% were observed. Distillation time was 8h to 10h and only one distillation could be done per day (the limitation being the condensor).

In traditional system B (Ambalangoda), a field trial was carried out on a still in Meetiyagoda and results contained in summary form appear in Table 1. No detailed studies were done on traditional system C (Citronella type), but it was observed that yield was very low 0.4% to 0.6%. Both types B and C have the disadvantage of having high costs of construction, mainly due to their static water condensors which are ground tanks of upto 10,000 gallons capacity.

TABLE 1. Field Distillation of Cinnamon Leaf Oil
Typical Results

System	Time of Distillation (hours)	Yield (%)	Efficiency (%)
1. Traditional	7	1.08	63
2. Manakoka (1)	7	0.65	41
3. Manakoka (2)	7	0.77	45
4. Manakoka (3)	6.5	0.78	49
5. Manakoka (3)*	6.5	1.15	67
6. C.Boitare	5	1.25	72
7. C.Boitare	4	1.25	72

*Higher rate of distillation with changes in condenser water.

3.2. Field Trials on the Manakoka

The main principle of the condensing system of the Manakoka was that most of the heat from the vapours would be transfered to the water of the latent heat exchanger (static water condensor of 400 gallons capacity). The condensed water would then be cooled in the air condensor. However, in practice, this did not work as envisaged at rates of distillation of above 800 ml/min, when there could be drastic overheating of the distillate (Table 2).

Field trials have shown that the main problem of the Manakoka was that the latent heat exchanger was faulty, because :

1. the capacity of the static water tank was too small,
2. the arrangement of the condensing coils was not satisfactory,
3. the length of condensing coil was insufficient.

TABLE 2. A Typical Manakoka Field Trial

Time (h)	Rate of Distillation (ml/min)	Yield of Oil (ml/min)	Temperature of L.H.E. (°C)	Temperature of Distillate (°C)
0.25	780	0.5	61	33
0.5	840	2.5	63	33
0.75	700	6.0	68	34.5
1.0	510	5.1	74	33
1.25	580	5.3	78	34
1.50	560	7.0	80	35
1.75	870	11.0	80	36
2.0	530	7.0	82	34
2.25	720	9.0	84	37
2.5	380	8.0	85	39
2.75	500	7.0	85	37
3.0	800	7.0	86	47
3.25	1020	18.0	86	91
3.75	680	2.0	88	70
4.25	800	0.5	84	60
4.75	550	1.5	86	60
5.5	330	2.5	89	50
6.0	625	5.5	90	98
6.75	570	1.0	89	64

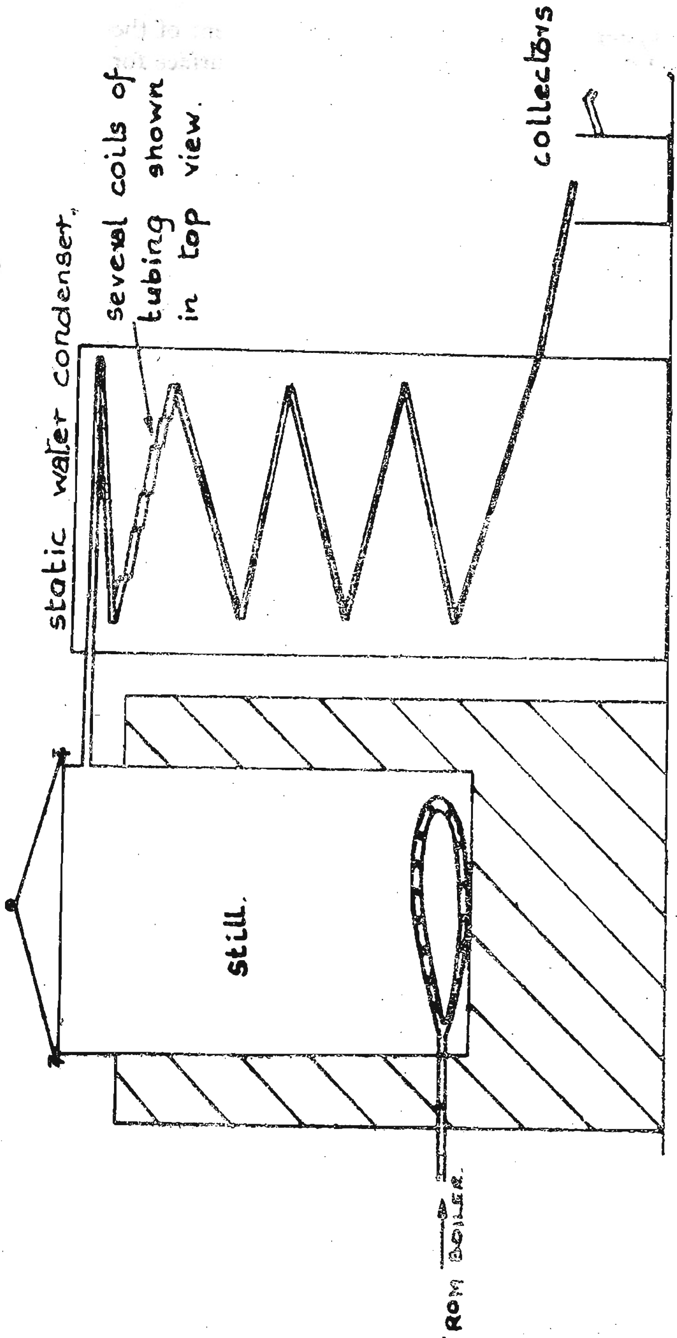
Total charge = 702 lbs, Yield of oil = 3½ bottles (7 hours), % yield = 0.77 after 7 hours distillation.

3.3. Design and Functioning of a New Condensor

Studies in the laboratory showed that the arrangement of condensing coils was the vital factor in the system. Using 2 gallon scale models of the condenser, it was found that if the condensing coils were evenly distributed or positioned at the bottom of the tank, then the water in the tank (and the condensate) is gradually heated up by the steam (produced by a steam generator) and after a short time (2h) the temperature of the tank reached 90°C and condensation did not take place. On the other hand, if the coils were arranged mainly on the surface of the tank then most of the heat is transfered to the upper surface of the static tank from which evaporation can take place. Distillation could then proceed for a much longer time (4h) before the distillate became overheated.

Using this principle a new condenser was designed and incorporated into an old Manakoka system still, where this condenser replaced the Latent Heat Exchanger and the air condenser. This system has been named the Prototype CISIRILL Boitaré where the dimensions of the condenser are as follows :

1. Size of static water tank — 1000 gallons (450 L)
2. Length of condensing tube — 90 ft (30 M)
3. Diameter of condensing tube — 2″(5cm) for 40 ft (13 M) and 1″ (2.5cm) for 50 ft (16 M)



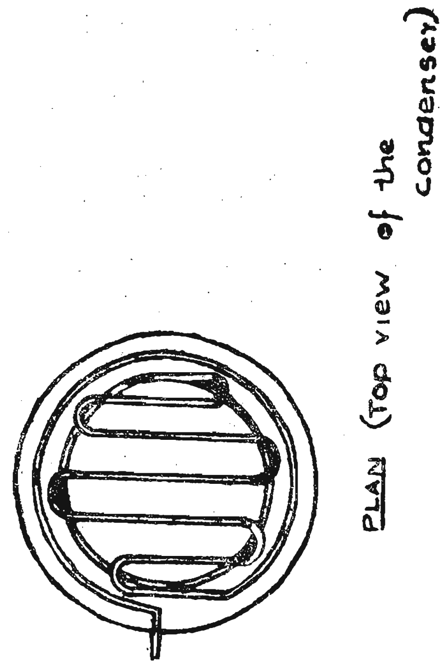


Figure 1. Cisirill Boitaré: Prototype

A most important feature of the system was the very special arrangement of the coils of the condenser which allowed for maximum heat transfer at the surface for the condenser (Figure 1, top plan)

Using this new condensor in the field trials it was found that steam entering the coil at the top of the condenser gave off most of its heat at the top surface, provided that sufficient tube length was available at the surface. The condensate quickly heated up the surface water to the range of 80°C to 90°C, at which temperature, a very fast rate of evaporation and therefore considerable loss of heat took place. At the same time, because the density of hot water is less than that of colder water, there was little mixing of water in the static condenser. As a result, the water at the bottom of the condenser was relatively cool and since sufficient length of condenser coil was available for heat transfer, the temperature of the emergent condensate was only slightly above room temperature (Table 3).

TABLE 3. Time course study of distillation of C. Boitarél prototype

Time (h)	Rate of Distillation (ml/min)		Yield of Oil (ml/min)		Temperature of Condenser (top) (°C)		Temperature of Distillate (°C)	
	1	2	1	2	1	2	1	2
0.25	1000	1095	+	15	64	72	35	36
0.5	800	1285	5—8	15	72	76	32	38
0.75	900	1290	10—12	13	78	80	36	38
1.0		825		7		84		36
1.25	1150		12		82		37	
1.5		1425		15		87		41
2.0	830	1100	5—6	5	84	90	37	39
2.5	1050	1110	10	3	68	88	37	42
3.0	950	1080	8	2	74	88	37	45
3.5	1000	1150	3	+	85		37	44
4.0	700	825	2	1	88		37	42
4.5	500		+		88		37	
4.75	940		+		88		37	
5.0	890		+		92		39	

+, trace. An extrapolation of these results show that 2, 1, 5, 0·5 bottles of oil were obtained in the 1st, 2nd and 3rd hours respectively in the 2nd trial.

TABLE 4. The performance of CISIRILL Boitaré prototype

	Trial 1	Trial 2
Charge (lbs)	564	560
Yield (bottles)	4 (1.2%)	4 (1.2%)
Time of distillation (h)	5	4
Time of Initial Heating (h)	1	1

The still body was loaded with 7 bundles of cinnamon leaf (approximately 80 lbs each) and choking was avoided. The furnace was fired to a maximum using firewood for the first 1 to 1½ hours, so that a very high rate of distillation was achieved thereby putting the condenser to the stiffest possible test.

The performance of this still is summarised in Table 4, and a diagram of the prototype C. Boitarè[1] is shown in Figure 1. This still has been operating in Dodanduwa from December 1977 and continues to give results similar to those given in Table 4. The still can be operated twice a day, but one precaution has to be taken, viz, about 500 gallons of water must be replaced from the upper part of the condenser each day to prevent overheating, if the still has to be used for two or more distillations/day.

Studies with the prototype still have led to further refinements for the new system of distillation. It has been decided to maintain the Manakoka principle of keeping the still body, steam generator and furnace in one unit, as this is as effective as an external boiler and costs less. However, the vapour outlet of the still body will be increased to accommodate the increased rate of distillation. There will also be a slight increase in coil length of the prototype, to give a total length of 35 M, and the condenser coils as in the case of the Manakoka, will be constructed out of aluminium.

4. Conclusions

As a result of the incorporation of the new condenser, no overheating of the distillate was observed even at the high distillation rates of 1000 to 1200 ml/min. The advantage of the new system may be summarised as follows:

1. Efficient cooling of distillate.
2. Water sparing (compared with traditional system)
3. Reduced distillation time, permitting more distillations per day.
4. Lower cost of construction.
5. Higher yield.
6. Maintains advantages of Manakoka of having the still body-steam generator 2 furnace in one unit and also have better materials of construction than the traditional system.

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