

Practical Application of Solar Tunnel Dryers

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1. ABSTRACT

Solar Tunnel Dryers (STD) are weather protected food dehydration tunnels that dry food economically and hygienically. STD are used to dry fruits and fruit pulp as well as concentration of fruit juices, especially of fruits that would otherwise quickly perish.

Fruit leather is prepared sorted and washed and fruits, which is then shredded with common Kitchen machines

The fruit pulp is mixed with preservatives and sugar and volumetrically distributed into plastic lined mould. After drying the fruit leather is stored in a cool room until finally packed or refined with chocolate.

Fruit juices are concentrated in a STD using similar drying moulds as for the fruit leather. The dryer has to be equipped with an absolute level grid to receive the moulds.

Sterilised fruit juice is poured into moulds to a depth of 2-3 cm for evaporation. 50% of the water content is evaporated on the first day. Thereafter the evaporation slows down until the final stage of the concentrate is reached, depending on the requirement of the final product. (E.g. Juice Concentrate, Paste, or Juice Leather)

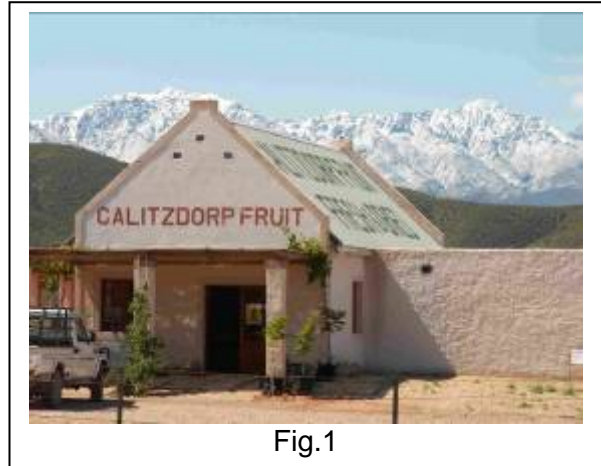


Fig.1

2. Introduction:

ELNATAN is a non profit organisation with a Christian background. ELNATAN's main purpose is to create jobs and to train adults in basic skills. ELNATAN has a solar engineering section which has built a 10m² Scheffler Reflector, a Solar Tunnel Dryer and mass produces the Lazola box cookers.

ELNATAN has a fruit drying and processing plant where the Solar Tunnel dryer is used. Raw materials are processed into fruit leathers which are refined with chocolate and yoghurt. We also produce fruit juice concentrates. All these products are sold to the public in our own shop. (Fig.1)

ELNATAN has a further section where standard building work is executed in our district.

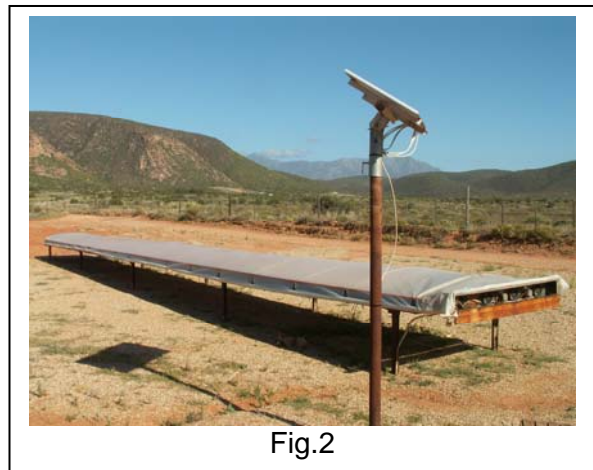


Fig.2

3. Background

Our Solar Drying Plant is situated in the south of South Africa in the Cape Province. We are approx. 100km from the Coast.

On average we have 300 sunny days per year.

Our average maximum Summer Temperature is 44 C.

Average winter minimum Temperature is 2.6 C.

We have a very dry climate.

We do have frost in the winter that qualifies to grow fruit from the prunus family like apricots, peaches, plums and nectarines but also grapes and quinces as well as citrus fruits. Our fruit has a short fresh life time and is many times available at low cost, especially when the normal market is unable to absorb the excess fruit at short notice. Weather changes also make necessary to harvest fruit quickly.

Some producers are far away from the fresh fruit market and have no other option than to dry their products.

In our area people have dried fruits for the last 150 years and have also produced fruit leather. Excessive grape juice was cooked until it became a heavy syrup which was used in the winter as a sugar substitute.

Our company is specialised to manufacture fruit leathers and to a lesser extent grape juice concentrate.

Through Heike Hoedt and Wolfgang Scheffler we were introduced to the paper, Solar Tunnel Dryer for Fruit by Albert Esper and Werner Muehlbauer from the Institute for Agriculture Engineering in the Tropics and Sub-Tropics at the University of Hohenheim Germany.

In order to produce products free of insects, bird droppings and dust we chose their tunnel dryer.

We changed their design to suit our purpose, but the basic design criteria we kept, 2m wide and 20m long. We have built one of these dryers 6 years ago and are very much satisfied.

The dryer has been built in 4 sections and can be dismantled and transported to any other location.

One third of the dryer is used as an air heater section and 2 thirds are used for drying.

The tunnel is covered with standard tunnel plastic UV protected and lasts approx. 3 seasons. The tunnel can be opened and closed by 3 people. The tunnel is equipped with 4 fans with a total capacity from 800 - 1000m³ per hour, powered by one solar panel 80W. (Fig.2)

4. Project

4.1. Fruit Leather

Standard fruit leather in our area is made from a pulp ground in a liquidiser type of grinder. Normally this type of pulp is cooked before drying.

We have changed the recipe by not grinding the fruit but shredding it and not cooking but drying it raw. This helps to retain the flavour. During the drying process the flavour evaporates first before the water evaporates. By shredding the fruit we are maintaining small individual pieces of fruit. These pieces retain the flavour in the fibre structure which makes our product more attractive and tasty.

4.1.1. Preparation of drying moulds.

We have chosen to make our moulds out of 6mm super wood (in Germany MDF) with the sizes of 600mm length and 400mm width.

The edge of our moulds have got a 15mm high wooden square bar. These moulds are light and handy to work. The moulds are lined with a thin layer of plastic (45 micron) which is strong enough that it can be removed easily from the finished product without tearing it.

For one dryer you should have at least 2 sets of moulds. If the dryer is packed without the use of the air heater section (full length) the dryer will take 120 moulds that means you require 240 moulds. When weather conditions permit (high ambient temperatures like 35 C), we do not use the air heater section.

4.1.2. Preparation of fruit

The fruit which we are using is of good quality and fresh and firm.

The fruit is sorted and washed early in the morning, when I say early, I mean it. It is good to start when it is still dark, because you need to finish the whole process of cutting the fruit and packing the dryer before 11am, that you have 2/3 of a day for the first drying process. The quality of your finished product is best when you can load the dryer early in the morning. Then the fruit has no chance to deteriorate. 30 – 40% of your excess juice is evaporating on the first day. If the first day is not fully utilised, the product is losing on colour and texture. I want to say at this point of time that it is important, that you have at least 2 days of full sunshine to create a good product. The final drying process can be in semi cloudy weather. (Fig. 3 & 4)



Fig.3



Fig.4

4.1.3. Grinding of fruit

We shred our fruit with normal household shredders which work on a batch system with other words we are grinding approx. 800gr. of fruit into a container then stop the machine, empty the container and start again. We have found that industrial shredders which work continuously into a big bucket are extremely expensive and the output does not justify the extra cost. We use one household machine for one or two years before we have to replace them. This has enabled us to start our production without a big capital layout. For our production we use 3-4 machines simultaneously. (Fig.5)

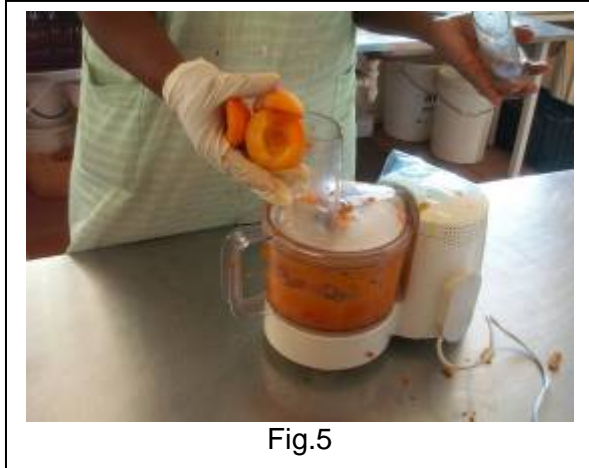


Fig.5



Fig.6

4.1.4. Mixing of fruit pulp

The shredded fruit is now immediately mixed with a preservative (sulphur dioxide in powder form) to prevent oxidation and fermentation. The quantity of the preservative is kept to a minimum only to prevent the destruction of the fruit until is dry. After drying the sugar and the low water content will preserve the fruit. The quantity of the preservative is so low, that most of the people do not realise that it has been used. The quantity of preservative depends on the type of fruit which you want to dry. After adding the preservative you have a little bit of time as the texture of the fruit is not deteriorating anymore. Add only sugar just before you are spreading the mixture into the mould then the sugar has no time to extract moisture from the fruit before it is poured into the moulds. (Fig.6)

4.1.5. Drying of fruit leather

The volumetric measured fruit sugar pulp is distributed equally and evenly with a plastic spatula unto the plastic lined moulds. It is important that the volumetric measure is kept accurately so that we get a consistent product. Uneven spread fruit give unequal drying time and create problems when weighing and packing. The drying time is approx. 3 days, depending on weather conditions. We have temperatures from 35 C to 44C in our area in South Africa during normal summer conditions. We do not need the air heater section in summer and fill the dryer completely to avoid too high temperatures. High temperatures (above 55C) destroy the flavour of the product which has to be avoided. After drying the moulds area taken out of the dryer and stored



Fig.7

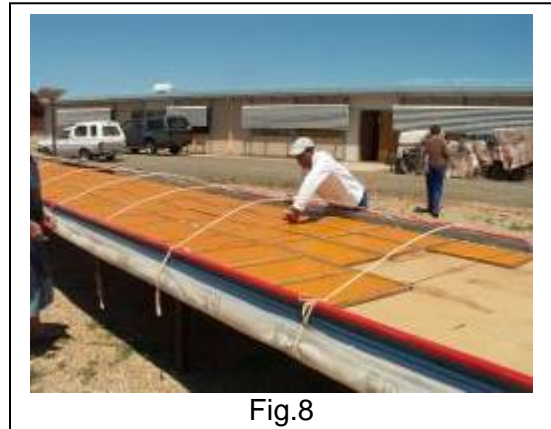


Fig.8

in an airy room criss cross wise so that the moisture of the product can be equalised (in the beginning the surface of the product is the most dry). After a day we check all moulds. Those which are lacking dryness are returned to the dryer to finish the drying process. One drying mould will be loaded with an average mixture of 0.47kg sugar and 2.21kg fruit pulp which gives a total of 2.67kg. The finished product weighs 0.92kg (Fig.7-11)



4.1.6. Storage

The finished dry product is taken to a concealed chamber where the product is exposed to a gas which we call Phostoxin, which has an active ingredient of aluminium phosphide which will kill any eggs of moths in case there was any contamination during the drying process or imparted from the original fruit. Thereafter we pack 6 layers of the fruit leather with the original liner plastic still attached to the leather on top of each other and wrap this package in a plastic and seal it properly with tape. Make sure that the packing from the fumigator to the cold store goes within a few hours that there is no more contamination possible. All products which are not packed immediately and sold are stored in a cool room at temperatures 12 and 14C. (Fig.13 & 13)

Our finished products are packed into rolls or in flat sheets or small snips. Part of our products are cut to size and covered in chocolate or yoghurt and sold as a delicatessen. This is keeping our people busy during the rest of the year. (Fig.14 & 15)

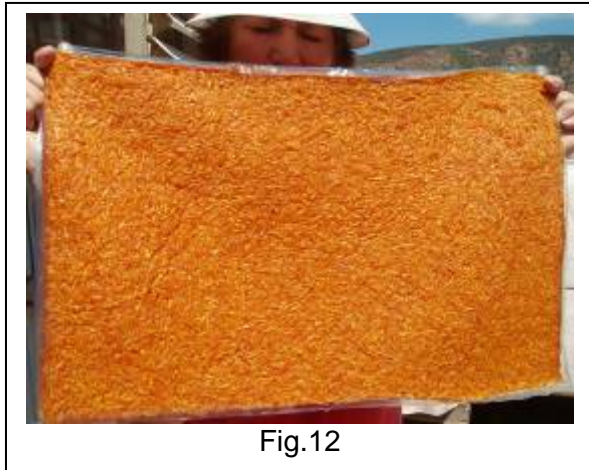


Fig.12



Fig.13



Fig.14

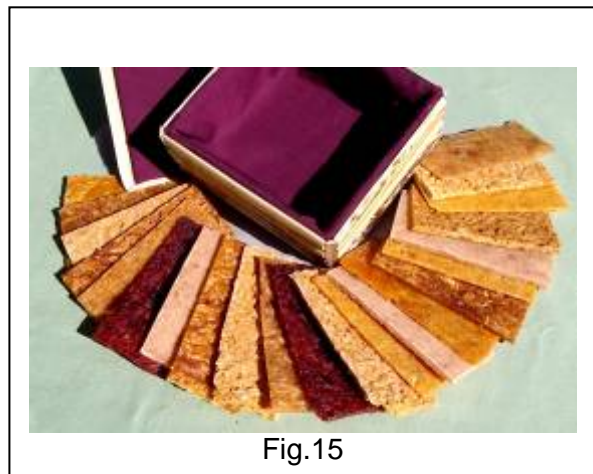


Fig.15

4.2. Fruit Juice Concentrates

We have in South Africa a special grape which originates from the Muscatel family, we call these Grapes Hanepoot. These grapes have a special strong muscatel flavour. These grapes are used mainly for table grapes or for drying to raisins. In times past the juice of these grapes was concentrated by cooking until it had a honey like consistency. Naturally most of the flavour was lost.

With our solar dryer we can produce a product which retains most of the flavour. We also make concentrate from other fruit juices for example quince jelly and use this mainly for diabetics. The quantities produced are small but there is a beginning.

4.2.1. Preparation of Dryer.

The dryer has to be absolutely flat, as you can guess otherwise the liquid will run to one side. In order to minimise this problem we have used similar moulds than for the leather, except that the rim for the moulds have to be higher (35mm high).

4.2.2. Concentration of juices in the dryer.

In order to prevent fermentation, the fruit juice has to be sterilised and is poured hot into the lined moulds to a depth of 20-30mm. 40 to 50% of the water content is evaporated on the first day. Thereafter the evaporation slows down until the final stage of the concentrate is reached. Some of the concentrate can be used as a jam; some like the quince jelly becomes leather.

We have not fully utilised all the possibilities which are there, but new products can be developed all the time. Important is to utilise valuable fruit juice which otherwise would have been wasted. The concentrate can be stored and used later on as required.

5. Conclusion

Solar Tunnel Dryers are ideally suitable to preserve fruit which would otherwise perish by producing fruit leathers and fruit juice concentrates.

These two products can conveniently be stored and transported as needed. Fruit leather has got a very popular market and can be profitably sold. Fruit leather also can be transformed further into a more valuable product by using chocolate or yoghurt coating. There is a great unexplored market to be developed and it is proven, that this can be developed in-expensive and economically viable.