

Dehydration of Cash Crops & Herbs using Hybrid-Solar-Dryer



Submitted to:
Poverty Alleviation Fund
Gyneshwor, Kathmandu

Submitted by:
Karnali Bachat tatha Rin Sahkari Sansthan Limited
&
Center for Renewable Energy

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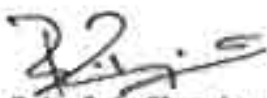
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Acknowledgement

We wish to acknowledge World Bank, Nepal and Poverty Alleviation Fund (PAF) program for financially supporting the project, "**Dehydration of Cash Crops & Herbs using Hybrid-Solar-Dryer**" based on Solar thermal energy harnessing device. We would like to thank all the members of Centre for Renewable Energy (CRE) and supporting staff from Karnali Bachat Tatha Rin Sahakari Sansthan for their cordial support to make the pilot project successful.

We appreciate Clean Energy Industries, especially Clean Energy Walk in Learning Centre (CE-Walc), for assisting the movement and providing technical support.



Babu Raja Shrestha
Team Leader

1 Introduction

Nepal is the agro-based country; a majority of the population are farmer and dependant to agriculture for their livelihood. Agriculture sector alone contributes 32.12 % to GDP. Nepal is blessed with natural beauty of assorted climatic zones and rich bio-diversity. This translates to the availability of a wide range of agricultural and non timber forest produce that can be harvested in a sustainable manner. However, the farmers have not been able to tap on these resources due to lack of knowledge of the high value cash crops and their methods of preservation nor the marketing strategies. The rate of agricultural production of the country is so low that it is not keeping at pace with the rate of population growth. The supply of food is in serious shortage.

In the rural areas of Nepal, preservation of agricultural product is one of the central problems. The producer needs to bring their produce to urban areas as their local markets are too small to accommodate all the fresh vegetables and fruits. However, because of lack of transportation infrastructure, this is often difficult, and results in high rate of spoilage of products. A large quantity of agro products is also getting wasted every year simply because of the lack of appropriate food conservation technique.

Considering this problem, there is an urgent need of supplying the farmers with appropriate technology for preservation of agro-products. Solar drying is one potential technology, particularly well adapted for Nepali conditions that could respond to this demand. The traditional way of conservation of foods by open sun drying is primitive and inadequate. The use of fossil fuel is not affordable as our country does not possess any commercially exploitable mineral resource. Unfortunately the fuel wood is also being scarce because of increasing depletion of forest which is posing a great deal of ecological and environmental threat to the country.

In this situation, there is need of some kind of food conservation technique that is simple, inexpensive, uses natural energy resource and is environmental-friendly. Solar Drying technology could be one such option.

The average solar insolation in Nepal is around $4.5 \text{ kWh/m}^2/\text{day}$. The average sunshine hours are given as 6.8 hours/day and the country has 300

days of sunshine/year. In general, the Tarai region of the country looks highly promising in this regard.

The simple dryer, which harness the thermal energy of the solar radiation is less productive for the average time duration for the drying ranges above 8 hours. The average hours, the dryer collector maintain the temperature above 45 degree centigrade is approximately 5 hours so the batch has to continue occupying drying space for next working day too. This problem is overcome by the Hybrid-Solar Dryer which utilizes the solar radiation as well as the waste biomass from the farm to supply energy for continuously drying operation even after the absence of solar radiation.

Increased incomes from farming demand for increases in inputs such as labor, energy and technology. Farmers may have small landholdings, but they are very laborious. Proper assistance by experts to these farmers will motivate them to focus on cash crop cultivation. Introduction of demand-driven marketing strategies by co-operatives or community-based small-scale food processing units will guarantee appropriate price for such farmers. These co-operatives or industries will be able to market fresh or dehydrated produce as per the opportunities and demands.

The advantages of dehydrating cash crop is that the products can be preserved and marketed at a later date so as to bring maximum revenue to the farmers, like when the market prices are high. Increased shelf-life of the products means that the agro-produce from rural areas can be made available for urban customers. Hybrid Solar dryers will be used to dehydrate the agro-products. These dryers will be commonly owned by the community or co-operatives and will be established as small scale agro-processing industries. These industries will reduce wastage of products that would otherwise have rotted away due to poor storage. By creating more jobs in the agricultural sector even during off-season periods, it will enhance the income of the farmers / local community, and will also contribute to food security.

2. Project Background

Nepal is an agricultural land the GDP depend highly upon agro-production. To uplift the GDP it is essential to increase the output of farmland. Increased incomes from farming demand for increases in inputs such as labor, energy and technology.

The resource of the small farmers is small landholdings, and the manual labor capacity. Proper assistance by experts to these farmers will motivate them to focus on cash crop cultivation. Introduction of demand-driven marketing strategies by co-operatives or community-based small-scale food processing units will be able to guarantee appropriate price for such farmers.

Hybrid solar dryer based on renewable energy source is a proven technology it is simple to operate and the quality of dehydrated product is high.

Hybrid Solar dryers will be used to dehydrate the agro-products. These dryers will be commonly owned by the community or co-operatives who will establish small scale agro-processing industries. These industries will reduce wastage of products that would otherwise have rotted away due to poor storage. By creating more jobs in the agricultural sector even during off-season periods, it will enhance the income of the farmers / local community by providing employment opportunity, and will also contribute to food security

Individual small farmers will be bound with cooperatives/user groups for the promotion of non-traditional high value crops cultivation, to enhance productivity and income generation. It will also promote the commercialization of dried cash crops which ultimately contribute to local food security too.

Central level marketing trading house will be established in capital. The institute will process and promote the dehydrated product. It will guarantee the market for the cooperative. The central level marketing institute will be conducting regular market survey to enhance the product diversification. The marketing principle will be based on demand driven concept.

3. Objectives

- Design and develop hybrid solar dryer to dehydrate cash crops
- Assist Solar Dryer manufacturing Industry to manufacture the hybrid solar dryers.
- Assist to establish Agro based cooperative to establish dehydrated food processing industry using Hybrid Solar dryer.

4. Activities

- Raise awareness of communities about cash crops, and form cash crop production groups by involving enthusiastic small farmers.
- Organize training for the small farmers to grow high value cash crops and guarantee the price for their product.
- Initiate the local community/co-operatives or private sector to setup vegetable and herb processing industries using hybrid solar dryers.
- Provide food processing/dehydrating training to members of the dehydrating industries.
- Continuous monitoring and evaluation of the products processing and exploration of possible market niches to extend the product range to make the industries sustainable.

5. Principle Obstacle

The critical political situation in the region has effected the time schedule of the program such as long time strikes and Bandh in the eastern region has slowed the process.

The cold wave in the terai reason this year has also caused delay in vegetable dehydration training.

Cash crop productions were delayed due to delay in formalization of collection centre. The legislative procedure to register co-operative is time consuming process. The other hurdle is to get accreditation from legal authorities to initiate food processing and marketing business. The policy is very confusing.

6. Activities completed during the program period

6.1 Chakchake VDC, Jhapa District

In Chakchake village development committee awareness program about the high value cash crops and dehydrated vegetables and herbs are conducted. The VDC has good potential for vegetable production but at present the small farmers are working individually and selling their surplus product at local hat bazaar at low price.

A village level community group is formed with 21 households of marginalized farmers.

Establishment of a cooperative, to run the cash crop collection centre and to initiate dehydrated vegetable and herbs production is one of the essential components of the program. Sajeewan Agricultural Cooperative limited is established with the 54 members of the five village development committee Chkchake, Rajgadh, Jalthal, Haldibari and Goldhap VDC.

The cooperative is registered and Jhapa district cooperative office.

Land is procured at Chakchake VDC to establish the collection centre and the Solar dryer. Infrastructures are Building is constructed at the centre (co-operative owned land).

One set of hybrid Solar Dryer unit and 15 units of modular tunnel type Solar dryer are installed. The total collector area of the dryers is amounting 40 square meters.

6.2 Clean Energy Walk in Learning Centre (CE-Walc), Biratnagar

One set of Solar hybrid dryer is installed at Clean Energy Walk in Learning Centre (CE-Walc) in Biratnagar. The performance of the dryer are experimented and studied. Sample products dehydrated vegetables are processed and identified deficiencies of the dehydrator system. The dryer is improved and ready for harnessing the solar energy.

Capacity building of the management team of the cooperative is one of the long term objective of the program. CE-Walc is conducting continues

research and development activities to develop vegetables, fruits and herbs dehydrating technology.

Capital Environmental P.Ltd., is initiating marketing strategies and establishing business infrastructure to market the dehydrated product produced by the Solar dryer based products processing co-operatives and communities in project areas.

- Market survey for dehydrated food in Kathmandu
- Collection of Legislative information for food processing industries
- Establishment/identification of food testing lab and authorities

6.3 Centre for Agro-Forestry Technology, Lahan, Siraha

Asparagus root drying technology is tested by using Hybrid Solar Dryer and One unit of Hybrid Solar Dryer designed by Jailaxmi Iron Furniture is installed at nursery premises of the (CAFT) centre at Lahan.

CAFT is commercially Dehydrating the Asparagus roots and marketing it at local level.

6.4 Trainings, awareness, promotional campaigns

Training programs, one of the integral components of the campaign, have been instrumental in building awareness and enhancing capacities of stakeholders involved or willing to be involved in the business of commercial cash crop farming and dehydration of agro-products.

Clean Energy Walk in Learning Centre (CE-Walc) has been facilitating on-job training for the technical staff of the newly established Solar Tuki service centers / Solar Tuki assembling industries. The training opportunities are open 365 days in year. Since the targeted populace is rural poor, the on-job training have been scheduled as per the trainee's demand and convenience.

CE-Walc is now furnished with the hybrid solar dryer and the modular tunnel type solar dryer. It has conducted various trainings as following:

- i. Mr. Ghanshyam Poddar, Ms. Nutan Shah, Ms. Krishna Kala Adhikari, Ms. Netra Devi shah and Ms Janaki Devi Yadav of Sajiwan Agro Cooperative, Chakchake participated in on job training on Nugget and

herbal production using solar dryer. The training was scheduled for 7 days and included all aspect of methodology of dehydration of the agro-products and operation and maintenance of the dryer.

- ii. Similarly Mr. Daya Ram Choudhari, Miss Sanju Choudhari and Miss Sujata Choudhari of CEntre for Agro-forestry Technology, Lahan Participated in the 10 days training. the major focus on the training was concentrated to dehydrate herbs (Asparagus roots drying).
- iii. Miss Pabitra Kapali, Ms Sita Humagain, and Ms Deepa Humagain participated in nugget production and drying training.
- iv. Mr. Dev Shrestha, Mr. Surendra Maharjan and Mr. Anil Maharjan, the engineering student from Institute of Engineering, Pulchowk Campus, Lalitpur performed performance testing of the dryers manufactured by Jailaxmi Iron Furniture and installed at CE-Walc facility. The test were conducted to evaluate efficiency and manufacturing methodology as part of their BE final year thesis work. The thesis titled "Performance Evaluation of Modular Type Hybrid Solar Dryer (Model STD-05C) is available in the library of Department of Mechanical engineering of Institute of Engineering, Pulchowk, Lalitpur.

Besides the on job training on food dehydration technology using solar dryer the CE-Walc is disseminating information on solar drying technology and its opportunity to self employment and new business.

7. Influence in government policy

Solar Dryer program has been in line with the both long term vision of 'The Tenth Plan or PRSP'

PRSP Long Term Vision	Solar Dryer Achievements
Accelerating economic development, improving living standard of the rural people, increasing the employment opportunities, and maintaining environmental sustainability through the development of rural energy systems	Solar Dryer based on freely available renewable energy and user friendly simple adoptable technology. Value addition to the locally farmed agro-products to fetch off season price is the attraction for self employment .

Commercializing the alternate energy technologies and reducing the dependence on imported energy through planned technology development.	Solar Dehydration process of agricultural product has made corridor for future technology diffusion through market forces
Keeping in mind long term consequences of the use of natural resources, use of traditional energy resources would be slowly replaced by the modern energy sources that are within the reach of purchasing power of rural people	Consumer financing and ties with financial institutions that have given rise to consumer financing have improved bank-ability of renewable energy entities and increased purchasing power of the consumers.

8. Conclusion

The program is related with the establishment of the operational cooperative and dehydrated vegetable and herbs processing marketing business modality. It is new product, therefore need to be précised in identifying the final products and it's processing methodology. Continues research to develop dehydrating methodology is needed. The dryer setup established at CE-WALC will be used for research and development of drying procedure and methodology. The facility will be utilized specially to capacity building trainings and to prepare trained skilled human resources.

9 Financial report

Financial statement

Description	Budget amount	Expenses	Income	Balance
Fund received from PAF			1,350,000.00	1,350,000.00
Matching fund Subsidy on Solar dryer from AEPC			290,000.00	1,640,000.00
Personnel:	301,000.00	301,000.00		1,339,000.00
Building & infrastructure construction	310,000.00	408,281.00		930,719.00
Solar Dryer Procurement (Rev Fund)	500,000.00	575,000.00		355,719.0
Training	100,000.00	66,085.00		289,634.00
Travel:	49,000.00	31,835.00		257,779.00
Evaluation/Information dissemination:	130,000.00	130,000.00		127,779.00
Bank Interest			12,489.42	140,288.42
General Administration/Overhead:	320,000.00	320,000.00		-179,771.58
Account receivable (PAF)			150,000.00	-29,771.58
Total	1,710,000.00	1,832,201.00	1,802,489.42	-29,771.58



Provide awareness of communities about cash crops, and form cash crop production groups by involving and motivating small farmers.

Organize training for the small farmers to grow high value cash crop and guarantee the price for their Product



Setup vegetable and Herb processing Industries using Hybrid solar dryers



Exploration of possible Market niches to extend The product range to Make the Industries.

Continuous monitoring And evaluation of the Product processing

Marketing Agro-product

Provide food processing/ dehydrating to members/ employees of food dehydrating industries



WETLANDS OF INDIA: ESTIMATION OF REVENUE LOSS

Annexes

Annex 1 : Vegetable and fruits – Solar drying methodology

Solar drying of fruit and vegetables

Centre for Renewable Energy (CRE)

B.R. Shrestha

Solar drying of fruit and vegetables:

For thousands of years people have sun dried fruit and vegetables to preserve for leaner times. New technologies brought changed techniques, but at present the increasing demand for healthy, low-cost natural foods and the need for sustainable income, are bringing solar drying to the fore as a useful alternative for surplus products. Save for tomorrow what you do not need today!

Advantages of solar drying

Food in the cupboard for later use increases household food security. It creates employment opportunities and a sustainable income. Dried products improve family nutrition because fruit and vegetables contain high quantities of vitamins, minerals and fiber. For diabetics dried fruit prepared without adding sugar is a healthy choice instead of desserts. Dried fruit can be used in stews, soups and casseroles or enjoyed as snacks. It can also be added to cereals for breakfast or used in making ice cream and baked products. It improves the bargaining position of farmers. Sometimes farmers sell at very low prices during the harvest season because they cannot store or preserve their surplus products. People are encouraged to establish their own gardens.

Methods of drying

Sun drying

Drying in the sun is very economical. You only have to spread the produce on a suitable surface and let it dry in the sun.

Disadvantages

Somebody has to stay at home throughout the drying period to chase off domestic animals, to remove the produce when the weather becomes too windy and dusty, or when it rains. The dried product is often of poor quality as a result of grit and dirt. The product is often unhygienic as a result of microorganisms and insects such as flies.

Solar drying

The technology and capital required to dry fruit and vegetables by solar dryers is basic and the entire operation can be completed in most kitchens. The structure can be very basic, e.g. a box frame covered with plastic sheeting.

Advantages of solar dryers

Drying is faster because inside the dryer it is warmer than outside. It is less risky of spoilage because of the speed of drying. (if the drying process is slow the fruit start to ferment and the product is spoilt). The product is protected against flies, pests, rain and dust. It is labour saving. The product can be left in the dryer overnight or during rain. The quality of the product is better in terms of nutrients, hygiene and colour.

The drying process

Precautions

Cleanliness and hygiene are very important in the processing of dried fruit and vegetables. To minimize the possibility of contamination, any person who is unwell or has infected wounds or sores, is ill with a gastric disorder or suffering from diarrhoea MUST BE EXCLUDED from the processing operations. All cuts have to be covered with waterproof dressing. Raw materials contaminated by moulds must not be used in processing.

Pre-drying treatments

Selection

- Use only ripe, good-quality fruit and vegetables.
- Select fruit and vegetables individually.
- Discard rotted, damaged or diseased fruit and vegetables.
- Remember, processing cannot improve poor-quality fruit or vegetables.
- Washing
- Clean all working surfaces before handling fruit or vegetables.
- Water for cleaning must be treated with a household bleach solution.

Prepare the cleaning solution as follows:

- Pour 50 parts of clean water in a clean bucket (e.g. 20 litre).
- Add one part of any household bleach (e.g. 400 ml) containing chlorine
- For safety reasons plastic gloves should be worn when mixing the solution.

(One bucketful of the treated water (20 litre) is enough for cleaning 20 kg of fruit. Use a fresh cleaning solution every day)

Selected fruit and vegetables should be washed and scrubbed individually in the treated water, while plastic gloves should be worn. Care must be taken to avoid breaking the skin of the fruit during cleaning and thereby contaminating the flesh. Washed fruit and vegetables should be placed into a clean basket or bucket and taken to the peeling or blanching area.

Blanching

Before drying, all vegetables should be blanched in steam to halt the action of enzymes. However, blanching of fruit is optional. Steam blanching is recommended because it prevents the loss of some nutrients and the products being dried from adhering to each other. Do not under-blanch, because the enzymes will not be inactivated totally and the dried vegetables will deteriorate during storage.

Procedure

Pour several centimetres of water into a large cooking pot that has a close-fitting lid. Heat the water to boiling and place over it, high enough to keep clear of the water, a wire rack or basket holding a layer of the vegetables (not more than 5 cm deep). Cover and let the vegetables steam for half the required times, then test to make sure all pieces are reached by the steam. A sample from the centre of the layer should be wilted and feel soft and heated through when it has been properly blanched.

Remove the vegetables and spread them on paper towelling or clean cloth to remove excess moisture while you steam the next load. Cover with towelling while waiting for further treatment or before taking them to the drying trays.

Peeling

Hygiene is of utmost importance when peeling. Peeling should not take place in the area where the raw materials are washed. The area should be swept thoroughly and washed before handling the fruit.

Peeling knives and working surfaces should be cleaned in fresh bleach solution before use.

The operator should wash his/her hands and arms thoroughly with clean water and un-perfumed soap.

Clean, sharp stainless steel knives must always be used.

Careful peeling with minimum removal of the flesh is important.

Peelings and seeds should be disposed of as soon as possible because they attract flies and other insects.

Peelings can be used as animal feed or as mulch, or be buried if there is no alternate use.

Cutting and slicing

Thickness of fruit pieces depends upon the kind of fruit being dried. Thicker slices will dry at a slower rate than thinner pieces. Very thin pieces tend to stick to the drying trays and will be difficult to remove. Thicker pieces may not dry fully and may subsequently deteriorate after packing. Packages of dried pieces of varying thickness appear relatively unattractive.

Cutting knives and working surface have to be cleaned with a bleach solution before use.
Slices should be placed in clean bowls which have been rinsed with clean water ready for loading onto the drying trays.
Before loading the trays, these have to be brushed clean and washed.

Dryers

A basic box-type low-cost solar dryer can be constructed at home or by village artisans. It is made of wire-mesh trays in a wooden framework surrounded by a clear plastic sheet. The solar cabinet dryer type has a surface of 10 m² and is capable of drying 20 to 35 kg of fresh produce (depending on commodity) over a period of 3 to 4 days. Smaller portable models of the dryer can be constructed depending on available funds for the dryer, construction and the purpose of drying (home consumption or marketing).

For commercial use the tunnel type Solar dryer with forced ventilation will be the appropriate to dehydrate the agro-products with uniform quality and shortening the day of drying period to one or two days.

The hybrid Solar dryer a combination of tunnel type dryer/collector and hot air based dehydrating chambers will be appropriate multipurpose dehydrating machinery for commercial production of dehydrated fruit, vegetable and herbs.

Tray loading

- Trays should be washed and cleaned to remove any fragments of dried fruit or contamination.
- Start to load during slicing rather than waiting until all the fruit has been sliced or cut. (This reduces the problem of sticking together in the bowls and will allow drying to start as soon as possible.)
- Lay the pieces of fruit on trays carefully and close to each other without overlapping to ensure the trays are loaded fully.
- Keep flies away and load trays quickly and continuously.

Dryer loading

The dryer should be positioned in a level area unobscured by trees or buildings so that it is fully exposed to the sun throughout the day.

If the wind blows predominantly in one direction for long periods the dryer should be placed end-on to the wind. This will reduce the cooling effect of the wind blowing direct into the drying cabinet, lengthening drying times. It will also reduce the possibility of dust entering the cabinet.

Before loading, the inside of the drying cabinet should be swept clean and then wiped out with a clean, damp cloth.

The plastic/Glass covers outside should be brushed or washed clean of dust because dirty plastic will reduce dryer performance and increase drying times.

The doors should be closed immediately after each tray has been loaded and not left open until the next tray is fetched.

It is important to keep flies and other insects from entering the cabinet and off the fruit because of the risk of contamination.

Drying

During the first few hours of drying, particularly during very hot and sunny weather, fruit may dry at such a rate that moisture condenses on the inside of the plastic covers. This can be avoided by opening the loading doors slightly (20 mm) to improve air circulation. The gap should, however, be covered with mosquito mesh. Doors should be kept open for a minimum period of time and closed again as soon as the weather becomes cloudy.

In poor weather drying will stop. Rain will rapidly cool the dryer and this will result in a moisture film on the cover because of condensation. It will be some time before the dryer functions again after the sun breaks through. Therefore, protect the dryer from rain.

Under fine and sunny conditions the fruit slices should be dry after 2 full days in the dryer. However, it is essential to test slices. If the slices are not sufficiently dry, they will become mouldy in a short time. A test for dryness is conducted for specific products. If the slices are not sufficiently dry, the process should be allowed to continue for 1 or 2 hours before checking again. The final moisture content of dried fruit should be approximately 10 % (on a wet basis).

Unloading the dryer

When the fruit is considered to be dry, the dryer should be unloaded as soon as possible. This must not be carried out in the early morning because dew and high humidity overnight may cause condensation of moisture onto the fruit. The best time to unload is in the afternoon on a sunny day.

Trays should be removed from the dryer and taken to a clean and covered area for removal of the dried product.

The operator must wash his/her hands and ideally wear clean gloves when handling the fruit.

The dried fruit should be stored temporarily in clean dry baskets before packaging so that the product can cool down.

Packaging and storing

Packaging should be carried out immediately after unloading and cooling because the dried slices will reabsorb moisture and be susceptible to attack by insects and other pests. Proper storage should take place in the absence of moisture, light and air. The use of brown paper bags folded tightly and then placed inside plastic bags is recommended.

- Store in small quantities to avoid large-scale contamination.
- Pack carefully to avoid crushing the vegetables.
- Glass containers are excellent, but these should be kept in a dark area.
- Each bag or glass container should be marked clearly with labels containing the date of packaging.

The dried products must be stored in a cool, dry and clean area which is secure and protected against rodents and other pests.

Specific products

Fruit	Temp.	Duration	Remarks
Mangoes Select firm, ripe mangoes Wash with clean water Peel Cut into slices (2 - 3 mm thick) Arrange on trays for loading into the dryer	45° C to 55° C	18 to 20 hours	Test for dryness: slices should be pliable, without sticking together
Pineapples Select firm, ripe fruit Wash Cut off the top and base Peel Cut into slices (2 - 3 mm thick) Arrange on trays ready for loading into dryers	45° C to 60° C	18 to 20 hours	Test for dryness: slices should be pliable, without sticking together
Bananas Select good-quality fruit Wash Peel and remove the 2 tips Slice into pieces (5 mm thick) Arrange on trays for loading into dryer	55° C to 70° C	18 to 20 hours	sulfured for 15 to 30 minutes Test for dryness: slices should be pliable, without sticking together
Apples Select good-quality fruit Wash Peel Split Core Cut into regular slices (2 - 3 mm thick). As you cut, dip the slices into lemon juice to retain the colour temporarily Steam blanch for 5 minutes and remove excess moisture Arrange slices on trays ready for drying	60° C to 70° C	6 to 10 hours	After peeling, coring and cutting into slices, these are sulfured for 15 to 30 minutes. (0.5% KMS or NaMS solution) Test for dryness: leathery, no moisture when cut and squeezed The yield varies from 10 to 15 per cent
Apricots Both the yellow and white varieties of it are suitable for drying. These can be dried whole or in halves	57° C to 67° C	10 to 20 hours	Sulfuring is done for 15 to 25 minutes. Variation in yield is from 15 to 19 per cent.
Pears Only ripe pears are suitable for drying. These are peeled, cut into halves, cored	63° C to 63° C	15 to 24 hours	sulfured for 15 to 20 minutes
Peaches These are cut into halves	63° C to 68° C	15 to 24 hours	sulfured for 15 to 20 minutes
Cactus pears (prickly pears) Select large ripe fruit Using a clean cloth remove the glochids, dust and dirt Wash and cut away both ends Peel as thinly as possible Remove the soft peel and keep to one side (It is easier to remove if the fruit is cut in half)	63° C to 63° C	15 to 24 hours	Test for dryness: slightly sticky

<p>Juice the flesh and sieve (This can be done by using a blender or a mixer)</p> <p>Boil the juice</p> <p>Add the soft peel into the juice together with sugar, lemon juice and salt. Cook for about 1 hour</p> <p>For 1 kg peel, you need 750 g sugar, 65 ml lemon juice and a pinch of salt</p> <p>Pour onto a sieve and allow to drain and allow to cool</p> <p>Arrange the pieces on trays and load into the dryer</p>			
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Vegetables	Temp	Duration	Remarks
<u>Pumpkin leaves</u> Select fresh, tender leaves Peel off the hairy outer skin Wash in clean water Steam blanch for 3 to 5 minutes Place on trays ready for drying	50 ^o C to 65 ^o C	9 to 11 hours	Test for dryness: crumble easily
<u>Tomatoes</u> Select fresh ripe fruit Wash in clean water Slice into regular pieces (vertically) Arrange the pieces on the tray for drying	60 ^o C to 66 ^o C	9 to 11 hours	Test for dryness: a handful will spring apart after squeezing
<u>Cabbage</u> Peel off the outer leaves Wash in clean water Cut the cabbage in two Core Chop into thin strands Steam blanch for 5 to 8 minutes Arrange on trays for drying. Spread evenly, not more than 1.5 cm deep.	50 ^o C to 65 ^o C	9 to 11 hours	Test for dryness: extremely tough ribs, the thin edges crumble
<u>Amaranthus sp.</u> Select young, tender and crisp leaves Wash Place loosely in a steaming basket and steam for 3 to 5 minutes or until well "wilted" Spread sparsely on drying trays, keeping overlaps to a minimum	45 ^o C to 55 ^o C	9 to 11 hours	Test for dryness: crumble easily
<u>Sweet potatoes</u> Select firm, smooth potatoes Wash Steam in small quantity of water until the potatoes are just tender (30-40 minutes) Peel Slice into pieces (3-5 mm) or shred Arrange the pieces on trays for drying	50 ^o C to 65 ^o C	9 to 11 hours	Test for dryness: slices extremely leathery, not pliable, shreds are brittle
<u>Carrots</u> Choose crisp, tender carrots without woodiness (Not necessary to peel good, young carrots) Steam until cooked through but not mushy (about 15-20 minutes depending on size)	50 ^o C to 65 ^o C	9 to 11 hours	Test for dryness: slices very tough, but can be bent. Shreds are brittle

Remove whiskers, tails and crowns Cut into rings (2-3 mm) or shred Arrange on trays for drying			
<u>Beetroot</u> Choose small ones without woodiness Leave 1 cm of the tops (they will bleed during precooking if the crown is cut) Steam until cooked through (20-30 minutes) Cool, trim roots and crowns and then peel Shred with a coarse blade of a vegetable shredder (slices are not recommended because they take a long time to dry) Spread thinly on trays for drying	50° C to 65° C	9 to 14 hours	Test for dryness: shreds are brittle
<u>Pumpkin</u> Deep orange varieties with thick solid flesh make the best product Cut in half (manageable pieces for peeling) and remove seeds and all pith Shred with the coarse blade of a vegetable grater Place in shallow layers in the basket, steam for 6 minutes Arrange shreds on drying trays ready for drying	65° C to 70° C	9 to 11 hours	The slices are placed in a 2 per cent common salt solution for 10 minutes. They are then blanched for 3-4 minutes in 2.0 per cent boiling common salt solution. Test for dryness: shreds are brittle
<u>Green beans</u> Select young and tender string less beans Wash thoroughly Steam for 2 to 3 minutes Cut into short pieces or lengthwise Arrange on trays for drying	50° C to 70° C	9 to 14 hours	blanched in steam for 3 to 6 minutes. Test for dryness: extremely tough ribs, the thin edge crumbles
<u>Spinach</u> After thorough washing for the leaves, they are then dried either as such or after steaming them for 4 to 5 minutes.	63° C to 68° C	7-8 hours	steaming them for 4 to 5 minutes.
<u>Cauliflower</u> The flower are removed and cut into pieces	50° C to 70° C	10 to 12 hours.	blanched for 4-5 minutes in boiling water, steeped in a 0.5 per cent so2 solution for about an hour and then washed
<u>Okra (Lady's Finger)</u> They may be dried either whole or as discs or as halves cut lengthwise	63° C to 65° C	6 to 8 hours	blanching in boiling water for 4 to 8 minutes these are rinsed in cold water to remove the gelatinous coating
<u>Peas</u> Only tender peas are dehydrated.	≤ 63° C		are blanched for 1-2 minutes in boiling water
<u>Potatoes</u> Only large, healthy and fully matured potatoes are suitable for the purpose. They should have	60° C to 66° C F	7 to 8 hours	They are blanched in boiling water. However, if there is

the minimum number of eyes. After thorough washing, they are either peeled manually with knives or mechanically with peeling machine. The peelings are washed away with water. After trimming, they are then placed in water to prevent browning. After blanching, the slices are then placed on trays at the rate of 600 gms. per square feet of the tray surface.			to be considerable delay in the process of blanching, the slices in that case are placed in water containing 0.05% potassium meta-bisulphate to prevent spoilage
<u>Turnip</u> peeling and cutting these into 3/16 thick slices	52 ⁰ C to 57 ⁰ C	11 to 30 hours	immersed in a 0.5 per cent, sulfur dioxide solution for 1-2 hours, and then blanched in boiling water for 2 to 4 minutes
<u>Onions</u> After removing the outer leaves, these are cut into discs of 1/10 thickness	60 ⁰ C to 65 ⁰ C	11 to 13 hours	The discs are immersed in a 5 per cent solution of common salt for about 10 minutes and then drained
<u>Garlic</u> There is no need of blanching or any other preparation in this case. After peeling and cutting into slices of 3/16 thickness these are dried	54 ⁰ C to 59 ⁰ C	11 to 13 hours	

This category includes celery leaves as well as other aromatic herbs such as parsley, basil, sage, tarragon, etc. All these should be dried at temperatures not exceeding 40 °C. (If it exceeds this temperature oils valued for flavour will be lost)

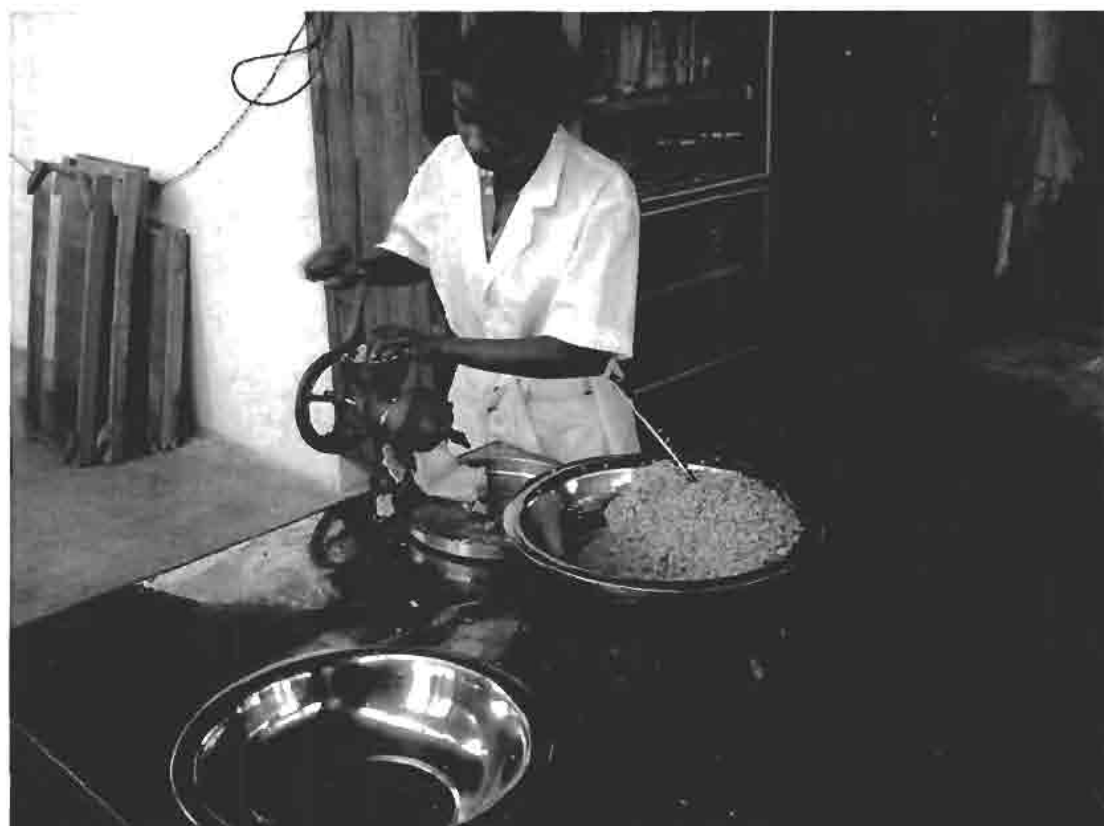
Herbs	Temp.	Duration	Remarks
<u>For best products</u> Water the herbs well the night before harvest. Harvest on a sunny morning soon after the dew has dried and choose plants that are reaching flowering stage. Harvest with sufficient stem, then strip off tougher leaves growing lower than 10 cm on the stalk. Hold in small bunches by the stem and swish the leaves through cold water to remove any dust or soil. Shake off the water and lay on absorbent towelling to allow all surface moisture to evaporate. Cut off the handle stems and spread the leafed stalks one layer deep on the drying trays. Put the dryer under a shade and cover the unventilated sides with a cloth to reduce the light on the herbs. Turn the herbs several times to ensure even drying	40°C		Test for dryness: crumble readily

Annex 2 : Training activities photos

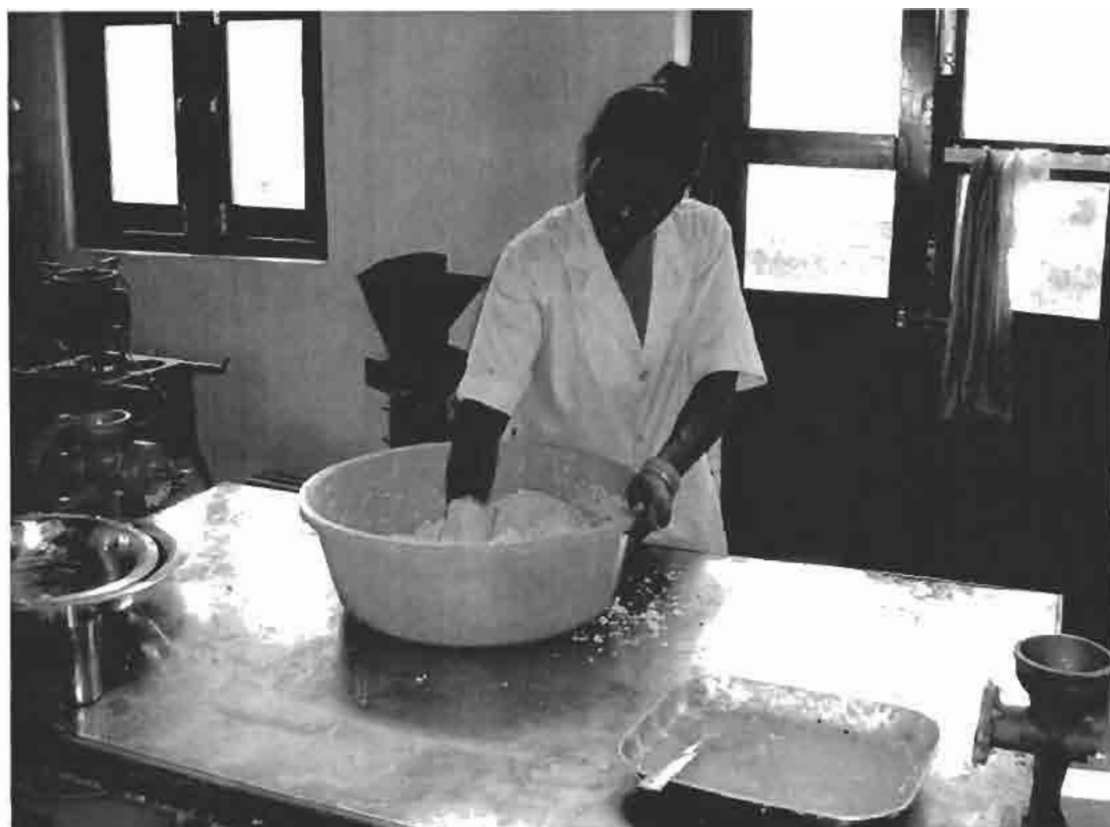
1. Nugget Production (on job training activities)



1.1 Cleaning/washing Black gram



1.2 Grinding cleaned Black gram



1.3 Mixing Black Gram with chopped and treated vegetable



1.4 Washing and treatment of chopped vegetables



1.5 Preparation of nugget and laying at wire mesh tray



1.6 Laying tray with row nugget in solar dryer



1.7 Nugget drying in modular solar dryer

2. Performance evaluation of Hybrid Solar Dryer



2.1 Bio-mass heating and recording of the performance data (BE Mechanical Engineering students – final year thesis work)



2.2 Sampling of dried nuggets

3. Operation and maintenance training of Solar Dryer and Dehydration of agro products



3.1 Trainees from Agro-Cooperative, Chakchake, Jhapa



3.2 Cooking Asparagus roots for test drying



3.3 Peeling of Asparagus roots



3.4 Cutting and laying Asparagus roots at tray

4. Community Mobilization and interaction with local groups



4.1 Women group Chakchake, Jhapa



4.2 Co-operative members, Sajeeban Krishi Sahakari Sansthan Limited, Jhapa



4.3 Executive committee member meeting at Clean Energy Walk in Learning Centre, Biratnagar



4.4 Meeting with Executive committee of Karnali Bachat Tatha Rin Sahakari Sansthan



4.5 Visitor from Motipur "Motipur Women Entrepreneur group"



4.5 Field visit “Motipur Women Entrepreneur group”

5. Centre for Agro-forestry Technology (CAFT), Lahan, Siraha



5.1 Hybrid Solar Dryer installed at nursery premises of CAFT, Lahan



5.2 Asparagus plantation at nursery premises of CAFT, Lahan



5.3 Collection and cleaning of Asparagus roots, at nursery premises of CAFT, Lahan