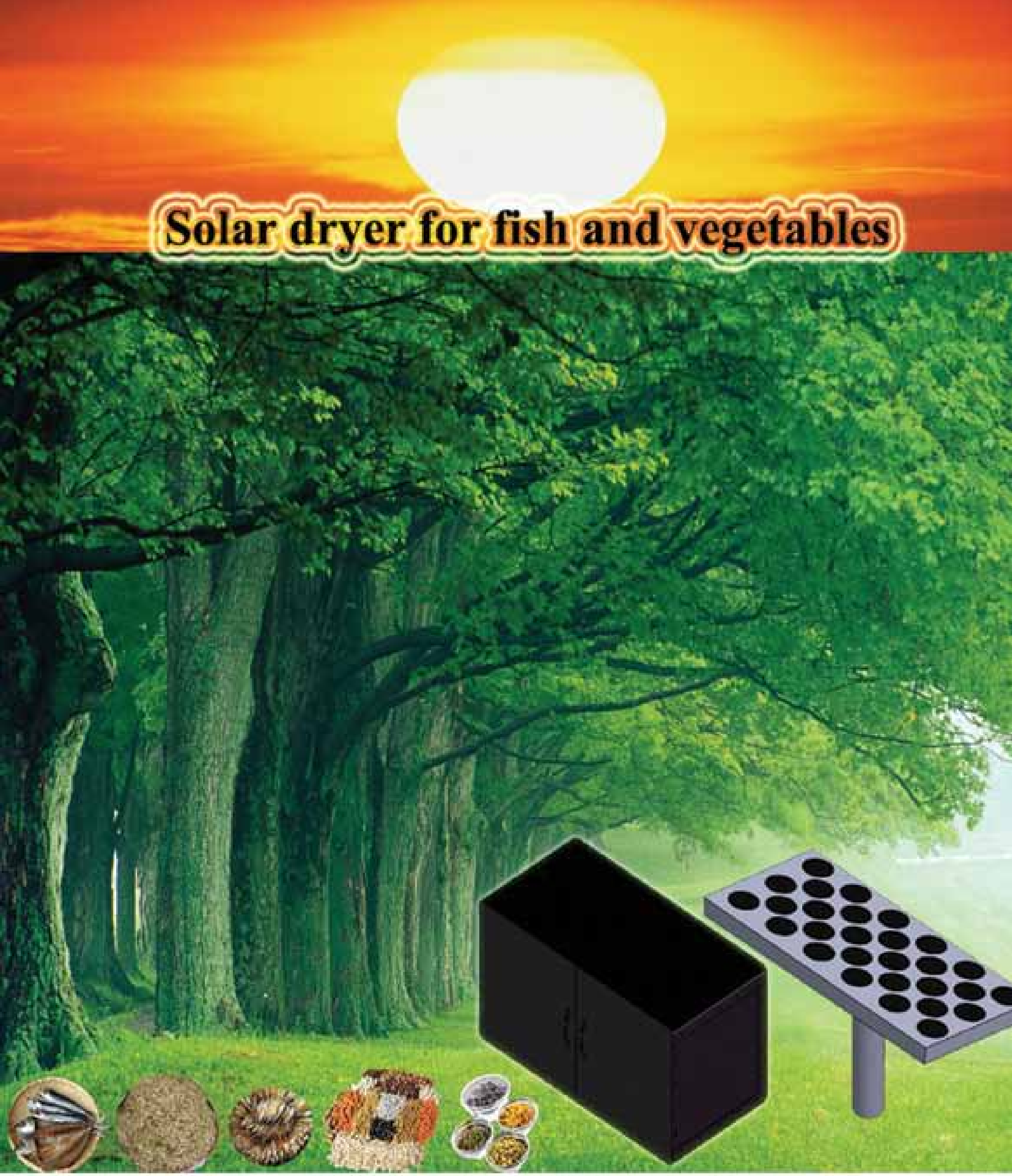
Solar dryer for fish and vegetables



Shri AMM Murugappa Chettiar Research Centre

Taramani, Chennai –600113.

December 2010

Booklet on

SOLAR DRYER FOR FISH AND VEGETABLES

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Title	:	**SOLAR DRYER FOR FISH AND VEGETABLES**
Prepared by	:	Er. M. Dhiwahar, Engineer. DST-Core support Programme. Shri AMM Murugappa Chettiar Research Centre.
Technology Advisor	:	Er. Nadanasundaram, Senior Manager. Murugappa group, Chennai.
Mentor	:	Er. M.V. Murugapan, Chairman. Shri AMM Murugappa Chettiar Research Centre.
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1. Solar energy:

Sun is a constant source of energy. Every day, the sun enriches the Earth with uncountable amounts of solar energy, most of which comes in the form of yellow light. All around planet Earth, sunlight is by far the most important source of energy for all living things. Without it, Earth is lifeless.

Solar light can be a free source of renewable energy for such everyday jobs as cooking, heating water, or warming up homes. The challenge is to find ways to transform solar energy into usable heat. The most efficient way to transform sunlight into heat is to shine lots of sunlight onto a dark surface. Dark surfaces absorb most of the visible light that interacts with them, and reflect very little. Visible light that is absorbed this way usually causes the dark-coloured surface to warm up. Of all colours, black is able to absorb the most light, and produce the most heat.

Very often there is confusion about the various methods used to harness solar energy. Energy from the sun can be categorized in two ways:

(1) in the form of heat (or thermal energy), and

(2) in the form of light energy.

Solar thermal technologies uses the solar heat energy to heat substances (such as water or air) for applications such as space heating, pool heating and water heating for homes and businesses. There are a variety of products on the market that uses solar thermal energy. Often the products used for this application are called solar thermal collectors and can be mounted on the roof of a building or in some other sunny location. The solar heat can also be used to produce electricity on a large utility-scale by converting the solar energy into mechanical energy.

2. Solar Energy Uses:

We have always used solar energy as far back as humans have existed on this planet. We know today, that there are multiple uses of solar energy. We use the solar energy every day in different ways. When we hang laundry outside to dry in the sun, we are using the solar heat to do work, drying our clothes. Plants use the solar light to make food. Animals eat plants for food. And as we learned, decaying plants hundreds of millions of years ago produced the coal, oil and natural gas that we use today.

3. About solar energy in India:

India is in the sunny regions of the world with most parts of the country receiving 4 to 7 kilowatt-hour of solar radiation per square meter per day and for 250 to 300 sunny days in a year. Rajasthan receives the highest annual solar radiation and North-eastern parts of the country receive the least. This solar energy can be made use of in two ways the Thermal route i.e. using heat for drying, heating and cooking or generation of electricity or through the Photovoltaic route which converts light in solar energy in to electricity which can be used for a myriad purposes such as lighting, communication, pumping. With its pollution free nature, virtually inexhaustible supply and global distribution makes solar energy very attractive.

4. About solar drying:

Food is a basic need of human beings after air and water. Food holds a key position in the development of the country. Food drying is one of the oldest methods of preserving food for later use. High moisture content is one of the reasons for its spoilage during the course of storage at time of harvesting. High moisture crops and other products are prone to fungus infection, attack by insects, pests and the increased respiration of agricultural product. There is spoilage of food products which could be prevented using dehydration techniques. Solar drying is in practice since the time of immemorial for preservation of food and agriculture crops. This was done particularly by open sun drying under the open sky. This process has several disadvantages like spoilage of product due to adverse climatic condition like rain, wind, moist, and dust, loss of material due to birds and animals, deterioration of the material by decomposition, insects and fungus growth. Also the process is highly labour intensive, time consuming and requires large area.

With cultural and industrial development artificial electrical heat drying came in to practice to increase the drying speed. This process is highly energy intensive and expensive which ultimately increases product cost.

Thus solar drying is the best alternative solution for all the drawbacks of traditional drying and electrical drying. Solar dryers used in agriculture for food and crop drying, for industrial drying process, which proved to be the most useful device from energy conservation point of view. It not only saves energy but also saves time, occupies less area, improves quality of the product, makes the process more efficient and protects environment also. Solar drying can be used for the entire drying process or for supplementing artificial drying systems, thus reducing the total amount of fuel energy.

5. Development of solar drying:

Solar drying is very important application of solar energy. Solar dryers use air collectors to collect solar energy. Solar dryers are used primarily by the agricultural industry. The purpose of drying an agricultural product is to reduce its moisture content to a level that prevents its deterioration.

In drying, two processes take place: one is a heat transfer to the product using energy from the heating source, and the other is a mass transfer of moisture from the interior of the product to its surface and from the surface to the surrounding air. Traditionally, farmers used the open-to-the-sun or natural drying technique, which achieves drying by using solar radiation, ambient temperature, relative humidity of ambient air and natural wind. In this method, the crop is placed on the ground or concrete floors, which can reach higher temperatures in open sun, and left there for a number of days to dry. Capacity wise, and despite the very rudimentary nature of the process, natural drying remains the most common method of solar drying. This is because the energy requirements, which come from solar radiation and the air enthalpy, are readily available in the ambient environment and no capital investment in equipment is required. The process, however, has some serious limitations. The most obvious ones are that the crops suffer the undesirable effects of dust, dirt, atmospheric pollution, and insect and rodent attacks. Because of these limitations, the quality of the resulting product can be degraded, sometimes beyond edibility. All these disadvantages can be eliminated by using a solar dryer.

The purpose of a dryer is to supply more heat to the product than that available naturally under ambient conditions, thus increasing sufficiently the vapor pressure of the crop moisture. Therefore, moisture migration from the crop is improved. The dryer also significantly decreases the relative humidity of the drying air and by doing so, its moisture-carrying capability increases, thus ensuring sufficient low equilibrium moisture content.

There are two types of solar dryer: the ones that use solar energy as the only source of heat and the ones that use solar energy as a supplemental source. The airflow can be either natural convection or forced, generated by fan. In the dryer, the product is heated by the flow of the heated air through the product, by directly exposing the product to solar radiation or a combination of both.

The transfer of heat to the moist product is by convection from the flowing air, which is at a temperature above that of the product, by direct radiation from the sun, and by conduction from heated surfaces in contact with the product.

Absorption of heat by the product supplies the energy necessary for vaporization of water from the product. From the surface of the product, the moisture is removed by evaporation. Moisture starts to vaporize from the surface of the product when the absorbed energy increases its temperature sufficiently and the vapor pressure of the crop moisture exceeds the vapor pressure of the surrounding air. Moisture replacement to the surface is by diffusion from the interior, and vaporization depends on the nature of the product and its moisture content. If the diffusion rate is slow, vaporization becomes the limiting factor in the drying process, but if it is fast enough, the controlling factor is the rate of evaporation from the surface, which occurs at the initiation of the drying process.

In direct radiation drying, part of the solar radiation penetrates the material, and it is absorbed within the product, thus generating heat both in the interior of the product and on its surface. Therefore, the solar heat absorption of the product is an important factor in direct solar drying. Because of their color and texture, most agricultural materials have relatively high absorption. By considering product quality, the heat transfer and evaporation rates must be closely controlled to guarantee both optimum drying rates and product quality. The maximum drying rate is required so that drying is economically viable.

Solar energy dryers are classified according to the heating mode employed, the way the solar heat is utilized, and their structural arrangement. With respect to the heating mode employed, the two main categories are active and passive dryers. In active systems, a fan is used to circulate air through the air collector to the product, whereas in passive or natural circulation through the product by buoyancy forces as a result of wind pressure. Therefore active systems require, in addition to solar energy, energy sources, usually electricity, for powering fans for forced air circulation or for auxiliary heating.

In the past solar drying of grains, fruits, vegetables, spices, medicinal plants and fish using natural convection and forced convection solar dryers were examined. Recent developments of forced convection solar dryers such as solar tunnel dryer, improved version of solar dryer, roof-integrated solar dryer and greenhouse type solar dryer for their use in rural areas for drying of fruits, vegetables, spices, medicinal plants and fish are also critically examined in terms of technology and economics in the rural areas of the tropics and subtropics.

A new forced flow type dryer, which consisted of air heater, fan and drying chamber, was developed for drying food products. The present drying system was successfully tested. Experiments have been performed to investigate the performance and drying behaviour of the food products and found that in this PV based solar dryer the temperature is around 15^{o}C higher than that of the ambient temperature which is more effective or favourable for drying of agricultural products as compared to traditional drying methods.

6. Working Principle:

This unit or system consists of drying chamber and 60W PV panel for converting solar radiation into electricity. This panel has been integrated with dryer for powering the 12V DC fan to circulate the air inside the dryer. In this case the drying unit is a single unit of black box which traps most of the solar radiation or heat. The incoming solar light fall on the PV module, which converts solar radiation into electricity. When the solar rays fall on the dryer its surface gets heated up, the air inside the dryer is in circulation by fan, so the air which passes over the surface of the dryer, gets heated due to convection. This hot air passes through the food product to be dried which is placed on trays absorbs the moisture present in the drying product.

7. Specification:

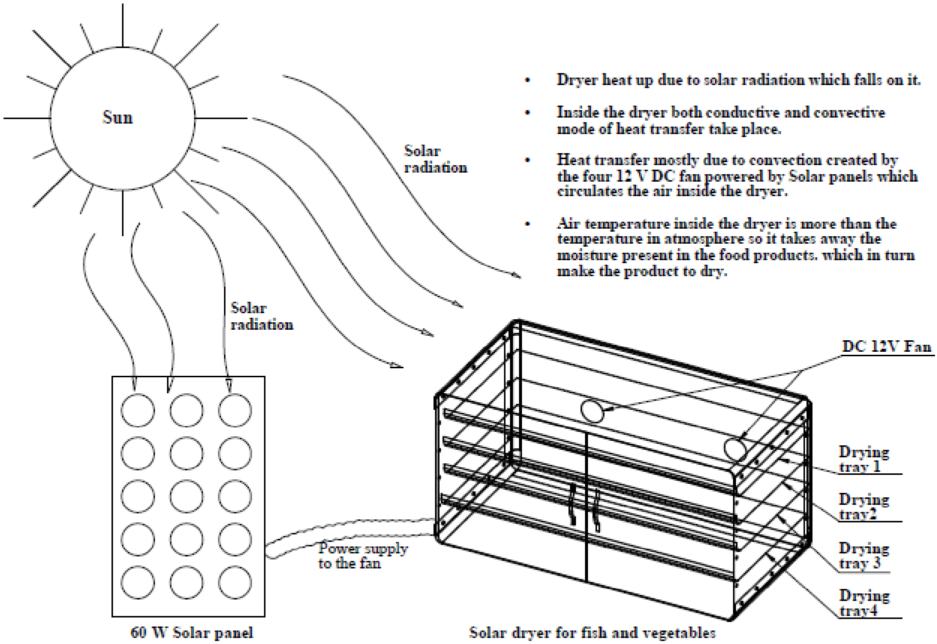
Design of a Photovoltaic based Solar dryer

This type of dryer is fabricated in our centre.

1. Capacity of the dryer : 20 Kg.
2. Type of material used : Aluminium and Stainless steel.
3. Type of joints : Bolt and nuts. (Easily assemble, disassemble)
4. Number of trays : 3 to 4
5. Type of product dried : Fish, Vegetables, Medicinal leaves.

Operation process:

- During daytime it will heated up by direct solar radiation. During at night-time heating up by firing charcoal or wood at the bottom
- During rainy and winter season same as night operation.
- Battery backup is needed for operation of fan to circulate the air inside the dryer.
- Electric power from PV panel to charge battery.



8. Schematic diagram of solar drying process using solar dryer

9. Physical size of the dryer:

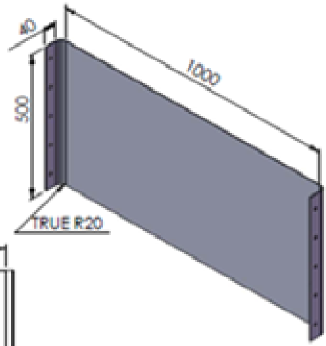
- Length : 1000mm, Breadth : 500mm, Height : 500mm
- Tray dimension : 980mm X 480mm, Tray equally spaced : 100mm

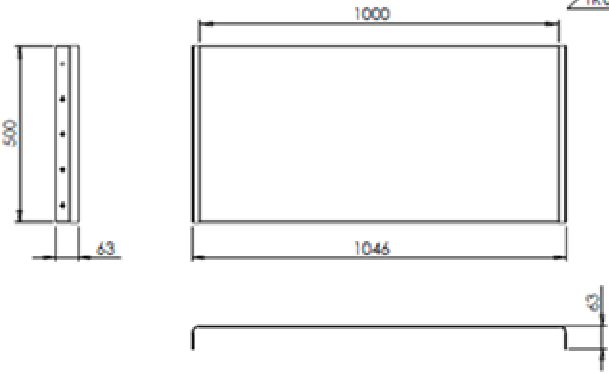
10. Material required for fabrication:

S.No.	Name of the component	No. of quantity required
1.	Aluminium sheet of thickness 3mm, (8'x4')	2 no.
2.	S.S Bolt and nut M6 of length 10mm	50 no.
3.	S.S Bolt and nut M4 of length 10mm	30 no.
4.	S.S Bolt M3 of length 50mm (depending on number of fan, each fan require 2 bolt and 6 nut)	12 no
5.	L-angle for foot support	4 no
6.	Red oxide paint	0.5 Ltr.
7.	Black paint	1 Ltr
8.	Solar panel 60 W, 12 V DC	1 no.
9	12 V DC fan	Min: 4 no. and Max: 6 no.
10.	3 coir wire	5 m
11.	Silk wire	2 m

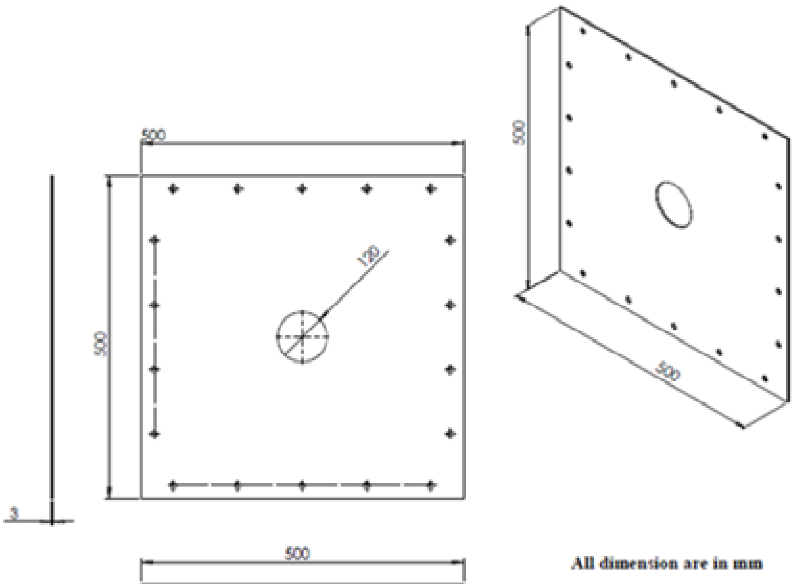
11. Dimension of the Top, Bottom and side frame:

Note: Top and Bottom frame are of same dimensions. Two side frames are of same dimensions.





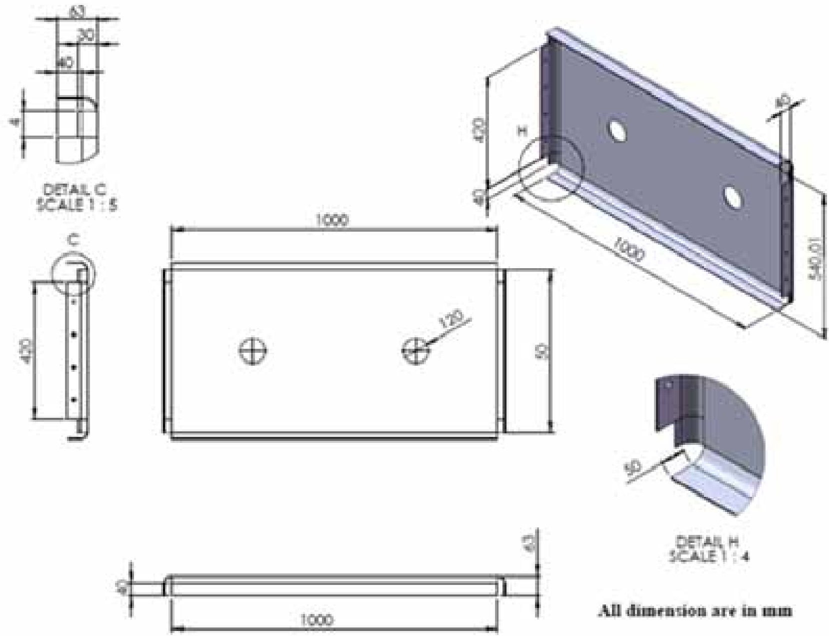
Top and bottom frame dimensions **All dimension are in mm**



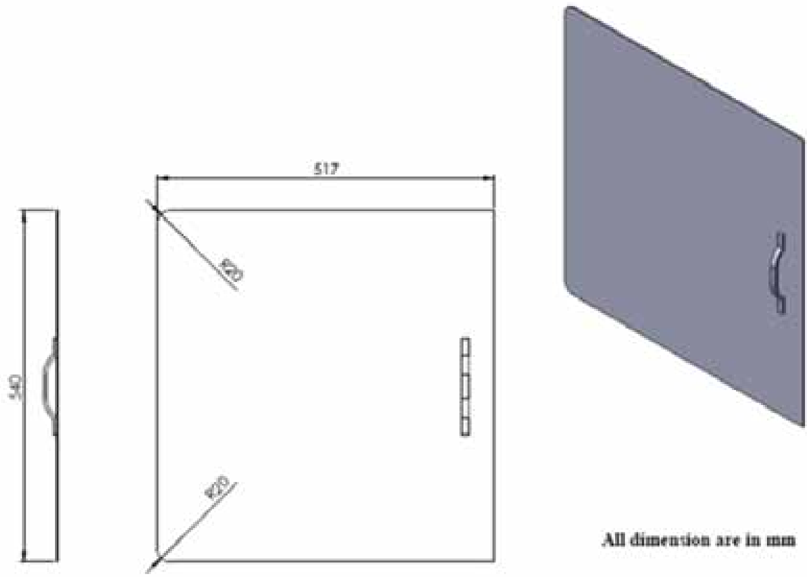
All dimension are in mm

Side frame dimensions

12. Dimension of the Back frame and door :

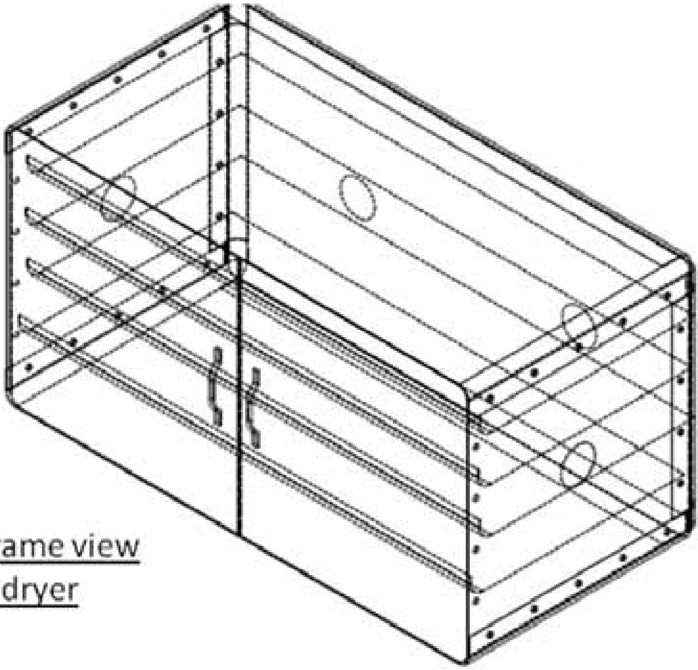


Back supporting frame dimensions

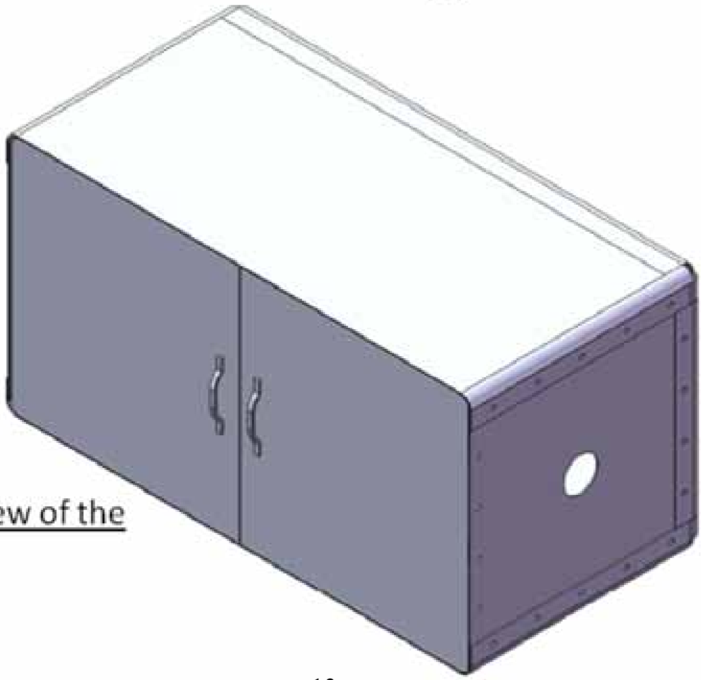


Door frame dimensions

13. Full assembled view of the dryer:



Wireframe view of the dryer



Full view of the dryer

14. Fabrication Process :

Aluminum sheets were cut and bent as per dimension and drilled at appropriate places for fixing Bolt and Nut. Trays were perforated by drilling 5mm holes for air circulation. We didn't use standard perforated sheet due its high cost.

Al sheets were cut as per dimension in this m/c

Dimension were marked to cut and bend the Al sheet.

Al sheets were bended as per dimension in this m/c

Tray were bended as per dimension in this m/c

Sheet were drilled as per the dimension

Sheets were joined by Bolt and nut joints

Trays were drilled for air flow

Assembled body

12 V DC fan were fixed

Assembled dryer with tray

Black painted assembled dryer in open condition

Black painted assembled dryer in fully condition

15. Drying of fish in both dryer and in traditional method:

Fish were tied and hanged inside the dryer

Fish in solar dryer and traditional before drying

View of traditional dried fish – Wireframe to protect the drying fish from animals.

Full view of Solar dryer with PV Panel

Weighing of dried fish in solar dryer

Weighing of traditionally dried fish

Dried fish were preserved in box

100 gm Powdered fish for nutrient test

16. Experiment with solar dryer:

16.1 Solar drying of fish:

16.1.1 Details of the fish variety used for testing:

Name of the product	Fish (Kana katha) – Indian Mackerel
Zoological name	Rastrelliger Kanagurta
Date of drying	19/10/10 to 27/10/10
Starting hour	10.00 am
Ending hour	04.00 pm
Total Weight before drying	4000 gm
Weight of fish tested in solar dryer	2000 gm
Weight of fish tested in traditional direct sunlight drying	2000 gm

16.1.2. Temperature measurement in ^oC

Day / Time		9.00am	10.00am	11.00am	12.05pm	01.00pm	02.00pm	03.00pm	04.00pm
19.10.10	Temp. inside the dryer	30.4	38.4	42.4	45.6	46.4	46.0	38.4	36.4
	Atm. temp	30.2	32.1	33.4	37.4	37.6	36.4	28.6	27.2
20.10.10	Temp. inside the dryer	30.7	45.6	48.0	43.3	46.4	40.2	37.8	34.6
	Atm. temp	30.4	32. 6	36.5	35.2	35.2	30.1	28.6	26.4
21.10.10	Temp. inside the dryer	30.7	32.6	42.4	46.8	48.1	42.4	38.5	36.4
	Atm. temp	30.5	30.6	32.6	33.4	35.6	33.6	28.2	26.5
22.10.10	Temp. inside the dryer	30.4	32.6	40.8	42.5	44.8	46.8	37.5	33.4
	Atm. temp	30.4	30.6	32.2	33.3	33.6	34.6	30.6	26.4
23.10.10	Temp. inside the dryer	30.3	43.1	44.2	46.7	49.2	50.4	45.8	42.6
	Atm. temp	30.2	30.6	32.6	33.4	35.9	36.1	32.1	31.5
24.10.10	Temp. inside the dryer	30.6	45.7	46.0	45.3	37.5	34.4	32.0	30.6
	Atm. temp	30.5	32.6	32.8	32.4	30.4	28.4	26.4	26.2
25.10.10	Temp. inside the dryer	31.5	41.6	41.8	42.2	40.3	36.4 – rain	32.4	30.4
	Atm. temp	31.4	32.2	32.4	32.5	32.2	30.2	30.6	30.2
Fish inside the dryer got dried.									
26.10.10	Atm. temp	30.5	32.6	34.6	33.4	33.2	30.1	28.6	28.0
27.10.10	Atm. temp	31.2	33.2	34.6	33.6	33.5	32.6	30.3	28.6

16.1.3 Weight of fish before and after drying:

Fish	Initial weight (gm)	Final weight (gm)	Time taken	Weight reduction %
Dried in open sunlight	2000 gm	903.24	72 hr	45.16
Dried in solar dryer	2000 gm	757.90	56 hr	37.89
If the fish need to dry 757 gm in traditional method it will took 83 hr. So time saved is 27 hr.				

16.1.4 Test Report dried fish:

Parameters	Result of fish dried in solar dryer	Result of fish dried in traditional method	Difference in level as compared with solar dryer	Procedure
Moisture %	16.65	14.68	1.97 high	As per BIS Methods
Ash %	14.06	17.05	2.99 low	As per BIS Methods
Fat %	17.42	19.28	1.86 high	As per BIS Methods
Protein % (N x 6.25)	47.27	48.23	0.96 low	As per BIS Methods
Carbohydrate %	4.62	0.76	3.86 high	Calculation by difference
Sodium (mg/100g)	3098	4577	1479 low	By AAS
Potassium (mg/100g)	528	448	80 high	By AAS
Calcium (mg/100g)	4330	3155	1175 high	By AAS
Iron (mg/100g)	3.9	4.4	0.5 low	By AAS

16.2 Solar drying of Vegetables and leaves:

Moringa green leaves were also tested in this drier. It is found that the leaves were drying at faster rate within 3.5hr of time, while traditionally it took 1 week time to dry. This dryer is best suitable for leaf drying.


Moringa leaves were washed


Moringa leaves were placed on tray


Leaves placed inside dryer to dry


leaves placed inside room to dry


Leaves dried in solar dryer


Leaves dried in room


3 to 4 hr leaves were dried in solar dryer


In 5 to 7 days leaves were dried in shade dryer or inside a room

17. Advantages of this dryer:

1. Both shade drying and open drying is possible.
2. Reduces drying time.
3. Open direct sunlight heating is possible by removing the top cover of the dryer and providing transparent thin polyethylene film sheet. This will transmit 99% of direct solar radiation.
4. Works throughout the year. It can work at night and during rainy season by burning biomass under the dryer.
5. Easily assembling and disassembling and light weight for transportation purpose.
6. Low maintenance.

For More Information, Contact:

Shri AMM Murugappa Chettiar Research Centre (MCRC)
Taramani, Chennai - 600113. Fax : +91-44-22430369
Email : energy@mcrc.murugappa.org
Web : www.amm-mcrc.org