

FRUIT DRIER

SUBHASH A AVASARE

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INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY
1973

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SYNOPSIS ✓

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of

Diploma Project on

FRUIT DRIER

By

SUBHASH ANANT AVASARE

INDUSTRIAL DESIGN CENTRE

We are a developing country

80% of our 600 million population stays in villages

Design for this country is the one for her villages

We are a country with great heritage

We had a technology of our own

The technology once developed in a society does not totally die

We are a country with ample resources that are wasted

A typical part of our country is district Ratnagiri

Here is a fruit drier to be used in this district

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We are the villagers who face the problems

What we need is the scientific outlook

Once we get it we solve our problems

A purposefull attempt is made not to standardise

— This will enhance an educative process in the society

Which will lead to a chain of enovative designs

I have just stretched my imagination

To what will such inovated fruit drier will look like

After a few years hence

fruit drier

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✓ 27.
FRUIT DRIER

Diploma Project

Submitted in partial fulfilment of the
requirements for the
Postgraduate Diploma in
Industrial Design

by

SUBHASH A. AVASARE

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1973

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Bombay

APPROVAL SHEET

Diploma project entitled.
'FRUIT DRIER'

by

SUBHASH A. AVASARE

is approved for the
Postgraduate Diploma in
Industrial Design

Guide

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Examiners

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1.

INTRODUCTION

Drying of foods in order to preserve them during the seasons of abundance for the consumption during the season of shortage is an old art. In India this technique was much widely used in olden days. The traditional dry fruits like Kokam 'Ambapoli', Manuka and dried mushrooms are eloquent testimony of our ancestors knowledge of dehydration technology.

The words dryer, evaporator and dehydrator are at present used as if synonymous therefore at this stage it is essential to clarify the difference between these terminologies. To dehydrate means to remove water by any means, squeezing centrifuging or evaporating. Drying means removal of all possible liquids, water, ether, alcohol etc. from the solids. Evaporation is drying not under well controlled conditions of temperature, humidity and air flow, whereas dehydrator ensures much controlled conditions. In this discussion it is too early to say what degree of controlled conditions.

We are aiming at, hence it is preferred to call the machine a drier rather than a dehydrator or an evaporator.

Just as the civil war stimulated the canning industry the Boer War and the First World War stimulated the dehydration industry. To conserve the cargo space enormous amounts of foods were dehydrated during the two world wars. In Germany in 1898 there were 3 drying plants and in 1917 there were 1900. It is this that increased her ability to maintain her food supply during 1939 to 1944. To give an idea of the space conservation may I illustrate with an example. A ton of apricot in canned form weighs 2800 lbs and in dried form only 400 lbs leaving aside advantages due to the less costly and light packaging. The most economical method of drying is by sundrying and a majority of dried fruits today are sundried. But in many condition the use of dehydrator is more advantageous to sundrying. The advantages of the dehydrator to sundrying are as follows.

- 1) Dehydrated fruits when cooked resemble the

cooked fresh fruits more than the sundried ones. 2) The dehydrated fruits are produced under more sanitary conditions. 3) Less land and trays are needed as the fruits can be spread denser in the dehydrator. 4) In the seasons of early rains the use of dehydrator prevents the losses due to rains. 5) Dehydrators work independent of atmospheric conditions. 6) Dehydrators prevent the loss of sugar contents as during the sundrying due to respiration or fermentation.

In India due to the undeveloped transport system fruits produced in the rural areas cannot be transported to the cities and other parts of the country in fresh conditions, hence different preservation methods are to be employed to preserve the excess of fruits which are almost a waste otherwise. If one goes through the districtwise crop pattern of Maharashtra it becomes quite clear that district of Ratnagiri cultivates certain fruits which are not cultivated anywhere else in the state, of which the Mango is her speciality that has become a world celebrity. The

district being very hilly the transport has always been a problem. Besides most of these fruits are harvested during the summer which is also the preparatory season for the next monsoon. Due to this most of the fruits are neglected and wasted. If a device is designed to dehydrate these fruits the wastage will be reduced and it will also increase the income of the poor farmer of this area. Hence an attempt is made here to design a dehydrator keeping in view the situation in a village in Ratnagiri district in the state of Maharashtra.

2

INFORMATION

TERRITORY

The district of Ratnagiri is a strip about 175 miles long and 30 miles wide between the 'Sahyadrys' and the 'Arabian Sea' intersected in many places by the Sahyadry ranges right up to the sea. The land can be divided into four parts. The flat barren table lands at the height of 1000 to 2000 feet, the slopes on which are found Mango, Cateu, Jackfruit trees, deep valleys thickly covered with coconut, beetlenut and kokam archards, and lastly the plains near the mouth of the rivers or streams where rice and vegetables are grown. Rivers of this area run for at the most 60 miles before they deliver to the sea the huge runoff of water that they collect from their catchments where average annual rainfall is barely below 100". The barren table lands that are covered with naked stones with a few bushes here and there are considered to have a potential to nurse mango or cateu grooves. Even the slopes are not fully utilised by the mango planters due to the uncertainty of the market. There is a potential in dried kokam to capture world market if it is processed properly. It should be possible to grow mushrooms in the coconut groves according to

one of the MATCO official and dried mushrooms have a worldwide market. Thus introduction of dehydrator in this area will enhance the promotion of different fruit products in the markets leading to more careful cultivation of different fruits.

2.2

FRUITS

The different fruits and vegetables are cultivated in Ratnagiri district.

Banana	500 hectares
Mango	5200 "
Jackfruit	200 "
Kokam	Not known
Pineapple	"
Jambhu	"
Coconuts	"
Beetlenuts	1000 hectares
Onion	300 "
Brinjals	400 "
Chillies	1600 "
Ginger	100 "

Pulses

In addition to this, ~~grains~~ ^{*pulses*} such as green grams, horse gram, black gram, wal, chevli are cultivated there. Certain local oil seeds such as Kavath, Mahua, Undal, and Kokam seeds are at present not properly attended to. All of them have to be dried at some

stage or the other. Similarly the fishes on which cannot be sold in the local market cannot be dried in the drier.

The different fruits that are dried are enlisted here with drying ratios etc. wherever possible.

Apricot

Shakarpara variety is dried in Afganistan and sent to India. They are cut into two halves sulphured for 15-20 minutes and dried for 10-20 hrs at temperature at 57°C to 68°C (135°F to 155°F). The yield is 15-19 % by weight.

Banana

Banana is dried raw as well as ripe. Raw banana is sliced dried and floured. Ripe banana is peeled sulphoured for 15 to 20 minutes, and then dried for 18-20 hrs at 54°C to 71°C (130° to 160°F) into banana figs. The yield of figs is 14-20 %.



Dates

In India they are picked at dung stage, i.e. when the tips turn brown cure on mats for 5 to 8 days and dried. They can be picked 3 to 4 days earlier dipped in NaOH solution (0.5 to 2.5 %) for 30 sec. to 2 minutes and dried.

Grapes

Large number of seedless kishmish grapes are imported to India from Afghanistan. They are hung dried in dark rooms which are better in taste than the sundried ones. Manuka or Raisin are dried large seeded grapes which are lay dipped before undrying. In case of dehydration they are lyedipped, sulphoured for 30 minutes and dried for 20 to 30 hrs at 65°C and 82°C (150°F and 180°F). The yield is 21-27 %.



Jackfruit

The jackfruit bulb is sliced the seeds are removed and dried, with or without sulphouring or the pulp can be dried as sheet or slab. By sundrying it takes 8 days for the jackfruit to dry in hot summer sun for 6 to 7 hours per day.

The market of dried jackfruit is not yet explored but it is expected to hit the urban market.

Mango

Mangoes are dried in both ripe as well as raw state. The raw mangoes are sliced and dried after or without salting. The dried mangoes can be powdered to add to the dishes. By sundrying the raw mangoes take 8 days to dry at 6 to 7 hours per day of hot summer sun. There is a lot of discolouration of the raw mango due to sundrying.

Ripe mango is dried either as slices or in layers of juice and sugar as 'Ambapoli'. Ambapoli of 10 layers takes nearly 15 days to dry by sundrying. Ambapoli has a good internal as well as export market but for its durability.

Kokam

Kokam like tamarind is used in Indian dishes for khatta taste. The fruit is cut to remove the seeds and juice and the fleshy skin is dried for four days in the summer sun to what is locally called as 'Ghul'. The ghul is then soaked in the juice for two hours and drained for 12 hours before drying it for a day. This procedure is repeated 3 to 4 times for a good quality kokam. The seeds are dried for 15 days to extract oil from ^{them} ~~it~~. This oil has a very good export market. The yield of kokam is nearly 10 % of the fruit's weight.

Chikku

Though not a very popular practice in India the attempt of drying chikku have been made in recent years. The chikku fruit has a good export market and there is always a possibility that dehydration of chikku may be popularised.

Beetle nut

They are peeled off ~~with~~ manually and dried for 21 days in hot summer sun and the hard stone is then separated from the dry fibrous cover.

Pineapple

During World War II, Friar and Von Holten of University of California arrived at a procedure of pineapple dehydration which is yet not used anywhere. $3/8$ " thick slices are to be sulphoured for 1 hour before drying them at 65°C (150°F) in air blast of 600 ft/min. The drying ratio is 6:1.

Peaches

Peaches are cut into halves and cored sulphoured for 15 to 20 minutes and then dried between 62°C to 68°C (145°F to 155°F) for 15 to 24 hours. The yield is 14 % to 19 %.

Pears

Pears are peeled out to halves and cored and sulphoured for 15 to 20 minutes and then dried at 59°C to 62°C (140°F to 145°F).

Vegitables:

Beans

Beans are cut blenched in steam for 3 to 6 min. and dried to brittleness. The drying ratio is 7:1.



Bittergourd (Karla)

It is cut into 0.25" thick slices, blanched in boiling water for 7 to 8 minutes and dried at 65°C to 71°C (150°F to 160°F) for 7 to 9 hours. The drying ratio is 26:1.



Brinjal

Brinjals are cut length wise into 0.25" thick slices, immersed in 0.5 % solution of SO_2 for 90 minutes, blanched in boiling water for 4 to 5 minutes and then dried at 48°C to 54°C (120°F to 130°F) for 9 to 11 hours. The drying ratio is 33:1.



Cabbages

Cabbages are cut to 0.25" thick shreds, blanched in steam for 9 to 10 minutes or dipped in boiling 1 % NaHCO_3 solution for 2 to 3 minutes and then dried at 59°C to 65°C for 12 to 14 hours. The drying ratio is 18:1.

Carrots

They are scrapped, cut to 0.25" thick sliced, blanched in boiling 2 to 4 per cent solution of NaCl for 2 to 4 minutes and dried at 68°C to 74°C for 14 to 16 hours. The drying ratio is 18:1.

Cauliflower

It is cut blanched for 4 to 5 minutes in boiling water, steeped in 0.5 % solution of SO₂ for one hour and dried at 59°C to 62°C.

Garlic

The individual buds are dried at 57°C to 59°C.

Knol-Khol

They are peeled out into 0.25" thick slices and dried with or without immersion a 0.25 % SO₂ solution for 30 to 40 minutes. Drying temperature should be between 54°C and 59°C for 11 to 13 hours. The drying ratio is 19:1.



Onions

0.1" thick slices of onion are immersed in 5 % solution of NaCl for 10 minutes and dried at 59°C to 68°C for 11 to 13 hours. If the temperature can be kept lower than 54°C one can better results. The drying ratio is 10:1. In recent years a number of people have started dehydrating onion in India.

Peas

Only tender peas or selected blanched for 1 or 2 minutes in boiling water and dried at temperature not exceeding 62°C .

Potatoes

Potatoes are peeled washed and cut to 0.25" thick slices. They are kept in 0.05 % solution of potassium-meta-bisulphite to prevent spoilage and then in boiling water for 3 to 5 minutes. They are dried at 59°C to 65°C , for 7 to 8 hours with a tray loading 1 to

1.5 lb/seft. The drying ratio is 7:1. It is essential to store it in inert gas such as N_2 . The potato dehydrating unit at Nasik or Nagpur has not been able to sustain itself because their prices are high compared to the other countries because of which it could not get export market and in local market people are reluctant to buy dehydrated potatoes when fresh potatoes are available year round.

Pumpkins

0.25" thick slices are first dipped in 2 per cent NaCl solution for 10 minutes and then boiled in the same before drying at $65^{\circ}C$ to $71^{\circ}C$ for 9 to 11 hours. The drying ratio is 19:1.

Ladyfinger

Ladyfinger are dehydrated in India in recent years.

Spinach

The leaves are dried after steaming for 4 to 5 minutes at 62°C to 68°C for 7 to 8 hrs. The drying ratio is 22:1.

Tomatoes

Tomatoes are boiled for 30 to 60 seconds, peeled cut into 0.25" thick slices which are dried at 59°C to 65°C for 9 to 10 hours. The drying ratio is 27:1. If it is to be powdered it need not be peeled.

Turnip

They are peeled into 0.25" thick slices immersed in 0.5 % SO_2 solution for 12 hours blanched for 2 to 3 minutes in boiling water and dried at 51 to 57°C for 11 to 13 hours.

Mushrooms

This tasty vegetable full of proteins is fast perishable and is the urgency to preserve it. The drying ratio is about 20:1. Mafco has some plans of cultivating and drying mushrooms. Though it is complained

that on dehydration mushrooms loose the
flavour. mushrooms whole or in pieces are
dried after blending for 2.25 minutes.
The dehydration is completed within 7 to
8 hours to reach 5 % or less moisture
content.

2.3

PRESERVATION METHODS

The fruits get spoiled due to micro-organisms. The growth of these organisms depends on number of bacteria present, temperature, air supply, moisture content. Hence spoilage can be reduced by reducing the number of micro-organisms by different methods. At low temperature the rate of growth of the organisms is very small similarly if the concentration of dissolved solids is more than 70 % it develops greater osmotic pressure in which the micro-organisms cannot grow. Reaction in contact with air reduces the growth of aerobic bacteria. Thus in case of the low temperature storages the micro-organisms are not killed but their growth is stopped. When a fruit is dried the concentration of dissolved solids is increased to more than 70 % . Use of antiseptics such as sugar salt or vinegar also increases the concentration of which salt concentration more than 15 % acts as poison for micro-organisms. Sodium-benzoate or benzoic acid also can be used as a preservative. The same principle is used for preservation in form of squashes, jams, syrup concentrates, and canning. Hexose sugars provide food for bacterial growth, therefore,

the food can be preserved by converting this sugar into alcohol or lactic acid by fermentation. This principle is made use of in preservation of alcoholic beverages as Sauerkrauts. Pasturisation deals in heating to a temperature at which most of the bacteria can be killed and those alive are rendered weak sterilisation means killing all organisms present. It can be done by heat and where it is not possible by electromagnetic radiation.

2.4

DRYING MORPHOLOGY

Drying is caused by evaporation. According to kinetic theory a phase transition like evaporation corresponds to the passage of molecules of the evaporating substance from liquid phase to vapour phase. This is not a one way traffic but is accompanied by return of some of the molecules from vapour to liquid phase. On an average the molecules which pass from liquid to vapour phase are those which possess higher energy. To increase the rate of evaporation it is essential to activate the surface molecules with extra energy. Latent heat of vapourisation is the heat required to transform one gram of the evaporating liquid to be transformed into vapour phase at the boiling point of the liquid. Latent heat of vapourisation of water is 539.55 cal/gm. Rate of evaporation can be increased by reducing pressure or by employing vacuum. The evaporation rate is also governed by humidity and the air velocity. Greater the velocity greater is the rate of evaporation, but the velocity should not be very great so as to drag with it the drying fruits.

The evaporation from the food material differs from that from a free surface. The rate of evaporation under the same condition is less for food materials because it takes time for the water in the interior of the food to come to the external surfaces. This process can be accelerated by cutting the fruit into smaller pieces. The rate of drying can also be increased by increasing the temperature but upto a certain limit so that the constituents of the fruit do not undergo undesirable changes. The drying rate also cannot be increased too much so that it gives rise to casehardening.

2.5

HEATING METHODS

The energy to activate the water molecules in the fruits for vapourisation is provided in form of heat energy. The easiest and cheapest way of doing so is to expose the fruits to the solar radiation. This is a direct type of heating with a limited amount of heat flow. It can be made more effective by concentrating solar heat with the help of reflectors.

Dielectric heating or microwave heating is a modern method of quick heating during which high frequency waves penetrate the matter and stimulate instant heat energy. The frequency range is 5 to 2500 mc at the voltage range of 3000 to 24000 volts. Peas and potatoes can be cooked on it in 2 to 5 minutes. This heat is produced as a result of inter molecular friction due to the vibration induced by the changing electron-magnetic field in the molecules of the food material. This is very expensive instrument.

Radiant heating is another method of heating in which the emitted energy is absorbed and converted to heat energy. Emission temperature ranges from 620°F for long wave-length to 4073°F for short wavelength radiation. The efficiency of long wavelength radiation is greater.

Other methods of heat transmission are direct heating and heating with hot air or superheated steam of which the former does not have control on the temperature which is very essential in our case. Heating with hot air is cheaper, more controllable, results in gradual drying and the air also performs the function of carrying the vapour away. The volume of air required to carry heat to the dryer is nearly seven times that required to carry the resulting vapour away. Hence volume of air required is calculated according to its heat carrying capacity and not the vapour carrying capacity.

Air can be heated by steam pipes, electric filaments or products of combustion of gases oil or wood. These products of combustion can be directly mixed with the air, to increase the efficiency.

There are mainly two methods of obtaining air flow. 1) Natural draft which is based on the tendency of hot air to rise and 2) Forced draft for which a motor is required.

2.6

DRYERS

Kiln Drier.

The fruit in layer about 3" to 12" are spread on the floor of upper storey and stirred. The lower storey houses a furnace room where air is heated and rises up through the previous floor. This can be used to dehydrate soft fruits. This is a natural draft driers.

Tower Dryer

Each stack in this dryer holds 12 trays kept one above the other hot air enter from the bottom. The bottom tray drier first and is removed and a tray is entered at top. This is also a natural draft drier but to accelerate the drying exhaust fan are being used in many places.

Cabinet Drier

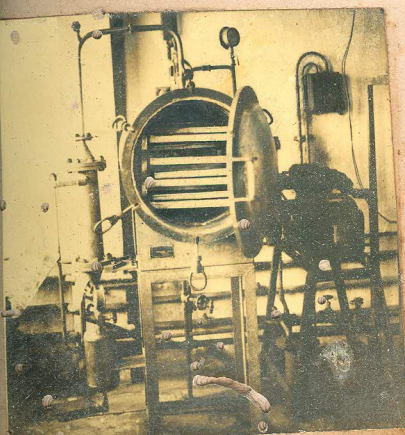


In operation this is not much different from the tower drier but for the heating system. The heat is provided by steam pipes or electric filaments between the trays. The one shown here is of the overall size 54" x 37" x 20", electrically heated with 3 kw heating element and 1/4 HP fan will cost near about 2000 to 2500 Rs. The total drying area in it is 44 sq.ft.

Oregon Tunnel Drier

A series of parallel slopping narrow chambers above a furnace room in which the trays enter at higher and cooler end and leave at the lower end. Each tunnel is nearly 20' long. This is a natural draft dryer but fan is now-a-days used for recirculation.

Vacuum Drier



Though it is costlier it accelerates the drying process due to the vacuum and also ^{reduces} the oxidation. The laboratory model shown here provides 12 sft. drying area. The cost of this model is about 6000 Rs.

TECHNOLOGY AND SOCIETY

While deciding about the scale of production it was felt that a large scale dehydrator can be set up in the Taluka Town where the raw material can be transported to and processed. But this will lead to the concentration of wealth in the hands of a few who have the resources and concentration of the people to these towns, in the same way as the cashew factories with a difference. The cashew factory ensures employment to the workers all round the year whereas dehydrator is a seasonal affair. Again the investment lying idle for the rest of the year is not an advantageous proposition leading to higher production over heads. Besides during the days of the harvest the labour is scarce. There are extra charges due to the transport of the raw material which add to the production cost.

If the scale is based on the production at a village the transport has to be manual due to difficult in-roads and the labour problems are the same. Besides there cannot be any standardisation about the raw material availability in village due to differences in the volume of

cultivation and yield. It cannot be overlooked that by introducing mass production technology in this society we will be doing injustice to the human skills.

The greatest type of exploitation is in robbing people of their capacities, ('Of their hands and feet' as Mahatma Gandhi put it). It was the Mahatma's approach that needs revival according to many a modern thinker. He said, 'we do not need mass production but the production by masses'. The greatest resources of India are the human beings, who are her subjects. Our country is now on the cross roads and it is high time we stop employing western technology blindly because it was not evolved out of the environments similar to ours. We should start our economics with the people and not with the other resources. As Dr. Schumacher, the eminent development economist said, 'India will have to learn to make smaller machines, big machines reduced to human scale'.

The main character of the machine will then be its simplicity. Only through which the masses will be educated.

If one machine has to pass from one family to the other due to the man-machine emotional bindings a typical social force in our country, will lead to a new social organisation such as cooperative marketing organisation, or further a social movement. Thus a machine can be employed to evolve a new social order.

3

ANALYSIS

3.1

FUEL ANALYSIS

A family of five people will peel off 500 kg of kokam fruits per day. The drying density is 2.76 lbs/sft (1.25 kg/sft) of dry kokam.

∴ Area required for drying = 80 sft (7.45 m²)

Weight wise percentage composition of kokam fruit is (approximate)

Pulpy skin 40 %

Seeds 40 %

Juices 20 %

The dry weight recovery is 20 % of the weight of fruit.

∴ Drying ratio = (40 + 20) : 20 = 3 : 1

In absence of adequate data let us take it to be 4 : 1

Hence the water to be vapourised = 300 kg to yield 100 kg dry fruit.

Maximum temperature allowed = 70°C

Room temperature = 30°C

Average rise in temperature of

water in kokam = $\frac{70 - 30}{2} = 20^\circ\text{C}$

Latent heat of vapourisation

of water = 539.55 cal/gm

Specific heat of water = 1 cal/gm/°C

∴ Heat required = 300 (539.55 + 1 × 20) kcal

168000 kcal

= 670000 BTU

= 196 kwh

Air required to carry the heat energy

$$\text{mass of air} = \frac{Q}{C_p (t_2 - t_1)}$$

Q = heat to be carried

C_p = specific heat of air = 0.237

t_2 = the temperature of air

t_1 = temperature to which the air drops

$$= \frac{420000}{0.237 \times 22} \text{ kg}$$

$$= 81000 \text{ kg}$$

The drop of temperature is assumed to be 22°C (40°F).

$$\text{Volume of air} = \frac{M}{\rho} \quad \rho = \text{density of air} \\ = 1.293 \text{ g/lit}$$

$$= \frac{81000 \times 10^3}{1.293}$$

$$= 62500 \times 10^3 \text{ litre}$$

$$= 62500 \text{ m}^3$$

$$= 2200000 \text{ cft}$$

If the air is to be supplied throughout the drying operation, which is to be finished in two days at the rate of 8 hr/day. The flow of air require is

$$\text{Flow of air} = \frac{2200000}{16 \times 60} \text{ cft/min}$$

$$= 2300 \text{ cft/min}$$

$$\text{or} \quad = \frac{62500}{16 \times 60} \text{ m}^3/\text{min}$$

$$= 65 \text{ m}^3/\text{min}$$

$$= 3900 \text{ m}^3/\text{hr}$$

Accounting for losses cool home (versatile)
fan with air delivery $4680 \text{ m}^3/\text{hr}$.
Sweep 400 mm and 1275 rpm will be best suited.
Price is around Rs.225/- This much air will
be more than sufficient to carry the necessary
moisture.

Cost of different energy

1) Electrical Energy Requirement

Efficiency of electrical furnace = 40 %

∴ Energy requirement = 490 kwh

∴ Cost at the rate of

4 p/kwh = 196 Rs.

2) Gobar Gas

The locally available fuel with composition of 55 % CO_2 and 45 % CH_4 620 m^2 of this gas give out 1.87×10^6 kcal

∴ Fuel value 3000 kcal/m^3

Efficiency of heat transfer = 40 %

∴ Heat input = 420000 kcal

∴ Gas requirement = 140 m^2

= 4950 cft

A normal family (The one we have assumed to be the production unit) can produce about 60 cft per day

∴ If all of it is used it will take

85 days to dry 100 kg kokam.

3) Natural gas or other similar gases

Efficiency of the heat transfer = 40 %

Fuel value = 11900 kcal/kg

∴ Fuel required = 35.3 kg

Cost at the rate of Rs.125/kg = Rs.43.5

4) Diesel, Kerosine or Furnace oil

Efficiency of heat transfer = 40 %

Calorific value = 10,000 kcal/kg

Furnace oil price = 30 p/kg

Price of kerosine = 80 p/kg

Fuel required = 42 kg

Cost of furnace oil = 13.2 Rs.

Cost of kerosine = 33.6 Rs.

The cost of the blower of this capacity
will cost Rs.2500 (Bombay Furnaces)

5) Wood as fuel

Calorific value = 4500 kcal/kg

Price of fuel wood = 50 p/kg

∴ Wood fuel requirement = 93.5 kg

∴ Fuel cost = Rs.46.75

6) Use of solar energy

The net energy incident on horizontal plane

$$= 3122 \text{ kcal/m}^2/\text{day}$$

Efficiency of the system is assumed to be 40 % in absence of reliable data about it

∴ If it is to be dried in two days the

$$\text{area required} = \frac{420000}{3122 \times 2}$$

$$= 67.5 \text{ m}^2$$

$$= 720 \text{ sft}$$

The area required to sundry = 80 sft

If the fruit is dried in sun in 80 sft area the days to dry it = 18, whereas at present the sundrying is completed in 7 days. This controversy may have resulted from following errors of judgement.

- i) Error in the assumption of drying ratio.
- ii) Error in the assumption of efficiency of heat transfer.
- iii) The value of incident solar energy is for Poona and that also yearly average whereas in reality it is the hot summer sun that is made use of.
- iv) Losses of juices by absorption in the soil of drying yard. This is one of them.

3.2

VALUE ANALYSIS

The initial drying of kokam will take 4 days and soaking them three times in juice takes three more days. Hence if the operation is to be accelerated it cannot be shortened more than to 2 days. The first is required for initial drying alone. The soaking at present is done at night, so is trickling. These operations amongst them spend 14 hours. 2 hrs for soaking and 12 hours trickling. At this stage it is essential to note that soaked kokam need not be trickled for so long if we can prevent the loss of juice by absorption in the drying yard floor. The trickling is done mainly during nights when no solar energy is available to dry the fruit. If the dryer can be operated during day time as well as night, it will reduce the waste of time in trickling. The best will be if soaking and trickling can be avoided whatsoever. This is possible by sprinkling the juice on the dried kokam (ghul) at certain interval. (According to Prof. Rege of UDCT, Bombay-19). This means that the drying fruit should be easily accessible.

3.3

MATERIAL ANALYSIS

Steel

The use of steel for structural purpose calls for sophisticated fabrication techniques such as welding which may not be available to a village carpenter. Secondly, it makes the structure heavy. The parts in contact with the fruit juice may possibly get corroded. Hence use of steel should be minimised as it is not locally available.

Wood

Is a locally available material and village carpenter is quite familiar with it. It is not fire resistant and in case wood burning is the source of heat some care has to be taken.

Bamboo

Bamboo in form of mat is a good covering material but for its porosity. A coating of cowdung is a good remedy on the porosity of the mat and is very widely used by local people. The mat is very easily foldable and light. But bamboo is not a good structural material because the joints are difficult to make.

3.4

SOCIAL ANALYSIS

We are a country with a great cultural heritage. We had a technology which gave rise to self sufficient communities. A technology developed in a society does not totally die. It remains in the society in forms of skills, legends, and the outlook. What is technology after all? Is it a few machines designed with the help of a few formulae. They are just the instruments, the means. Technology is the attitude leading to these means. When a technology is said to be belonging to the society it refers to a particular attitude of the society, we worship our impliments, our machines which according to western outlook are just the means of production. This is our culture our attitude our technology. If a design is imposed on society ^{it} does not start a questioning process which leads to education. Education of the masses should lead to a chain of innovative designs which are the contemporary solutions to the problems. It should be possible for any villager to built these machines for himself and educate himself in the process. This education should lead to a new design. The standardisation of any type will lead to stagnation of this educative process, which should be avoided.

In this paper an attempt is made to follow up this philosophy as far as possible. The appropriate scale is considered to be a family scale at which it is worked at present.



HYPOTHESIS

4.1

TECHNICAL

- The heat should mainly be solar.
- In case of its shortage wood burning should be resorted to.
- In case of solar heating it is essential to circulate air for keeping the temperature low.
- The circulation of air also accelerates the drying operation.
- In case of wood burning air is used as heat transfer medium.
- Use of a solar reflector will be advisable or additional asset.

4.2

FUNCTIONAL

- Operation of trickling and soaking should be eliminated if possible or else minimised.
- Handling should not stain the transparent covering glass or plastic or the reflector.
- Should be portable or foldable if possible by one or maximum two men.
- The parts like reflectors and transparent cover should not be damaged during transporting.

4.3

PRODUCTION

- The machine should be built by a village carpenter.
- Most of the materials and processes involved should be strictly local.
- Any sophisticated production processes should be avoided.

SYNTHESIS



It is essential at this stage to note that no effort is made here to design the machine. An attempt is made to foresee instead the product after it has gone through a long innovative process. This will be the imaginative product evolved by educating the society. The man taking the design decisions is a common man who is confronted with the problems, has to his disposal only the local materials and skills.



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