ROBUSTA COFFEE DRYING ALTERNATIVES IN SOUTH THAILAND

— INCLUDES A NEW SOLAR DRYER

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Summary

A solar dryer, as described and fed with warm air from a Black Plate Transpired Air Solar collector at defined rates and operational times, increased drying efficiencies of parchment coffee about 20 to 40%, and about 3.4 times compared to cherry coffee. Drying times for parchment coffee in the solar dryer were about 1.5 times faster than for parchment coffee dried in the open or in a polyethylene tunnel on concrete or bamboo tables. Coffee produced from parchment in the solar dryer, inside or outside a polyethylene tunnel on tables or cement, was all of acceptable quality. Cherry coffee in all but two instances, produced coffee that was not acceptable and had serious faults, including fermented, sour and fruity aromas and flavours.

Parchment coffee drying efficiencies, outside the solar dryer, were nearly double those for fresh cherry, and at the same time produced more acceptable coffee than cherry.

Using parchment produced from an inexpensive, efficient pulper/demucilager such as the VINACAFE machine, helps dry coffee far more quickly, produces far cleaner coffee of better quality and with far less likelihood of mould development and possible OTA contamination.

It is recommended that pulper/demucilagers be adopted to produce clean Robusta coffee that dries more than twice as fast as fresh cherry.

The solar dryer and collector unit for drying costs 7,500 Thai Baht for the materials for the black solar collector and two solar drying trays, each with a capacity of 90 kg and costs about 2.6 Thai Baht/kg of green bean to run (40 Baht = 1 USD). The Solar Dryer/Collector unit used may be recommended for those who wish to dry coffee quickly and safely. The complete unit was designed by the senior author.

A cheaper alternative that dries coffee more slowly but safely is a 7x4x2m high polyethylene tunnel, costing 5,000 Thai Baht with a capacity to dry 740 kg of product for each loading is recommended to improve coffee quality.

Introduction

Robusta coffee is grown in southern Thailand at low altitudes of usually less than 200 m.a.s.l. Part of the harvesting time coincides with the rainy season so conditions for natural drying of fresh cherry are often wet and less than ideal. As a result, coffee often gets wet and re-wet during traditional patio sun drying of cherry and produces poor quality coffee with off-flavours and moulds and may be contaminated with Ochratoxin A (OTA). Drying times may extend to two weeks or more under rainy conditions. A survey of over 94 farms has recently found presence of OTA in around 73% of dried cherry green bean samples and with around 14% of those with levels of OTA at or above 5 ppb. None exceeded 12 ppb and 11% of all samples had mouldy or fermented coffee.

During the course of the FAO TCP/THA/3002 (A) Coffee project, trials were planned to seek ways to address these issues of drying and improving quality of coffee and avoiding OTA contamination and mouldy coffee.

Various options are open to farmers to dry coffee with minimal risk of re-wetting, quality deterioration and OTA. Reduction in the drying time by using a tunnel of polyethylene to protect the coffee, or a solar dryer to speed up drying or wet processing cherry coffee to parchment, which also reduces drying time as the skin and mucilage are removed from the fresh cherry. Also, coffee may be dried on the cement of a patio or on tables to reduce contamination and hopefully reduce defects in coffee bean quality and OTA levels.

The work conducted at the Chumphon Horticulture Research Centre (CHRC), in south Thailand involved comparing demucilaged parchment and cherry coffee dried on tables or cement in or outside polythene drying tunnels. In addition a solar dryer with separate

transpired black plate collector was tested for drying of demucilaged parchment coffee. CHRC is the key government agency for researching both Robusta coffee and coconut and is located in the coffee/coconut areas of south Thailand.

Materials and methods

Materials

The trial consisted of the following treatments. Three (3) separate runs under varying drying conditions were conducted.

No.	Product and method of drying	Open air	Polyethylene tunnel
1	Parchment dried on a bamboo table	Yes	Yes
2	Cherry dried on bamboo table	Yes	Yes
3	Parchment dried in enclosed solar dryer	-	-
4	Parchment dried on cement patio	Yes	Yes
5	Cherry dried on cement patio (standard)	Yes	Yes

The demucilaged parchment used in the drying trial was produced by the VINACAFE pulper/demucilager, 0.5 MT/hr of fresh cherry capacity, which has been evaluated and described in separate trials in this report.

Bamboo tables 3.25 x 1.2 m made from split bamboo and whole bamboo and 0.4 m high were constructed and coffee was dried on the usual blue nylon fishing net material, used for patio dried Robusta in Thailand. Mesh size of the net is 1.5 mm or 16 meshes per inch. Both parchment and cherry coffee were dried on bamboo tables, both inside and outside the polyethylene tunnels. The weight of product loaded onto each table, in the drying area of 3 x 1 m was 90 kg (= 30 kg/m^2).

Patio drying of cherry on blue nylon fishing net is the standard practice in Thailand. An area of 3 x 1 m loaded with 90 kg of cherry was the test unit for drying on cement both inside and outside the polyethylene tunnels.

▲ **Bamboo table**

▲ **Patio drying cherry coffee**

Patio drying of parchment was done on the blue nylon fishing net as for cherry. An area of 3 x 1 m loaded with 90 kg of parchment was the test unit for drying on cement both inside and outside the polyethylene tunnels.

The polyethylene tunnel, 7 m x 4 m x 2 m high was constructed from 30 mm dia PVC pipe and covered with heavy duty 200 micron UV resistant clear polyethylene.

▲ **Parchment drying**

▲ **Tunnel**

A Solar Dryer 3 x 1m was constructed for drying of parchment coffee. The dryer was loaded with 90 kg of parchment coffee. The Solar Dryer was connected to a 3 x 1.5m **Black Transpired Air Solar Collector,** with hot air from the Solar Collector fed to the Solar Dryer via a small electric centrifugal *SEIWA* portable blower (Model SWB 580B), with power consumption of 500w and operating pressure of 8000 pa and an air volume of 2.5 cu.m /min at 16,000 RPM. (The Dryer unit and Solar Collector plans and specifications are given in Annex A). The cost of construction of the solar collector and two solar drying trays was 7,500 Baht or USD 190. Costs to operate the blower for 12 hours per day are 18 Baht (40 Baht = 1 USD).

▲ **Solar drier**

▲ **Solar drier**

Materials and methods

Fresh Cherry was collected and sorted to give 2% overripe and 5 % green cherry. The fresh cherry was either loaded into the various drying test units of 3 x 1 m or processed into parchment and the parchment loaded into similar 3 x 1 m test units. In all cases the loading rate was 30 kg/m^2 of product.

All coffee was raked daily four times per day at 08.30, 11.00, 14.00 and 16.00 hrs.

Coffee on the patio was left exposed to the sun during the day and covered with plastic tarpaulins at night or when raining occurred. Concrete drying units were not be covered for the first 5 days. They were then protected from rain after day 5 by covering with a tarpaulin at night and during rain.

The polyethylene tunnel was left open during the day and closed during rain and at night.

The blower on the solar dryer was operated continuously between 07.00 hrs and 18.00 hrs. A better result, even faster drying, may have been attained by operating the blower

from before sunrise to after sundown as some condensation occurred on the inside of the polyethylene cover of the solar dryer in the mornings, which was mopped away at 07.00 hrs.

Future trials may well look at operating the blower for a few hours longer in the morning and evening to possibly speed up drying and reduce condensation.

Data collected

Moisture levels were recorded daily for all trials, by the oven drying method for the whole experiment, and Water Activity (Aw) with a Hygropalm meter from day 6, until the moisture content reached 12%. The Aquaboy meter was used to measure moisture content from when M.C., was less than 20%.

Temperatures in the coffee were measured 4 times per day at raking.

When dried to 12 to 13 percent moisture (wet basis) coffee from each drying treatment was stored in a woven polypropylene sack in the store, until all samples were de-husked and tested for coffee quality and cup taste.

Standard meteorological data were kept for rainfall, temperature, RH % and Class A pan evaporation.

Mycology data and OTA data were collected for all samples using the standard international sampling handling, plating and chemical methods.

Results and discussion

Table 1 below presents data for Drying Times and Moisture Contents for the various sampling/drying conditions.

Table1. Drying times and moisture content for alternate drying methods of Robusta coffee

Coffee type & drying method	Runs	Outside tunnel			Inside TUNNEL		
		MC (%)		Drying period (days)	MC (%)		Drying period (days)
		Initial	Final		Initial	Final	
1. Demucilaged parchment Dry on net/bamboo table	1	55.79	12.74	7	54.3	11.9	8
	2	57.55	12.04	10	53.6	11.4	11
	3	54.67	12.54	10	54.7	11.6	12
Mean		56.00	12.44	9	54.18	11.6	10
2. Demucilaged parchment Dry on net/cement yard	1	53.77	11.93	8	53.6	12.7	9
	2	54.65	10.76	11	53.4	10.9	14
	3	54.67	12.05	9	55.5	10.8	10
Mean		54.36	11.58	9	54.15	11.46	11
3. Demucilaged parchment Dry in solar dryer	1	54.82	10.13	7	N.A.	N.A.	N.A.
	2	56.75	11.45	6	N.A.	N.A.	N.A.
	3	52.43	11.57	6	N.A.	N.A.	N.A.
Mean		54.67	11.05	6	N.A.	N.A	N.A
4. Cherry Dry on net/bamboo table	1	68.88	11.41	8	65.9	11.1	12
	2	65.38	11.02	13	65.2	10.8	13
	3	65.21	11.68	10	66.8	12.6	10
Mean		66.49	11.37	10	65.95	11.51	12
5. Cherry Dry on net/cement yard	1	65.77	11.24	10	64.8	10.7	10
	2	67.18	11.41	13	65.8	11.6	12
Mean		66.48	11.33	12	65.28	11.12	11

Demucilaged parchment from the VINACAFE pulper/demucilager consistently dried faster in the solar dryer, boosted with hot air under pressure from the black solar collector, for all drying runs. In the solar dryer the parchment only took an average of six days to dry to around 12% M.C.

For parchment and cherry dried in various ways, both inside and outside the polyethylene tunnel on tables or on the cement patio took either 10, 11 or 13 days to dry to around 12% M.C.

Table 2 shows data on Drying Efficiencies calculated as dried green bean kg/m^2/day produced for the various products and drying alternatives. Maximum efficiency (1.89 kg green bean/m^2/day), was attained with drying parchment in the solar dryer, followed by drying of parchment in the open air on a bamboo table (1.3 kg green bean/m^2/day). Next was the drying of parchment on concrete in the open air, (1.1 kg green bean/m^2/day).

Drying efficiency of fresh cherry was similar, whether dried on bamboo tables or cement or inside or outside the polyethylene tunnel. (Drying efficiencies ranged from 0.47 to 0.59 kg green bean/m^2/day for cherry drying).

Costs to run the blower for the solar dryer amount to 18 Baht/day of 12 hours, or for six days of drying 108 Baht. The blower as used with one drying unit gives a drying cost for drying 90 kg of parchment was 1.2 Baht/kg or for the equivalent of 35 kg of green bean 2.6 Baht/kg.

In summary parchment drying in a solar dryer is around 3.4 times more efficient than drying of cherry as it dries much more quickly. Drying of parchment in the open or in a polythene tunnel is nearly twice as efficient as drying of fresh cherry. In other words the drying yard area can be greatly reduced by drying parchment in a solar dryer or simply by drying parchment in the open or a polyethylene tunnel.

Drying temperatures in the parchment ranged from minimum of 24 to 48°C during the various drying runs. Drying Run 2 was the coolest with the majority of temperatures ranging daily from about 25 to 34°C. Run 2 was in the cooler part of the year in December 2005, with cloudy overcast weather and rain. For Run 1 and Run 3, the daily temperatures in the parchment in the solar dryer ranged from about 35 to 42°C. At no time did temperatures reach high levels where coffee may be damaged. Generally the solar dryer lifted parchment temperatures by 4 to 5°C. The important point is that the continuous ventilation of the coffee in the solar dryer, with even a small temperature rise, increased drying efficiency and reduced drying times considerably.

Table 2. Drying efficiency (kg green bean/m^2/day) with alternate drying methods of Robusta coffee

Type & drying method		Outside tunnel		Inside tunnel	
		Drying period	Drying	Drying period	Drying
Sample / drying condition	Runs	(day)	Efficiency	(day)	Efficiency
1. Demucilaged parchment	1	7	1.55	8	1.35
Dry on net/bamboo table	2	10	1.20	11	1.12
	3	10	1.18	12	0.99
Mean		9	1.28	10	1.13
2. Demucilaged parchment	1	8	1.25	9	1.20
Dry on net/cement yard	2	11	1.11	14	0.83
	3	9	1.33	10	1.19
Mean		9	1.23	11	1.04
3. Demucilaged Parchment	1	7	1.76	N.A.	N.A.
Dry on solar dryer	2	6	2.00	N.A.	N.A.
	3	6	1.94	N.A.	N.A.
Mean		6	1.89	N.A.	N.A
4. Cherry	1	8	0.79	12	0.54
Dry on net/bamboo table	2	13	0.45	13	0.46
	3	10	0.60	10	0.63
Mean		10	0.59	12	0.54
5. Cherry	1	10	0.60	13	0.50
Dry on net/cement yard	2	13	0.45	13	0.44
Mean		12	0.52	13	0.47

Table 3 gives the cup tasting results for parchment and cherry coffee dried in alternative ways. Data show that acceptable clean cups were attained from parchment coffee no matter how it was dried. Only two out of ten coffees produced from natural drying of fresh cherry were acceptable. The remainder all had faults most giving a fermented aroma and/or off tastes. Clearly coffee produced from parchment produces a better cup. Coffee dried more rapidly in the solar dryer still produced an acceptable cup with no serious defects.

Table 3. Cup tasting assessments for parchment and cherry dried in alternative ways

Coffee type & drying method	Runs	Outside tunnel	Inside tunnel
1. Demucilaged parchment	1	Acceptable, bland	Acceptable, harsh
Dry on net/bamboo table	2	Acceptable, little pulper damage	Acceptable, harsh
	3	Acceptable, little baggy	Acceptable, baggy, mild
2. Demucilaged parchment	1	Acceptable, bland, thin, flat,	Acceptable, mild, baggy, sweet
Dry on net/cement yard	2	Acceptable, bland, thin	Acceptable, mild, slightly bitter, sweet aroma
	3	Acceptable, little metallic flavour,	Acceptable, thin, bland, mild

Table 3 continued

Coffee type & drying method	Runs	Outside tunnel	Inside tunnel
3. Demucilaged parchment Dry in solar dryer	1	Acceptable, sharp	Acceptable, mild, slightly bitter,
	2	Acceptable, Bland, little baggy, green taste	Acceptable, mild, slightly bitter
	3	Acceptable, faded bean, fresh, little sour	Acceptable, mild, slightly bitter, little sour
4. Cherry Dry on net/bamboo table	1	Unacceptable, fermented,	Acceptable, clean, mild
	2	Acceptable, thin odd flavour	Unacceptable, fermented, fruity
	3	Unacceptable, fermented	Unacceptable, sweet, fermented, stale
5. Cherry Dry on net/cement yard	1	Unacceptable, fermented, bad	Acceptable, mild
	2	Unacceptable, fermented, worst sample	Unacceptable, mild, sweet

It can be concluded that a solar dryer as described and fed with warm air from a Black Plate Transpired Air Solar collector at defined rates and operational times increased drying efficiencies of parchment coffee about 20 to 40% and about 3.4 times compared to cherry coffee. Drying times for parchment coffee in the solar dryer were about 1.5 times faster than for parchment coffee dried in the open or in a polyethylene tunnel on concrete or bamboo tables. Coffee produced from parchment in the solar dryer, inside or outside a polyethylene tunnel on tables or cement was all of acceptable quality. Cherry coffee in all but 2 instances produced coffee that was not acceptable and had serious faults, including fermented, sour and fruity aromas and flavours.

Parchment coffee drying efficiencies were nearly double those for fresh cherry, and at the same time produced far more acceptable coffee than cherry. More trials would help refine the processes, but clearly, using parchment produced from an inexpensive, efficient pulper/demucilager such as the VINACAFE machine, helps dry coffee far more quickly, produces far cleaner coffee of better quality and with far less likelihood of mould development and possible OTA contamination.

It is recommended that pulper/demucilagers be adopted to produce clean Robusta coffee that dries more than twice as fast as fresh cherry.

The solar dryer and collector unit for drying costs 7,500 Thai Baht for the materials for the black solar collector and two solar drying trays, each with a capacity of 90 kg and costs about 2.6 Thai Baht/kg of green bean to run. The Solar Dryer/Collector unit used may be recommended for those who wish to dry coffee quickly and safely. A cheaper alternative that dries coffee more slowly but safely is a 7x4x2m high polyethylene tunnel, costing 5,000 Thai Baht with a capacity to dry 740 kg of product for each loading.

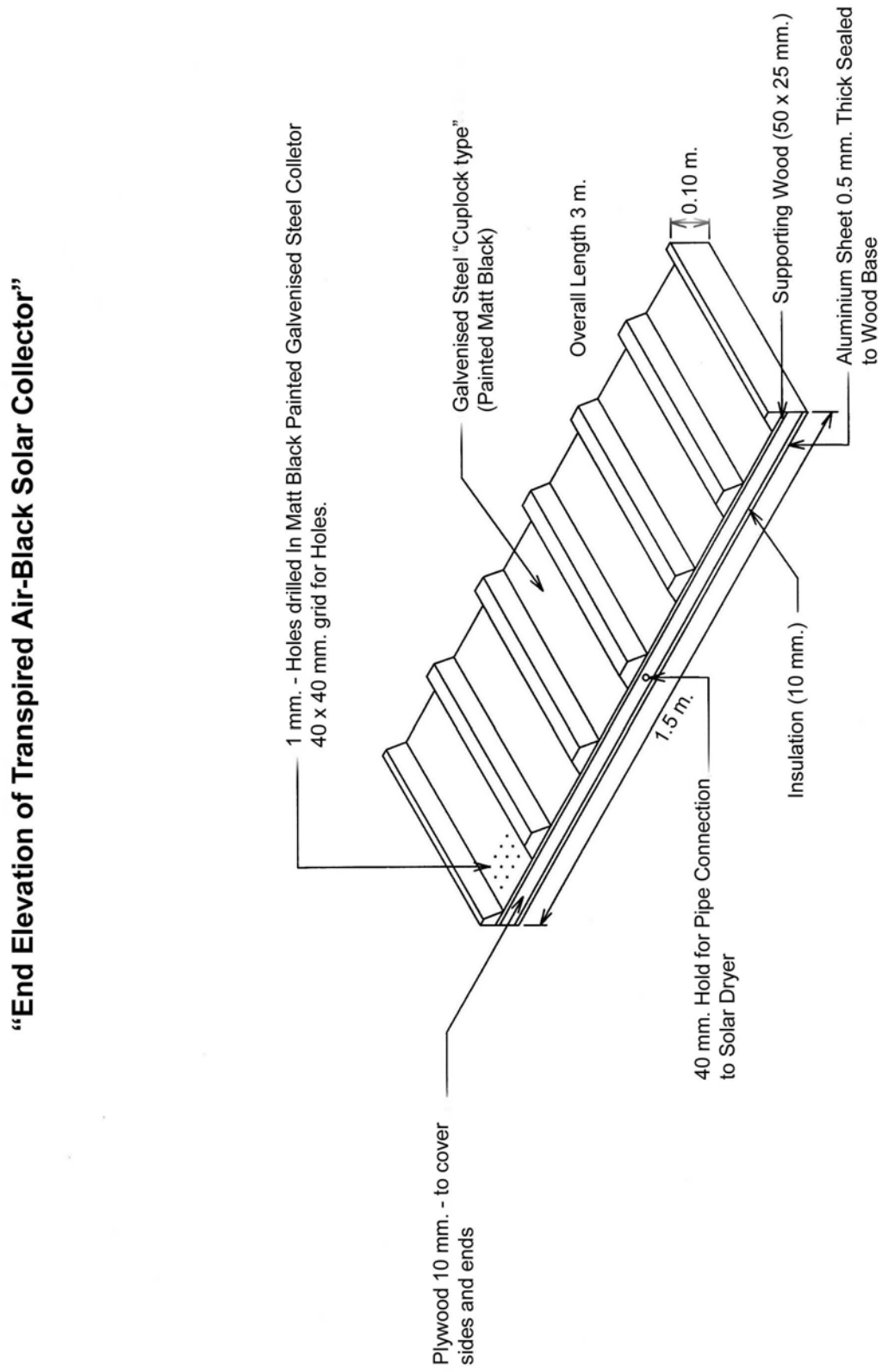
Table 4 shows that no OTA forming fungi were present in any of the samples from the whole trial.

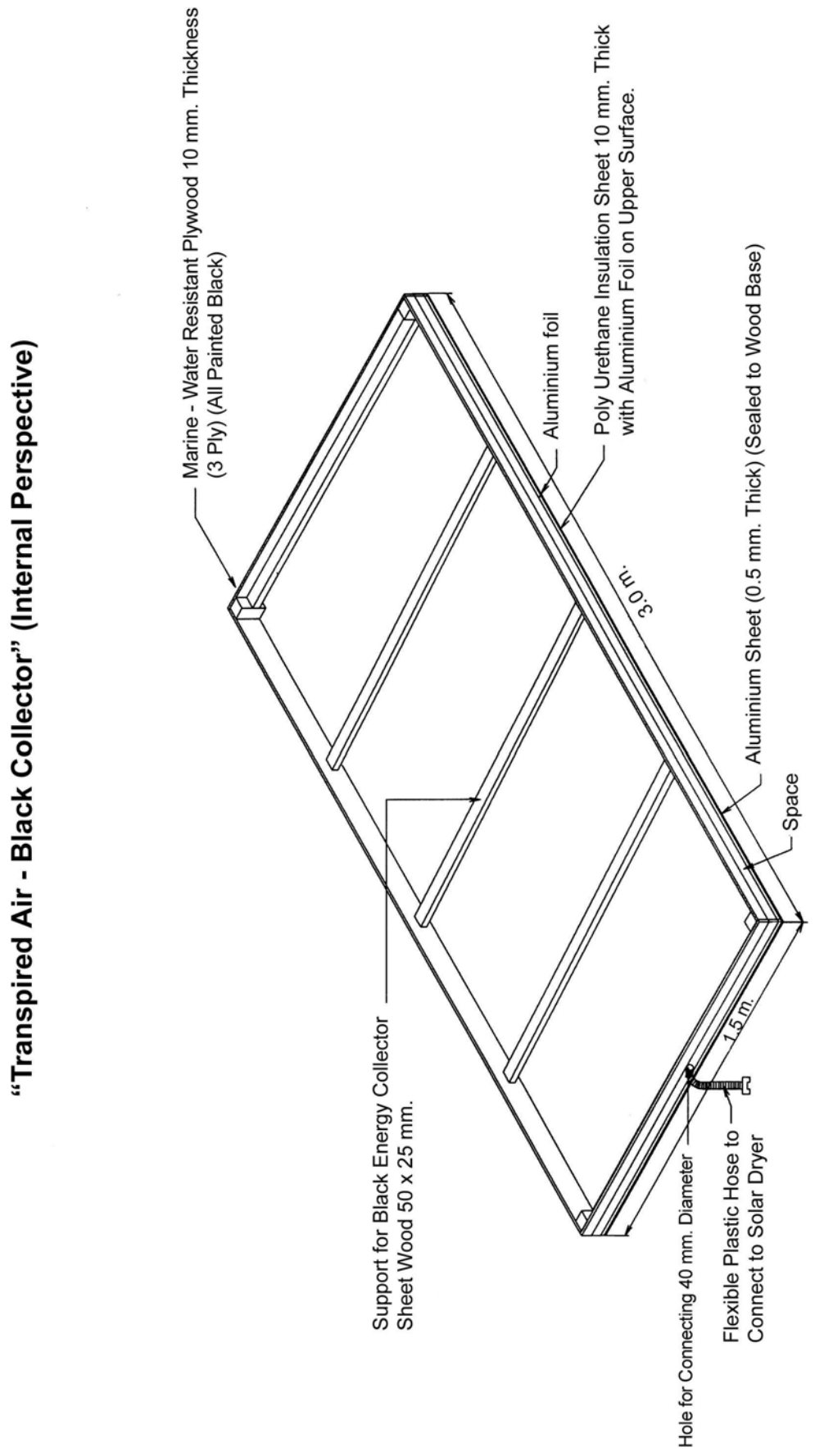
Table 4. Detailed mycology data from trial

No	Code	Treatment	Found OTA	Not Found OTA
1	Dry cherry	On bamboo table (In chamber)		0
2	Dry Cherry	On bamboo table (Out chamber)		0
3	Dry cherry	On cement yard (In chamber)		0
4	Dry cherry	On cement yard (Out chamber)		0
5	Parchment	On bamboo table (In chamber)		0
6	Parchment	On bamboo table (Out chamber)		0
7	Parchment	On cement yard (In chamber)		0
8	Parchment	On cement yard (Out chamber)		0
9	Parchment	Solar-A		0
10	Parchment	Solar-B		0

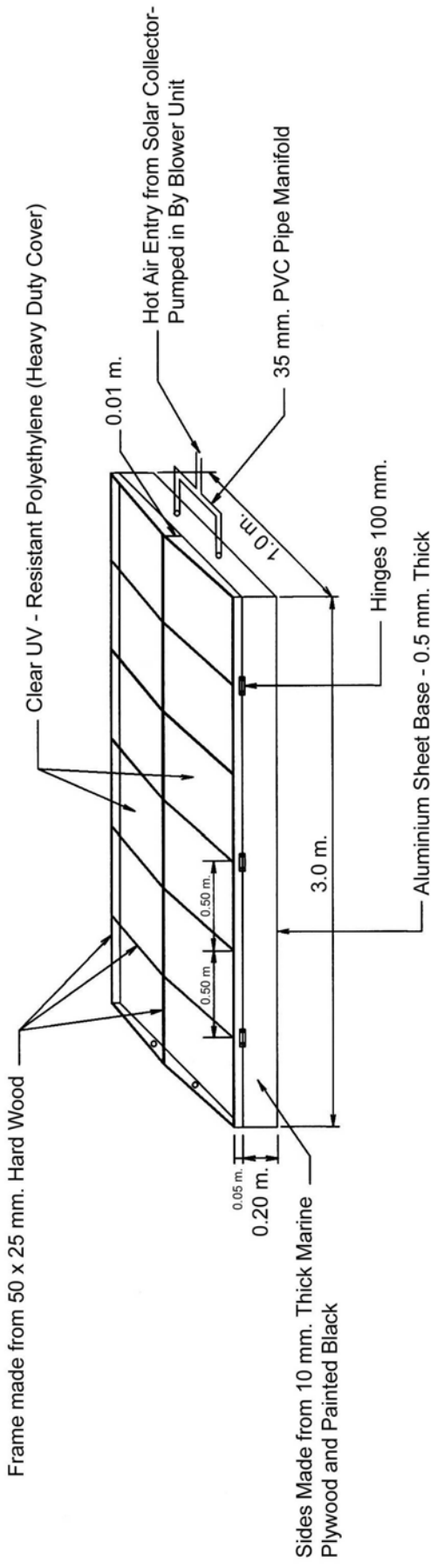
Annex A

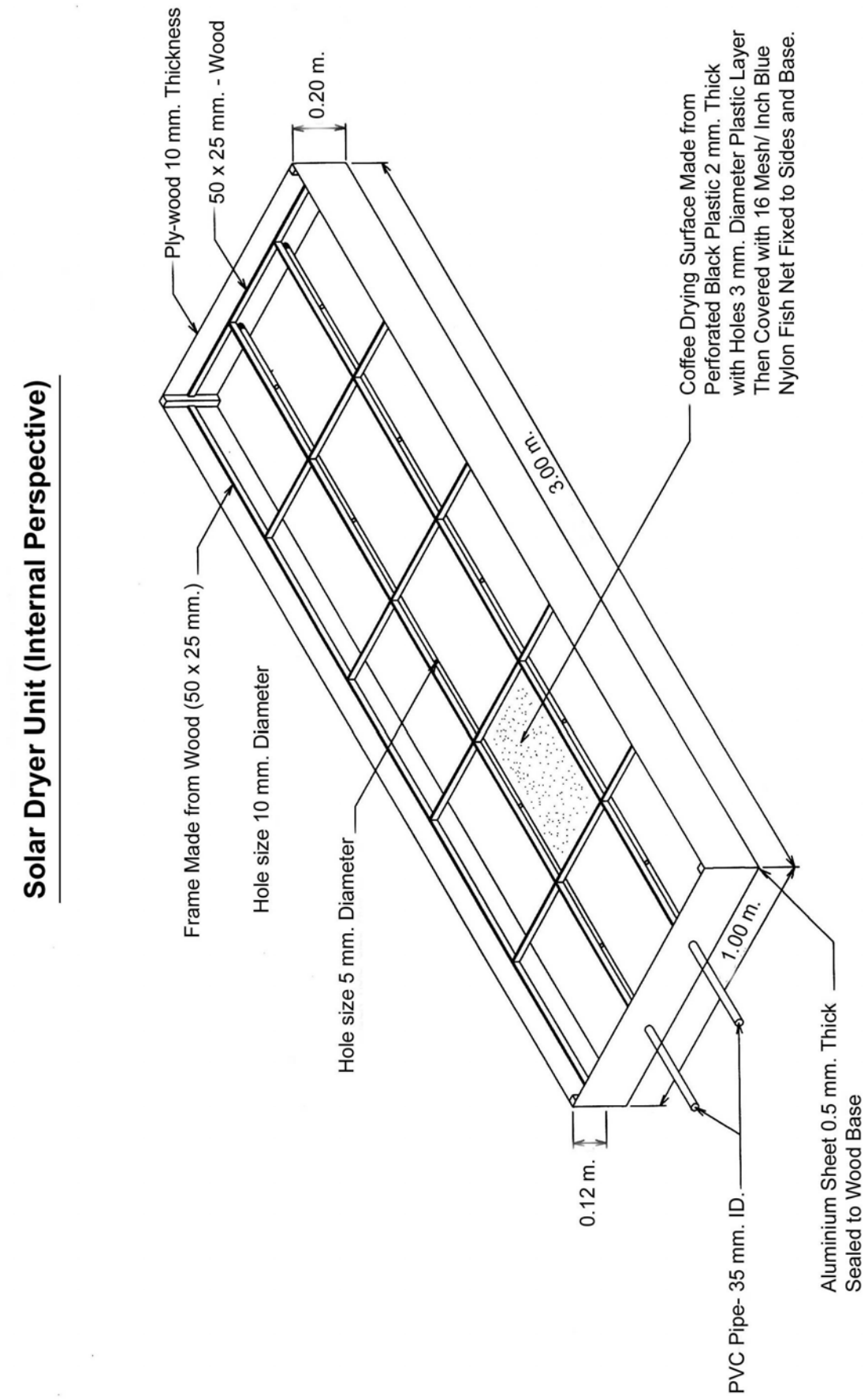
Plans of Transpired Air Black Plate Solar Collector and Solar Dryer Units.




"Transpired Air - Black Collector" (Internal Perspective)
Marine - Water Resistant Plywood 10 mm. Thickness
(3 Ply) (All Painted Black)
Aluminium foil
Poly Urethane Insulation Sheet 10 mm. Thick
with Aluminium Foil on Upper Surface.
3.0 m.
Aluminium Sheet (0.5 mm. Thick) (Sealed to Wood Base)
Space
Support for Black Energy Collector
Sheet Wood 50 x 25 mm.
1.5 m.
Hole for Connecting 40 mm. Diameter
Flexible Plastic Hose to
Connect to Solar Dryer

Side Elevation of Solar Dryer Unit




Solar Dryer Unit (Internal Perspective)
Ply-wood 10 mm. Thickness
50 x 25 mm. - Wood
0.20 m.
Frame Made from Wood (50 x 25 mm.)
Hole size 10 mm. Diameter
Hole size 5 mm. Diameter
3.00 m.
Coffee Drying Surface Made from Perforated Black Plastic 2 mm. Thick with Holes 3 mm. Diameter Plastic Layer Then Covered with 16 Mesh/ Inch Blue Nylon Fish Net Fixed to Sides and Base.
1.00 m.
0.12 m.
PVC Pipe- 35 mm. ID.
Aluminium Sheet 0.5 mm. Thick Sealed to Wood Base