Small Solar Tunnel Dryer

Introduction :

Many years ago a *solar tunnel dryer* was developed at the university of Hohenheim, with the purpose of preserving agricultural products by the means of drying. As a joint development of the Institute for Agricultural Technology in the Tropics and Subtropics at the University of Hohenheim and the company Innotech, solar dryers of the type Hohenheim are by now in use in over 75 countries.

The device is employed for the hygienic preservation of foods. Seasonal agricultural surplus, deficient transport capabilities for fresh products and insufficient preservability of undried products are overcome hereby. At the same time, the quality of goods dried in this way is substantially superior to traditional drying.

Fishermen in Bangladesh use the solar dryer for the hygienic drying of their catch, farmers in Togo for bananas, spices are dried this way in China etc.

The solar tunnel dryer is 20m long and 2m wide. It can be loaded with between 300 and 500kg of goods to be dried .

Our intent was to build a small version of the solar tunnel dryer, based on the same time-proven functional principle. This is applicable for trial purposes (before a large dryer is to be built), lesser loads and for mobile operation.

This smaller version is also interesting for family house gardens in Europe, as it is handy and – through appropriate implementation of the ventilator and solar panel – suitable to sustain a day of bad weather in fall, without partially dried goods becoming subject to mold. The device functions independently of any external electrical supply since it is energy self-sufficient and is therefore environmentally friendly as well.

As this manual mainly targets a do-it-yourself construction, I describe two versions. Hereby it becomes clear what is important and how materials can be varied. Tunnel dryer a) is simply and heavier, tunnel dryer b) is lighter.

Both versions function equally well.

The content of the list of materials can be used as a guideline or can be implemented exactly.

Functionality of the Solar Dryer

The black painted half of the base plate serves as the collector and transforms incoming sunlight into heat. In the process the heated air becomes relatively dry and is then blown over the goods to be dried, where it takes up humidity. It is not necessary to paint the other half of the base plate black as well, since this half is covered by the goods to be dried anyway. Incoming sunlight on this half of the device additionally helps to evaporate humidity from the foods.

Due to the ventilator powered by a photovoltaic module, reasonably stable temperatures can be achieved within the device. Under strong sunlight the temperature inside the dryer rises quickly. The ventilator must therefore provide a strong air stream to prevent temperatures from becoming too high within. Since the PV-module provides maximum power in this case, the ventilator also runs at maximum speed. When the solar radiation is weak, the module provides less power and the ventilator runs more slowly, whereby the air remains within the dryer for a longer time span.

If the whole area of the dryer was loaded with foods, the results would not be uniform. Due to the air collector mounted “upstream”, the foods dry uniformly and simultaneously.

Advantages of the Solar Dryer:

- Both the air inlet and outlet of the solar dryer are insect-tight. Insects, such as wasps or fruit flies have no access and cannot contaminate the foods or chew up parts of them.
- Less dust can collect on the goods to be dried in a dusty climate
- A brief episode of rain does not affect the drying results adversely
- In temperate latitudes (central Europe, for example), high humidity, or low outdoor temperatures the foods dry faster compared to traditional air drying
- no running operating costs, environmentally friendly, energy self-sufficient

Solar Tunnel Dryer a) :

List of Materials:

Quantity		Size in mm
1	Plywood (20 mm dick) - *Base Plate*	2070 X 1000 X 20
2	Plywood (20 mm) - *Side Plate*	2050 X 50 X 20
1	Plywood (20 mm) - *Gable*	1000 X 171 X 20
6	Wooden slate (10 mm) - *Protection for Foil Cover on strut*	495 X 25 X 10
1	Wooden slate (10 mm) - *for Mosquito Net*	960 X 25 X 10
1	Aluminum Bar - *Ridge Pole*	Ø 8 ,Length : 2100
	Stainless Steel Wire	0,5 m
3	Flat Iron (20x3 mm) - *Strut*	1416 X 20 X 3
1	Ventilator, 50m³/h, e.g. 1,7 W	100 X 100 X 2
1	Kitchen Strainer – *Cover for Ventilator*	
22	Wood Screws (Spax)	4.5 X 40
6	Wood Screws (Spax)	4x20
12	Small metal construction Screws or blind Rivets	M4 / 4x12 Blind Rivets
8	Combination: Screw + washer+ rubber washer	Ø3 X 10 / (...) / Ø12 X 3
4	Screws to fasten the Ventilator	Dependent on mounted Ventilator
	Mosquito Net	
1	UV resistant, transparent Foil	2200 X 1400
	Small Nails	1x10
1	Photovoltaic Module 5W (or more), + Cable	Caution: The Voltage must correspond to the operating Voltage of the Ventilator
2	Aluminum angle profile 15x15x2	2,2m
2	Aluminum Square Tube15x15 – *Weight for Foil*	2,2m
1	Framework	See Photo
	Black Paint, non-toxic	ca 100ml

The choice of screws, naturally, depends upon the materials you have at your disposal. The combination screw + washer + rubber washer allows waterproof fixation of the foil onto the struts of the dryer. The rubber washers further help to avoid damage to the foil.

Two Examples for this Combination:

Fig. 1 ***One possible Combination for the rainproof Fixation of the Plastic Foil***

Fig. 2 Another Possibility

Fig. 3 and Fig. 4: Solar Tunnel Dryer Type a)

Assembly:

The plywood plate 2070 X 1000 X 20 serves as the base plate.
The plate 1000 X 171 X 20 has to be sawed into shape to create the “gable”. An 8mm hole needs to be drilled into the ridge to mount the ridge pole.

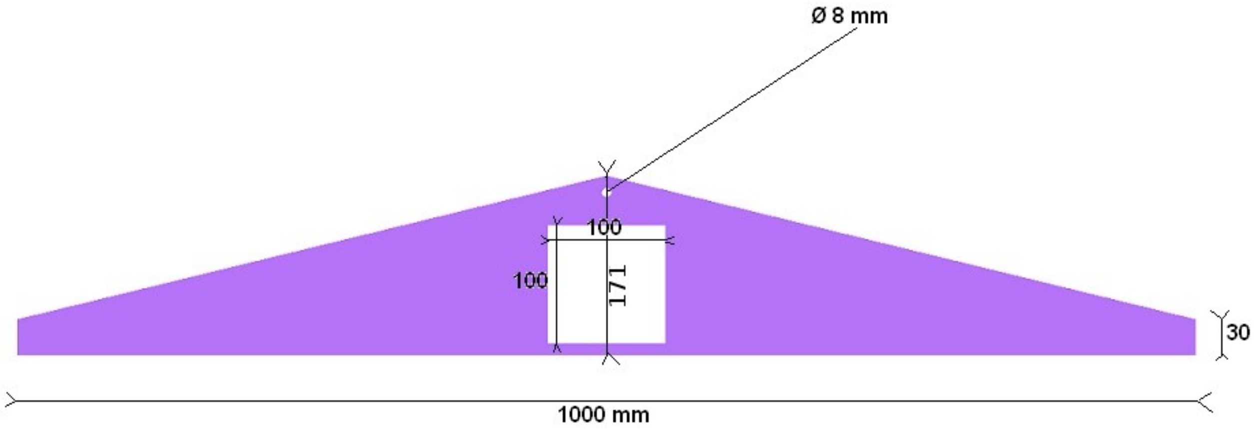

Fig. 5:Gable

The side plates are mounted on to the base plat, from the sides, with the 4,5x40 wood screws. The gable plate is screwed on to the front side of the base plate. The half of the base plate that faces the gable is to be painted black. Use food-safe paint!

The three struts are bent out of the flat iron (20x3, 1416 long) as follows:
20 mm from the (both) ends bend at an angle of 104° degrees.
495 mm after the first bend, a second bend at an angle of 150° degrees is made. The simplest approach is first to draw the desired form (fig.6) on to the ground with a crayon and then to bend the three struts accordingly.

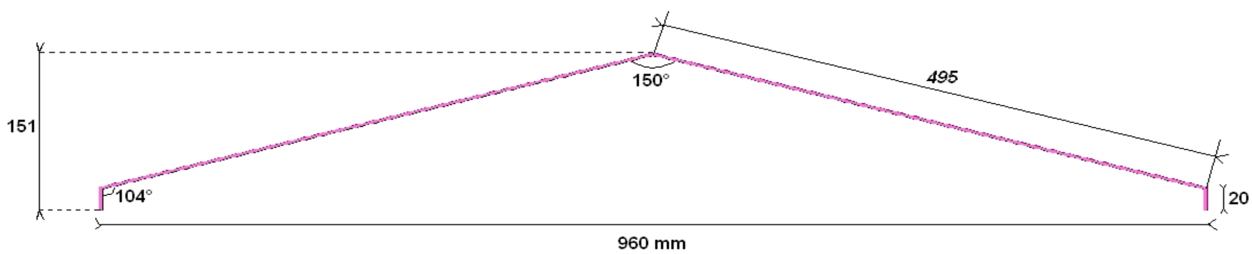

Fig. 6: Strut from bent Flat Iron 20x3

The wooden slates 495 X 25 X 10 serve as a mount for the foil. They are screwed on to the three flat irons. The slates are necessary for protection, since the iron, when exposed to sunlight, can become so hot that the plastic foil would melt.
The slates can be mounted with blind rivets 4x12 or M4 screws. For this purpose, drill 4mm holes into both the iron and wooden slates correspondingly. The head of the blind rivet or screw should submerge into the wood. It's sufficient to use two screws or blind rivets on each side of the dryer. On the ridge, the upper edges of the wooden slates should be filed off in such a way, as to prevent them from pressing through the foil.

Now the bent flat irons are screwed on to the side plate with the wood screws 4x20, from the inside and in equal intervals. The furthest strut (facing away from the gable plate) should end precisely with the base plate. The mosquito net can be clamped between the last strut of the frame and wooden slates. For this purpose, it is best to double-fold the edge of the net.
The mosquito net can be nailed, or screwed, to the base plate together with the remaining 10mm wooden slate. The most important thing is that the construction is insect-proof. Instead of simply mounting the net on the wood, it can be stretched onto a detachable frame. This method makes it easier to clean the dryer with a small broom.

Now, the 8mm wide aluminum rod is to be inserted into the hole in the gable and to be tied to the struts with stainless steel wire.

Then spread the UV-resistant plastic foil centrically over the base frame of the dryer. Transparent greenhouse foils work well
The foil should overhang approx. 6cm on both sides (longitudinal). On both gable sides an overhang of approx. 20cm is good. It serves as rain protection for the ventilator and prevents rain from entering the dryer through the mosquito net.

The foil is to be attached along the ridge of the ply wood gable and on to the struts with the combination screw + washer + rubber washer.

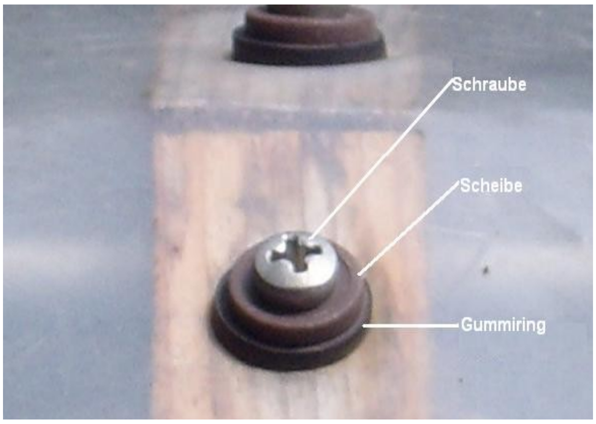

Fig.7: Attachment of the foil along the ridge

On the longitudinal sides the foil must be weighted, so it lies flat on the dryer (insect-proof) and cannot be elevated by wind. We use blind rivets to clamp the foil between the two aluminum profiles (bracket and square).

When very windy, this clamp rail can be fastened to the framework of the solar dryer by means of two clamps or a piston clamp.

Fig. 8 : Weight for the Foil: Corner Profile on the down side

Fig. 9 : *Square Profile on the upper Side*

***Fig.** 10 : Covering of the Ventilator*

Fig. 11: Frame

The underframe of the dryer can be constructed as preferred. A suitable working height is favorable. We welded two gantries out of steel angle plates . A cross wise strutting (in this case flat aluminum) was necessary for a stable stand.

It is worthwhile to lay the goods to be dried onto a grid, so that ventilation can also happen from underneath. We inserted a few rods beneath our plastic grid. This way the bottom side dries well (see fig.4). Employing a grid has the additional advantage, that it can easily be removed for cleaning. Single frames strung with grids are also a good option.

Fig. 12: Frames strung with a Grid: the Frame has “legs”, so that air can sip through underneath.

It is not necessary to paint the wooden parts of the solar dryer, as the foil provides sufficient protection from rain. Paints and other treatments for wood give off toxic substances that should not contaminate foods.

Solar Tunnel Dryer b) :

List of Materials:

Quantity		Size in mm
4	slate (5 mm) from beech or ash - *arches*	1025 X 27 X 5
1	wooden slate (5 mm)	1000 X 30 X 5
1	slate (5 mm) from beech or ash - *ridge*	2200 X 30 X 5
8	Wooden block (5 mm) – *mount for arches*	60 X 23 X 5
1	plywood (8 mm)- b*ase plate*	2200 X 1000 X 8
2	plywood (8 mm)- *side plates*	2200 X 100 X 8
1	plywood (8 mm) -ridge	1000 X 225 X 8
1	Ventilator, 50m³/h, eg. 1,7 W	100 X 100 X 2
2	wooden slate – *weight for foil*	2400 X 20 X 20
2	wooden slate – *frame for base plate*	2200 X 30 X 50
2	wooden slate – *frame for base plate*	975 X 30 X 50
2	trestle	
46±4	large screws	Ø4.5 X 40
20	small screws	
16	Combination: screw + disk + rubber ring	Ø3 X 10 / Ø12 X 3
	Screws to fasten the ventilators	
	Mosquito net	
1	UV-resistant, transparent foil	2400 X 1400
1	Photovoltaic module 5W (or more)+ cable	Caution: the voltage must correspond to the operating voltage of the ventilator
1	Kitchen strainer - *cover for ventilator*	
	Black paint (non-toxic)	ca 100ml

Fig. 13: full View of Dryer b)

This dryer model is a lighter version, therefore a frame is needed for adequate stiffness of the base plate. For this purpose, screw the slates 2200x50x30 and 975x50x30 on to the base and side plates (see fig.14).

As underframe we use two trestles from a DIY superstore.

If necessary, the trestles can be clamped to the frame.

If drying is to occur at low outdoor temperatures frequently, the area within the frame (under the dryer) can be laid out with styrofoam plates, to minimize heat loss.

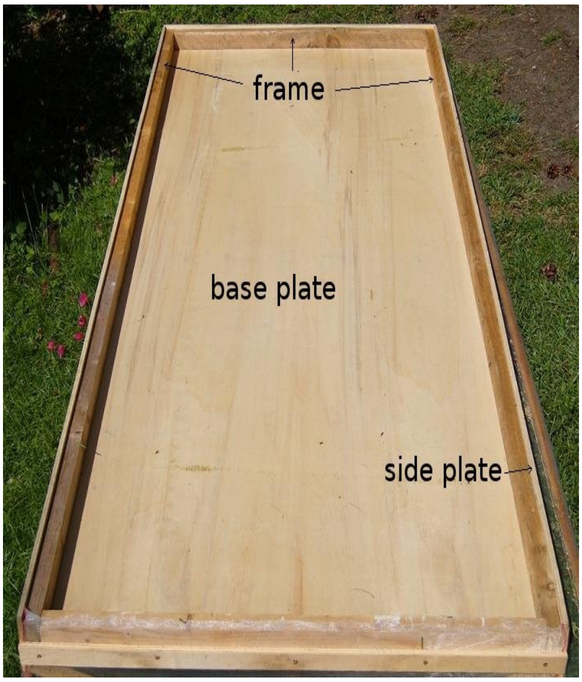

Fig. 14: Base Plate with Frame, viewed from below

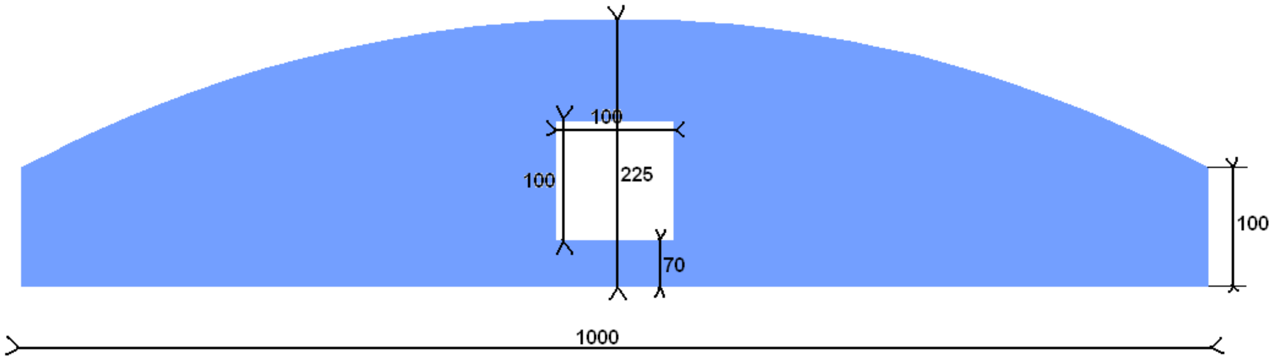

Fig. 15: Gable

The gable is cut out of the1000x225x8 plate.

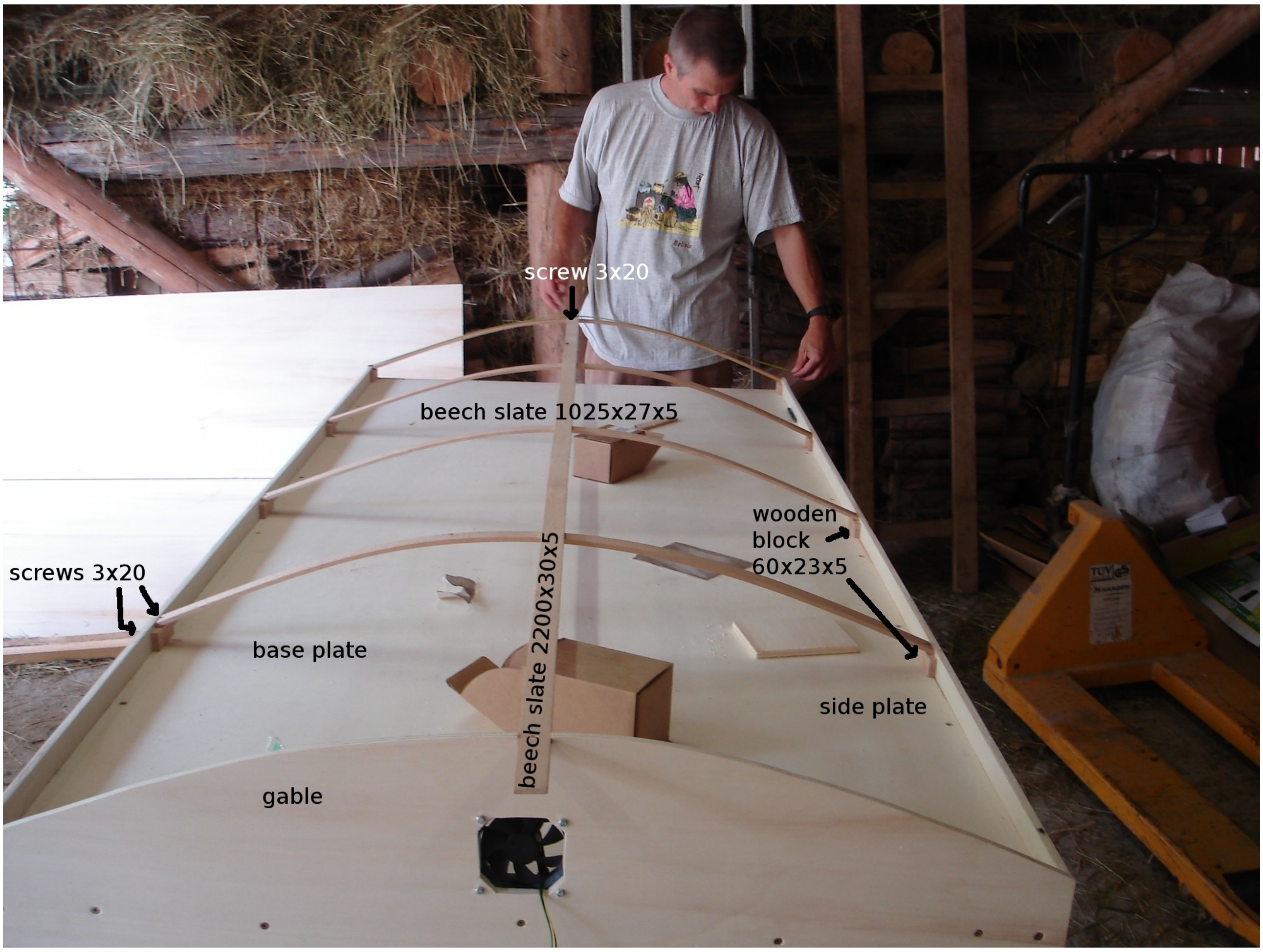

Fig. 16: Basic Framework

The beech slates 1025x27x5 are each bent into an arched form and screwed onto the wooden blocks. The length of the slates is important, since it determines the height of the arches. Therefore: Pay attention to accurate length!

Join the arches to the ridge slate 2200 X 30 X 5.

Attach the mosquito net to the open end of the dryer to keep out insects (see dryer a). The ventilator also receives an insect-proof grid cover (the kitchen strainer)

With the aid of the combination screw + disk + rubber ring, the foil is screwed tight to the ridge slate and is weighted with the woods 2400 X 20 X 20 on the sides.

Fig. 17: Fastening of the Plastic Foil to the Weight (wooden Slate)

Variations

Other Materials

The solar dryer can, of course, also be built from other materials. The following photo shows a dryer that we have built in India.
The base plate is made from a corrugated sheet, as is used for roofs. All other parts are made of steel, except for the wooden slates at the contact surfaces of the foil and the ridge is made out of a plastic pipe
To avoid strong heat loss under the dryer, regular kitchen aluminum foil was glued over the entire bottom surface of the corrugated sheet iron (on the outside).
Three screens strung with stainless steel are used for the food products.

Fig. 18: Solar Tunnel Dryer made from Corrugated SheetIiron and Steel Profiles

An interesting modification, is to cover the side of the dryer where the foods are to be placed with sheet metal. This way it is easier to wipe the dryer with a moist cloth. If you intend to dry juicy fruit or tomatoes, you will value this.

Fig. 19: Tomatoes are dried over an area covered with offset-sheet metal (0.5mm aluminum). (Afghanistan)

Naturally, the cover of the dryer can also be constructed from glass plates. On the other hand, the device thereby becomes decisively heavier and the effort for construction rises accordingly.

If no UV-resistant plastic foil is at hand, a regular plastic foil (painting supplies) can be used. When exposed to sunlight over longer periods of time, it will, however become brittle and cracked and – if the solar dryer is to remain outdoors throughout the whole year - must be replaced every year.

Generally the following points should be regarded, regardless of the specific outlay of the dryer.

- Maintain the ratio of the black area to the drying area (1:1)
- Approximately maintain the height, regardless if the dryer becomes longer or wider
- Build insect-proof
- Maintain the volume flow per m² (see "Selection of the Ventilator")

Dimensioning of the Fan for bigger dryers

In case the size of the dryer is changed the fan has to be adapted accordingly**.**

The choice of fan depends on one important parameter: the size of the absorber. The absorber is the black area of the solar dryer where no food is placed.

Generally:

per m² of black absorber area a volumetric flow rate of
40 to 50 m^3/h air is required.

Example: A drier with an absorber area of 2 m², that is twice the size of the dryer models described in this manual, needs a volumetric flow rate of 80 to 100 m³/h.

Experience has shown that the velocity of air at the dryer outlet should be V = 0,2$m.s^{-1}$ or less, so that the pressure drop is low and the fan therefore doesn't need much power.
Following the dimensioning of a fan is demonstrated using the example of our solar dryers 1 and 2.
The volumetric flow (Q) is velocity into cross section (A): $Q=V \times A$
V is the velocity of air at the dryer exit
A is the cross sectional area (red in the drawing)

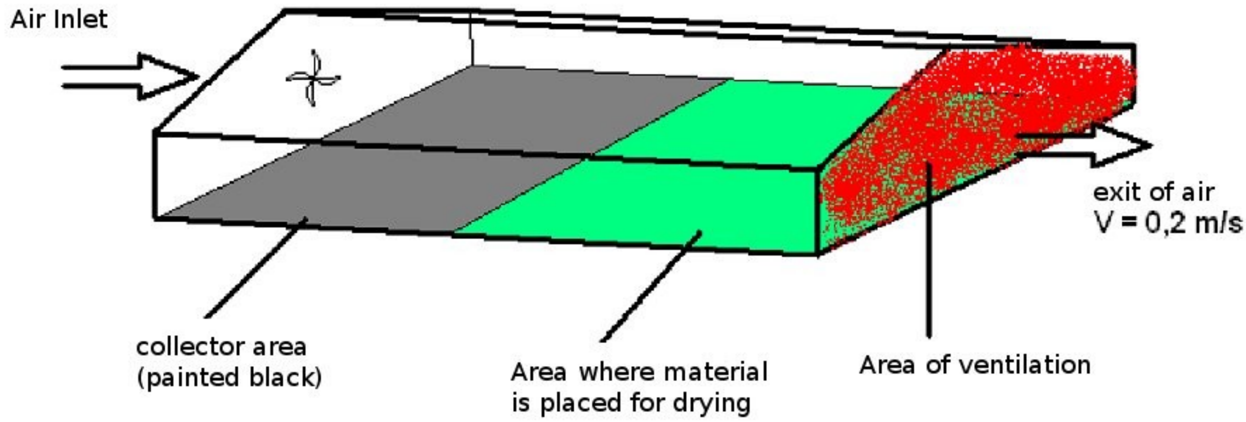

Fig.20: ***areas of the dryer***

First of all we want to see if we have chosen the cross section of our solar dryer well.

Our two dryers have different cross sectional areas:

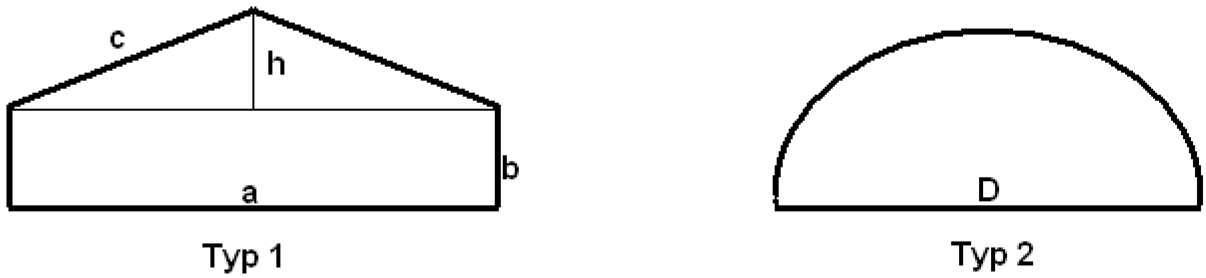

Fig. 21: cross section

Cross section of dryer 1:

consists of a rectangle and two triangles.

$$A = a \times b + \frac{a \times h}{2}$$

Therefore:

$$A = 0{,}96 \times 0{,}03 + \frac{0{,}96 \times 0{,}151}{2} = 0{,}1 \ m^2$$

About 50 m^3/h = 0,0139 m^3/s of air shall be moved per m² of black area.

The dryer has 1m² collector area. Dividing through the maximum speed of 0,2m/s results in the minimum cross sectional area of the dryer available for ventilation.

In our case: $0{,}0139 \div 0{,}2 = 0{,}069\, m^2$.

For dryer 1 the minimum area for ventilation is 0,069m² . This means that the actual cross section of 0,1m² is big enough.

For dryer 2 :

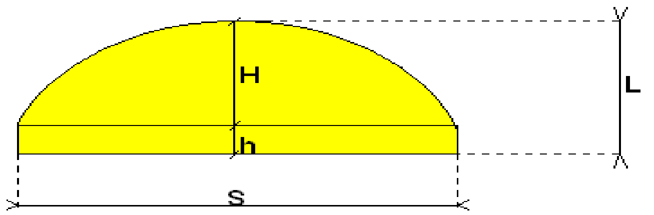

Fig. 22: cross sectional area of dryer 2

the area consists of rectangle A1 and the section of a circle A2.

A1 = $S \times h = 0{,}980 \times 0{,}033 = 0{,}032 m^2$

A2 = $\frac{H}{6S}(3H^2 + 4S^2) = \frac{0{,}13}{6 \times 0{,}980} \times (3 \times 0{,}13^2 + 4 \times 0{,}980^2) = 0{,}086\, m^2$

A_{total} = A1 + A2 = 0,118m²

The collector area is 1,2m². Therefore a volumetric flow rate of 60m³/h or 0,017m³/s is required.

A minimum of 0,085m² has to be provided for ventilation. For our dryer 2 the area of ventilation is therefore well enough above the minimum requirement.

Choice of fan:

Suitable fans are available e.g. from venders of electronic components. The specifications of a fan always include a mention of how many m³ of air the fan can move per hour (flow rate). That flow rate should be roughly correct. Around 10m³/s above the calculated value is still OK.

The voltage required by the fan has to match the voltage provided by the PV panel.

Dimensioning the PV panel:

Voltage x required current (Volt x Ampere) of the fan results in the power the fan needs to receive from the PV panel. The fan should also run under overcast weather conditions. The PV panel therefore needs to be chosen bigger. A factor of 2,5 is reasonable.
Example: If a fan requires 2W we should choose a 5 W panel.
PV- panels of such small sizes are available from suppliers of manufacturers of solar lanterns or solar toys.

Correlations

First of all a few interesting correlations established by the Institute of Agricultural Engineering in the Tropics and Subtropics, University Hohenheim, Stuttgart.

Data (Fig.23 to Fig.28) were measured on large (20x2m) solar tunnel dryers. The results can serve as a guideline for our small tunnel dryers. The absolute values from the following graphs are, of course, not mappable 1:1, since there are climate dependent differences in humidity and outdoor temperature. They, however, demonstrate the general relations quite nicely.

The drying time depends on the thickness of the foods. Example : Apples

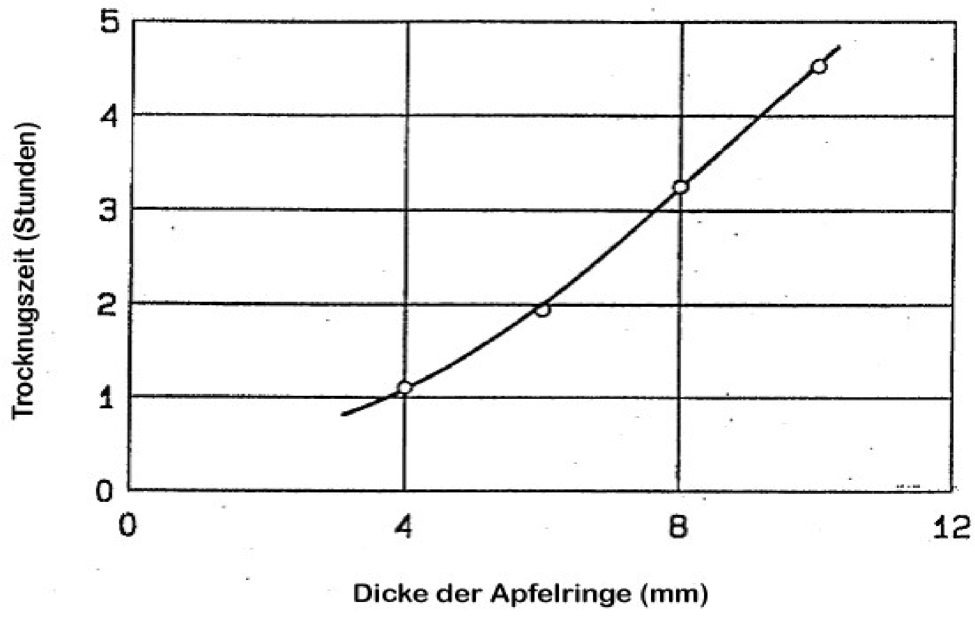

Fig. 23 : Influence of the Thickness of Apple Rings on the drying Time (from Plant research and Development, Volume 44, p. 69)

Remark:

In the graph there is no information regarding the temperature levels in the dryer used for these experiments.

My experience: At a temperature of 56°C within the dryer (August, best weather) apple rings with a thickness of 7mm need approx. 7 hours to dry.

The drying time is decisively dependent upon the temperature within the dryer:

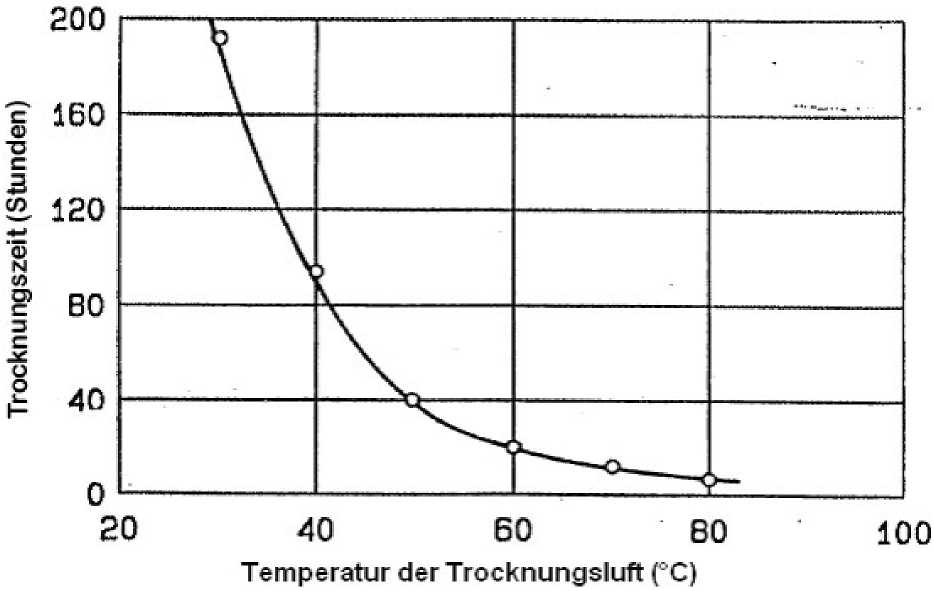

Fig.24: Influence of the temperature of the drying air upon the drying time of grapes
(from Plant research and Development, Volume 44, p.70)

Caution is, however, to be taken. If the air is too hot, bad quality of the dried goods results. Discoloration and/or changes in the structure of the dried foods can occur. Nutrients within the foods are destroyed.

If somebody wants to try it out: Simply turn off the ventilator and the temperature within the dryer will rise.

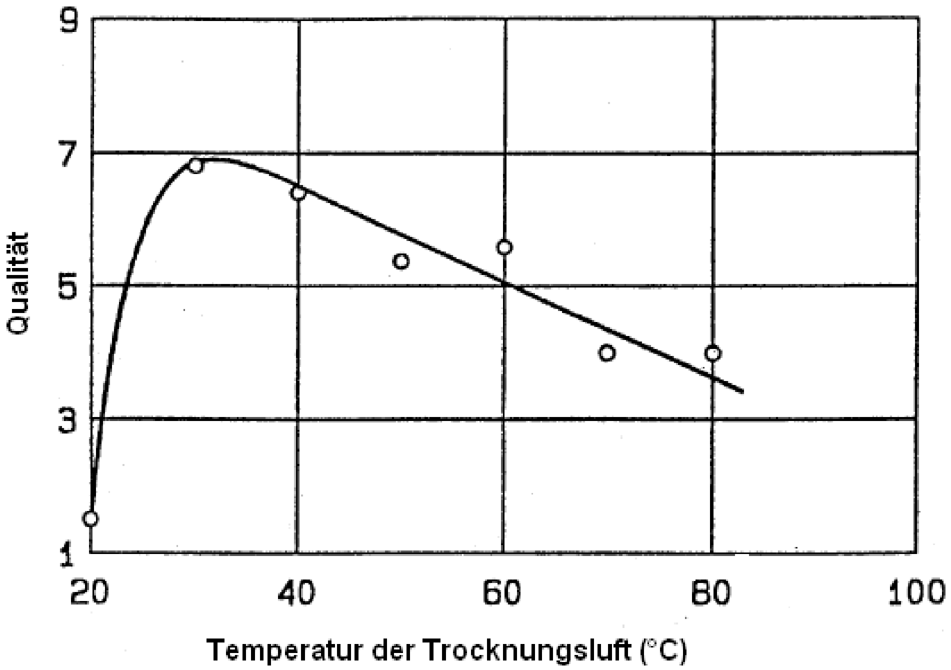

Fig. 25: Influence of the Temperature of the drying Air upon the qualitative Properties of Raisins
(from Plant Research and Development, Volume 44, p.71)

We have built the solar dryer in such a way that, under normal operation, temperatures that would damage the dried foods are not reached. At the same time sufficiently fast drying is achieved.

The drying time in the solar dryer is shorter than under direct sunlight:

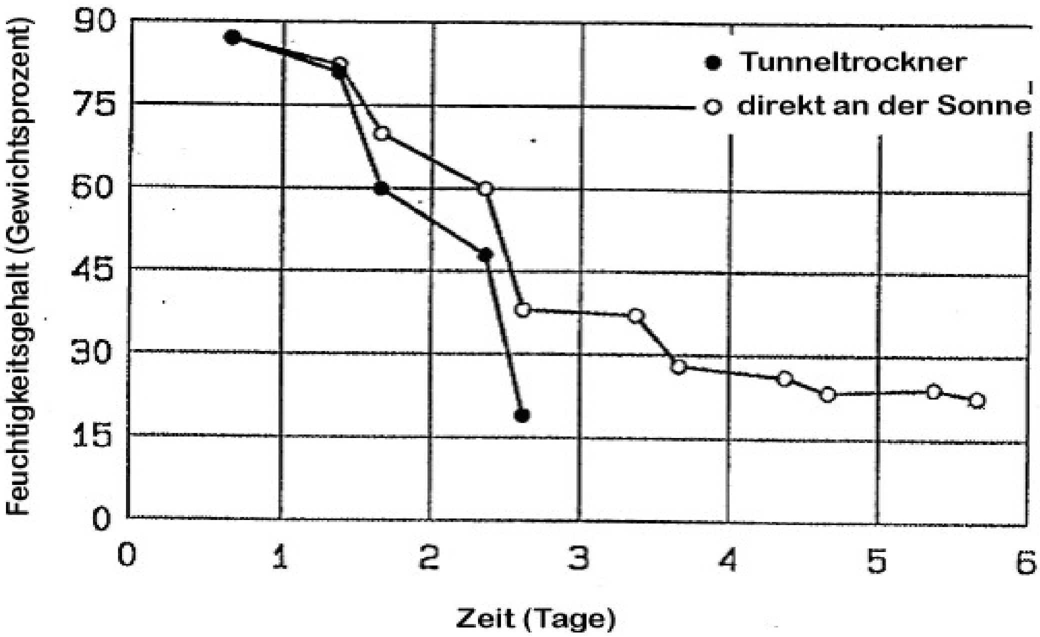

Fig. 26 : Drying of Apricots in a solar Tunnel Dryer compared to Drying under direct Sunlight
(from Plant research and Development, Volume 44, p.74)

This effect is most noticeable under conditions of high humidity. If the outdoor air is dry, the difference between the results in a solar dryer or under direct sunlight is less.

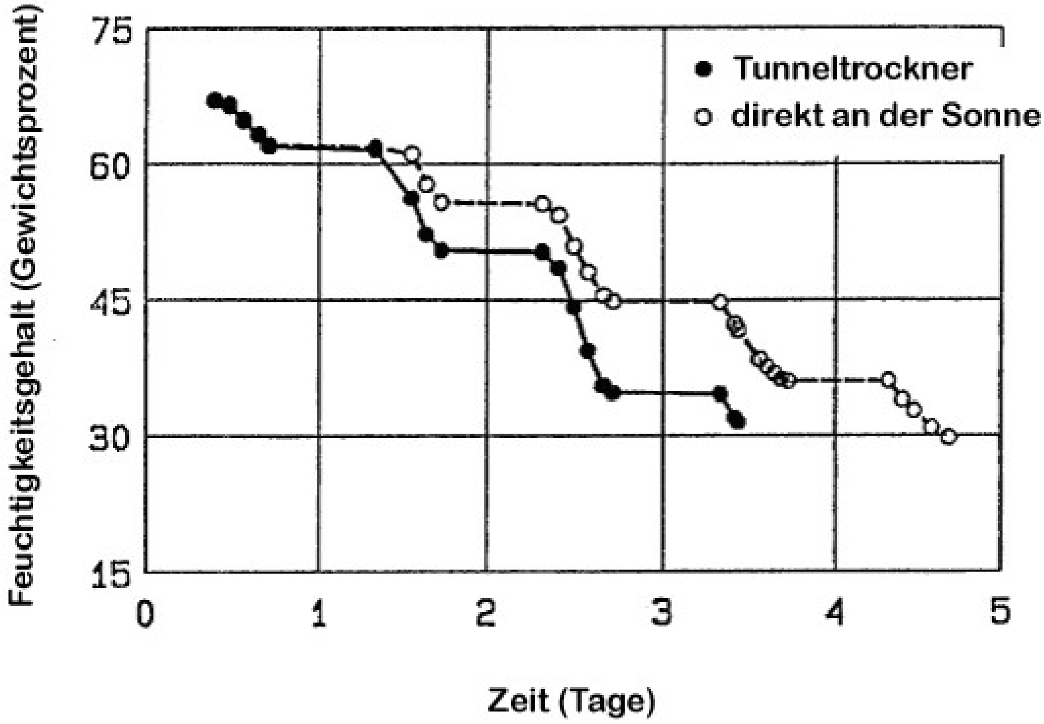

Fig. 27 : Drying of Bananas in a solar Dryer compared to Drying under direct Sunlight
(from Plant research and Development, Volume 44, p.75)

Let's get started!

What can be dried?

Pretty much everything, or not?
The aim of drying is to stop the natural process of decomposition of the formerly "living" raw materials by dehumidification as early as possible. If timely dehumidification is not achieved – or the process is interrupted for too long – the foods spoil. Usually this occurs through mold.

Fruits or vegetables with a high water content are at risk (e.g. tomatoes, apricots, plums) . It is sensible to dry such goods only when the weather allows uninterrupted drying from beginning to end. In addition, whole fruits should not be placed in the dryer, since the skin is a natural protection against dehumidification. Preferably, the fruits are to be cut into slices, or are at least to be halved, to achieve a surface area as large as possible surface for evaporation.

Fruits or vegetables with a high water content are best dried on a reusable baking paper, to prevent juice spilling into the dryer. The dried goods are also more easily removed from the baking paper than from the screen of the dryer.

Fig.28 : Tomato slices on baking Foil

Fig.29 : Now the dried Slices can easily be removed

The solar module is chosen in such a way, that a slight air stream occurs even on a cloudy day. This ensures that an occasional day without sunshine can be bridged.

Herbs and leafy vegetables, such as chard or spinach, have a large surface area and little gross weight – they dry very fast. It is best to remove and package them immediately when they are dry. This way taste and color can be preserved.

To retain color, the vegetables can also be blanched (briefly placed into boiling water) before drying. In the process enzymes responsible for changes in color are destroyed. The blanching time depends on the type and size of the vegetables.

Diced carrots need approx. 10 min, cauliflower 5 min. For broccoli and celery 3 min are sufficient. Blanching can also be done in steam, rather than in boiling water. This way fewer substances are lost from the vegetables.

Fig.30 : The diced Carrots on the left were dried directly, those on the right were blanched for 10 min before.

To retain the pretty colors, the dried goods must be protected from light when stored. Otherwise bleaching will occur.

Herbs with fine leaves, such as thyme or dill, can be dried on baking trays. This way it is easier to package the whole harvest and the dryer doesn't end up full of crumbs.

Fig.31 : Dill on Baking Trays

Fig.32 : House Tee Mixture „All across the Garden“ with Lemon Balm, Black-, Rasp- and Strawberry Leaves, Sage, Marigold-, Yarrow- and Borage Blossoms

Fig.33 : The Leaves shrink markedly and become very brittle. It's best to package the Mixture immediately.

In the summer, we use our two solar dryers to handle the zucchini glut. My favorite tool for cutting is the vegetable slicer.

Bush beans also often ripen in masses. We lay them directly into the dryer when freshly harvested – with very good results.

Fig. 34: The Dryer full with Zucchini Slices. This way the Harvest lasts well into the Winter.

And, of course, apple slices in large amounts for “Muesli” (breakfast cereal).

Fig.35 : Apple Slices without end

Fig.36 : approx. 400gr dried Apples


Fig.37 : Chocolate-Apple rings

Apple rings taste especially well, when they are half coated with plain chocolate. Simply melt some cooking chocolate. Stir in some cream to make the chocolate more fluid. Dip the apple rings so that they are half covered and then place them on baking paper to let them cool off. Chocolate-apple rings are a well received bring along for all occasions.

Another tip: It is better to load the dryer in the morning, rather than in the evening. This way the drying process begins immediately. Otherwise our foods are subject to beginning spoilage in the meantime.
If we start in the evening the foods might start to rot because the air is cool and humid during the night.

What doesn't work:

I had to realize, that tortellini are not really fit for drying. They have a small surface area and a lot of filling. Despite drying for several days, barely noticeable mold occurred inside, leading to a bitter taste. The surface composed of pasta dough dries quickly and then only little internal humidity reaches the surface area, where it can evaporate.

Homemade noodles, on the other hand, dry very quickly.

Here **a tip for the gardeners** among us:
Those who want to dry their own seeds for preservation should pay attention to the fact that drying temperatures above 42°C impair the germination capacity progressively. The temperature in the dryer must therefore be monitored and adjusted by partially shadowing the plastic foil, if necessary. For this one can simply place a towel over part of the foil, to the extent necessary that the desired temperature level is reached.

Naturally, it is equally important to package the dried seeds in such a way so that they are protected from humidity.

How to package?

Once dried, the packaging is the most important factor in ensuring quality and durability of the dried goods.
We use large screw cap jars with twist-off caps. They are humidity- and moth-proof.
It's best to store the jars protected from light, to avoid bleaching of the colors.

Fig. 38 : The whole Harvest – Apples, Pears, Plums, Bush Beans, Zucchini, Orache (wild Spinach Substitute)

The dried goods can, of course, be shrink-wrapped as well. Small household appliances, usually used to shrink-wrap freezer bags, work well. Very important: Only use food-safe foil bags/tubes. To avoid infestation with parasites the foil should be thick enough.

Infestation with food moths can kill the whole joy of it all, when one intends to consume the tasty dried fruits or vegetables stored, at some time in the middle of winter. If the two following steps are observed, this experience will be avoided:

- Always package the goods immediately when they are dry enough. Never let them lie around. Fill into the jars when still "warm".
- Best to always package in screw cap jars. Screw the cap tight.

Fig. 39: plodia interpunctella, the Indian meal moth

Fig. 40: not so tasty anymore: dried apricots with moth infestation

If there is danger, or suspicion, that moths could have become active already, it helps to heat the dried goods anew. So, simply to place them in the dryer again until they are well heated throughout. If not otherwise possible, this can, of course, be done in the baking oven as well.
We handled moth infestation of walnuts this way. Many kilograms of walnuts had become inedible from June onwards. Not to let this happen again, we thoroughly heated the whole harvest from the previous year in the drier the next spring. A few minutes above 60°C are sufficient (temperature within the nuts). This temperature is achievable by turning off the ventilator. The nuts suffered no kind of damage and no moths developed.

What to cook?

Enough recipes can be found in various other sources and there is, of course, limitless room for fantasy. Therefore here only a few brief personal remarks:

My absolute favorite “dry-food” is vegetable lasagne with dried zucchini slices.
The zucchini should be well soaked previously. If they are only soaked for a few hours, instead of over night, the resulting flavor reminds of dried mushrooms.
Very tasty!
A variation of this is vegetable lasagne with spinach/chard or orache, which don't even need to be soaked beforehand. Simply stack them between the sheets of pasta. They can cook in the lasagne sauces.

If one cooks in a sun oven (solar cooking box), the dried vegetables don't need to be soaked, since the sun oven operates at a low temperature and cooking times are usually more than two hours.

If the dried vegetables are to be cooked without using a sun oven, a pressure cooker is worthwhile. This is, by the way, the simplest way to get bush beans cooked until they are soft.

Oh, and dried cauliflower (cook well until soft!), seasoned with Indian spices and served with rice is mouth watering.

Finally, one more important topic, with which the “solar freak” is naturally confronted by well meaning critical contemporaries and by the weather conditions themselves again and again:

What to do when the sun doesn't play along?

“Timing is everything” seems to me to be the proven guiding principle concerning the direct utilization of solar energy. Nobody would lay themselves into a deck chair in expectation to tan when the sun doesn't shine – well and so it is with solar drying as well. Simply keep an eye on the weather!

In the case that clouds appear and a thunderstorm arrives we don't have a problem. Drying simply continues the next day. Even a whole day of cloudy skies can be bridged without a solar dryer, if the fruits have already dried a little bit (surface dried).

But this is the limit. On a second day without sunshine mold will appear. If such an unfavorable weather condition is imminent and half dried goods are in the dryer, it is recommendable to remove the content. A possibility would be to continue drying over the

radiator or a tiled stove (in fall, with cool outdoor temperatures).
There is also the option of employing a dehumidification agent that is food-proof and continuing the process in the closed solar dryer. Since this requires more effort – who has dry calcium chloride lying around at home – here only a reference to the explanation of the procedure:
www.solarfood.org/solarfood/pages/solarfood2009/3_Full_papers/Technologies/53_Scheffler.pdf
Grained zeolite are also applicable – although almost nobody has them lying around at home either. Since they are easier to handle, however, here a little inspiration:

Fig. 41: Apple slices can complete the drying process over dry(!) grained zeolite. For this the whole thing is additionally covered with a baking tray of equal size from above.

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Fig. 23 corresponds to "*Fig 4 influence of the thickness of sliced apple rings on the drying time"*

Fig. 24 corresponds to "*Fig 7 influence of the drying air temperature on the on the drying time of grapes"*

Fig. 25 corresponds to "*Fig 8 influence of the drying air temperature on the quality characteristics of raisins"*

Fig. 26 corresponds to "*Fig 13 drying curves of apricots dried in the solar tunnel dryer compared to sun-drying"*

Fig. 27 corresponds to "*Fig 14 drying curves of bananas dried in the solar tunnel dryer compared to sun-drying"*

Figure 30 from www.lepiforum.de
(Classification-key for types of butterflies identified in Europe)

for further reading:

at **www.solarfood2009.org** a whole number of lectures and presentations pertaining to solar drying worldwide can be retrieved.

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