Expert consultation on planning the development of sundrying techniques in Africa

Proceedings of the Expert Consultation on Planning the Development of Sundrying Techniques in Africa

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Contents

V. Country status reports

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Foreword

Contents - Next

An Expert Consultation on Planning the Development of Sundrying Techniques in Africa was organised by the Food and Agricultural Industries Service (AGSI), of the Agricultural Services Division' FAO and financed by the FAO Regular Programme. The Consultation was

hosted by the FAO Headquarters, Rome from 12 to 16 December 1983.

Two fact-finding missions organised by FAO visited the following countries: Ivory Coast, Morocco, Nigeria and Senegal (July 1983) and Kenya, Sudan, Upper Volta and Zaire (August/September 1983). The findings of these missions contributed in an important way to the preparation and results of the Expert Consultation.

Apart from the FAD staff, the Expert Consultation was attended by 15 representatives from 11 African countries (Cameroon, Ethiopia, Ghana, Gabon, Ivory Coast, Kenya, Morocco, Niger, Nigeria, Senegal and Zaire), as well as 5 observers from international institutions (France, Israel, Italy, U.K.). In all, 28 participants studied 26 different documents (13 Technical Papers and 13 Country Status Reports), held discussions and exchanged experiences for five days under the Chairman-ship of Mrs. M.T. Basse, Technical Adviser to the Presidency, General Secretariate, Dakar, Senegal.

Contents - **Next**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

Acknowledgements

Contents - Previous - Next

The Food and Agricultural Industries Service, Agricultural Services Division, FAO. expresses its warmest thanks to all those who' through their work and their active cooperation, have contributed to the organization and success of this Expert Consultation. In particular, our thanks go to the African delegates and the observers who presented papers.

The reports and technical papers presented and the opinions expressed during the Expert Consultation are exclusively those of their originators.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

I. Recommendations

Contents - Previous - Next

The meeting approved the following recommendations.

INSTITUTIONS

1. It is recommended that FAO promote cooperation among national, regional and international institutes doing work in the field of solar drying, such as TRDI, CIAT, GERDAT, NIHORT and TECHNION, by organising regular meetings.
2. It is recommended that FAO continue to keep decision makers informed of developments in the field of solar drying by arranging meetings to which representatives of interested countries, potential donor countries and equipment manufacturers should be invited.
3. It is recommended that future FAO Expert Consultations in this field, be limited to specific commodities.
4. It is recommended that local specialised institutes participate in the experimental phase in order to compile information to be diesiminated to the farmers, to carry out tests to ascertain the commercial acceptance of the products and to study storage conditions in accordance with FAO's advice.
5. It is recommended that national institutes define minimum quality standards of food products as well as types of storage conditions and packaging. The organisations or services concerned should control quality and guarantee the products' conformity with

established norms.

6. It is requested that FAO urge Governments to encourage the efforts of producers through appropriate price policies.

INFORMATION AND TRAINING

7. It is recommended that FAO, as a follow-up to the present meeting' arrange a study tour for senior personnel from each interested country to places where solar drying is used at an advanced level.
8. In order to apply solar drying techniques, the African countries request that training of specialists in the food sector be strengthened.
9. It is recommended that FAO put emphasis on the training of rural people in order to acquaint them with the use of driers.

FAO ASSISTANCE

10. It is recommended that FAO give assistance to interested countries for the purpose of improving traditional drying methods
11. It is recommended that FAO develop and define the methodologies to be used in cottage and industrial-scale projects.
12. It is recommended that FAO expand its investigations on solar drying to include also

post harvest losses.

ACTUAL USES OF SOLAR DRYING

13. It is recommended that FAO, assist the rural sector in particular to develop methods of drying perishable products, such as fruits and vegenables, tubers and other plant material, as well as meat and fish.
14. It is recommended to establish a revolving fund' from which producers could be paid reimbursements for expenditures incurred during the experimental as well as the operational phase.
15. Projects should be oriented mainly towards improvement of living conditions of rural people by enabling them to establish stocks of better quality food and in larger quantities. This would improve self-sufficiency and save foreign currency.
16. It is recommended that these activities be promoted so that migration of rural people to urban areas may diminish and employment possibilities in rural areas may increase while at the same time relieving rural women of the drudgery of certain types of work.
17. It is recommended that the management of collection centres be entrusted either to groups of producers or to private investors capable of securing the supply of fresh products and the commercialisation of the dried products.

SURVEY MISSIONS

18. It is recommended that FAO send fact-finding missions to those countries that might request them, for the purpose of identifying pilot projects or target areas where solar drying techniques could be introduced and for supporting the establishment of solar drying programmes.
19. The countries represented at this meeting request that FAO urgently send missions similar to Preparatory Missions I and II to other countries whether or not represented at this meeting.
20. When the missions have completed project identification activities it is recommended that the interested governments formulate projects, including objectives, programmes of work as well as estimates of the resources needed to implement the projects.

PILOT UNITS AND PROJECT DEVELOPMENT

21. All the delegates request that the already identified or proposed projects be implemented as soon as possible by FAO.
22. It is recommended that the installation of drying units in rural areas be preceded by an experimental phase in order to ensure the success of the operation and demonstrate its economic viability to the rural people.
23. It is recommended that only the most suitable areas be chosen for the collection and

processing centres and that appropriate material, equipment and extension methods he used.

24. It is recommended that FAO publish a report on the performance of driers and a guide facilitating the selection of equipment, with due regard to the products to be dried, desired capacity and climatic conditions.
25. It is recommended that priority be given, with FAO assistance, to the drying of three types of products:

    i. well-known products, traditionally dried and consumed as such;
    ii. surplus fresh products (sometimes unsold);
    iii. special products intended for semi-industrial drying and new products.

26. It is recommended that FAO set up a project or establish a regional centre in Africa for comparative, practical trials with solar driers of various designs.

COUNTRY RECOMMENDATIONS

(These recommendations may be completed at any time upon request of a country).

1. GABON - FAO should send a mission to study the problems of the Gabonese chocolate

product ODIKA and to formulate a project.

2. MOROCCO - The three projects identified by the preparatory mission should be implemented as soon as possible with the help of FAO? which should also urgently support Phase II of the Fig and Prune Drying Project (packaging) units for dried products.
3. NIGER - FAO should field a mission to formulate a project on drying of tomatoes and sweet peppers.
4. ZAIRE - FAO should as soon as possible settle the requests for two projects for financing; i.e. one project for women in the market and commercial sector in Lower-Zaire and in the Kinshasa region and another for a pilot study in Kiwu.
5. IVORY COAST - FAO should, as soon as possible? come to a decision on the financing of identified projects and the preparation of project documents.
6. ETHIOPIA -

    a. It is recommended that FAO assist the Government in carrying out a feasibility study on a dehydration plant at Debre-Zeit which includes sundrying on farms.
    b. It is recommended that FAO assist the Government in carrying out a study on the methods being used at present for drying tobacco, onions? chill) and grapes at Nura-Era and Wollega and in proposing an improved system of

drying.

c. It is recommended that FAO assist the Government in the design of a solar drier for hibiscus flowers at Zwai.

7. KENYA -

i. FAO should assist in the documentation of existing traditional sundrying techniques with a view to their improvement.
ii. FAO should assist in a technical and socio-economic evaluation of ongoing sun drying projects.
iii. FAO should assist in formulating and seeking sources of financing for the already proposed projects (Karer and Marigat) as well as for other projects that will be proposed.

8. GHANA -

a. It is recommended that FAO send a fact finding mission as soon as possible, to ascertain the possibility of establishing a solar drying system for tomatoes.
b. To improve the traditional methods of sun drying, it is recommended that FAO render technical assistance through the Food Research Institute of Ghana and the Ministry of Agriculture in order to assist rural families in setting up

solar drying units.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

II. Introduction

Contents - Previous - Next

In addition to staple products, such as cereals' which are consumed in large quantities in Africa, other commodities, e.g. onions, tomatoes, tubers, spices and a great variety of other vegetables' plant products and fruits are widely used as food supplements.

These products are of great importance to human nutrition since they add to the staple diet minerals and vitamins which would otherwise be lacking. They also help to make the food more attractive visually and more appetising.

The products in question have a relatively high water content. Consequently they may deteriorate easily after harvest. Surveys carried out by FAO have shown that post-harvest

losses vary from 30 to 50 percent in tropical areas, These surveys have also shown that the still widely used traditional sundrying techniques are the most appropriate and economical means of preservation of most of these commodities for lowincome consumers.

Progress in solar drying techniques has been made recently, especially in Asia and Latin America. The achievements in these regions have shown that refinement of traditional methods may improve the qualities of the dried products and reduce losses. Very recently temperate climate countries have succeeded in making important progress in the design of small and medium sized solar drying units. It was considered to be of particular great interest and urgency to make African countries acquainted with these achievements.

The objectives of the Expert consultation may be summarised as follows:

1. To alert decision-making bodies (Ministries of Planning, Agriculture, Cooperation, etc.) to the necessity of intensifying the use of solar drying techniques' to show them how these techniques may contribute to self-sufficiency and to inform them about recent progress and the new perspectives that have arisen since 1980.
2. To collect and exchange knowledge and experience acquired from small-scale drying in the countries represented at the meeting.
3. To indicate methods of enhancing the efficiency of traditional drying techniques by modifying them in the light of recent results of applied research and pilot experiments

conducted in rural areas, with a view to reducing losses and saving energy.

4. To disseminate information on preparatory or related measures required for the improvement of hygiene and quality of the dried products.
5. To outline the socio-economic and technical requirements for the establishment of small industrial drying units in rural areas for the purpose of enabling decision making bodies to formulate aid programmes.
6. To include in the discussions comparisons of experiences from Asia, Europe the Middle East and Africa and to outline types of equipment commercially available.
7. To promote exchange of views among African countries concerning existing ways of formulating recommendations and guidelines for future programmes.

Contents - **Previous** - **Next**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

III. Summary of work and principal conclusions

Contents - **Previous** - **Next**

After the welcoming address and the election of officers, the provisional agenda prepared by AGSI was adopted, after minor changes in the timetable.

Following the opening session' the representatives of Cameroon, Ethiopia, Ghana, Gabon, the Ivory Coast, Kenya, Morocco, the Niger? Nigeria, Senegal and Zaire made statements on the situation of dried products and techniques being used in their countries' and on significant national experiences. Also, Ethiopia and Senegal submitted technical documents. Written statements from Tanzania and Upper Volta? who were unable to attend? were transmitted to delegates.

The new possibilities offered by natural drying of perishable or fragile produce such as fruit, vegetables, roots and spices were emphasized; the processing of cereals, fish and meat was also touched on, although this was not on the agenda.

Delegates were able to take note of the most relevant improve_ meets, often simple to introduce in Africa, to bring traditional drying techniques up to date. Methods were described, that could be used to identify projects for FAO assistance' with a view to increasing the income of rural people.

Some of the speakers provided information on industrial equipment recommended for small industrial units in rural areas' which would create jobs in the countryside.

Lastly, the technical and socio-economic commissions prepared a series of recommendations and suggestions, general and specific? addressed to FAO and to governments' which were adopted at the closing session after various amendments.

The concerns of the African delegates, expressed through questions raised during the discussions and set out in their recommendations, cover 26 points.

FAO should organise other meetings' similar to the present one' for either "decision-makers" on development programmes' or for research workers, to permit a quicker dissemination of information in a field that is rapidly expanding (cf. Recommendations 1, 3, 4 and 26).

The establishment of pilot units appears to be an indispensable preliminary for adapting equipment and procedures to local conditions, so that potential entrepreneurs, private or governments can see for themselves that the equipment is viable, and has potential for development. The pilot units could also produce dehydrated products for desirable, and sometimes compulsory market tests.

These same units can later be used for training staff and for assisting government officials by developing the necessary organisation, in particular with regard to the supply of raw materials (cf. Recommendations 4, 5 14, 16, 17, 22, 23 and 25).

Study tours for high level staff should be organised in other countries and in university

centres, cooperative or private organisations, already working with solar drying units, This would improve their understanding of specific problems in this field so that they would in a position to formulate development projects and plans, with the benefit of thorough knowledge of the subject and a valid methodology (cf. Recommendations 7, 8, 10, 11, 12 and 16).

The revival of solar drying of the more perishable agricultural products appears to be a promising method of reducing post-harvest losses, improving rural incomes and contributing to self-sufficiency, even of reducing some imports through substitution products. It should be accompanied by an incentive price policy (cf. Recommendations 6, 9, 12, 15, 16 and 22).

The fielding in 1984 of other fact-finding and project formulation missions is urgently requested, for countries present that were not visited in 1983. Priority should, however, be given to the implementation of projects already identified or pre-identified (cf. Recommendations 18, 19, 20, 21 and 23).

A better knowledge of existing equipment is also essential, and the countries present wish to have as soon as possible information on such aspects as costs, reliability, construction standards, comparative trials, ease of use (cf. Recommendations 2, 7, 9, 24 and 26).

While preserving the traditional marketing channels best suited to dehydrated products, there should also be proper organisation of collection, control, additional processing, and packaging of such products,

The establishment of centres in rural areas provides an exceptional opportunity for creating an industry that would encourage the population to settle in rural areas instead of cities, thus improving their diets through the consumption of traditional foods (cf. Recommendations 9, 13, 15, 16, 17 and 22).

Lastly, it appears from the various scientific papers presented that solar drying, given the low operational temperatures (about 60), preserves the nutritional value and the flavour of products processed. Biogas and photovoltaic cells can provide the additional energy required for industrial units.

It has been demonstrated that solar drying is viable and is being developed for small units or for domestic use. The solutions depend on the scale or the output desired. For large-scale industrial units with a high output, the interest of solar drying is for the time being limited to energy saving.

The various forms of technical assistance that FAO could provide in this connection were also explained in detail.

As Mrs. Basse concluded, on behalf of all participants, "it was a brilliant idea to have this meeting... one must remember that the path ahead will be difficult, but it is heartening to see the progress made recently in improving solar drying and putting it within the reach of rural people and even industry."

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.1. Report of the first preparatory mission on improvement and development of sun-drying techniques in Africa

Contents - Previous - Next

- M. Fabre and S. Mihailov

The Mission was staffed as follows: 1 Technology Expert (ML Fabre); 1 Marketing Expert (S. Mihailov) and visited the following countries during July 1983: Ivory Coast, Morocco' Nigeria and Senegal.

The Mission's terms of reference were as follows:

- to survey the products that are currently used for drying as well as the techniques involved
- to survey the finished products
- to propose methods and means that would lead to the development and improvement of these techniques and to consider whether they could be applied to other locally available products
- to formulate project proposals adapted to local conditions and aimed at benefiting the small type African family farm enterprise

PRESENT SOCIO-ECONOMICAL CONTEXT

The four countries visited have many socio-economical aspects in common. This is true especially of the three West African countries: Senegal, Nigeria and the Ivory Coast. In fact' some socio-economical factors are identical. It would seem worth while therefore to examine these factors in order to understand better the reasons for the traditional techniques used and in order to propose improvements.

PRODUCTION PATTERNS

Cash crop products for industrial processing and eventual export are generally grown in large, well organised plantations. This applies to coffee, cacao, pineapple etc. Many horticultural products harvest especially garden vegetables, are produced as a family enterprise on small plots of land and with limited resources. These products are essentially grown for domestic consumption. The products that are used for drying are generally the surplus of fresh fruit and vegetables not consumed at harvest time. They constitute a reserve stock for off-season consumption. Small quantities, fresh or dried' not used for domestic consumption' are sold on local markets by women in order to obtain cash. These quantities are generally limited to the weight a woman can carry on her head in a basket, about 10-15 kilos. Most horticultural products are cultivated without the use of draught animals or tractors.

ROLE OF WOMEN

With the exception of Morocco, where women lead a somewhat secluded life, the West African woman has a prominent role in the production, preparation and marketing of horticultural products, especially garden vegetables. It is the women, who take care of the production. They tend the gardens' harvest, prepare the products and sell surplus production.

It is for this reason that all efforts to improve traditional techniques should be directed towards women. The extension agent will have to convince women or groups of women about the benefits of proposed improvements.

FOOD HABITS

The diet of African people does not vary much from one country to another. It consists of:

- a basic component: cereals (rice' maize, millet) or humid starchy products (cassava and its by-products, yam, sweet potatoes, taros etc.) which carry the greatest part of the calories and constitute the filling part of the food
- a sauce - made of vegetables, seasonings (often very hot) and also' but rarely, of animal proteins (meat, fish, poultry) often in small quantities. This sauce conveys some variation to the diet as well as vitamins and other necessary elements and furthers the digestion of the starchy component.

It is important to note this detail since most of the dried products will be used to make this kind of sauce, which the Africans expect to be tasty (abundant use of spices) and often bitter. It should also have a certain stickiness, which the mucilage rich vegetables can give. This explains the great popularity of gombos (okras), baobab leaves and gum arabic in the

savannah countries.

FRESH PRODUCTS

Since the Africans are living under climatic conditions that constitute major problems for the preservation of food, they always prefer fresh vegetables and fruits. In most areas, however, especially in those where irrigation is not possible, production and availability of fresh products are limited to the rainy season During the dry season they have to eat products preserved in various ways. Among the various preservation techniques, solar drying is certainly the easiest and the most frequently used. Solar drying is without doubt the preservation method of choice also from a sanitary point of view, provided the drying is done properly and the finished product stored under satisfactory conditions.

DRIED PRODUCTS

While peasants cat with complaisance their own home-grown dried products and while other people living in small rural communities readily buy dried products on the local markets, the consumer living in bigger towns or cities is often reluctant to buy such "farm products",

which somewhat disdainfully are considered "picked products", always sold in dried form (leaves, seeds, various fruits picked from wild plants) and not always having an attractive appearance.

Improvements in quality and packing may help to open up new markets in towns, where the consumer may be happy to find products reminding him of his native village. The flight from rural areas to the cities is a major problem in Africa. This tendency, although having many adverse aspects, may offer the farmers new markets for dried products.

The case of mediterranean fruits (grapes, figs, plums, apricots, dates) is different. These fruits are considered "noble" calorie-rich products (dates are more noble than figs). Their consumption is offer linked to moslem traditions and they are eaten in great quantities to break the fast during Ramadan.

DIFFERENCES BETWEEN FRESH AND DRIED PRODUCTS

With only a few exceptions, dried products are generally vegetables or fruits. The dried products are often ground into powder, usually by pounding. This reduces their volume and consequently also the need for storage space. Ground products are also easier to add to the traditional sauces. Grinding also ensures complete dehydration and thereby better

conservation. Dried products are often mixtures of different fresh products ground together and dried in ball shapes (onions and tomatoes, peppers and tomatoes, bissap and tomatoes etc.).

Both fresh and sundried products are used for making sauces but the quantities of dried products used are always smaller than fresh products.

Consequently the off-season diet is less balanced and contains less vitamins and minerals. The dried, ground products are purchased in very small quantities (by grams) on the local market.

Certain imported concentrated products (Maggi seasonings, dehydrated soups and tomato concentrates) are also used for the preparation of sauces. The development of dried vegetable production will, therefore reduce costly imports and improve the diet of the African people in quality as well as in quantity.

Flow chart of harvested fruits and vegetables

With very few exception the role of middlemen, merchants (bane banes) is limited because the quantities available for sale are limited; in addition, collection of the products is often difficult owing to bad road conditions. Nevertheless a certain quantity of dried products finds its way to the markets of larger communities.

QUALITY OF DRIED PRODUCTS

Many dried products were found to be of unsatisfactory quality. Dust contamination seemed to be the most important problem. Some products contained stones and soil, suggesting that sorting-out and pre-treatment procedures have been deficient. In some cases the products seemed to have been prepared from over-ripe fruit and vegetables or from fresh produce in different stages of ripeness. More serious were damages caused by rodents, insects and mites, probably due to improper packing and storage.

TECHNIQUES APPLIED

In most cases drying techniques are very simple: the sliced or diced raw products are simply exposed to the sun on all kinds of flat surfaces, for example flattened or swept ground, roofs or terraces of buildings, flat rocks, roadsides and even railway platforms. The products to be dried may be placed on rocks, mats, corrugated iron or on trays made of a variety of materials: wooden sticks, split bamboo canes, fishing nets, jute bags etc.

Pre-drying procedures include, in some cases, washings with saline alcaline solutions

(ashes) and even with fatty emulsions, which result in better colour conservation and quicker evaporation of water. It was observed in Nigeria that slices of dried gombos kept a beautiful green colour after having been soaked in the juice of green lemons. Shade drying is practiced occasionally.

In some places various vegetables were ground in a mortar before being sundried in small balls for example tomatoes and onions and tomatoes and bissap. The advantage of this technique is that the tomato pulp, which is quite watery is absorved by the fibrous texture of the onions (leaves and bulbs) or by the bissaps (leaves and flowers).

LOCAL RESEARCH AND EXTENSION ACTIVITIES

A certain amount of research has already been undertaken in the four countries visited, mainly on processing technologies and various typos of driers. Experiments have been done with the following types made of locally available material: tent driers, box driers' cabinet driers and seesaw driers.

Officials in charge of development programmes in the visited countries have also made efforts to encourage the establishment of collection centres, which would undertake to process fresh produce as well as packaging, storage and marketing.

DEVELOPMENT PROSPECTS

The improvements that have to be made will necessarily affect the traditional system but care should be taken not to upset rural way of living, which often reflects excellent adjustment to the environment. The following are the proposed actions for improvement of the present system.

1. increase of horticultural production. Part of the increased production should be used for sun-drying. The policy of drying only casual surplus of produce should be changed to cultivation of products destined specifically for sundrying.
2. losses (sometimes 50 %) could be reduced through the use of more efficient techniques. (adequate pretreatment of raw products, improved sundriers, improved storage and packaging)
3. establishment of small drying enterprises or cooperatives that could produce larger and more homogenous quantities of finished products. This would attract middlemen who could be instrumental in the marketing of larger quantities.

Improved flow chart of harvested fruits and vegetables

MEASURES RECOMMENDED FOR FAMILY TYPE ENTERPRISES

The measures to be recommended for improvement of drying vegetal food products in small family farms must be geared towards the following objectives:

- drying of larger quantities
- better quality of products, reduced spoilage
- longer shelf-life of finished products.

PREPARATION AND PRETREATMENT

The speed and efficiency of drying procedures are related to the extension of the product surfaces exposed to the sun as well as to the underlying volumes of material. It is advantageous, therefore, to cut, slice or chip the product. To this end one should have a cutting board, sharp knives and planes for slicing.

The cut products become vulnerable and fragile. In most cases metabisulphite washings or SO2- fumigation in a closed room or a tent will prevent discolouration (Maillard's reaction)

and increase keeping qualities. Various types of easy-to-clean containers can be used: large basins and plastic buckets, big wooden boxes lined with plastic fertiliser bags etc.

Small fumigation chambers can be constructed with locally available materials: turf, clay and sand reinforced with bamboo sticks. The chambers should be sufficiently large so as to accomodate several wooden trays holding the products.

DRYING

Improved driers capable of rapid drying under dust-proof conditions have the following characteristics:

- greenhouse effect by fitting transparent air-tight coverings over the products exposed to the sun
- increased thermic absorption by blackened surfaces
- air circulation by convection (air inlet low-air outlet high)
- possibility of increasing thermal absorption by arranging black surfaces in rows alternating with rows of exposed products in upwards order
- possibility of certain adjustments: regulation of air circulation by partial closure (total

closure during night) of air inlets and outlets, shade drying by covering or semicovering of exposed products.

The farmer should be able to make most of these driers himself using local materials almost at no cost. Only transparent covers will have to be purchased (used fertiliser bags of transparent plastic can also be used).

Some of these driers, in particular one-tray types, are of very limited capacity since only small quantities per drying cycle (515 kilos par m) can be processed. For that reason it is recommended to use an improved version of the seesaw drier capable of drying larger quantities during shorter time.

TRADITIONAL SEESAW DRIER

The traditional seesaw drier has a rigid, rectangular frame, the length of which being 3 times the width' resting on a support with an axis. This support is oriented north-south and is sufficiently high to allow the frame to be tilted 30 - towards east in the morning and towards west in the afternoon.

The material for drying is placed on a number of trays, which have a wooden frame 100 x 50

cm and a mesh bottom, which can be made of a variety of materials, such as wire netting, old fishing nets, bamboo lattice or any other material that will allow vertical air circulation and maximum evaporation.

IMPROVED SEESAW DRIER (SEE APPENDIX 1)

The bottom of the drier is made of galvanised corrugated iron sheets reinforced crosswise by wooden planks and lengthwise by two wooden planks, about 15 cm high. The upper surface of the bottom is painted black. Good thermal insulation can be provided by attaching insulation plates made of lignified wood fiber, expanded polystyrene various layers of corrugated cardboard etc. to the underside of the bottom.

The removable trays are placed on top of the corrugated iron bottom either in a continuous row or with space between them, which will result in better heating of the air above the blackened surface of the corrugated iron bottom. In this case the edges of the trays should be propped up with wooden supports.

A greenhouse effect is obtained by placing a transparent plastic sheet over the filled trays. This sheet rests on the raised edges of the trays and is kept stretched by the weight of bamboo canes fixed to the sides of the plastic sheet. When not in use the sheet is rolled around the

bamboo canes.

Air circulation is secured by convection (the tendency of hot air to rise), the drier being tilted at an angle of 30 : fresh air enters at the lower end of the chamber formed by the trays and the plastic covering' escaping at the upper end. A 3 m long drier tilted 30 has 1.40 m difference in levels of air inlet and air outlet.

Air circulation can be improved still more by making the air outlet opening wider (28 x 50 cm) than the air inlet opening (15 x 50). In this way the room enclosed by the drier bottom and the plastic sheet widens gradually from air inlet to air oulet . This will improve convection and prevent the formation of "hot air bubbles" inside caused by air dilatation.

STORAGE

When the products have been dried to such an extent that they will keep, they must be packed, using containers or material ensuring hermetical conditions, e.g. metal containers with suitable lids, polyethylene bags, closed clay containers etc. The packed products should be stored in a dry place and be inspected from time to time.

QUALITY OF FINISHED PRODUCT

The quality of the finished product depends, to a large extent on the quality of the raw material which should be harvested at the proper stage of ripeness and transported carefully and rapidly to the site of drying. In addition, good quality of the finished product requires careful sorting' washing, cutting or slicing and dipping in dust (and dust) proof conditions.

Eventual grinding and pounding of finished products should be done as late as possible in the storage period because of the difficulty in detecting alterations and damage in powdered material.

INDUSTRIAL PROCESSING

There are many advantages in carrying out drying operations in small size collection centres situated in rural areas and managed by small producers, farmer's associations or even privately owned enterprises capable of handling large quantities of products. The methodology of setting up and operating such centres or enterprises is described in the Report of the Second Preparatory Mission.

CONCLUSIONS AND RECOMMENDATIONS

The findings of the Mission permit the following statements:

- people in the four countries visited understand how to utilise the freely available solar energy to preserve many kinds of fruit and vegetable products. These technlogies are often empirical but sufficiently developed to stabilise products that otherwise would spoil and be lost without dehydration
- apart from a few exceptions only small quantities are dried' not because it would be difficult to produce greater quantities but because the products are used mainly for seasoning
- the quality of the dried products is far from uniform and the flavours are often flat or stale. Nevertheless, flavour as well as bitterness, spiciness, viscosity and colour correspond to African taste
- dust pollution is an important problem. It can be reduced by means of plastic coverings for driers, which at the same time will shorten drying time because of the greenhouse effect.
- infestations of insects and mites are frequent and will be reduced only by better storage and packing
- the use of plastic materials for drying and packaging will improve and enhance

production. These materials are a great asset to the drying industry because they are durable and relatively cheap

- farmers' and local development organisations' favourable attitude towards proposed improvements augur well for any aid programmes that may be implemented
- it is important that proposed development programmes be realistic and well adjusted' in the socio-economical sense, to the small scale horticultural enterprises of the African countries. With a view to this the following facts should be taken into consideration:

  • the low purchasing power of the farmers call for simple and cheap solutions making use of locally available materials and utilising local craftsmen's ingenuity and skill
  • local customs are almost always based on sound principles and should be respected
  • horticultural work is mainly done by women in many African countries
  • the over-all production of dried products is at present relatively small. Also the units offered for sale to consumers at local markets are small, usually available as unweighed heaps of little more than 10 grammes

- the Mission believes that there is a good basis for successful development programmes that will be of benefit to a large number of producers and consumers as well and that the implementation of such programmes will require only relatively modest resources.

SEESAW DRIER (In cm) and continued

Contents - **Previous** - **Next**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.2 Report of the second preparatory mission on sundrying techniques in Africa

Contents - **Previous** - **Next**

- E. Espiard and S. Mihailov

The Mission was staffed as follows: 1 Technology Expert (Etienne Espiard); 1 Marketing Expert (Serge Mihailov) and visited the following countries during August and September 1983: Sudan, Kenya, Zaire' Upper Volta.

CONCLUSIONS

The sundrying technique used in the visited countries is still a traditional one by direct exposure to the sun on racks or sometimes directly on flattened ground. Consequently, the quality of the product is very poor and dried products are consumed only when fresh products are lacking.

The solar driers where the material being dried is directly exposed to the sun and protected against dust from the air and rainfall by a transparent cover (glass or plastic) did not improve the aspect of the product.

In all the countries visited, the mission did not hear of or see any case of indirect solar drying which would have given dried fruit and vegetables of first class quality. The few good quality products found on the market came from industrial drying plants using diesel oil for artificial heating.

A considerable market exists for dried products. Numerous products' (especially vegetables) dried in the traditional way' are marketed on a regular basis in the so-called semi-desert countries, such as the Sudan and Upper Volta, and this market could be expanded with products of better quality (better looking and more hygienic).

The African market will, largely, remain a market for poor customers, who could barely pay

for quality. Therefore assistance should be given to help promote marketing of products of improved quality.

Indirect sun drying, which can only be used for green or pigmented vegetables and for fruits, can easily be developed in the visited countries because numerous farmers, in remote areas, could produce more vegetables, fruits and spices if they were assured of an outlet for their dried products, which are less perishable than fresh produce and need not be transported rapidly.

In the small garden plots near the cities and also on the market, great quantities of unsold products could be saved by sundrying. Taking into consideration the rainy season with abundant supplies and the dry season with shortage, sundrying is a good way of saving surplus production for the dry season.

RECOMMENDATIONS

It is recommended to:

Demonstrate that it is possible to produce good quality dried vegetables, keeping the colour and the taste of the fresh product, with sundriers easily manufactured at the family and/or

industrial level. For this purpose 5 projects (out of 9 identified) have, as an objective, information and training.

Participate in the development of new irrigated agricultural areas which cannot profitably produce fruit and vegetables for fresh consumption, due to the distance between the production sites and the food consumption centres and/or lack of a fast transportation system.

Supplement these two operations with a marketing program aimed at promoting a sales strategy for these products, which could be considered "new products", because of their superior quality.

IMPORTANCE OF FRUIT AND VEGETABLE LOSSES BETWEEN PRODUCTION AND FOOD CONSUMPTION

The FAO publication "Food Loss Prevention in Perishable Crops" (1981) gives the main conclusions regarding this question.

- Fruits and vegetables are particularly perishable because:
    - their humidity is high (70 to 95%)

- the rate of respiration is high to very high. Calories production vary from 0,5 to 10 million joules per metric ton and per day at 0 C, and from 5 to 70 million joules/mT/d. at 20C
- their texture is fragile and does not withstand piling-up (crushing even in small boxes).

- In general, losses are estimated as follows:

  - from 15% to 50% in developed countries, depending upon the type of product, the climatic conditions, the way of harvesting and the packaging, transportation and distribution process;
  - from 20% to 60% in developing countries, especially in tropical areas.

In general it is considered that average loss is 40% and this has been confirmed during the mission, except in the Sahelian countries where the losses are lower because people practice traditional solar drying. The Upper Volta authorities estimate their vegetable losses at 20% only.

The world horticultural production is evaluated at 1.200 million metric tons i.e. as much as cereal production.

In other words, the fruit and vegetable losses could be evaluated at 500 million metric tons for this one sector.

Any system that will save part of the production can have a very important effect.

WAYS OF SAVING CROPS

The aforementioned FAO publication outlines the following measures that would contribute to the production of losses:

- improving harvesting, sorting, packaging and transport conditions
- improving marketing and sale of fresh products
- establishment of rigid sanitary and public health regulations covering all operations from harvest to consumption
- developing food preservation methods especially small scale drying technology or other appropriate technologies. Sundrying falls into this category of development
- initiation of training programmes concerning prevention of losses in horticultural crops.

TENDENCIES IN DEMAND AND MARKETING OUTLOOK FOR DEHYDRATED FRUITS AND VEGETABLES

Urban centres in Africa have developed much more rapidly than the birth rate (already very high) has increased. While total average demographic growth is around 3% per year, urban centres have developed by 7 to 10% due to rural migration. The new urban populations can generally be divided in two groups:

Group A = wage earning minority with some purchasing power (maximum 25%)

Group B = "floating' majority with low purchasing power (minimum 75%).

Each group has distinct purchasing and consumption habits that must be taken into consideration in promoting a product.

Group A (well-off people)

- they consume 3 varied meals a day. They keep to traditional cooking but try also imported dishes introduced to the country by foreigners (dishes consisting of vegetables with a separate sauce, salads,. .)

- they consume only traditional dried products (old fashioned image, country fashion) when absolutely necessary-to prepare a particular dish and complains about the poor quality of loosely sold dry products.

Group B (low income)

- consumes only one meal a day, generally at night, made of 90% starchy food mixed with a vegetable sauce (West Africa). In East Africa starchy food is partially replaced by vegetables richer in proteins: (chick peas, green beans' etc.)
- indispensable ingredients for the preparation of the sauce are generally vegetables, spices, leaves, sometimes fresh in fullseason and dried the rest of the year. Some tomatoes and onions are used when the price is cheap in peak periods
- Group B has no choice and buys the least expensive food in order to subsist and therefore purchases very few fresh vegetables.

PRESENT NEEDS

Products that are consumed in addition to the basic starchy food are fresh or dried vegetables, leaves, gombos, chilli, to which sometimes tomatoes, onions or even potatoes are

added. Dried tomatoes and onions are generally in powder form which makes them liable to adulteration. Various substitute products are imported, such as Maggi and Liebig sauces and "cubes", tomato concentrates, etc.

PROSPECTS

There is already an open market for dried products. It could be developed by expanding production of new dry products (not yet dried in the traditional way). For example:

a) Same product but of higher quality

To meet consumers' needs pertaining to Group A (well-off), products should be as attractive (presentation, packing) as substitute products.

Depending upon the retail price, consumers from Group B (low income) could also buy improved dried products' especially in periods of shortage when prices of traditional products are too high for them.

b) New dried products

Products, such as tomatoes and onions, very much in demand when fresh, but seasonal and expensive, are much used in manufactured products (imported tomato concentrate' Maggi sauce) should be able to take a place in the market in a dried form provided that they are properly processed. Dried fruits could also be commercialised as delicacies.

c) Packing

In order to protect the product and enhance its commercial value' it should have an appropriate low-priced packing.

For this purpose packages should be small - 10 to 50 grams. corresponding to quantity needed for a sauce. The catering package for sale of large quantities could also be launched.

SUN DRYING

Sun-dying of agricultural products, such as leaves' flowers, fruits, seeds, vegetables, roots an tubers, as well as meats and fishes is generally used in most hot countries, mainly in African sahelian or semidesertic countries. The mission found that this was the case in Sudan and Upper Volta. With the exception of tobacco and tea drying in the Sudan, sun drying is generally done under very poor conditions. Fresh products are exposed directly to the sun

without any preparation and without dust protection; they are exposed to ultra-violet radiations' which discoulour chlorophyl and carotene and brown the products (Maillard's reaction).

Several research centers or institutes ("Karen Center" in Kenya, "Institut Voltaque de l'Energie" in Upper Volta ...) are testing new solar driers with dust protection' but the mission did not see any drier operating with external air heaters.

Drying by wood burning (another form of renewable energy), is mainly used for meat and fish and also to some extent, for cassava or plantain bananas (seen on the Kinshasa market) but, rather surprisingly, this type of drying is little or not at all used in countries with abundant forests.

DRIED PRODUCTS - QUALITIES AND DEFICIENCIES

Appendix 1 gives an exhaustive list of fruits, vegetables, leaves, roots and tubers seen on the markets. Cereals, maize, corn and oil seed containing more than 20% oil (including palm nuts, peanuts, soya seeds) are excluded from this list.

The quality of these products is far from uniform. It is good for the usually dry vegetables

(beans, lentils, peas, chick peas, full medams ...) and low for leaves, flowers, fruits and vegetables with the exception of:

- hot Pimentos (fel fel, chillies, pill pill ...)
- dried sulphited fruits from Malindi in Kenya.

Most of the green or red products were discoloured and browned like tossed hay. Furthermore' all products contained a high percentage of foreign matter (sand and dust). However, we did not see any products with parasitic insects or mites. Nevertheless' these products seemed to have kept their nutritional value.

Sun-drying, even with the actual techniques, remains one of the best ways of saving seasonal surplus production and to ensure supplies between abundance periods. Sundrying also makes transport of the produce from production to consumption centres easier.

The cost of tin-plate and the difficulties in obtaining it in Africa is a restraint for the development of the canning industry.

The lack of facilities for transporting frozen goods is a considerable restraint for the development of the frozen food industry.

Minimum quality standards of sundried products should be as follows:

- moisture: less than 10%
- content of ashes: less than 3%
- colour: resembling fresh produce.

DRYING PRINCIPLES

Sun drying of leaves, flower, fruits, vegetables, roots and tubers requires the application of the following principles:

- preparation of the raw material for food consumption (washing, sorting, peeling ...) to avoid spoilage
- protecting raw material against loss of quality during the drying process (blanching against enzymatic action)
- facilitating fast drying by:
    - increasing the exposed surface of the products (dicing' slicing' spreading-out of products),
    - catching as much as possible of sun radiation by appropriate absorbers (black plates perpendicular to the sunbeams),

- increasing the circulation of air around the product,
- avoiding heat loss (insulation of areas not exposed to the sun)
- avoiding direct sun radiation of the product since this affects the appearance adversely (discolouration).

- protecting dried products against:
  - rehydradration
  - dust contamination
  - harmful effect of light

SUN-DRIER CLASSIFICATION AND TERMINOLOGY

Sun-driers are classed according to the systems of heating the product:

- natural drier: this drier uses the sun action on the ambient air to which the product is exposed. It is a process which is not applying the basic principles discussed above and this drying process is omitted from this report.

In the specially constructed driers' the raw products are spread out in an enclosed space where they are protected against dust contamination and subjected to a controlled air flow. There are various types of such driers:

- direct driers: in these units, the material to be dried is placed in an enclosure, with a transparent cover. Heat is generated by sun radiation of the product itself as well as of the internal surfaces of the enclosure. The heat causes the moisture to evaporate from the product. In addition it expands the air in the enclosure creating air circulation
- indirect driers: in these driers the sun radiation heats exclusively the air. The hot air is then led by thermocirculation or by forced circulation into a chamber or cabinet holding the products to be dried
- mixed driers: are indirect driers' where the hot air from the exterior solar heater is combined with direct solar heating of the products through the transparent roof of the drying cabinet.

Direct driers can be used for several products as seeds, roots' tubers or some fruits as red pimentos' but they are generally the cause of many disappointments and we recommend strongly to use indirect or mixed driers, which ensures much better drying conditions.

DECRIPTION OF AN INDIRECT DRIER (see Figure 1 - Indirect solar drier showing external air heater, cabinet drier with trays and chimney for extraction of humid air.)

The indirect drier has three main components:

- external air heater
- drying room (or cabinet) with its trays
- air circulation and evacuation device with eventual recycling.

External air heater. A good air heater consists of an enclosure' rectangular in cross section. The ceiling of the enclosure is a transparent sheet allowing the sun rays to heat the black painted bottom.

The drying cabinet. Can be a simple cupboard shaped chamber with doors facing north. The cabinet can hold several trays placed on racks or trolleys. The hot air from the external air heater enters the cabinet through an opening at the bottom, rising through the mesh trays with the vegetal products towards the top.

Humid air extraction and eventual recycling. The top of the cabinet has a device for extraction of the hot humid air with possibility of recycling in case the air is not completely saturated with humidity. Extraction of air can be effected through:

- a chimney with an umbrella cap (natural extraction)
- a chimney with a wind ventilator
- an electrical fan, mainly for recycling.

Controls and analysis (indirect driers). It is considered advisable to check the temperature and humidity of heater inlet and outlet air, air in contact with the products and drier outlet air.

In addition, residual humidity of dried products should be analysed and total weight of ingoing and outgoing products should be recorded.

Various types of direct and indirect driers are shown in figures 1 - 6.

Figure 2 - Seesaw drier

Figure 3 - Fixed solar drier

Figure 4 - Combined direct/indirect solar drier, The transparent cover can be replaced by an opaque cover in case the products may suffer damage by direct radiation.

Figure 5 - Indirect solar drier. The roof fitted with photo-thermic absorbing panels is the air heater. Hot air circulation (from top to bottom) requires a fan.

Figure 6 - Recycling drier with dehumidifier/condenser. Hot air from the external air heater passes into the drying cabinet and removes moisture from the products. The cooled air gravitates to the condenser where it deposits its moisture. From these the air re-enters the solar air heater, condensation can be improved by cooling to temperatures below the dew point by a source of refrigeration (cold water, solar absorption refrigerator etc.)

MANUFACTURERS OF DRIERS

CANADA

- BRACE RESEARCH INSTITUTE
MACDONALD COLLEGE
800 SAINT ANNE DE BELLEVUE
Dryers type 1 and 4

THAILAND

- INTERNATIONAL DEVELOPMENT
RESEARCH CENTER (I.D.R.C.)
ASIAN INSTITUTE OF TECHNOLOGY

QUEBEC H0A 100 CANADA
P.O. BOX 2754 BANGKOK
Dryers 2 and 5

FRANCE
- ETS CAUSTIER
ROUTE DE PRADES
6600 PERPIGNAN
- associated with the
CENTRE D'ETUDE SUR LE SECHAGE SOLAIRE
from PERPIGNAN UNIVERSITY
AVENUE DE VILLENEUVE
66025 PERPIGNAN
Dryers type 1, 3, 4, 5

- UNION TECHNIQUE D'AQUITAINE U.T.A.
VILLENEUVE SUR LOT - Dryer type 2

INDUSTRIAL PROCESSING

The following considerations apply only to small size enterprises situated in rural areas and managed by small producers or farmers' associations.

ORGANIZATION AND OPERATION

The following points are relevant:

LOCATION

Location of an enterprise should be chosen according to the availability of the following resources and facilities:

- sufficient production, or possibilities of sufficient production of raw material within a radius of 5 to 7 km equivalent of 2 hours walk. Ethnic homogeneity would be advantageous
- a good all-year road system allowing traffic of motorised vehicles

- own water supply
- electric power supply, desirable but not indispensable, provided that other energy resources, are available like fuel oil, wood, vegetal waste for production of biogas, etc.

MEASURES FOR SECURING SUFFICIENT QUANTITIES OF RAW MATERIAL OF ADEQUATE QUALITY

The enterprise cannot function unless delivery of a minimum quantity of raw material of adequate quality is secured. This necessitates the adoption of a regulation to be observed by members of the association or cooperative in question. This regulation should specify:

- minimum quality requirements of raw material
- minimum quantities to be delivered
- if possible a time table for deliveries in order to make optimal use of the plant's resources.

Privately owned plants should include the same requirements in delivery contracts. Payments for delivered products should always be based on quality and quantity.

COLLECTION AND TRANSPORT OF CROPS

Only fresh and suitably ripe products should be collected. Fruits, onions, tomatoes and peppers should have a high dry matter content. Delivery to the plant should take place shortly after harvesting. Care should be taken that the products suffer no bruises or other kind of damage during transport.

Wooden crates for transport should be of suitable construction. Soft wrappings should be used for fragile fruits.

The conditions of delivered partially dried products should be defined: softness, caking' ratio of fresh and partially dried weight etc. Such precautions will ensure homogeneity of dried products as well as continuous and full use of plant installations.

Transport of products can be improved by the use of better vehicles and equipments, e.g. wheel barrows, specially fitted bicycles, small carts with rubber tyres, pack-saddles adapted to the wooden crates used etc.

CONTROL OF DELIVERIES

Purchase price of delivered products should be based on quality and quantity. Quality control may be an incentive for farmers to produce better quality products.

QUALITY

Quality control should include: determination of dust damage, foreign matter and defect products, residual humidity and an evaluation of processing qualities.

Periodical testing of samples in specialised laboratories would be useful as a current control of the reliability of testing done in the plant.

QUANTITY

The delivered products should be weighed on scales. Estimates of volumes are unreliable.

PREPARATION AND TREATMENTS

Some treatments are difficult to carry out by the producer and can be done better in the collection centre. Insecticide fumigation involving the handling of methyl bromide or phosphine is dangerous and is economical only if large quantities are treated.

FUMIGATION

The technique of choice consists in covering piles of crates with a plastic chute. Air-tightness is secured by heaping sand or rail on the edges after the required amount of aluminium phosphide has been introduced. This kind of treatment can be done in the open air with negligible risks.

PRETREATMENT

If drying or partial drying is done by the producer treatments for colour preservation must be done immediately after slicing or cutting and before the product is placed on trays.

Blanching and sulphitation are done by rapid soaking in boiling salt water with potassium metabisulphite added, in a large tub that can be heated by fire. The unstable pigments of

green products such as chlorophyll in gombos, herbes, etc. will be stabilised in this way and browning due to Maillard's reaction will be reduced to a minimum. This treatment is not absolutely necessary for carotene rich products, such as tomatoes and peppers, whose pigments are more stable.

STABILIZATION BY SO2 - FUMIGATION

This treatment, recommended for white grapes, apricots and white figs, can be done easily by placing the loaded trays inside a plastic tent in which sulphur is burnt.

The work involved in treating larger quantities of produce in the collection centre can be rationalised, for example by the use of a stainless steel tank mounted on a fireplace, baskets lifted by pulleys and moved on suspended rails, in a room with concrete floor with drainage.

DRYING

The type of equipment to be used is related to the kind of product to be dried and the operations involved (complete or partial drying).

Complementary drying above 60 requires a drying cabinet with trolleys, artificial heating and forced ventilation.

DESINSECTIZATION AND STORAGE

Products considered sufficiently dry to prevent fermentation and fungal growth should be packed in such a way that they are protected against dust, noxious animals and against regaining of humidity. The stored products should be kept in complete darkness to avoid damage by photophile insects. If necessary, fumigation (with insecticides) of the packed products can be carried out in plastic tents or in drying cabinets.

PACKING

Some products are sold in powder form. For the reasons mentioned previously, pounding and grinding should be done at a late stage, preferably immediately before marketing. Pounding with a morter gives a better product than mechanical grinding in a mill, of which there are various types, but requires more labour and often also sifting.

Packing for consumers can be done at little cost. Products sold in polyethylene bags can be weighed on small scales. Packings should carry indications of nature of the product, net weight and origin. This information can be printed or stamped on a label placed visibly inside the bag (not to be used for powdered products). Polyethylene bags can be closed with scotch tape.

Go To Next Page

Contents - **Previous** - **Next**

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

WATER AND ENERGY SUPPLIES FOR AFRICAN DRYING UNITS

Contents - **Previous** - **Next**

Water is needed for cleaning of rooms and equipment and for washing and treatments of raw material. If no public water-supply systems are available, which is the case in many places in Africa, water has to be obtained from other sources, e.g. wells, drillings or streams. This requires pumping, which can be done manually or by pumps powered by electricity or combustion engines, windmills or animal powered norias (scoop wheels). Turbid water can

be cleared by means of sand filters.

Energy - Complementary drying (temperatures above 60 C) requires heat, which can be produced by burning of wood or fuel oil provided the latter can be obtained at low cost, which is the case in Nigeria.

Electricity is required for lighting' ventilation of drying cabinets, pumping, fuel oil burners, small type equipment like grinders etc. Unless electricity can be obtained from centrally generated supply systems it will have to be produced by the plant itself by generators powered by combustion engines, windmills (only for limited needs), photovoltaic cells (high investment costs) or hydraulic energy.

EQUIPMENT FOR TESTING OF RAW MATERIAL DELIVERED

- Scale, 0-50 kilos or 0-200 kilos, according to average weight of deliveries
- refractometer 0-30C
- simple hot-air stove
- scale 0-200 g (0,01 g sensibility)
- aluminium cups (70 mm diameter)

- containers and filter paper

Equipment for humidity analysis requires electrical power; if unavailable, analysis has to be done at suitably equipped laboratories.

EQUIPMENT FOR PREPARATION AND PRETREATMENT OF RAW MATERIAL

- Tables for cutting, knives, planes, electrical cutters
- tubs or other containers for sulphitation, basketry, pulley on suspended rail
- plastic tents (6 m) for SO2, BrCH3 and phosphine fumigations.

DRIERS AND DRYING CHAMBERS

Seesaw driers (Figure 2) and indirect driers (Figures 1, 3, 4, 5, 6) are sufficient in most cases. Solar drying alone, however? is insufficient if drying procedures require temperatures exceeding 55-60 C. In this case complementray heating must be done in a drying room or cabinet with air heated by firewood, biogas or fuel oil. In general heating by fossil oil is economically feasible in Africa only in oil producing countries.

It is considered that a drying chamber suitable for African conditions should have the following characteristics:

- capacity: 4 trolleys each carrying 50 trays, 100 x 50 cm
- heating: wood heater furnished with an adapting device to make oil or gas burning possible
- ventilation: fan powered by a 5 CV diesel engine or an engine capable of using low quality gas
- structure - masonry (bricks or breeze blocks) or metal frame with glass wool insulation, metal doors.

ADDITIONAL FURNISHINGS AND EQUIPMENT

- building for housing the drying chamber, if metal type (ground dimensions 6 x 2,5 m)
- concrete area in front of the drying chamber for loading and unloading trolleys (minimum size: 20 m)
- 8 trolleys (4 in the drying chamber' 4 being loaded or unloaded)
- 400 trays (200 in the drying chamber, 200 being loaded or unloaded
- constructions for loading and unloading and for storing treating material (wood)

ESTIMATED COSTS

	French francs
Drying chamber	
• Drying chamber (metal type)	170 000
• drying chamber (masonry type)	according to offers
• burner adapting device' doors 8 trolleys' fan	35 000
Material for making 400 trays:	
• wire mesh, 200 m	8 000
• 1200 5 mm iron rods	1 620
• wood for frames' nails and staplers	no estimate supplied
Motor for ventilation (Bernard Diesel, 3,3 kw 5 CV	3 500
Building for housing the drying chamber (50 m)	according to offers

• concrete area	
• building for storage of wood	

STORAGE

Stored dried products should be protected against rehydration, dust, odours, attacks of insects? mites and rodents.

Bulk storage of the products prior to packing should be in airtight containers: multilayer plastic bags, metal containers' plastic buckets with airtight bids etc. Storage rooms should be solidly build and provide complete darkness.

METHODOLOGICAL APPROACH FOR SETTING UP A SMALL SCALE INDUSTRIAL DRYING PLANT

1. Basic data collection

In order to design a new drying plant it is necessary to obtain the following data

2. Agricultural products to dry

- **list of variety of products**
- **quantities to dry**
- **harvest periods**
- **cost price of products**
- **analysis of samples of products**

3. Monthly climatic data

- **temperatures - maximum - minimum - average**
- **dry bulb temperatures at 0600 h and 1200 h**
- **dew point temperatures at 0600 h and 1200 h**
- **rainfall in mm - maximum - minimum - average**
- **hours of daily sunshine - maximum - minimum - average**
- **wind speed**

4. Food consumption habits

- **preparation of raw products**
- **usual packings**
- **recommendations regarding marketing aspects**

5. Data for lay-out

- **plan (drawing) of available area**
- **main data concerning:**

  • water (quantity, quality, coat)
  • electrical power
  • fuel supply possibilities (oil, gas, wood)

6. Outline of procedures

- **estimate of recoverable solar energy**
- **required drying time for each product (laboratory teats)**
- **choice of drier type**
- **flow sheet (preparation, drying, packing)**
- **ratio raw material/utilized material**
- **equipment specifications**

- **staff required (by function and by category)**
- **technical data to calculate production costs, including amortization**
- **programme implementation and time schedule**

7. Financing

- **total investment cost**
- **proposed capital structure and financing**
- **production cost**
- **estimated operating coat**
- **cash-flow and profitability**

8. Feasibility study and decision regarding investment

9. Detailed engineering

This includes all estimates of production Methods, sufficiently detailed to implement the project, purchase equipment, to start construction work and to initiate plant operation:

- **plant operation**
- **equipment and supplies (purchase and delivery)**

- **staff training**
- **initiation of plant operation**
- **time schedule and programme of work.**

APPENDIX 1

DRIED PRODUCTS IN AFRICA 1, 2, 3, 4

APPENDIX 2: FOOD LOSS PREVENTION IN PERISHABLE CROPS

RECOMMENDATIONS

An international action programme of post-harvest food loss prevention in perishables of plant origin should be initiated. A proper balance should be maintained between post-harvest scientists and economists, engineers and food technolgists in project formulation and implementation.

All projects designed to increase food production or improve food marketing should give consideration to the post-harvest implications of the project including both project development and project monitoring phases.

All post-harvest food loss reduction activities should consider the environmental impact of that activity. Environmental and health issues should be part of the documentation of project proposals and the planning process.

Each country should attempt to identify the principal problem areas affecting losses in perishables of plant origin occurring in its own post-harvest system with a view to establishing appropriate priority areas for action. Since the value of the product may be doubled in the postharvest period, these value changes need to be assessed for specific crops. The scale of priorities should be compiled on the basis of the magnitude of the losses, their economic and nutritional importance and the feasibility of applying effective remedial action that is operationally and economically reasonable. A system's approach should be used in this process taking into account biological, physical, economic and social factors with reference to the various economic groups including the rural poor. There should be full participation of the expected beneficiaries in the planning of food loss reduction activities. Traditional technologies should not be ignored.

The use of proper temperature management procedures should be promoted. This

includes simple cooling systems such as shading from direct sunlight and use of evaporative cooling. Where appropriate, more cool stores and better utilisation of existing cool stores should be promoted. The International Institute of Refrigeration should co-operate with national and international organisations to organise training in refrigeration management, design, operation and maintenance of suitable for conditions experienced in developing countries.

The search for low cost cooling systems should be intensified. This should include the application of solar energy and other renewable sources of energy to power cooling systems. Practical research programmes should be drawn up by national and international agencies and institutes to adapt refrigeration techniques to the needs of developing countries.

There should be development and promotion of gentle handling of horticultural produce at all steps in the harvesting and marketing system when it is technically feasible and economically viable. This includes the development and use of improved market and field containers that are used to harvest, transport and store horticultural produce. All training manuals should emphasise that mechanical damage is the major factor in providing pathways for infection of produce by micro-organisms. The avoidance of mechanical injury should be an essential criterion on the design of harvesting and handling machinery. The importance of efficient marketing systems as a factor in the

prevention of post-harvest losses particularly the less durable fruits and vegetables hats also to be recognised and such systems adapted to suit the requirements of efficient perishables' marketing.

There should be active encouragement of rigid sanitation and public health procedures of all produce handling and operation areas, sanitary operation of equipment, containers and stores, and sorting out and proper disposal of diseased and damaged units from the produce.

The relevant International Agricultural Research centres of the Consultative Group for International Agricultural Research in collaboration with national and other international institutes should be encouraged to initiate or expand a co-ordinated programme of research to resolve outstanding problems related to post-harvest factors and storage behaviour of horticultural crops, e.g., root crops. Plant breeders in these institutions should consider long inherent storage life as an important criterion of selection in the breeding of fruits, vegetables, roots, and tubers.

Research to develop small scale drying technology or other suitable appropriate technologies for transforming horticultural crops should be promoted. The use of these technologies should be promoted where their benefits have been clearly demonstrated.

Every country should be cautioned against the use of hazardous protective agricultural chemicals until the following actions have been accomplished:

- **analytical laboratories and inspection services have been established to monitor the proper use of pre- and post-harvest agricultural chemicals;**
- **guidelines have been developed and are being applied to educate farmers and food handlers in the proper and safe use of hazardous compounds and safe disposal of empty containers.**

Information should be available in each country as to which national and regional laboratories have the facilities to identify decay organisms.

A variety of types of training programmes in prevention of losses in horticultural crops should be initiated. These should be designed to suit the differing needs of the people in different parts of the harvesting and marketing chain. While most training should be provided within their own country exchanges with other countries may be beneficial in some cases. The transfer of existing good storage technology fro M national and international institutes to potential users should receive priority in the programmes of these institutions.

The following publications should be prepared:

- **technical loss prevention manuals for commodities or groups of commodities;**
- **a world-wide directory of institutions and training programmes involved with prevention of losses in perishable crops;**
- **guidelines for loss assessment.**

An international information network on food losses in horticultural crops should be established making as much use as possible of existing national and international programmes to facilitate technical co-operation between similarly oriented institutions. The information to be collated in a World Directory (13b) should form the basis for establishing International and Regional co-operation in improvement of training at all levels.

APPENDIX 3: PROJECT IDENTIFICATION CARRIED OUT BY THE SECOND PREPARATORY MISSION

KENYA

1. **Solar fruit and vegetable drying - pilot plant to teach and train farm women in this technology in order to save seasonal over-production, in collaboration with the**

Ministry of Health (KAREN Center for Research and Training).

2. **Kenyan Fruit and Vegetable Sun Drying Project to maintain production in PERKERA Scheme at Mariat, in cooperation with:**

    - **the National Irrigation Board**
    - **the Keryo Valley Development Authority**

SUDAN (in collaboration with the Food Research Center in Khartoum)

1. **Solar drying pilot plant for hibiscus flowers, vegetables and tobacco leaves in "Djebel Mahra" zone (West Sudan).**
2. **Solar drying pilot plant for green limes in South Sudan.**

UPPER VOLTA

1. **Solar drying pilot plant for fruits (mango, tomato ...) and vegetables in order to save and utilize the seasonal overproduction, in collaboration with the Ministry of Rural Development (O.R.D.) at Bobo Dioulasso.**
2. **If feasible, solar drying pilot plant for onions and other vegetables as a substitute**

for importations during the dry season, in collaboration with the same Ministry at Boguende or Garango (east).

3. **Possibly a solar drying pilot plant for mangoes and green beans in the Export Cooperative Center at Ouagadougou to save nonexportable products in collaboration with I.R.F.A.**

ZAIRE

1. **Project for five (5) solar drying pilot plants to save the seasonal overproduction and to teach and train:**

- **women shopkeepers in Kinshasa (one center)**
- **market gardeners in the "green belt" of the Kinshasa area (one center)**
- **cooperative of vegetable producers in the Mbansa N'Gungu zone (3 centers)**

in collaboration with the "General Secretariat for Women in Development".

2. **Drying pilot plant (combining solar heat and pinewood) to be set up in Kiwu province in order to utilize fruits and vegetables which cannot be marketed due to the remoteness of this rich area, in collaboration with the Ministry of Agriculture (CECOPANE).**

Contents - <Previous - Next>

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.3. Socio-economic dimension of sun-drying technology applied to food

Contents - <Previous - Next>

- Nena R. Bustrillos

SUMMARY

This paper discusses consideration for socio-economic variables in the introduction of improvement in sundrying technology especially associated with foods in the context of a production-consumption system. The author calls for the close study of process and tools of the traditional method, the nutritional contribution of dried foods to the diet and

the social process at work, keeping track of who are particularly involved.

Data on women's labour in food production and processing place them at a vantage point in assessing the suitability of technology to local needs, resources, and human demands, and justifies their participation in both the research and development phase as well as in technology transfer phase. Use of local labour and materials, simplicity of operation, ease in maintenance, and low cost as well as multiple uses make improved drying techniques -solar drier in particular- more readily acceptable.

Adoption of new drying technology by villagers depends not only on suitability of technology, but on promoters for technology. Essential are the knowledge and skills of promotors to guide villagers and their sensitivity to poor and illiterate needs as well as their ability to work with existing groups. Whether this organization would provide the future structure of the project depends on the ability to manage inputs towards objectives, to expand and to reach poor women. While technical skills have been developed through learning by doing management skills it remains a continuing gap of such groups.

Training depends on needs of various groups involved in the adoption process. Hence, training of artisans, food processors, promotors, managers, etc. will require different emphasis. Schemes of training have been mentioned combining problem solving and

learning by doing what is correct. Constraints to poor women's access to training are recognized as revolving around length of training, timing, financial support for the family, care of children, place and unsuitable methods for the non-literate.

For improved drying to be elevated from household use to rural industry status for the poor, institutional measures that provide equity of access to land, credit, subsidy, price support would be essential. It is only through such measures that some guarantee of the active participation of the poor and disadvantaged women in running their own enterprise and benefitting from it is assured while food is conserved. This is the developmental goal that has to be achieved in a project of this kind.

SOCIO-ECONOMIC DIMENSION OF SUN-DRYING TECHNOLOGY

The elegance of any technology is in its application - its wider use to benefit those who are involved, especially the poor. Such application depends on the sensitivity of those in charge to the social, economic and institutional processes from the onset of a programme, both in the design and introduction of technologies. Such recognition shortens the period of research and development. This paper will deal with these processes with emphasis on small scale use of sun-drying.

There are hardly documented examples detailing socio-economic processes in sun-drying as a direct' indirect process or in combination with other methods. Such an analysis would require the items shown in Appendix I and is best done together with technological evaluation.

DRAING AS PART OF A PRODUCTION/CONSUMPTION SYSTEM

It is simpler to deal with sun-drying as a technical separate process but in reality it cannot be divorced from production as conditions of the raw material, location, storage and other variables are related. Moreover in the Africa setting' the production system of food crops is generally women's responsibility after planting which includes weeding' harvesting, transporting, storing, processing and marketing as shown in table 1 (1). Therefore, improvement/or revival of drying for increasing income might require increase in production and more work for rural households perhaps including men and women. In this case safeguards must be adopted so that time use is not increased and control over the production/processing system does not transfer to hands of men nor benefits be concentrated on men, as has occurred with cash crops. The reverse is the omission to consider it at all.

To illustrate it is worthwhile to consider the earlier attempts to introduce the newest short non-lodging variety of rice to small farmers in Laguna, Philippines. Farmers were jubilant as they watched the promise of healthy growth and the heading of rice plants Harvest came earlier and this doubled and tripled the usual harvest from the previous taller varieties. But the jubilation of farmers, however, was short-lived. The plentiful rice harvest could not be contained in the streets or on the few cemented pavements, in the plaza and the dry ground to dry Nor were there enough mats or the scarce plastic to use; not enough rice straw bags/sacks to contain the plentiful harvest; there was not even adequate labour to cope with the windfall: the stirring, the watching, sheltering, etc., even with the assistance of children who miss school and the men who traditionally leave the process to the women. And some living space had to be given up.

TABLE 1 - DIVISION OF LABOUR BETWEEN MEN AND WOMEN IN RURAL AREAS OF AFRICA (% OF TOTAL LABOUR)

Task	Men*	Women*
Land clearing	95	5
Turning the soil	70	30
Planting	50	50
Hoeing and weeding	30	70

Harvesting	40	60
Transporting crops from farm to home	20	80
Storing crops	20	80
Processing food crops	10	90
Marketing excess crops	40	60
Trimming tree crops	90	10
Carrying water and fuel	10	90
Caring for domestic animals	50	50
Hunting	90	10
Feeding and caring for children, men and the aged	5	95

*** With or without some help from children**
Source: United Nations Economic Commission for Africa, African Training and Research Centre for Women: Women of Africa: Today and tomorrow (Addis Ababa, 1975), p. 6

It is obvious that drying is a critical requirement of grain and other production systems

and varietal introduction need to go further beyond pest control and irrigation. Technologists realize that various products requiring drying present different types of technical problems, associated both with nature of product, location, supply, labour and other social, economic and institutional problems, distribution of benefits included.

FOOD PATTERN, A BASE

Dried product development has to consider the current meal pattern, nutritional problems and regional differentiation. What are the major foods in the localities affected or the alternative when so needed - during particularly scarce season? Regional differentation of such food patterns, even within a country, have been documented in nutritional literature, especially to guide relief operation for disaster and may well be of use to those planning food projects (2). What is the role of dried foods within this pattern? In general, with grain-based meals - dried food forms the bulk of the family food; grains, lentils, fish and beans in many rural areas are prepared from dried products.

To some extent, in some countries, dried fruits and vegetables are used for soup and sauces although there is a preference for fresh fruits, vegetables, fish and meat. Ritual

foods, condiments, and herbs are likewise dried. Moreover, can dried foods contribute to better weaning food for drought-stricken areas especially, to meals of the elderly, to reducing cooking time and fuel required for preparing and cooking. What are these foods? Home economists in the country can help assess such food patterns, how to improve these with dried and other foods and develop new ways of using such foods.

TRADITIONAL METHODS. SOURCE OF GUIDE TO METHODS

Traditional methods of sun-drying products have been practiced for centuries and applied to different products from the most perishable food to less perishable food. It is the simplest, most natural and least expensive method of preserving vegetables and fruits and has hardly changed. Generally food is strung on sticks or placed in open baskets, on mats or on roofs and left to dry in direct sunlight (3). Dried vegetables vary. In some places pickling food like cucumber is popular for drying, Cassava leaves (Maniho esculentum), sweet potato (Ipomea batatas), okra (Hibiscus esculentum) and other green edible leaves women collect in surplus are dried. In Zambia families differ in their methods; some blanch and add some salt while others just blanch; still others do not blanch (3). Sundrying includes not only the process of dehydration itself but also the pre-processing techniques and storage.

Knowledge of details of this whole process, materials and tools used, who does it for how long, and how stored, would provide a base for improvement and comparative data later. Important considerations are the quality and quantity of raw material, storage and the effect on nutritive value and palatability. Traditional techniques of direct sun and shade drying of fruits and vegetables as practiced in Kenya, for example, result in excessive losses of micro-nutrients, especially Vitamin C and carotene. Pre-processing techniques of blanching before solar drying resulted in better nutrient retention, especially carotene, better palatability and appearance when done under laboratory conditions (4).

MARKETABILITY OF PRODUCTS

Dried pumpkin leaves, cowpea leaves and bean leaves, and okra were the main dried vegetables sold in a Zambian area (5). These were sold to neighbours who approached them for cash or barter and only about a quarter is taken to market. Money was used only for buying small items like oil, cigarettes and local beer. Transport was a main constraint in taking goods to the market. Since they think everyone dries their vegetables, the interviewees' market is limited. There is almost no taboo against dried food per se. Such taboo if any would be associated with the food and not the fact that it

was dried.

PARTICIPATION AND PERCEPTIONS OF WOMEN

Where drying is a tradition, introduction of improved techniques in drought-prone localities, where the problem is felt, may be most welcome. What are their problems in terms of techniques, tools, dryers location, storage, and who is responsible? In this case leadership of women in Africa who are much involved in cultivation, food processing and other activities, is called for. Of course large scale activities must not aggravate the work situation, as women also have domestic responsibilities. This point justifies inclusion in a baseline information of household activity and time use pattern depicting differences by gender and age. Additional observations can verify households work load situation in detail.

In a development strategy women's participation and men's support would be needed - not as a passive recipient of informationnot just as labourers but more actively in assessing the technology in relation to their problems and goads, discussing and weighing alternative solutions, and taking control of directions and resources.

- **Do they see the problem as scientists and technologists view it?**
- **If so, what priority do they give to this problem?**
- **What are the alternative solutions?**
- **What benefits can they derive from food drying?**
    - **for insuring supply throughout the year?**
    - **for improving family food?**
    - **for increased income?**
    - **for ritual foods?**
    - **for status, etc.?**

A case in Asia is cited to illustrate the point. Where rural food processing through drying was being introduced at the technical development phase it was found that solar drying technology would not spread automatically in the area (6). People living close to the drier testing site showed little interest in preserving foodstuffs for their own use. Instead they spoke most often of how to make money from the use of the driers. Thus the trading possibilities of solar dried foods was investigated. This illustrates that benefits must be perceived and articulated by those who are potential users and not by those who are testing or introducing it.

SUITABILITY OF TECHNOLOGY

Women can also participate in determining suitability of and improvement of new sun-drying technology to suit their needs - whether this be for family or commercial use. Some of the questions to ask are the following:

- **Would the pre-processing require more labour and more materials?**
- **What is the cost?**
- **Can they afford it (added time and money)?**
- **Are materials required easy to acquire?**
- **Is any change simple to follow, to operate?**
- **Has a new drier been designed with due consideration to their work posture and preference, their strength of grip?**
- **Can it be constructed in the village by the villagers using local materials?**
- **Are the products acceptable to them?**
- **Can this new drier be used for other products?**
- **Is there another simpler way or alternative?**

The involvement of people in the research and development phase shortens the period of testing and points out other factors missed previously. Tray driers with white polythene instead of black cover were well received in Zambia. In Thailand rice farmers

prefer rice driers to be on high land and near the threshing area and commented that the required type of plastic covering may not be available locally and its life span is not more than eight months; they also thought that the drier being used for only two months a year, or even less, may not appear to be a good investment especially since the difference in price between wet and dry paddy is not so much (7). Users can even come up -with multiple advantages of the gadget as shown in another test of solar drier floor. After one day of storage at drier temperature (52 C) he reported that the grain had to some extent parboiled (8). Although this has not yet been verified by experiments it just shows that users can contribute ideas.

Although local materials for improvements are used when possible' one must be aware of their construction defects to prevent undue discomfort of operation. For example, with a bamboo screen constructed for the floor of the drier, considerable grain was caught in the screen. To remove the grain, the operator had to enter the drying chamber and sweep the grain with a broom. At 130F inside the dryer, this was a most unpleasant task for him (8).

Use of fish net in fish drying racks proved better than wire mesh or perforated metal sheets previously used as it prevents sticking of the fish (9).

Introduction of even slight improvements such as wooden tools for raking or scooping

rice or nuts, especially cashew, spread on the drying round helps reduce stooping, and cause less damage to food material (10).

COST OF TECHNOLOGY

High cost and complexity can be a deterrent to acceptance even when farmers realise its importance in saving their harvest and are attracted by the novelty. So if farmers and women hesitate to adopt new drying technology the cost factor has to be investigated. It is known that sundrying is the most economical method of drying food including grain. In a test with sundrying of rice compared to flat bed drying the cost of the former was less than half of the latter but is reported to be as low as one fourth of mechanical drying (11). However, artificial drying comdements sundrying during the rainy season when harvesting is being done or when rice cultivation is continuous. Therefore, reduction of cost with simple modifications can increase its acceptance. A drier introduced in Bangladesh cost $ 90 (see table 2) but with modification this was reduced to $ 57 and it can dry at least 8 mounds (229.2 kg) a day of wet paddy under monsoon conditions. (12) This same drier with probably some modifications to increase the internal temperature could be used in drying other foods during the off-season.

TABLE 2 - SOLAR PADDY DRIER CONSTRUCTION COSTS

Material	Quantity	Cost (US$)
1) Bamboo	80 pcs "dooli"	11.25
	10 pcs "poro"	14.06
2) Polyethylene film (low density, 100 micron)	56 sq. meters (10.5 pounds)	10.69
3) Woven bamboo ("chatae")	4 pcs.	4.50
4) Wire, rope, cord		3.38
5) Charcoal	6 tins	1.41
Burnt rice husk	2 sacks	2.25
	Total Materials . US$ 47.54	
Labour	Time (man days)	Cost (US$)
1) Drier making	10	11.25
2) Bamboo screen making	21	23.63
3) Carrying costs		5.63
	Total Labour = US$ 40.51	

Note: Bangladesh currency has been calculated at the official mid-1981 rate of 1 US$. 17.77 take
Source: Clark, S. and Saha H., Solar Drying of Paddy in Renewable Energy Review Journal: 4(1) June 1982.

It is apparent that technological improvement continues as people use them and feed back their evaluation to researchers. It is also important to realize that for many rural people who cannot take any economic risk, the economic return is a factor to be reckoned with.

COMMITMENT AND SKILLS OF PROMOTORS AND FACILITATORS

No instant adoption of new drying technology by villagers is expected, even when technology or practice introduced is tailored to local needs and requirements. The promotor and/or technician who in traduces such technology is a key person in adoption. Her/his knowledge, attitudes and skills on the topic is essential. And so is her/ his rapport with groups and people, which makes introduction of an idea easier.

Since the project will deal with women, women promotors would more likely interact with women. Choice of such promotors from the village itself is usually bound by the

village hierarchy rather than the ability or commitment of a person. And although the individual of higher status could provide role models of change for poorer and lower status, the temptation of these women coopting the resources and the project for their own benefit must be minimized - or guarded against. To counter this village elitism' increase the number of promotors in a village, provide skills training for short-term tasks and a long-term credit system support. This has been tried in some schemes with some success (13).

It must be recognized that village women as promotors may be illiterate and therefore training will have to be adjusted - with more visuals, demonstrations, learning by doing' return demonstration and shorter intensive training as they cannot forego their other duties. And close technical supervision is needed even after careful intensive and intermittent training.

In addition to the villagers, technical staff must also be chosen although there might be difficulty in finding qualified women in the country willing to go to far-flung and poor villages.

MOBILIZE VILLAGE GROUPS/ORGANIZATIONS

Where women have already traditional organizations it is well to utilize these to initiate a project. Whether this organization would provide the future structure of the project depends on the ability to manage inputs towards objectives, to expand and to reach poor women. The role of societies, clubs, or established groups in information flow, legitimization of activities and group action is well known. The corn mill societies of Cameroon which operate grinding mills have evolved from a recognized need and has continued to do so (14).

It has repeatedly been mentioned that while technical skills have been developed through learning by doing, management skills remain a continuing gap of such groups. Lessons from other countries and other enterprises would be useful especially in the unsophisticated systems. There probably is no dearth of such skills, however rudimentary these are. The task is to identity who has organizational/management skills among the local people and endeavour to sharpen these.

TRAINING AND INFORMATION

The training programme will depend on needs of various groups involved in the adoption process. Hence, training of artisans, food processors, promotors, managers, etc. will

require different emphasis. Training village promotors has taken different paths. One is where village technicians are brought to a national training centre and then, upon return' they in turn train a number of persons who also then train another group in their village. This is exemplified in the Chinese system with learning by doing as the core of training' hence even non-literates are trained (15). Another scheme is to train extension technicians who directly train groups in villages, whereas another variant is where a demonstration centre is placed where the problem is felt and training is done in situ with scientists participating.

The effectiveness of various schemes has not been evaluated but it is axiomatic that the better the village people are trained even on technical matters the faster they can solve problems that arise. However, close linkage with technical supervisors would be needed. The whole process of problem identification, alternative seeking, technical knowledge and skills acquisition are part of the training process, of learning by doing what is correct. Moreover, visits to exhibits, demonstration villages' and attendance at forums for exchange of information can apply to village people as well. Constraints to access of women and the poor to such training must be recognized and measures adopted to correct this. Such constraints revolve around length of training, timing' financial support for the family, care of children, place and methods of training the poor and women. Otherwise, the danger of including only the elite is ever present.

LINKAGES ESTABLISHED

To mobilize a programme and for future expansion, linkages need to be established with various research, extension, information source, and marketing organizations. Conflicts of institutional interest do arise but under certain situations people's group welfare and interest supersede sectoral interests.

POLICY SUPPORT

It is not too early to consider policies and measures that facilitate the establishment of rural industries around sundrying. Their existence provides the incentive and potential support for planned enterprises. These are equity of access to land, credit' subsidy, price support and support to research and development. Denial of such access to or discrimination against women or the poor closes the door to initiatives of this group. If improved drying is to be elevated from household use to rural industry use, then institutional measures would be essential. It is only through such measures that some guarantee of the active participation of the poor and disadvantaged women in running their own enterprise and benefitting from it is assured while food is conserved. This is

the developmental goal that has to be achieved in a project of this kind.

CONCLUSION

Considering social, economic and institutional aspects' the introduction of new techniques and new equipment for drying has been discussed within the contest of the production consumption system. The relation to the acceptance of the product, its place in the food consumption pattern' the suitability of the technology to cultural needs, and its economics are considered. However, the establishment of rural industry on a small scale must be assessed and policy measures in terms of training' research, credit, marketing and subsidy need to be adopted if the rural poor families and women are to be encouraged. Such measures have to rectify any discrimination against or indifference to women's access to such institutional support. As we proceed to develop projects and pursue the implementation it may be worthwhile documenting the processes and factors as outlined in Appendix 2, which could contribute to the body of knowledge of technology transfer.

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Go To Next Page

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

APPENDIX 1: SOCIO-ECONOMIC DIMENSION OF SUN-DRYING TECHNOLOGY APPLIED TO FOOD OUTLINE

Contents - Previous - Next

1. CONDITIONS AND NEEDS

Ecological conditions

Crops, Food produced by subsistence household

Area planted per season

Culture type (Mono or diversified) annual or perennial groups

Who grows, harvests, processes, etc.

- time spent
- subsistence
- sale as fresh
- surplus, how disposed-as

- **animal feed**
- **preserved**
- **fuel**

Food consumption pattern by region

- **major - weaning food**
- **alternative - natural**

2. TRADITIONAL TECHNOLOGY

Products dried/Produced

Describe traditional processing of particular product

- **include treatment**
- **equipment**
- **labour**
- **materials**
- **product acceptance**

3. SUN DRYING

Any innovation/improvement local people introduced themselves or thought but cannot implement

Other products desired

- **weaning food**
- **condiments**
- **ritual food**
- **for sale**
- **for longer storage**

4. STABILITY OF NEW TECHNOLOGY

- **Consumer acceptance**
- **Consider working position, posture, physique of operator**
- **Labour cost in terms of time (by gender, age)**
- **Simple to operate, maintain**
- **Benefits perceived, such as**

meets multiple uses,
provides employment
improves

- **Low cost' possibly from local materials using local labour**
- **Size and manageability of operation**

5. INSTITUTION ASPECT

- **Commitment and technical know how of key persons**
- **Support/approval in adoption process of village local people through local participation/ organized action**
- **Training: choice of promotors**

  organization and
  technical training

- **Linkage to information/extension/research and market network**
- **Marketing channel**
- **Policies/measures**

Land access
subsidy
credit
pricing
support to research and development
information exchange/support

6. IMPACT (FIELD LEVEL)

- **Conservation**
  - **food**
  - **nutrient**
  - **energy**
- **Developmental**
  - **Benefit**
  - **Participation/in control of resources**
  - **Diet improvement - infant mortality reduced**
  - **Organizational skills/viability**

- **Time saved**

APPENDIX 2: CASE STUDY ON SUN DRYING (FOOD PRODUCT) PROJECT OUTLINE-METHODOLOGY

1. BACKGROUND AND JUSTIFICATION

- **Ecological condition**
- **population**
- **food pattern**
- **major and alternative**
- **any dried food**
- **cropping or food production**
- **the problem**

2. OBJECTIVES

Conservation or Developmental

- **nutritional**
- **participatory**

3. LOCATION AND PARTICIPANTS (WOMEN)

Characteristics of both described also time used by participants men and women - time dissegregated

4. TECHNOLOGY CHANGE - DESCRIBE METHOD, TOOLS, TIMING

- **Traditional**
- **Improvement**
- **New introduction**

5. RESOURCES USED

6. INSTITUTIONAL LINKAGE

Research and development, including policies, training/extension or promotion marketing (role of home economics)

7. PROCESS: describe step by step

8. CONSTRAINTS

9. EVALUATION

impact on

- **food conservation**
- **new/or other alternatives**
- **participation rates in decision making/ control of resources**
- **time saved**
- **employment**

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.4 Development a pilot project in Fiji

Contents - Previous - Next

- Riccardo Mattel

INTRODUCTION

Self sufficiency in food supplies is probably the most important goal of the development policy in many countries. Unfortunately, most of the developing nations are still heavily relying on imported foodstuff to counteract chronic deficits.

Fiji is not an exception: the nutritional habits of its population are rapidly changing, especially in the growing urban areas. Large quantities of meat and flour and' mainly western types of food, are imported and consumed. In order to limit its dependence on imports, Fiji is looking towards its local resources to improve food production.

Cassava is a staple food in Fiji, its production is increasing and it is slowly replacing other traditional food crops in the diet. The potential for this crop is enormous; a surplus could be easily produced and made into flour to replace part of the wheat four used for baking. This will considerably reduce the imports of this and other cereals from overseas.

The increase of livestock production in Fiji - particularly goats, poultry and pigs -

prompts a search for locally produced feed in order to replace the grain that is imported at high cost.

Again, cassava was considered to be the answer to this problem. In both cases, i.e. flour for bread or pellets for animals, cassava has to be processed as dried chips or slices. It was in this context that the Ministry of Agriculture in Fiji supported by the Root Crops Development Project - planned a pilot project to investigate the technical feasibility and the economic viability of cassava chipping and drying technologies

The Root Crops Development Project is an FAO Regional Project which deals with most Pacific countries and assists them in implementing their own research programmes.

We may have frequently made reference to cassava as animal feed, but this was necessary since the National Food and Nutrition Committee gave this aspect high priority in its policies and market requirements.

However, since the chips technology is the same for both human and animal products, we assume that this study will contribute to the development of both.

BACKGROUND

Cassava is certainly the most important subsistence crop in Fiji. There are only sweet varieties which are planted all year round, as a monoculture or mixed with other crops. In rural arose, almost every family grows cassava as a backyard or garden crop for its own consumption.

Fresh mark et e generally exist only in urban areas and prices are fairly high. Commercial farmers in flat areas are planting cassava on ridges which allows mechanization of some operations and reduce the cost of production.

Since cassava is not a seasonal crop, it does not require any form of preservation unless it is used as flour or animal feed.

OBJECTIVES OF THE PROJECT

The purpose of the study was to identify and disseminate a chipping and drying system for small or medium size processing which can be applied to a farm, a group of farms (or cooperative) or to a processing centre.

Areas, remote from fresh markets and lacking a consistent demand, but with a high agronomic potential, became the target for cassava cash cropping.

CHOICE OF TYPE OF TECHNOLOGY

The fixing of prices of cassava chips depends on the cereal market which cannot easily be controlled. Therefore' a low cost processing system of chips was an essential condition to get attractive returns, given the competition with fresh cassava for which prices and demand on the markets are generally consistent.

Factors to be taken into consideration were therefore:

1. **The necessity for a low capital outlay, minimum labour input, for equipment construction, use of cheap, locally available materials, easy to build but durable equipment;**
2. **The adoption of simple but economically viable methods with low labour input, fuel and water for processing and maintenance operations;**
3. **Flexibility of the system to changing supply; i.e. possibility to increase the throughput of the plant to absorb increasingly higher cassava production or to face**

a growing demand for chips with minimal additional expanses; possibility to lower the throughput to meet a decrease in root supply without excessive economic losses, i.e. low fixed costs and low depreciation.

In short: the development of an appropriate level of technology.

DEVELOPMENT AND TESTING OF TECHNOLOGY

Sundrying of cassava chips is a common practice in South East Asia: Malaysia' Thailand and Indonesia.

Chips of various shapes are generally spread on large concrete floors for sundrying. Turning over and removal are done manually or by tractors with high labour inputs, heavy losses and contamination.

Early studies conducted by CIAT (Centro Internacional de Agricultura Tropical) showed that cassava drying could be drastically improved by placing chips on inclined mesh trays raised above the ground.

Comparative trials between tray-drying and concrete floor drying systems showed that

tray-dring improved air circulation between the chips, took better advantage of the drying power of the wind and allowed an increase in the loading rate to 10 kg/m and more This shortened considerably the drying period and decreased the number of times the chips had to be turned-over or collected.

The result was a more convenient use of the drying surface, reduction of labour input needed and a very low level of contamination and losses. Furthermore, shortening the drying period reduced insect infestation.

DEVELOPMENT AND TESTING

Preliminary chipping and drying trials were conducted at the main Research Station of the Ministry of Agriculture. Tests were carried out on a new design of slicing machine and a prototype solar drier, both entirely developed in Fiji by the Central Workshop (UNIDO funded) of the Ministry of Economic Planning and Development.

Results led to the choice of the mesh tray system which was tossed under field conditions at a smaller research station in the project area. During this stage, officers and workers wore trained in equipment making and operation; the performance of the most cassava varieties was checked.

TRAINING OF TARGET CROUPS AND DEMONSTRATION OF THE NEW SYSTEM

The new technique was applied in the target area on a full scale. Under the supervision of the project staff' a small group of farmers carried out a complete harvest-processing-sale cycle using cassava grown on their own land but with government inputs. The ma, chinery wee provided by the project but the drying equipment was assembled and operated entirely by the people involved who received worker's wages at the local rate.

Farmers in the surrounding area showed interest in the technologies because:

a. **it was new;**
b. **it wee simple;**
c. **they could earn money with it;**
d. **they could use dried chips mixed with coconut meal and molasses to improve feeding of their goats.**

Cassava cuttings were distributed to these farmers so they could grow more cassava

and use the new harvest for the production of chips with the project equipment but at their own expense.

Cassava dried chips were given to poultry farmers and to feedmanufacturers for testing; the complete system wee shown to the public at the occasion of a Provincial Agricultural Fair.

ADVICE AND ASSISTANCE TO TARGET GROUPS AND EXTENSION SERVICE

This was planned to promote and coordinate the activities of the interested farmers: i.e. planning the production' building and managing the machinery and marketing the product.

The project staff wee expected to act as a link between the Research and Extension people for the transfer of the know-how and to collaborate closely with them during the subsequent phases of dissemination and assistance.

EQUIPMENT PLANT DESCRIPTION OF A PILOT UNIT

1. **Cassava Slicer - output 1 ton/hour of slices, adjustable thickness device, electric or gasoline operated. Four models already built in local workshop. One man operation.**
2. **Washing Drum - output 1 ton/hour. Manual. Made from a 44 gallon drum. One man operation.**
3. **Drying Platforms - 5 m (2 yd x 3 yd). Made of aluminium gauze, supported by chicken wire mesh fixed on a timber frame. The trays rest on simple bamboo rails, inclined 25 facing North; wind and sun drying system. Can be stacked on top of each other and sheltered from the rain while still allowing air circulation between chips. They can be used in forced ventilation drying systems.**
4. **Bagging Platform with hopper (copra grader type)**

PLANT LAY-OUT

The position of the different elements has to be chosen carefully in order to rationalize all the processing operations. The site should be on an elevated area and far from anything that may constitute a barrier against wind and sun.

If this is not already available, the "Truck access" area is divided in two parts: on the right the truck will unload cassava roots and drums of water and on the left the bags of

dried chips will be piled up for loading, once the truck is empty.

PROCESSING LINE

The sequence of the processing line is as follows:

Plant lay-out (continued)

ECONOMICS

CAPACITY OF THE PLANT

Considering the seasonal fluctuations which affect production and drying rates, the daily processed quantity varies from 0.5 to 2 tons of fresh tubers.

Assuming six working days per week' the average quantiy amounts to 24 tons per

month and 300 tone per year.

Obviously the figure of twenty-four working days is a theoretical one, especially for a tropical country like Fiji with a very broad range of climatic conditions determined by the seasons and by local geographical environment.

A centre of such capacity will serve an area of about 15 hectares, since the expected national yield is around 20 tons per hectare

COSTING

The following cost refers to a plant with 200 m of drying surface and a processing throughput of 2.5 tone of fresh tubers needed to produce 1 ton of dried chips.

- **Equipment cost, including slicing machine, washing drum, drying platforms and miscellaneous: US$ 3000**
- **Processing costs: labour (27.5 man-hours) and fuel (1 gallon): US$16.5**
- **Maintenance ad depreciation cost: US$ 34 per month**

RETURNS

The price of cassava pellets on the world market is generally 20% lower than that of maize' which in July 1983 was about US' 240. fixed price of about US' 180 for chips was therefore the minimum to guarantee attractive economic returns to all the parties involved.

TABLE 1 - COMPARATIVE RETURNS BUSED ON F$ 180/TON DRY CHIPS c5/KG FRESH ROOTS

	5 hectares Farmer-process	5 hectares Farmer	10/ton chips/month processor
dReturns/ton	107	68.75	38.5
" /ha	858	550	—
" /month	343	229	351
" /year	4,120	2,750	4,212

The most critical point is the price of the raw cassava which is set at 5c/kg. At 6c/kg the activity will be uneconomical for the industrial processor and at 4c/kg for the farmer.

An average of 5 ha will provide to the farmer-processor approximately the same monthly returns as the industrial processor, calculated on a yearly basis (350 F$), after deductions of depreciation, while 8 ha are needed for the industrial farmer.

CONCLUSION

The quantity of technical, economic, social and marketing information and data resulting from this study' enabled us to define the factors which will determine the viability of the technology.

a. **Location, geographic and socio-economic aspects;**
b. **Price paid to farmers for fresh cassava;**
c. **Price of dried chips.**

a. capacity throughout the . Sundrying depends on weather conditions, therefore, a processing plant will not run at full entire year in those areas with a marked rainy season.

Careful prior planning has to be done taking into account depreciation costs, reimbursement of initial investment and volume of fresh cassava Other important

conditions are the accessibility, remoteness and inadequate transport to the urban market and the lack of a local fresh market (limited demand of urban centres).

The farmers or the industrial processor involved have to bear in mind that sundrying is a processing method requiring attention and dedication. Carelessness in timing and lack of accuracy prolong drying time and result in a low level product of poor marketability' storability and nutritional value.

For this reason the employment of reliable and responsible workers is a prerequisite.

b. The price of chips has to be high enough to be competitive with the price paid to farmers for possible alternative crops and low enough to provide a reasonable return to the industrial processor in order to obtain a finished product which can compete with imported cereals.

c. Marketing policies must take into account that the replacement of some cereals with cassava is obviously possible only when the price of nutritionally equivalent mixtures of cassava and a protein complement is lower than that of the cereal to be substituted.

Contents - Previous - Next

4.5 Marketing considerations in the promotion and development of sundried products (methodological approach)

Contents - Previous - Next

- H. Creupelandt and E.S. Seidler

INTRODUCTION

The products: fruits, vegetables, spices, herbs, tubers.

Selection criteria:

a. **Those products already on the market in dried form and offering a real prospect in terms of expanding demand;**

b. **Those products intended for the fresh market, but for which a certain potential demand in dried form can be assumed;**
c. **Referring to (a) and (b) those products offering prospects for expanding the market by offering a better quality produce at rewarding prices;**
d. **Those products mainly and in certain caves, exclusively produced in dried form for the market which offer prospects for increasing main market share and return to producers through the use of more appropriate drying methods (spices, herbs).**

The following considerations on marketing implications refer essentially to products under (a) and (b) i.e. vegetables and certain common fruits.

THE RAW MATERIAL

At present. As a rule unsaleable produce for the fresh market which implies a certain degree of deterioration affects the final quality after drying.

Envisaged.

a. **Produce intended for fresh market to be diverted for drying, before deterioration**

sets in. This should be done on account of lower quality grade or of being in surplus;

b. **The retortion for drying purposes of good quality but low grade produce during the grading-sorting process immediately after harvest (fresh market rejects) should apply to situations where shipments to rather distant markets have to be faced;**
c. **The specific production of raw material for drying purposes which may go as far as selection of suitable varieties.**

The selection between (a) (b) and (c) will be determined by market and economic (profitability) criteria.

For a start, produce finding no ready outlet on the fresh market will have to be retained to avoid deception amongst producers (too low returns).

PROCESSING

Solar drying in a simple low cost form or raw material of acceptable quality.

BENEFITS

- **Preserves the product and thereby:**
    - **reduces losses by reducing inherent product perishability;**
    - **extends availability of product;**
    - **can reduce seasonal gluts of produce.**
- **Facilitates transport - produce is lighter, lose susceptible to damage on bad roads, etc.;**
- **Allows easier and cheaper handling of the produce;**
- **Increases the storage life of the product;**
- **Prepares the produce for consumption - spices and herbs mainly consumed dried.**

MARKETS

Efforts will concentrate on small-scale sundrying for local rural and urban populations - will not consider large-scale dehydration (industrial plant) or export marketing of produce.

Farmers prefer to soil on fresh markets where returns are higher. Prices for low quality dried produce, as presently offered, constitute moreover a disincentive to divert timely part of the crop for drying. As such farmers and market operators hold on to fresh produce sales attempts until a rather advanced stage of product deterioration.

It can be assumed that the rapidly expanding populations in urban areas in the Third-World provide' amongst the generally low income consumers, a growing market for sun (solar) dried produce However, beyond the quantitative aspects, this market will have to be tested in terms of quality acceptance and the corresponding price relationship. Producers and market operators are not interested in quality as such but in bettor return prospects.

MARKETING

Analysis of rather detailed market studies to be conducted during the solar drying projects; existing channels, operators, market practices, sources of supply, seasonality and price fluctuation, packaging, etc...

The market and consumers, acceptability tests will have to be organized by the project staff itself but in direct collaboration with selected market operators and, of course,

existing outlets and potential and users.

TECHNICAL AND ECONOMIC FEASIBILITY

On the basis of:

- **the market survey;**
- **the technical information acquired (drying);**
- **the results of the market acceptability tease and price prospects;**
- **the factual cost data elaborated on the production (raw me, serial), processing (drying) and marketing (distribution)**

a realistic cost-return assessment will have to be made by the projects taking into account also the size of the market.

PRODUCTION AND MARKET DEVELOPMENT

Hill depend entirely upon the projects findings and the conclusions reached under the cost-return assessment mention d above. at this point a decision will have to be made in terms of what products' location of areas offering the beat prospects, type and

organization of producers to be involved (individual, farmers, groups) marketing channels and market operators to be used, type of packaging to be used, etc.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.6 Marketing consideration in the promotion and development of sundried products

Contents - Previous - Next

- H.F. CREUPELANDT

BACKGROUND

The products with which this Paper will be dealing are fruits: vegetables, spices, herbs and tubers which' when listed, number well over seventy varieties in Africa. These

products, though being secondary foods, are nevertheless often considered essential foods and are a major source of vitamins as well as minerals. Spices and herbs are flavour enhancers consumed mainly with staple foods in order to make the bland food more tasty. In addition, spices and herbs are sometimes consumed for their medicinal properties.

The process of sundrying removes water from the product and this is one of the lowest-cost preservation methods. Preserving the product through sundrying reduces the inherent product perishability and thereby reduces produce losses. The availability of the product, which is normally seasonal in its fresh form, is also able to be extended. Processing of the product can also reduce seasonal gluts, thereby facilitating more stable prices when fresh produce is removed from the market for dehydration. Other benefits from dehydration are that it facilitates the transport of produce making the product lighter' and also less susceptible to damage when the products have to travel over long distances on bad roads. Sundrying often permits easier and cheaper handling of produce.

Sundrying is also required in certain cases to prepare produce for consumption, such as many spices and herbs which are often suitable for use only in their dried form.

Sundrying or dehydration of products in many developing countries _ is often

characterized by a low level of technology with techniques in common use generally producing a product of poor quality. Production expansion and the development of markets for sundried produce will depend on improving technology, allowing better quality and more hygienic products to be produced, the consumers' response in terms of willingness to pay better prices for higher quality produce and the overall profitability for shone involved in the production and drying process.

Another important point when considering products and their marketing is that the dried product will only be as good as the quality of the raw material used in the process. Poor quality raw materials will only produce poor quality dried produce; often, increased production of sundried produce to satisfy market requirements will need to be based on suitable raw material at least in terms of its relative freshness and absence of deterioration. Another factor which affects the quality of sundried produce is the packaging of the final product.

Inadequate packing, allowing the product to become adulterated or affected by dirt, water, etc., will render the product virtually unacceptable for sale. Furthermore, good packaging is required in order to safeguard the quality of the product, especially in the case of herbs and apices, where the flavour and aroma of the product needs to be protected' if it is to be sold.

MARKETING CONSIDERATIONS

This paper basically concerns itself with the small scale sundrying of produce, essentially vegetables, which will be developed to meet the needs of local, rural and urban populations. Large scale dehydration of produce or the export marketing of produce are not considered in any detail as they are beyond the scope of this Expert Consultation.

The market for sundried products which are already known and accepted is generally an increasing one. Urban populations in most Third World countries are rapidly increasing with many cities registering population increases of over 15% per annum. The largest part of the increasing population comprises low income consumers who will provide a growing market for sundried produce which they are acquainted with from their earlier homes in the rural areas. Furthermore, the diets of most low income families in the rapidly expanding cities generally comprise bland carbohydrates which need to be made more palatable and varied by the introductions of spices or herbs. However, it should be realized that the existing market mostly for low quality and low price products processed by rudimentary sundrying techniques from unsold fresh market left-overs. This consideration implies that the launching of a solar drying

undertaking using better but often also more costly raw material will have to be preceded for each product by market acceptability tests and a serious analysis of the related cost-return implications to producers and market operators.

In considering the organization and scope of production for potential solar drying enterprises and the main marketing considerations associated with the different levels' four levels of organization can be identified:

Firstly, very small-scale or household level production and processing where the need is to improve basic processing techniques and work needs to be done on improving the quality and packaging of surplus production together with investigating possibilities of expanding the range of products handled and to improve their access to markets of those producers.

Secondly, village level or small scale production whereby village associations or co-operatives act as processors of individual householders' production perhaps using larger scale improved technology or possibly acting as marketing centres providing the services of bulking' packing' transporting and marketing sun dried produce on behalf of individual farmers.

Thirdly, medium-scale enterprises adopting improved and perhaps larger equipment

which will receive their raw materials from a number of villages. These medium-scale industries might be able to produce better products through using better equipment or purely by organizing their plants more efficiently. Access to markets for these larger plants' dealing with larger volumes, is often easier than for the smaller processing units in that the larger units are able to undertake better product preparation' packaging and transport' and can assemble lots of suitable sizes required to enter the wholesale trade. Problems of adequate raw material supply are' however' often encountered.

Fourthly, there are the larger industrial units which generally do not utilize solar energy but generally rely on manufactured sources of energy. These plants are however not considered in this Paper, as mentioned earlier.

In discussing the scale of processing it should be noted that? as plants become larger, the need for production discipline and production planning to meet the requirements of these larger plants will become more apparent. Problems of available produce volumes, varieties, seasonality of production, etc., have to be tackled with due consideration being given to the overall level of produce supplies as farmers will always give first priority to supplying the higher price fresh market, rather than the less remunerative processing market. When produce is contracted for processing, it often finds its way onto the fresh market, when produce availability is inadequate to meet fresh market demand.

MARKET DEVELOPMENT AND EXPANSION

In planning the marketing of increased quantities of processed products it is convenient to divide the products into existing products are new products. In identifying or improving markets for existing products (i.e. products already handled) one has to undertake market research covering the following aspects:

- **existing product types and quality;**
- **existing sources of supply;**
- **existing market channels presently being utilized and relative importance of each;**
- **seasonality of supply;**
- **market price trends during the year as well as produce quality and price relationship;**
- **product packaging.**

Once this information has been gathered it will allow the planner to identify supply gaps, the planning of supplies to markets where or during periods when prices are highest and will provide the basis for improving product quality and packaging in order to meet existing and potential market demand.

Where enterprises are dealing or plan to deal with new products, i.e. products not previously handled, quite extensive research to obtain information on whether the products are currently available in the market at any time or in any form and from any sources, is required. However, even if the product that is planned to be handled is already known in the market, market acceptability tests are recommended, particularly if quality, presentation and price differences have to be sorted out.

Due attention must be given to consumer preference and to the fixing of prices at realistic levels. If sun-dried produce is priced too highly, the consumers have the option to switch to substitute products of fresh products.

Market research and consumer acceptance testing as suggested above should be undertaken at the initiation or expansion of processing for either existing or new products. A marketing plan for the products should then be drawn up indicating tines

- **flow of produce to the plant (volumes, prices, logistics);**
- **seasonality of operation (costs, overheads);**
- **packaging, storage and transport operations;**
- **marketing channels to be used;**
- **prices to be charged.**

In the main, the products that will be considered by farmers, cooperatives and private entrepreneurs for processing will already be known to the consumers but product quality and availability (supply) are often uncerain and market requirements are not being met. There is often a need to improve the availability of the products by better production planning which will necessitate provision of storage for the processed products where raw materials are only available seasonally. Where raw materials are available throughout the year, then the arrangement a of adequate and continuous supplies to meet market demand will not require storage but better production planning. In addition to improving the availability (supply) of processed products to the market as a means of satisfying market demand and providing producers with additional incomes there is often a need to improve product quality and packaging to gain greater consumer acceptability. This is especially the case where the aim is to expand market penetration by catering to the requirements of higherincome consumers.

Another area of market development that can be considered, is meeting the requirements of institutional consumers (schools, hotels, hospitals, etc.) for sun-dried products. Here one has to concentrate on providing a product of good quality in reasonable quantities, at a reasonable price (taking account of the prices for fresh products). Regularity of supply and consistency of quality are important factors in meeting the needs of this market.

GOVERNMENT FACILITATING SERVICES FOR MARKET DEVELOPMENT

In the main the operation of small and medium-scale solar drying plants will be undertaken by private entrepreneurs. The Government can assist private entrepreneurs in adopting better techniques and in securing the necessary equipment through implementing small enterprise development programmes. These programmes could inform private entrepreneurs or groups of the availability of suitable technology and perhaps could provide the necessary facilities to establish and to provide initial operating capital for the proposed processing unite.

The Home Economics Services of many countries could promote the increased consumption of sundrier produce and could introduce new products into peoples dicta by devising, publishing and distributing recipes which include the use of more and possibly new types of sundried produce. Nutrition education programmes might also encourage increased consumption of dried produce by emphasizing the vitamin and mineral composition of many sundried products.

In those countries that have Government marketing extension personnel these officers could advise farmers and co-operatives on the introduction of better handling, packing

and transport techniques and could advise on ways and means of increasing or diversifying the production and marketing of sundried products.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.7. Sundrying of fodder: application to other grass products

Contents - Previous - Next

- M.A. Salcedo

SUMMARY

Sundrying is still nowadays an important way of conserving agricultural produce. The increase in energy prices has an obvious impact on this technology.

Solar energy is a very suitable low-temperature drying technique for fodder (which is the main topic of this paper) or other products such as cereals, Boys, sunflower seeds, or plants for medical use.

In order to collect the solar energy' simple technologies can easily be applied such as the transformation of roofs of agricultural buildings or green houses used for cash cropping.

The choice of the type and size of solar collectors depends on the specific drying conditions of each product.

Nevertheless, one must keep in mind that this new technology has to be included in the production line as a whole. This document will discuss the drying of fodder in barns with solar energy' carried out by SOLAGRO and IDRR.

SOLAGRO is an association that deals with the study and disseminatation of the utilization of renewable energy in the field. of agriculture.

From time immemorial the technique of sundrying has been used for the conservation of agricultural food products. The artificial drying -in this case the drying of grass products in barns- stemmed from the desire of the farmers to obtain a better use of their crops.

Through sun-drying a better quality of fodder could be obtained and, when harvested at the right moment, it could conserve the best nutritive qualities and reduce the poet-harvest losses to a maximum (a 30% increase in comparison to grass dried in the fields), besides protecting the farmers against the consequences of adverse climatic conditions. This will constitute an element of security for the farmers, that cannot be overlooked.

LOW TEMPERATURE SUN-DRYING TECHNIQUES OF GRASS PRODUCTS

The traditional way of haymaking, by drying in the field, was most commonly used in of drying led to considerable loss of dried grass, the more the product was exposed to adverse climatic conditions.

This technique consists of harvesting the grass when it is still wet (50% loss in weight after 12-36 hours of being spread out in the fields) and then spreading it out on planks for ventilation in the storage rooms (see Figure 1. Drying of grass spread out on planks in storage rooms).

The air is heated by fossil energy (oil, fuel) but the increase of energy prices has induced the farmers to apply ventilation with cold air. The quality of the product has suffered from this and slowly this technique has been disregarded. It must be

remembered that for the drying of agricultural products, the flow of the ventilating air and its temperature have to be precisely regulated in order to obtain a product of good quality and free of moisture and other alterations. This technique could also be adapted to the drying of medicinal plants by using trays, stacked one above the other. The size of the installation and the electric power used, will be less the lower the water content is.

USE OF SOLAR ENERGY

The finding of alternative sources of energy became a crucial question. What kind of energy is requested in order to produce a small but noticeable increase (3 to 4 average in 24 hours in our climate) to create a considerable air flow (20 000 to 40 000 m /hour depending on the products and the quantities to be dried, from 25 to 50 T.D.M.). Therefore it would be a waste to use energy (fuel, gas, electricity) that can produce high levels of temperatures, if solar energy can be used.

Solar energy, received through a collector, is well adapted to these demands and can be used in very dispersed locations.

Various types of collectors can be used for drying.

1. **Greenhouses, of the classical type of marketgardening greenhouses (tunnel greenhouse), which can also be used outside the drying season and this enhances the investment (Figure 2. Drying in a greenhouse).**
2. **The roofs of agricultural buildings constitute important surfaces for sun exposure; the transformation of the roofs into sun collectors started 3-4 years ago. There are two types, depending on the temperature required:**

    a. **these roofs are mainly used for the drying of cereals under a transparent cover (Figures 3 and 4. Drying on roof with transparent coverings). They considerably increase the temperature (up to 20 during 12 hours of sunshine) and are less sensitive to windcooling;**
    b. **driers without a transparent cover (Figure 5. Drying on roof without transparent covering) and with a simpler and less costly construction; these sun roofs are used for the drying of grass products.**

These types of sun collectors have the advantage of being simple and can be manufactured by the farmer himself. To obtain the proper dimension, it is, however, necessary to calculate the ratio between the various elements: the air flow used (which depends on the volume of the product), the surface of the collector and the space in

which the air circulates (these calculations can be made on mini computers).

The collector can also be used for other products, as well as the heating or air-conditioning of livestock buildings. They could be used in a collective way, if production is spread over a period of time. However? the compatibility between the dried products, the airflow and the temperature must be checked, if one wants to keep the nutritive qualities for an ultimate storage.

Moreover, this type of procedure needs electric power (for instance 6 kw for an installation drying 25 TDM) and it will be possible to establish a ratio between the total energy that is recuperated and the electric power used. This ratio, that could be evaluated in the installations showed a variation of 3 to 24. This clearly indicates the importance of suitable measurements and size of the installations.

ECONOMIC ASPECTS

Two sun-drying installations are considered, one for grass, the other one for cereals, both located in the southern Pyrenees. It has not been possible to carry out a precise economic analysis of these units, because of their recent installation and therefore, the figures have only an indicative value for France.

TABLE 1 - INVESTMENT AND OPERATING COSTS OF GRAIN-DRYING INSTALLATION

Specific solar investment (sunroof 320 m, ventilator sheath' perforated floor)	94 000 (tax free)
Other investment	120 000 " "
Operating cost (1F/quintal of mais, dried to 23 - 15%)	2 400 " "
Cost in case maize had been dried in an agricultural cooperative	13 880 " "

The above mentioned operating cost are only valid for the 1983 campaign. That year was an exception because neither sunflower nor soya were dried (construction work not completed). On the other hand, maize could be entirely dried with the sundrying technique because its moisture was only 23% at harvest time.

In case of more humid years, a drier -operated with fuelis planned for drying maize; which was not calculated in the initial investment.

GRASS-DRYING INSTALLATION

Here again, we have only one year of experience. However, a prospective study has been carried out on the financial implications of this installation.

This study underlines the necessity for the farmer to adapt his entire production system to the new conditions created by the drier. In such circumstances, the investment (solar roof 11 500 FF, ventilator, planking 53 300 FF) could be returned in 7 years; it will take 13 years if the production system remains the same.

It is not feasible to try and make a comparison with a drying system run with fuel' which has almost entirely disappeared because of the excessively high cost.

In conclusion' this technique can also be used for the drying of medicinal herbs, as is done in the Alps, in thick layers' with 1.50 m of trays, one above another. This technique gives the best use of a dispersed and free solar energy.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.8. Proposal for an international network of research on

small scale sundriers

Contents - Previous - Next

- M.D. Griffon

INTRODUCTION

Sundrying techniques have to go beyond the experimental stage before they can effectively contribute to a reduction in post-harvest losses and before they can be disseminated on a large scale.

In fact, sundrying techniques are not sufficiently disseminated. Numerous projects, quite well dispersed, exist and there are many prototypes, but they remain on the experimental level.

These projects are certainly interesting, but they are mostly too meticulous and we would like to go beyond that stage.

If sundrying is to be taken seriously to improve the post-harvest system, the following would be indispensable:

i. **Setting up of interdisciplinary teams;**
ii. **Establishment of an international network of groups, either using sundrying techniques or experimenting with them;**
iii. **Co-ordination of experience gained by each group and adjustment of the sundrying techniques to this experience.**

MULTIDISCIPLINARY GROUP

In order to promote the use of solar energy in an effective way, we feel that specialists of various disciplines have to collaborate:

A multidisciplinary group

Research work is already based on a multidisciplinary collaboration in France:

Expert in thermo-dynamics	ESAM of Bordeaux	J. R. Puiggali

Expert in fluids	University of Perpignan	M. Fournier
Engineer in industrial food products	ENSIA (Ecole Nationale Suprieure des Industries Agricoles et Alimentaires	J.J. Bimbenet
	SIARC (Section Ingnieurs Industries Alimentaires Regions Chaudes)	J.P. Hebert
	CEEMAT (Centre d'Etudes et d'Exprimentation du Machinisme Agricole tropical)	M.D. Griffon, A. Themelin
Agro-biochemist **Ethnologist** **Socio-economist**	The Institutes of Gerdat, fruit, cocoa, cotton, rubber, wood, oil, food production	Fruit: P. Estanove and Y. Lozano Coffee, cocoa: J.C. Vincent Rubber: P. Leveque Cotton: J. Gutknecht Wood : C. Sales Oil: J. Graille Food production: J.C. Miche
Manufacturer	SERESOL (Socit Etudes et Ralisations solaires)	J. Proust and G. Moreau

Experimental work	University of Bordeaux	Estate of "La Bastide"
	University of Perpignan	Estate of the University
	CEEMAT/SIARC in Montpellier	Experimental fields of GIS (Groupement d'Intret Scientifique) "Energetic systems and utilization of space" on the Estate of "La Valette"

The French team has come up with two types of small capacity sundriers but with reliable and acceptable results:

i. **a SERESOL sundrier "family type" which is particularly suited for the mediterranean zones which are located above 30 degrees latitude. It is compact and combines a heat collector and drier;**
ii. **a SERESOL sundrier "tropical type" with a separate heat collector, heat storage element and dryer. It is suitable for all latitudes and particularly well suited for tropical areas.**

The two driers have the following characteristics in common:

a. **The drying takes place without the products being directly exposed to the sun. This avoids the photo-oxydation of photo-sensitive vitamins and of phenolic compounds;**
b. **a greenhouse effect resulting from a transparent plastic material and an absorber made of black porous material;**
c. **a total energy autonomy the natural ventilation is insured by a solar chimney;**
d. **the total volume of the moist products that can be dried amounts to 6-9 kg/m per 3 days and 10-15 kg/m in case of drying on trays.**

AN INTERNATIONAL NETWORK

The objective is to establish an informal network of teams that are engaged in solar energy for the drying of agricultural products.

However, if one wants to pass the stage of prototypes, it seems necessary to use a standard methodology and standardized material in order to enable collaborating teams to profit from the work of partners and to use the results obtained by others.

Only with the use of standardized material could the teams compare their results and enhance their knowledge.

This standardized material exist and has already been tested by our French multidisciplinary teams

It is proposed to use the "tropical" SERESOL drier as a common tool to the various teams in the network. Ten collaborating stations among 20 laboratories (foreign institutions) have already been selected which were interested in this approach and had met with criteria of selection:

- **scientific and technical knowledge;**
- **adequate testing equipment;**
- **financial contribution to the shipment of the drier.**

Three distinct regions have been identified:

AFRICA	Burundi
	Cameroon
	Central Africa
	Mali
	Morocco
INDIAN OCEAN	Seychelles

	Comoros
CARIBBEAN and SOUTH AMERICA	Brasil
	French Guyana
	Martinique

Six stations have already received the SERESOL "Tropical" sundrier and the other four will receive the sundrier before the end of 1983. The experiments, based on a common procedure, could start in January 1984.

ADAPTATION OF THE TECHNOLOGY

After the first experimental phase has been completed - according to a common procedure - by the various teams in the networks during which data could be transferred and compared each team will improve their own material according to the local constraints encountered.

This adaptation will require thorough research of the locally available materials and a full mastery of the technology by the users.

There are already various ideas of adaptation:

i. **The partner in Mali (ISFRA) works currently on the production of a porous absorber with recyclable products (very small rubber particles from used tyres in water suspension);**
ii. **Our partner in the Cameroon (ENSP Yaound) studies the optimal slope of the collector and found a correlation between the functioning of the collector and the constraints imposed by the products to be dried;**
iii. **Our partner in Montpellier is undertaking a comparative study of the functioning of sundriers by combining natural and forced air circulation.**

The collection of the improvements suggested by each team will be handled by the organized and disseminated to all teams, who, will catalyze action undertaken by local development organization or national officials in charge of these matters (planners, bankers, etc.) and {he rural users.

This development phase has to take into consideration the human potential and the local resources available in the relevant countries.

FURTHER DEVELOPMENT PROSPECTS

The results expected of the development of these efforts and their subsequent expansion are twofold:

i) On the technical level

On the basis of the results obtained under various climatic conditions, to bring to light the functioning, the advantages and inconveniences of different techniques - such as natural drying, sundrying in natural and in forced air circulation which are applied to small drying units meeting the needs of small village communities.

ii) ON THE SOCIO-ECONOMIC LEVEL

To make an economic estimate of the preceding technical criteria in relation to constraints of various production system, this will eventually lead to a combination of different techniques (predrying - final drying) and/or promote the utilization of various production units as a common tool, thereby taking into consideration the impact of the technical/economic constraints inherent to these techniques.

Contents - Previous - Next

4.9 Solar drying of agricultural produce in Israel present experience and future prospects

Contents - Previous - Next

- I.J. Kopelman

The purpose of the following document is to outline the major current activities in solar drying of fruits, vegetables, herbs etc. in Israel. The document is divided into two main parts; an overall view followed by a detailed description of the activities.

Israel has a large commercial vegetable and herbs solar drier plus a few similar semi-commercial installations. The units are operated by indirect air-heated flat surface solar roofs backed up by fossil-fuel heating. Substantial activities in the country are also related to the development of solar systems hardware (collectors' glazing components, storage of heat, etc.) that can support, among other things' a drying operation. Such

development involve: (a) simple and practical maintenance for small driers; (b) total systems for low temperature air heated flat surface solar roofs; (c) parabolic solar collector systems for steam generators. The Government encourages the utilization of solar energy in commercial plants by subsidizing (up to 50%) the capital cost of the solar installations. Experience indicates that the economic feasibility of solar drying is at present of a limited nature. It depends upon climate; type of product and length of season; cost of alternative sources of heat (coal' fuel oil, diesel oil? gas); cost of capital, etc. However, efforts are continuously being made to improve the durability of the solar drier components. A breakthrough in technology of storage of solar heat will also be required for economical large scale solar drying operations.

PRESENT SITUATION OF DRYING UNITS

- **Large Drying Units**
- **Commercial installation**
- **Maon region - Western Negev**
- **Afula region - (under construction)**
- **Pilot installation**
- **Eilat region - Southern tip**

SMALL DRYING UNITS

Description of the large drying unite is as follows:

MAON REGION

A solar roof with an area of 1 100 sq.m has been operating for the past few years in the "Maon Spices" plant, at the Western Negev. The solar roof is being used as a substantial energy source for the dehydration process of the agricultural products: parsley, paprika and wild marjoram. The herbs and plants being used as raw material for the production of spices are harvested from the fields of the Maon region settlements. They arrive at the plant with a water content of 80%-85% and after being dehydrated down to a water content of 6%-10%, in a drying chamber on a total area of 300 sq.m of perforated moving belt.

Rock wool insulation sheets 25 mm thick, were installed on the roof support beams' on top of which black painted corrugated steel plates were incorporated. At a few centimeters from the steel plates wee put a transparent rigid plastic layer UV resistant (Qualex) which is used for glazing.

Fresh air enters through adjustable openings at the upper end of the roof. The air flows between the glazing layer and the steel plates and is heated as it proceeds through 30 cm wide ducts.

ELIAT REGION

Solar energy is used for preheating of air used in a spray-drying operation in the Hills-Koors Algae Production Ltd. The solar roof is of approximately 150 sq.m. It consists of prefabricated panels composed of 4050 mm cast-foam insulation' selective-surface coating and tough, nonreflective solar film glazing. The panels (marketed by Energy Systems and Engineering under the name SOLIRAC) are highly thermal efficient; however, the current price (approximately 90$ per sq.m of panel) make the unit somewhat expensive. Nevertheless, the system could be found to be costeffective in cases where the climate is particularly favourable for solar heating and particularly in new structures where the panels can be installed in place of regular roof components.

AFULA REGION

(Under construction - scheduled to go into operation - May 1984) It is a modern drying plant (approximately 1 ton per hour throughput) for herbs and spices (primarily oregano, basil and sage). Although the prime source of energy for drying could be from fossil fuels, a 15-20% saving of energy is expected by means of simple and inexpensive solar heating. The single storey plant is constructed from prefabricated metal sheets (Behlen structural systems) resulting in a structure having a 24 m span, 33 m long convex metal roof with an approximately 3 200 cubic meter of space. The roof will be painted with black lacquer. Insulation matresses will be placed upon the upper ceiling panels.

Such simple modifications will yield an approximately 950 sq.m maintenance free solar roof with practically no added costs to the structure and with an expected total energy saving of 15% to 20%.

Further possibilities for modifications of the solar roof will be studied during the full operation of the plant. These will include the feasibility of adding glazing material and selective painting of the roof resulting in further saving of energy.

SMALL DRYING UNITS

The Electra Company has been engaged in the last several years in a development program for solar air driers. The program has been concentrating on domestic size scale units with emphasis on simplicity and low cost per unit.

Other small scale units for solar drying have been evaluated in different research institutes primarily by the Agricultural Research Organization at the Volcani Center.

SCHEMATIC DIAGRAM OF THE AFULA DRYING - BEHLEN TYPE CONVEX ROOF (by INTRADCO LTD.)

SCHEMATIC DIAGRAM OF THE MAON SOLAR ROOF DRYING INSTALLATION

SCHEMATIC DIAGRAM OF THE SOLIRAC INSTALLATION (by ENERGY - SYSTEMS AND ENGINEERING LTD.)

ELECTRA (ISRAEL) LTD.. FOOD DRYING BY SOLAR ENERGY DOMESTIC DRYING UNIT

Contents - Previous - Next

4.10. Improved sun-drying and solar drying: basic considerations and selected applications

Contents - Previous - Next

- D. Adair

INTRODUCTION

The principles underlying improved sun-drying and solar drying are explained in simple terms and attention drawn to the basic questions which the decision-maker must ask when the introduction of these technologies is under considerations. Examples of methods of improving sundrying are described and several types of solar driers illustrated. It is suggested that carefully monitored demonstration projects be established as the first step to introduction of this technology into new areas.

Sun-drying has been used universally as a method of preserving agricultural produce, but it is not universally applicable to a common standard of efficiency and reliability. In many countries, therefore, it has been largely superseded by drying processes in which biomass or fossil fuels are used as sources of energy. The biomass fuel option may be regarded as an indirect method of solar drying - biomass concentrates the sun's energy and stores if for use at the processor's convenience, day or night.

In countries where there are serious constraints on fuel supplies, and where climatic conditions are not inherently favourable for sun-drying, developments in food preservation may depend on the introduction or improvements of the traditional sun drying process. The decision-maker must ask three important questions when considering specific proposals in this connection:

1. **Has the proposed technology proved efficient and reliable?**
2. **Is it suitable for the intended users and for the produce available at the places in question?**
3. **Are its benefits proportionate to its costs?**

The first of these questions concerns purely technological matters, and accordingly the decision-maker must be guided by appropriate specialist advice. Caution is necessary in this connection, however, as such advice generally derives from the findings of drying

studies, or from established empirical practice elsewhere. These findings are always to some extent -and perhaps to a large extent- site-specific. There must be assurance that the findings have been related correctly to conditions at the proposed new sites of application - particularly to the solar irradiation levels and distribution patterns' and to the prevailing ambient temperatures and relative humidities. The state of the art is such at the present time that assurance of this kind will generally be obtained only by carrying out carefully monitored performance trials at the new site, with provision for adaptive changes of the technology.

THE DRYING PROCESS

The decision-maker will be better able to use specialist advice effectively if he possesses at roast a rudimentary understanding of the principles underlying the technology on offer, and these principles are not difficult to comprehend. They may be summarized as follows:

1. **Sun-drying and solar drying would more correctly be called sun/air drying and solar/air drying, Their efficiency is largely determined by their provisions for moving air across the surfaces of the produce and for heating the air.**

2. **The produce being dried may receive energy by direct absorption of solar radiation, by transfer from the air surrounding it, and by transfer from the surface e on which it lies.**
3. **The energy received may raise the temperature of the produce as well as causing the evaporation of moisture from its surfaces.**
4. **For most produce the drying rate in the early stage of drying is determined by the rate of evaporation of moisture from its surfaces; this depends largely on the temperature and humidity of the surrounding air -which are interrelated- and on the speed of air movement. Raising the bulk temperature of the produce may be counter-productive at this stage.**
5. **In the later stage of drying, the drying rate is generally determined by the rate of movement of moisture from the interior of the produce to its surfaces; this depends largely on the temperature of the produce. Raising the bulk temperature of the produce is helpful at this stage, provided levels harmful to product quality are not attained.**
6. **Drying rate depends also on the shape and size of the produce's constituent unite and on the depth to which they are packed for example thin slices dry more quickly than thick slices' but for cassava optimum drying rates are attained by chipping rather than by slicing.**

It is important to boar in mind that most communities are highly conservative with regard to their foods. A new drying technique, however efficient it may be, will not be accepted if it results in a product significantly different in character to that with which the consumer is familar.

THE STARTING POINT

In the simplest traditional sun-drying process, produce is spread in thin layers on the ground, turned occasionally and covered or moved to a shelter when rain falls. It exposes the produce for extended periods to risks of deterioration caused by dust and dust-borne organisms, and to the depredations of insects, rodents, birds and other animals. For fruit and vegetable produce the simple process may entail a loss of nutritive value e.g. through destruction of vitamin C or provitamin A and may lead to discolouration and the development of off-flavours. Where ambient humidity is high the process may be unreliable, even where solar irradiation levels are high, and extensive mould growth may take place in the produce under these conditions.

IMPROVED SUN-DRYING

Over the centuries, farming communities have recognised the limitations of the simple process and have improved upon it, using me, serial readily available to them. More recently, such improvements have been made the subject of systematic scientific research.

USE OF DRYING FLOORS AND PLATFORMS

Process hygiene is greatly improved if, instead of spreading produce on open ground, a clean firm, smooth surface is employed - such as plastic sheets, cement, concrete, wood or metal. Where land is available for the purpose, specially constructed drying floors are used, or platforms raised above ground level.

The improvement in hygiene may be accompanied by a minor improvement in drying efficiency arising from the fact that the materials used to make the floor or platform absorb solar radiation more efficiently than coos soil, and thus becomes hotter and transfer more energy to the produce. This effect is most evident when metal sheeting - such as the flat roof of a building is used. It partly explains also why many farmers use the surfaces of adjacent roadways as drying floors, despite the obvious disadvantages of

this practice.

USE OF BLACKENED SURFACES

Matt black surfaces absorb solar radiation more efficiently than others, and so the improvements not d above can be enhanced by use of such surfaces. It has been demonstrated for example (Thanh 1978) that the time required to dry cassava chips on a concrete floor is reduced by about 15% if the floor is painted black. Where plastic sheeting is used as the surface supporting the bed of produce' black is preferred to transparent for this reason.

USE OF WOVEN MATTING

In many countries, produce is spread on woven matting for sundrying purposes. This practice probably evolved as a protection against contamination and for convenience of handling but it has been shown (Duff 1974) to speed up drying to a small extent by facilitating air movement around the produce.

USE OF MESH TRAYS

Movement of air around produce is further facilitated by drying on mesh trays rather than on solid platforms. This practice is adopted in Australia, where some 100.000 tonnes/annum of dried fruit -mainly grapes- are produced by sun-air drying. It is also used widely in Colombia both for coffee drying and for cassava drying. Work carried out in Colombia under a joint TDRI/CIAT project has led to an improvement in the eatablished tray drying process for cassava chips. The trays used in this are illustrated in Figure 1 (see Figure 1. Cassava Drying Trays (Colombia) - Sources Best (1979)). They are mde of plastic netting (35 holes/cm) stretched on wooden frames and supported by chicken wire. The trays are mounted on bamboo supports at an inclination clove to the angle of repose for the chips (28), facing the direction of the prevailing wind. In practice the actual angle of inclination depends to some extent on the wind speed, and this also determines the quantity of chips which can be placed on the tray for drying without intermittent turning. For light winds (up to 1 m/s) loadings of 10 kg/m are possible; for steady winds (over 2 m/s) this can be increased to 16 kg/m . The time used for drying by this method is approximately the same as that for drying of chips on a blackened concrete surface. For the latter, however, loadings cannot be increased above approximately 6 kg/m . When all costs are taken into account' the tray drying

method is found to be less expensive than drying on blackened concrete (Best 1979).

Drying on trays is essentially a wind assist d drying method. Where wind conditions are favourable, appreciable drying occurs overnight for cassava chipped and spread in the late afternoon. This effect does not occur to any significant extent for chips spread overnight on blackened concrete surfaces.

SOLAR DRYING

In sun drying, produce is exposed directly to solar radiation and -more or less effectively- to the wind. In solar drying, the produce is contained in an enclosed space, and the air in contact with it is heated by solar radiation. By heating the air' its humidity is reduced and thus its efficiency as a vehicle for removal of moisture is increased For this reason, solar drying affords a means of preservation particularly suitable for use in those places whore sundrying is unreliable because ambient humidities are too high.

In small driers, matched to the requirements of a single farmer' movement of air across the produce is generally induced by natural convection - the tendency of warm air to rise. In larger units -suitable for communal or co-operative use or for industrial use- air is moved by means of a fan; this is termed "forced convection". The latter units are

inherently more efficient, but they require a supplementary source of energy to drive the fan. (It may be mentioned, however that TDRI and the Kenya Industrial Research and Development Institute are currently planning a collaborative study of the performance of driers using fans powered by photovoltaic cells).

In some solar driers the covers, or part of them, are transparent to allow exposure of the produce to screened solar radiation. This is not essential' however' and it must be avoided for those kinds of produce which deteriorate in sustained exposure to sunlight.

SMALL DRIERS

Numerous small driers have been described; these fall into three broad categories:

- **Cabinet driers**
- **Tent driers**
- **Driers with pre-heating chambers**

The first of these is of sturdy construction - essentially a glass or plastic topped box with base and sides constructed from wood, plastered earth, brickwork, or other suitable material. The aides and base can be fabricated to give high insulation, and thus

the cabinet dryer is particularly suitable for use whore high temperatures are required in the drying process. By restricting the ventilation of the cabinet, temperatures as high as 80 C have been obtained in work carried out in Barbados by the Brace Institute (Lawand 1966).

The second and third types of drier are generally constructed from plastic sheeting or film -black or transparent- held on a structure comprised of a suitable locally available material e.g. bamboo.

TDRI is not aware of any country in which driers of these three types are in routine use by the farming community. There is a considerable fund of knowledge of their performance, however, gained on a trial basis or through the efforts of enterprising farmers in many countries. Frequently' also, the ideas incorporated in their design have been discovered or adopted by farmers; for example many coffee producers in Colombia use plastic sheeting to protect sun-drying trays from rain in a manner which effectively converts the trays into a solar drier.

Figures 2-4 illustrate designs of drier which have bean used in TDRI work overseas.

Figure 2. Solar Cabinet Drier - Sources Curran and Trim (1982)

Figure 3. Solar Tent - Source: Curran and Trim (1982)

Figure 4. Solar Chimney Drier- Source: Curran and Trim (1982)

SOLAR DRIERS WITH FORCED CONVECTION

As noted above, these driers require motive power to drive a fan. They are suitable for use by groups of farmers under central management and in agro-industries. They offer considerable economies in their costs of construction. Two examples drawn from TDRI experience may be cited in this connection.

PEPPER DRYING IN THE REPUBLIC OF KOREA

Red peppers (Capsicum annuum L) are important in the dietaries of the Republic of Korea and? as the harvest extends only from August to October, the greater part of the crop is preserved by drying. Traditionally whole peppers are sun-dried, a process which can take up to three weeks when weather conditions are unfavourable. Substantial reductions in drying time can be effected by preslicing the peppers, but this leads to loss of pungency. In recent years medium and large scale producers have turned to artificial

drying of whole peppers using fossil fuels. The Food Research Institute, Suweon, -with TDRI collaboration funded by FAO- has developed the use of solar drying, with forced convection as an alternative process.

The drier employed has been described in detail by Trim and Ko (1982) and is illustrated in Figure 5 (see Figure 5. Forced Convection Solar Drier - Source: Trim and Ko (1982)). Essentially it consists of: a frame made of bamboo; an outer covering of clear plastic and an inner covering of clear plastic and an inner covering of black plastic, separated by a distance of approximately 10 cm; and a fan/ducting system to draw air from one side of the wall cavity which distributes it within the dryer, and expels it through the roof. Peppers are placed on drying racks constructed from plastic mesh stretched on bamboo frames. The total rack area is 22 m and a loading of approximately 14 kg/m of whole peppers is attained.

In operation, temperature variation within the drier is negligible with a maximum of 5C, when based on average daily temperatures at 6 selected widely-spaced points. Table 1 shows a typical set of figures for hourly variation of average drier temperature; in this instance a maximum rise of 33 C above ambient was attained.

Table 1 - Hourly variation in ambient and solar drier temperatures

Time	Temperature (C) Ambient	Solar
10.00	21	37
11.00	23	51
12.00	23	52
13.00	22	55
14.00	23	52
15.00	23	47
16.00	20	34
17.00	18	22

Sources: Trim and Ko (1982

Table 2- Average drier temperatures attained on 11 days of varying insolation

Irradiation (averaged over 24 hours)	Average Temperature (C)		Collector Efficiency* (%)
	Ambient	Drier	
176	26	52	31.8

120	22	33	31.7
204	25	45	33.6
200	27	48	35.5
194	24	46	38.4
174	22	41	35-9
174	20	44	45.2
177	21	41	36.7
81	1	32	52.2
148	22	44	46.9
178	17	43	46-5
Average: 166	22	43	39.5

*** Collector Efficiency = (Energy Collected x 100) / (Solar Energy Received)**
Source: Trim and Ko (1982)

Average drier temperatures attained on 11 days of widely varying insolation are shown in Table 2 alongside the corresponding average ambient temperatures.

Comparative trials have been made of solar drying and the traditional sun-drying process. The results of one of these are shown in Figure 6 (see Figure 6 - Comparison of efficiency of solar drying and traditional sun-drying of red pepper). These demonstrate that for whole peppers the solar drying process is more rapid' and capable of yielding a product of lower moisture content' than the sun-drying process. Organoleptic tests and laboratory assessments of colour and capsicin content (an index of pungency) have revealed no significant difference between the products.

This type of drier is widely adaptable for use with a variety of produce.

COFFEE DRYING IN KENYA

Action is currently being taken in Kenya to improve the drying techniques for parchment coffee in smallholder co-operative factories. TDRI is responsible for the design, installation and commissioning of three prototype drying installations based on a solar assisted drying process. The construction of the first of these was completed and commissioned at Rukera in November 1983.

The design of the drier is shown in Figure 7 (see Figure 7 - TDRI Parchment Coffee Drying System). The drying bins are contained in a building of which the roof forms a

simple "bare plate" solar collector black painted corrugated iron with a hardboard ceiling suspended 30 cm beneath it. Air is drawn through the cavity between the roof and ceiling by means of a diesel-powered fan' the air being drawn also around the diesel engine block before entering the fan and being propelled into the drying bins. Temperature increases of up to 15 C have been obtained by passage of air at 8.5 m/s across the roof cavity, with an additional 3-4C increase derived from the waste heat of the engine.

INTRODUCING THE TECHNOLOGY INTO NEW AREAS

Most farmers appreciate the importance of efficient produce drying, but where this is perceived as an operation involving no direct expenditure, there may be resistance to the idea of purchasing materials to construct improved sun-drying facilities or solar driers. Such resistance may best be overcome through the establishment of well managed demonstration projects in which selected technologies are employed on sites readily accessible to the neighbouring farmers. Farmers will recognise the following benefits:

1. **Increased output of dried products from a given area engaged in drying operations;**

this is important in areas, where there is a heavy constraint on land availability.

2. Substantial reduction in wastage where climatic conditions at harvest are unfavourable for simple sundrying.
3. Improved quality of a marketed product. This improvement is generally recognized on the market, where the product is valued accordingly.
4. Extension of the season in which drying can be undertaken with a resulting larger harvest, or additional crops to be grown and preserved.

In addition, there may be other advantages to the community which would be apparent in a full cost/benefit study, for example: improvement in public health resulting from increased retention of the vitamin content of produce' or simply from increase in the quantity of food available, reduction in cash out-flow resulting from decrease in the quantity of food purchased from outside the community; increased foreign exchange savings or earnings for the country.

The costs of purchase and maintenance of drying facilities have to be weighed against these benefits. Maintenance may be high in drying' unless farmers are careful in their handling of the relatively flimsy structures of solar driers and their relatively fragile plastic coverings. The driers are subject to damage in high winds and pouring rain' and their plastic covers are also to a certain degree subject to photodegradation. A realistic estimate of maintenance costs can be made only on the basis of on-site experience over

several seasons of drier operations. This will also provide information on additional costs involved in crop-drying, for example the costs of provision for packaging or storage.

Communal or co-operative processing facilities are generally of more sturdy construction, even when they are constructed largely from plastic sheeting, and they are generally under closer supervision when in use. These advantages may be decisive where the choice between on-farm and centrally managed drying has to be made, particularly if the question of extension of credit to cover drying costs arises.

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Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.11. Photodegradation of plastics

Contents - Previous - Next

- B. Brenndorfer

The most common use of plastics in solar collectors and dryers is as a transparent cover allowing incident radiation to pass through and impinge on an absorber surface - or on the commodity being dried. Used in this way' plastics must be able to withstand elevated temperatures, high levels of insolation' high humidities, wind loading and the effects of heavy rain over long periods of time. Low cost, low density, and good optical properties make some plastics very suitable for use in solar collectors and dryers. Stemming from its convenience as a building material, black polythene also finds use as an absorber material. However its shiny surface - a characteristic of the manufacturing process - is not conducive to high absorption efficiency.

Photo-degradation in plastics is caused by the ultra violet (UV) component of solar radiation, that is radiation of wavelength from 0.295 to 0.400 um. This is absorbed by some plastics' and causes the breakage of bonds in the polymers leading to photo-oxidation.

The physical effects of photo-degradation vary from loss of transmissivity and discolouration to crazing of the surface and embrittlement of the plastics. Loss of transmissivity will result in a lowering of the efficiency of a collector or drier and crazing or embrittlement will render the plastic more prone to damage by wind and rain. Degradation of plastics occurs more rapidly at higher temperatures and thus deterioration is often worst at hot-spots such as points where the plastic is supported or

attached to the framework.

Polymers vary greatly in their resistance to weathering, some such as polymethylathacrylate (PMMA) and polytetrafluosoethylene (PTFE) are transparent to UV radiation and hence not susceptible to photodegradation, others such as polyethylene deteriorate rapidly in UV radiation. The resistance of polymers such as polyethylene to UV degradation can be improved by the use of additives which absorb the UV radiation and remain stable, or by coating with another polymer which is opaque to UV radiation.

A wide range of clear plastic sheet and film with properties suitable for use in solar energy applications which also have good resistance to weathering is now avaiolable. Plastics commonly used for glazing in solar collectors include PMMA, polycarbonate (FC), glass-fibre reinforced polyester (GRP), polyvinylfluoride (PVF), fluorinated ethylene propylene copolymer and polyester film (FEP).

PMMA is used in the form of a rigid sheet which can be thermoformed to different shapes. ICI have subjected "Perspex" to outdoor exposure over a period of 10 years in the UK with only a 4% loss in transmissivity. A similar time under tropical conditions resulted in only slight discolouration. PC sheet is sesceptible to micro-cracking when exposed to outdoor weathering, even in the standard UV stabilised form and so existing

commercial polycarbonate glazing material is not adequately protected against UV radiation. GRP is light, has a high light transmissivity and good impact resistance. When protected either by stabilising to resist UV degradation or by coating with PVF film this material shows good resistance to weathering. In unprotected forms the surface of the sheet develops micro-cracks and develops fibre prominence' both of which decrease its light transmissivity.

PVF film is used both as a protective coating for other plastics to increase their resistance to UV and also on its own in solar collectors. Tedlar PVF is quoted by Du Pont as having excellent weatherability with no discolouration or significant loss of transmission after prolonged exposure. FEP exhibits good weathering characteristics' for their FEP film Du Pont claim that all its properties remained constant for 5 years during continuous exposure in Florida. Polyester films also possess good transmissivity and stability to UV radiation.

As the long term stability of polymers to UV radiation can vary greatly with additives used, great care should be taken when choosing a plastic for prolonged exposure under the conditions found in solar collectors. Specifying the polymer will not always be sufficient. In order to achieve the length of service of which UV resistant plastics are capable, methods of attaching the plastic to the framework, commonly used in simple agricultural systems, such as stapling or nailing' are unsatisfactory as they create point

of stress where the material is likely to fail.

When attaching plastic sheet to the framework a method should be chosen which will distribute any stresses on the sheet as evenly as possible over its whole length or width.

The most simple method of achieving this is to attach the sheet by means of battens running the length and width of the sheet. Sharp edges on the battens and framework should be avoided where possible. Use of a soft compressible material between the batten and the plastic will give a more weatherproof seal as well as giving a more even stress distribution, especially in cases where the framework has an uneven surface.

A groove and caulk strip with the caulk strip clamped to the framework along its length also ensures an even distribution of forces on the polymer sheet. This method however requires a higher level of skill than the previous method of attachment.

The properties of these polymers are summarised in the table below but in general, their availability in Third World countries will depend on the presence of a manufacturing agent or stockist within the country.

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Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.12. Schage solaire au Maroc

Contents - Previous - Next

- Abdel Kader El Mazhor

RESUME

Le schage "naturel" ou schage solaire traditionnel qui consiste utiliser l'action du rayonnement solaire et de l'air atmosphrique, est une pratique ancestrale qui est encore largement rpandue au Maroc.

Les conditions climatiques du Maroc s'apprtent trs bien une application de l'nergie solaire au schage des produits agricoles.

Toutefois, les techniques utilises restent rudimentaires, et aboutissent gnralement des productions de qualit mdiocre.

Dans le but d'obtenir des produits de meilleure qualit, et de tirer le maximum de profit de cette source d'nergie gratuite qu'est le "solaire", le Maroc mne actuellement diffrentes actions pour le dveloppement du schage solaire amlior.

INTRODUCTION

Au Maroc, les techniques artisanales de transformation et de conservation des denres alimentaires sont nombreuses et trs varies. Parmi ces techniques, le schage naturel qui consiste exposer le produit au rayonnement direct du soleil, occupe une place prpondrante particulirement dans le milieu rural.

C'est une technique de stabilisation, qui permet de prolonger la dure de conservation des excdents de production ne pouvant tre vendus ni consomms immdiatement. L'intrt de ce mode de conservation rside dans sa simplicit et son faible cot.

Parmi les produite schs traditionnellement, on cite essentiellement:

- **les fruits: figues, prunes, raisins**
- **les lgumes: piments, poivrons, carottes, navets ...**
- **les plantes aromatiques: menthe, verveine, menthe sauvage, persil, thym...**
- **les viandes et poissons.**

LE SECHAGE TRADITIONNEL AU MAROC

LES FRUITS SECHES

a) Les figues

Le schage traditionnel des figues est trs frquent dans les rgions o le figuier est rpandu.

Des figues ayant atteint un degr de maturit suffisant sont cueillies et transportes l'endroit du schages qui peut tes la terrasse d'une maison ou une parcelle de terrain entoure d'une clture pour empcher l'accs d'animaux.

Ces aires de schage sont en gnral exposes un ensoleillement maximum et sont tapisses d'herbes (Alfa, lentisque...) pour viter le contact avec le sol.

Les figues sont tales sur ces aires sans traitement pralable.

Aprs schage les figues sont ramasses et tries. Les plus grosses' a peaux blanches' sont aplaties et enfiles dans des fils d'alfa de manire former des chapelets; ceux-ci sont destins la commercialisation.

Quant aux autres figues non enfiles (mlange de plusieurs varits) elles sont entasses dans des sacs an plastique ou en tissu. Pour une meilleure conservation, certains mnage leur ajoutent un additif qui est le plus souvent un des mlanges suivants:

- **thym sch et broy**
- **thym sch et broy**
- **sel**
- **sel menthe sauvage sche et broye**

Malgr ces prcautions' on constate l'apparition de petits vers a l'intrieur des figues.

Les figues sches ne rentrent dans aucune prparation culinaire. Elles sont consommes telles quelles surtout au mois do "Ramadan".

La dure de conservation varie selon les conditions de schage et de stockage et peut aller jusqu' un an.

b) Les raisins

Le schage traditionnel des raisins a lieu en t' il permet de traiter le surplus des productions en vue de rpartir sa consommation dans le temps.

Les raisins cueillis suffisamment mrs, subissent un traitement qui d'aprs les agriculteurs (rgion de Fes Taounate) facilite le schage.

Ce prtraitement consiste tremper les grappes de raisins dans une solution (appele "liane") dont la composition varie selon les mnages.

Mthodes de prparation de cette solution:

- **Dans un panier (couscoussier) plac sur un sceau, on mlange les cendres des branches de lantisque au son d'orge. On verse de l'eau sur ce mlange et on rcupre le filtrat auquel on ajoute du sel et un peu d'huile d'olives.**
- **On mlange la paille de fves rduite en cendre avec de l'eau' du sel et de l'huile d'olives.**
- **On mlange la chaux avec des cendres de pailles de fves, de l'huile d'olives et de l'eau.**

Les grappes de raisins sont trempes pendant quelques minutes dans l'une de ces solutions, puis exposes au soleil.

Aprs schage, les raisins grapps sont parfois enduits avec de l'huile d'olives, et conservs dans des sacs en tissu ou dans des pts en terre cuite.

La dure de conservation peut aller jusqu' un an si les raisins ont t bien schs et conservs dans de bonnes conditions, dans le cas contraire, on constate diffrents types d'altration:

- **pourriture**
- **dveloppement de moisissures**
- **fermentation**

Les raisins secs ou "Zbib" sont utiliss comme garniture du couscous et peuvent entrer dans la prparation de tajines de viande ou de poulets (la place des lgumes). Ils sont galement consomms tels quels en mlange avec d'autres fruits secs (figues, amandes, noix, dattes...).

c) Cas de figues de barbarie

On ne pratique le schage que pour des fruits qui ont atteint un degr de maturit trs avance.

Il existe deus mthodes de prparation avant le schage' la premire consiste en l'enlvement de l'corce du fruit, la seconde consiste dcouper le fruit en quatre morceaux gaux.

Le produit ainsi prpar est tal sur la terrasse d'une maison ou bien sur le sol revtu on gnral de feuilles de caroubier. La dure de schage peut aller de 20 30 jours.

Le produit sch est conserv dans des sacs en jute ou en tissus pendant 4 6 mois au maximum.

Avant sa consommation (en hiver) il est imprgn d'huile d'argan ou d'olives.

Il est signaler que le schage des figues de barbarie n'tait pratiqu que dans certains villages de la rgion du Bouse o l'approvisionnement en denres tait difficile en hiver. Actuellement cette pratique ont en voie de disparition.

LES LEGUMES

Le schage des lgumes est moins pratiqu, mme dans le milieu rural, du fait de l'abondance de la production frache sur une grande priode de l'anne.

Cependant, le schage de centains lgumes demeure indispensable, c'est le cas des piments et poivrons rouges schs et rduits en poudre et qui sont utiliss presque quotidiennement dans les prparations culinaires, comme colorant alimentaire.

MODE DE PREPARATION

On hoisit des piments et poivrons bien mrs et rouges, on leur enlve les grains et on les tale sur le sol avec la face interne expose au soleil pendant quelques jours.

Ces piments et poivrons prschs sont introduits dans un four chaud pour avoir une dshydratation complte, aprs l'on procde leur broyage. Le surplus du piment broy est vendu au souk. La partie destine l'auto-consommation est imprgne dans de l'huile d'olives et du sel et conserve dans un bocal ferm hermtiquement.

LES ALTERATIONS

Les altrations ayant t observes dans les piments en poudre sont:

- **l'apparition de moisissures cause de l'humidit' la poudre prend un aspect filamenteux;**
- **le changement de couleur' si on ne met pas la poudre l'abri de l'air.**

CAS DES PLANTES AROMATIQUES (Menthe, menthe sauvage, thym' verveine ...)

Les plantes sont rcoltes au stade de la floraisons On forme des petits bouquets qu'on suspend le long d'un fil.

Le schage a lieu l'ombre et peut durer de 4 a 5 semaines jusqu' dshydratation complte.

Aprs schage, on applique un lger broyage la main pour sparer les feuilles des tiges. Ces dernires sont cartes et seules les feuilles sches sont conserves dans dos petite sacs en plastique. La dure de conservation peut aller jusqu' un an.

UTILISATION

- **menthe sche : prparation du th la menthe**

- **thym sch : usage thrapeutique (diarrhe' maladies digestives ...)**
- **menthe sauvage: aromatisant utilis:**
- **dans le caf**
- **lors du stockage des figues sches**

L'INTERET DE RELANCER ET D'AMELIORER LE SECHAŒ TRADITIONNEL

Autrefois, un grand nombre de produits agricoles ont t conservs par schage traditionnel. Actuellement ce schage n'est appliqu qu' de petites quantits au sein des mnages en vue de l'autoconsommation' et trs rares sont les produits traits par le schage et destins la commercialisation.

Le dclin de ce mode de conservation est essentiellement d aux altrations que subit le produit sch au cours du stockage (dveloppement des moisissures, infestation par insectes, etc ...) cause des mauvaises conditions de schage et de conservation.

On peut donc envisager d'amliorer cette technique de conservation par l'introduction de procds aussi simples (tel que le schage solaire amlior) mais plus srs que les mthodes artisanales et moins coteux que les procds utiliss dans l'industrie.

L'amlioration et l'extension du schage tout en contribuant la valorisation d'un certain nombre de produits agricoles mal utiliss ou peu employs permettront:

a. **Le maintien du niveau de production de certains produits' dont le Maroc tait grand producteur et dont il est devenu importateur' c'est le cas de certains fruits schs notamment les raisins et les pruneaux;**
b. **de procurer aux agriculteurs pratiquant le schage un revenu supplmentaire;**
c. **de mettre a la disposition des consommateurs les aliments connus comme traditionnels, qu'ils apprcient mais qu'ils ne peuvent laborer eus-mmes;**
d. **l'implantation dans le milieu rural d'units semiindustrielles de schage et de conditionnement permettra de crer des emplois nouveaux pour les gens sans qualification, ce qui rsoudra au moins en partie le problme du chomage et freinera l'exode rural vers les villes.**

ACTIONS ENTREPRISES POUR L'AMELIORATION DU SECHAGE TRADITIONNEL

Le schage traditionnel des fruits et lgumes (comme on vient de le voir a travers les exemples prcdents) est pratiqu de faon rudimentaire sans aucun traitement pralable ni protection du produit au coure du schage et du stockage, ce qui abouti a des produits

dont la conservation est difficile a maintenir.

Ces rsultats mdiocres obtenus par la plupart des agriculteurs proviennent essentiellement des causes suivantes:

- **la rcolte**
  - **mlange de varits diffrentes**
  - **mlange de produits des degrs de maturit diffrents**
- **le transport sur les lieux de schage se fait en vrac dans des sacs ou dos d'ne, o l'entassement se traduit par l'crasement des fruits les plus mrs**
- **le schage: les aires de schage sont le plus souvent en terre battue, revtue par des branchages ou du plastique.**

Le produit est tal sur ces aires sans triage ni traitement pralable.

Le schage qui dure plusieurs jours suivant la temprature ambiante est irrgulier et donne des rsultats non satisfaisants. En effet' la masse de produit scher est trs htrogne du fait des diffrences de varits, de maturit et de grosseur.

De plus, il n'y a aucune protection du produit contre les intempries, les poussires et les

insectes qui y trouvent un aliment de choix et y pondent leurs oeufs.

Ainsi si on dsire obtenir des produits schs de meilleure qualit, il est indispensable de respecter les conditions suivantes:

La rcolte

Les produits destins au schage doivent tre bien m^urs, intacts et non crass, leur livraison au chantier de schage doit tre immdiate pour viter le dbut d'ventuelles fermentations.

Le transport

Il doit tre effectu dans de bonnes conditions pour viter les crasements. Il serait mme prfrable d'oprer le schage sur les lieux de rcolte.

Le triage

Le triage aurait pour rle d'liminer les produits crass ou non mrs Les carts de triage peuvent tre schs sparment puisqu'ils donnent un produit de moindre qualit.

Le calibrage

La dure de schage est proportionnelle a la grosseur du fruit sans le calibrage, le schage serait irrgulier.

Lavage - traitement

Le produit tant poussireux, il faut procder a un lavage par trempage plusieurs reprises dans de l'eau.

Un traitement dans une solution adquate (cas des figues: solution bouillante de chlorure do sodium et de mtabisulfite de potassium) permet outre la destruction des parasites adhrents au produit, d'accrotre l'allure du schage.

Le schage

Pour viter les altrations du produit pendant le schage, il faut assurer sa protection contre:

- **les attaques d'insectes**
- **les poussires**
- **les condensations et roses nocturnes ou matinales, qui provoquent une rhumidification partielle du produit.**

Le respect de ces conditions nous amne concevoir des schoirs solaires pouvant viter les inconvnients lis au schage solaire traditionnel, et amliorer les conditions de schage. Les expriences qui ont t menes ont montr quo le schage solaire ralis dans les conditions adquates, aboutissait a une production d'une bonne valeur marchande pouvant amliorer le revenu des agriculteurs et la valeur nutritive des produite auto-consomms. Il apparat donc important d'encourager les agriculteurs l'utilisation de schoirs solaires. Toutefois' les schoirs a proposer doivent tre d'un cot rduit, facile a transporter et entretenir et d'une conduite trs simple.

C'est dans ce cadre gnral que s'inscrit l'action mene actuellement par les diffrents tablissements intresss par le schage solaire :

- **Le Centre de Dveloppement des Energies Renouvelables (CDER) en collaboration avec l' Ecole d'Agriculture de Temara exprimente un four solaire avec panneau rflchissant orientable et concentrateur parabolique fixe, pour le schage des produits exigeants des tempratures assez leves (suprieures a 60C).**
  Ce four pourra tre utilis en Agriculture pour le schage de produits tels que les pulpes de betteraves' les fourrage. (Luzerne . .) dont le cot actuel de schage est onreux.
- **Le Dpartement de Technologie Alimentaire de l'Institut Agronomique et Vtrinaire Hassan II mne en collaboration avec la Direction de la Production Vgtale (DPV) et**

la Socit de Dveloppement Agricole (SODEA) des expriences et recherches pour la mise au point :

- **d'un prototype de schoir solaire a claies, de conception et de fabrication simples et de conduite facile;**
- **des conditions optimales de prtraitement et de schage pour diffrentes catgories de fruits et lgumes' en particulier des abricots.**

- **Le Ministre de l'Agriculture et de la Rforme Agraire (M.A.R.A.) a lanc en 1981, dans le cadre du plan quinquennal 1981-1985, un programme de dveloppement du schage solaire amlior en milieu rural.**

Ce programme touche dans un premier temps deus rgions du Maroc, la rgion d'Al Hoceima et la rgion de Chefchaouen, compte tenu de l'importance de la production du figuier et du prunier dans ces rgions et de l'exprience acquise par les agriculteurs dans le domaine du schage solaire traditionnel.

Ce programme consiste en la ralisation d'une unit de traitement et de conditionnement de fruits schs' dans chacune des rgions.

Ces units se chargeront des oprations suivantes :

a. **la rception et le stockage de figues et/ou de prunes sches;**
b. **le triage : cette opration permet de classer les fruits en deus ou trois catgories (qualit extra, qualit standard et qualit infrieure);**
c. **la dsinsectisation : tous les fruits subiront avant leur emballage une dsinsectisation au bromure de methyle ou l'oxyde d'thylne;**
d. **conditionnement - emballage : les fruits seront emballs en conditionnement divers pour rpondre la demande de consommateurs individuels et de collectivits;**
e. **traitement de fruits de qualit infrieure : les figues de qualit dite infrieure seront transformes en pte puis dcoupes en baguettes. Ces dernires seront soit enrobes de chocolat soit enveloppes avec une feuille de pte de farine et cuites (biscuits fourrs).**

Chaque unit de traitement et de conditionnement de fruits schs sera approvisionne par l'intermdiaire de cinq autres centres de collecte de fruits rpartis a travers la rgion.

Ces centres de ramassage, conus pour tre des centres de mise en valeur agricole seront dots de moyens et d'quipements ncessaires leur bon fonctionnement : (chambre de fumigation, magasin, bureau, logement pour le chef du centre, quipements de prtraitement de fruits frais, schoirs solaires, etc...).

Autour de chaque centre, les agriculteurs seront groups en coopration et seront intresss la gestion du centre. Le centre de collecte mettra la disposition des agriculteurs adhrs la

cooprative les moyens adquats pour le schage des fruits' les caisses pour la livraison des fruits schs et prodiguera aux agriculteurs les conseils techniques quant au mode et la conduite du schage solaire. Il se chargera galement de rceptionner les quantits de fruits requises et d'assurer le stockage temporaire et la dsinsectisation des fruits schs.

Les agriculteurs devront a l'inverse raliser le schage des fruits suivant les indications du centre et confier la vente de la production au centre qui paiera cette production pour le compte de l'unit de conditionnement la livraison.

Le prix de vente sera fix la veille de chaque campagne en prsence des agriculteurs' des reprsentants du Ministre de l'Agriculture et de la Rforme Agraire, des autorits locales et des reprsentants de l'unit de conditionnement.

Au prix moyen sera appliqu une prime ou un prlvement pour tenir compte de la qualit des diffrents lots.

CONCLUSIONS

De part ses conditions climatiques (ensoleillement intense' longue dure d'ensoleillement pendant la priode de rcolte des principaux produits, faible hygromtrie de l'air, etc ...) et

la nature des produits susceptibles d'tre schs (la plupart des produits mrissent une priode o les conditions climatiques sont trs favorables' fort pourcentage de matire sche la maturit' etc...); Le Maroc prsente un potentiel considrable pour l'application de l'nergie solaire au schage des produits agricoles.

Les diffrents projets en cours de ralisation pour le schage solaire des produits agricoles montrent l'importance qu'accorde le Maroc au dveloppement de ce type de schage.

Ces projets ne constituent qu'une premire tape d'un programme qui vise gnraliser le schage solaire dans le milieu rural pour la plupart des produits agricoles susceptibles d'tre dshydrats.

Cependant, ce mode de schage ne peut connatre une large diffusion que si d'une part les technologies proposes s'adaptent bien aux besoins et aux possibilits des agriculteurs qui en sont les utilisateurs potentiels et si d'autre part, l'accroissement de la production gui en dcoule engendrera un surplus au niveau des agriculteurs.

OPERATIONS DE TRAITEMENT DES FRUITS AVANT LE SECHAGE

CAS DES FIGUES

a) Triage - calibrage - lavage

Un triage manuel devra supprimer tous les fruits non consomma, bles, de mauvaise prsentation, peu mrs ...

Le calibrage permettra la sparation des fruits en deus ou trois catgories selon la grosseur.

Les fruits tant poussireux, on procde leur lavage par trempage plusieurs reprises dans l'eau.

b) Traitement

Il consiste en un trempage dans une solution bouillante de chlorure de sodium (40 g de sel/litre) et de mtabisulfite de potasse (5 g/l) : 8 10 plonges successives (50 60 secondes).

Ce traitement permet d'obtenir les rsultats suivants :

- **Nettoyage des fruits encore sales**
- **Destruction de parasites externes**
- **Craquelure de l'piderme des figues, ce qui augmente l'allure du schage**

- **Coagulation des sucres des fruits; le sel ajout a l'eau empche la perte des sucres par osmose**
- **Destruction ou blocage des diasteass responsables de brunissement sous l'effet du SO2 libr par la mtalbisulfite.**

CAS DES PRUNES

Les diffrentes oprations sont assez semblables a colles ra, lises pour les figues.

Le traitement des prunes consiste en un trempage dans une solution de soude pendant 12 15 secondes dont le but est de fendiller la peau du fruit pour on faciliter le schage (2 ou 3 plonges dans une solution 40 grammes de soude on paillette par litre).

Un rinage de 10 15 secondes doit suivre l'bouillantage.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

4.13. Amlioration du schage solaire des lgumes

Contents - Previous - Next

- Ibrahima Lo

INTRODUCTION

Depuis trs longtemps la zone des Niayes situe sur le litoral allant de Dakar Saint-Louis est reste la principale rgion marachre du Sngal. Elle approvisionnait en lgumes tous les marchs de Dakar et mme ceux de certaines rgions. Mais avec les annes successives de scheresse qui se sont abattues sur les pays du Sahel, les agriculteurs n'arrivaient plus subvenir leurs besoins (matriel et alimentaire) avec les bnfices raliss durant la saison hivernale.

Des lors, il leur fallait dvelopper d'autres activits pondant la saison sche pour combler leurs dficits alimentaire et montaire. C'est ainsi qu'un peu partout dans les autres rgions du Sngal se sont dvelopps ct des villages de petits jardins o on cultive : choux, tomate, oignon, gombo, oseille, persil, etc... Le marachage est surtout men par les femmes. Il a

apport dos modifications alimentaires importantes et est devenu pour elles une activit conomique, rmunratrice dont bnficient galement le carr et le quartier.

Mais ce dveloppement trs rapide du marachage a entrain de grandes productions et a caus sur les marchs une offre beaucoup plus grande que la demande. Ce faisant, d'importantes quantits de lgumes (tomate et oignon surtout) ont t perdues faute d'avoir t vendues, consommes ou conserves.

Certes dans certains villages des mthodes traditionnelles de conservation par schage direct au soleil existent mais elles s'avrent trs limites et peu efficaces.

Pour rpondre ce besoin certains centres de recherches comme le C.E.R.E.R. ont tudi et mis au point divers schoirs solaires.

LE SECHAGE TRADITIONNEL

LES SECHOIRS

Le plus souvent il n'existe pas de schoirs proprement dits. Les produits scher sont tals dans un rcipient ou sur une natte et exposs directement au soleil sur le toit des cases

pour les mettre l'abri des enfants et des animaux. Dans le cas des oignons le schage peut se faire sur pied en terre. C'est--dire avant de les dterrer, on laisse les oignons en terre durant une semaine sans les arroser, ensuite on les expose au soleil.

LES PRODUITS SECHES ET LES METHODES DE PREPARATION

Les produits marachers qui sont gnralement schs sont : gombo, oignon, tomate, oseille (bissap), choux...

Les mthodes de prparation des produits avant schage dpendent de leur taille, leur texture et leur forme. Elles consistent briser l'enveloppe qui s'oppose la migration de l'eau contenue dans le produit.

Ces mthodes de prparation sont :

Produits :	Mthodes de prparation
Tomate	- Couper en tranche
	- Piler et mettre en boulettes ou galettes

Oignon	- Sur pied en terre
	- Couper en tranches
	- Piler avec du sel et mettre en boulettes ou galettes
Gombo	- Couper en rondelles
Chou	- Dtacher en feuilles
Bissap (oseille)	- Dtacher en feuilles

LE SECHAGE

Cette mthode de schage se caractrise par :

- **des dpts de poussire et dbris divers**
- **l'infection par les mouches et insectes**
- **les moisissures et autres contaminations**

Le temps de schage est variable, il dpend de l'ensoleillement et du type de produit. Il est gnralement de 3 4 jours. Les quantits transformes par-schage traditionnel sont trs faibles.

LE SECHAGE SOLAIRE

BUT DU SECHAGE SOLAIRE

Le but du schage solaire est d'accrotre les capacits et les performances du schage traditionnel :

- **en amliorant les conditions d'hygine**
- **en rduisant les tempe de schage**
- **en amliorant la qualit du produit fini**

PRINCIPE DESFONCTIONNEMENT

Cette mthode consiste agencer certains matriaux (corps transparent, corps noir et corps isolant) pour crer un effet de serre dans une enceinte. Cet effet de serre sera responsable de l'augmentation de la temprature de l'air dans l'enceinte et favorisera sa circulation naturelle. Les produits scher sont tals sur des claies amnages l'intrieur du schoir.

LES SECHOIRS

Les schoirs employs sont du type direct ou mixte.

Schoir tente

Ce schoir a la forme d'une tente canadienne compose :

- **d'une structure en bois**
- **une couverture transparente en polythylne clair**
- **un absorbeur en polythylne noir**
- **une claie de schage (filet de pche)**
    - **Surface d'exposition : 3,35 m**
    - **Cot total : 24.000 F.CFA**
    - **Capacit : Variable suivant la densit et la forme du produit**

Schoir "CASE"

Il a la forme d'une case d'o son nom. Il est constitu par :

- **un coffrage circulaire fait avec du contre-plaqu**
- **un isolant (coque d'arachide ou spath de mas)**
- **un absorbeur et une couverture transparente en polythylne**
- **une claie de schage**
- **un support en bois qui permet d'orienter le schoir**

    - **Surface d'exposition : 0,5 m**
    - **Cot total : 3.700 F.CFA**

Schoir "BAN AK SUUF" ou schoir "BAS"

Il est entirement construit avec de l'argile et du sable, Il comprend galement une couverture transparente, une claie de schage et un absorbeur (charbon de bois)

• Surface d'exposition : 0,5 m

• Cot total : 1.000 F.CFA

Schoir "MIXTE"

Il est constitu par les mmes matriaux utiliss dans le schoir tente mais diffre par sa forme

et sa partie prchauffage ou capteur.

• Surface d'exposition : 2,8 m

• Cot total : 26.000 F.CFA

LES RESULTATS OBTENUS

Les conditions optimales de schage solaire correspondent un maximum de temprature admissible et un minimum de taux d'hygromtrie de l'air.

Pour viter de cuire les produits ou de dtruire certaines vitamines, il est conseill de ne pas dpasser la temprature maximum de 55 C. Cette temprature intrieure peut tre rgule grce des couvertures amnages sur les schoirs.

LES SECHOIRS

Malgr leur diffrence de forme et de matriaux employs, donnent des tempratures assez

voisines et presque le mme temps de schage pour les diffrents produits marachers.

- **Gain en temprature environ : 20C**
- **Perte en poids des diffrents produits**

Produit	Perte de poids	Dure de schage
Oignon	88%	2 journes
Tomate	77%	2 journes
Gombo	81%	1 journe
Feuille de chou	82%	1/2 journe
Feuille de bissap	85%	1/2 journe

Tout ce qui est feuille (chou, oignon, bissap ...) peut scher en une journe. Tandis que les boulettes ou les galettes obtenues aprs avoir pil certains produits (tomate, oignon) ne schent qu' la priphrie la premire journe, le schage complet n'intervient qu' la deuxime journe.

Les produits schs gardent toujours leur couleur initiale. On peut rhydrater les feuilles sches en les plongeant dans de l'eau chaude. On obtient ainsi une nouvelle feuille souple qui peut entrer dans la prparation des sauces.

Les produits schs peuvent tre gards au moins trois mois dans des sacs en papier bien referms sans qu'ils se dgradent.

EXPERIENCE DU C.E.R.E.R. EN MILIEU RURAL

La dmarche du C.E.R.E.R. ne consiste surtout pas commercialiser les schoirs solaires mais favoriser leur promotion au niveau des populations directement intresses par le problme de la conservation des aliments. Ceci se fait en gnral en s'appuyant sur une structure locale (cooprative, groupement de jeunes' associations de femmes ...) et de la manire suivante :

Figure

KOUMBIDIA (Rgion de Sine Saloum 12 km de Koungheul)

Ce projet a eu pour point de dpart une enqute sur le marachage que le GRET (Groupe de Recherche et d' Echanges Technologiques) a men Koungheul. Cette enqute a dbouch sur les problmes d'exhaure, de transport et de conservation des lgumes.

Une premire mission en 1981 a permis d'introduire 3 tentes solaires rparties dans les diffrents quartiers de ce village Des premiers rsultats satisfaisants ont t obtenus. Les villageois ont pu construire eux mmes un schoir type "BRACE" usage individuel.

Une enqute mene sur l'utilisation des schoirs a permis de constater que les femmes souhaitaient avoir un schoir individuel plutt qu'une tente collective et qu'elles taient mme prtes a participer aux frais de construction.

C'est ainsi qu'en Mars 82 le CERER a ralis en collaboration avec les artisans du village 25 schoirs solaires de type "CASE".

L'ISBA (Institut Sngalais de Recherche Agronomique) intervient galement dans ce projet au niveau de l'encadrement des paysans, de la sensibilisation, du suivi des schoirs et des produits schs.

DJIRAGONE

Djiragone est un village de la Casamance, situ dans l'arrondissement de Bounkiline. Il se distingue par le dynamisme de son activit de marachage.

En 1982, suite de nombreuses pertes qu'ils avaient enregistres au niveau de la production de tomate et d'oignon' les responsables de l'AJAC (Association des Jeunes Agriculteurs de la Casamance) ont contact le C.E.R.E.R. pour qu'il les aide rsoudre le problme pineux de la conservation des lgumes.

C'est ainsi qu'en 83 le CERER et l'AJAC ont organis un sminaire de formation sur les techniques de construction des schoirs salaires. Sminaire qui regroupait 30 participants dont des femmes et des artisans locaux (menuisiers, maons, forgerons' vanniers). Pendant deux semaines' diffrents modles de schoirs ont t construits et tests :

- 8 schoirs mixtes, 3 schoirs "CASE" et 3 schoirs "BAS".

Des rsultats satisfaisants ont t obtenus. Les produits schs ont t conserves dans des sacs en papier ou en plastique et seront consomms bien aprs la saison marachre.

De l'avis des femmes, ces lgumes schs gardent un bon got (surtout les tomates qui donnent un concentr sec aprs schage).

Le suivi scientifique et technique permettra de dterminer lequel des schoirs convient le mieux aux populations de cette rgion. Ce projet se poursuivra dans d'autres villages de la Casamance.

CONCLUSION

Au Sngal le schage dos aliments n'est pas un fait nouveau. Il est frquent de voir les femmes scher du couscous, de l'arachide' du mas . . . Certes l'utilisation des schoirs solaires est toute rcente mais dans beaucoup de villages cette nouvelle technologie semble bien accepte.

La fabrication et l'utilisation des schoirs solaires en milieu rural ne posent aucun problme, la seule difficult rside dans l'approvisionnement en polythylne (souvent il faut venir jusqu' Dakar pour en trouver). Ces schoirs sont trs conomiques car on utilise que des matriaux locaux ou localement disponibles pour leur fabrication.

Sur le plan conomique, certains produits schs tels que tomates' feuilles de choux, oignons ... qui sont utiliss au niveau de certains villages dans la prparation des sauces, ne sont pas encore commercialiss dans les marchs o on ne trouve que le gombo et le "bissap" schs.

La prsence en toute saison de lgumes frais imports ne favorise pas la vente des produits schs. Toutefois' une meilleure sensibilisation des populations avec l'appui des mdias pourrait favoriser une plus grande diffusion des schoirs solaires au Sngal.

Schoir Mixte

Projet schoir B.A.S.

Schoir B.A.S.

Schoir TENTE

Schoir CASE

COUNTRY STATUS REPORTS

ALL COUNTRY STATUS REPORTS HAVE BEEN REPRODUCED AS PRESENTED BY THE AUTHORS. ONLY TYPOGRAPHICAL CHANGES HAVE BEEN MADE.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

5.1. Le sechage des fruits, tubercules legumes et epices au Cameroun

Contents - Previous - Next

- E. Tchienge

LA SITUATION DU CAMEROUN

Le Cameroun est situ en Afrique Centrale, limit l'Ouest par le Nigria, au Sud par la Guine Equatoriale, le Gabon et le Congo, l'Est par la R.C.A. et le Tchad et au Nord par le Lac Tchad.

Le Cameroun, considr gnralement comme une Afrique en miniature, se caractrise par sa grande diversit gographique et climatique. Ses ressources agricoles sont galement trs diversifies. Le Sud du pays se caractrise par un climat quatorial chaud et humide de zone forestire, et le Nord par un climat chaud et sec des savanes et des steppes sub-sahliennes.

Cette diversit cologique permet au Cameroun de produire une gamme tendue de produits agricoles qui assurent actuellement l'autosuffisance alimentaire pour ce qui est des produits vivriers, au moins sur le plan quantitatif' tant entendu que le Cameroun n'importe que du bl et une partie de riz ncessaire la consommation locale.

A moyen terme et avec l'introduction d'une politique rigoureuse de rduction des pertes aprs rcolte dont l'un des volets serait le schage des produits vivriers (fruits, tubercules' lgumes et pices), cette agriculture est susceptible non seulement de nourrir correctement tous les Camerounais, mais galement d'augmenter les revenus des paysans et d'conomiser les devises qui auraient servi a l'importation des produits agricoles. Elle permettrait l'exportation d'un surplus agricole vers les autres pays d'Afrique Centrale.

LE SECHAGE DES PRODUITS VIVRIERS

Le schage des produits vivriers au Cameroun se pratique presque exclusivement l'chelle familiale, utilisant des techniques et moyens peu adapts.

Le schage des produits agricoles ne fait pas actuellement l'objet de recherches en vue de son amlioration et de sa promotion. Cependant les moyens traditionnels utiliss dans

les milieux villageois permettent de prparer et de scher des quantits importantes de produits vivriers.

Les produits habituellement sont :

Les lgumes et les lgumineuses

Les oignons, les arachides, les haricots et les graines de courge sont schs habituellement au soleil. Ensuite, les arachides et les haricots se gardent dans les greniers o la fume de bois aide leur conservation.

Les lgumes (Ndol, feuilles de haricots doliques, feuilles de courge, etc...) sont lavs, coups en fines lamelles bouillies et ensuite lavs avant d'tre schs au soleil ou au feu.

Beaucoup d'autres lgumes et lgumineuses qui pourraient tre schs en vue de leur commercialisation ne le sont pas l'heure actuelle, malgr la forte demande sur des produits analogues imports.

Les tubercules

Les drivs du manioc (farine et gari) sont certainement les produits les plus couramment schs, la fume pour les boules ou en vrac au soleil. La difficult principale rside dans la

pnibilit de la prparation manuelle du manioc (pluchage' fermentation et rouissage, pilage, broyage' mise en boule, etc...).

La patate douce et certaines varits locales sont galement sches aprs avoir t lgrement bouillies.

Il est important ici de relever l'importance du pr-schage de certains tubercules (macabo, ignames, patate ...) avant leur mise en silos ou en tout autre lieu permettant leur prservation, et ceci compte tenu de la forte humidit habituelle de la rgion.

Les pices

Les piments, le poivre et de nombreuses autres pices locales (corces et racines aromatiques' noyaux de certains fruits et racines) sont habituellement schs au soleil.

Les difficults et obstacles

Au Cameroun il existe de nombreux organismes susceptibles de promouvoir le schage traditionnel amlior ou industriel des produits vivriere. Ce sont :

- **La Dlgation Gnrale la Recherche Scientifique et Technique (DGRST)**
- **Le Centre National d'Etudes et d'exprimentation du Machinisme Agricole**

(CENEEMA)

- **Le CAPME, Centre d'Assistance aux Petites et Moyennes Eh, treprises.**

Le CENEEMA et le CAPME sont des institutions capables d'assurer l'tude, la mise au point et l'exprimentation de matriels de prparation et de schage de produits agricoles. En outre' le CAPME peut porter assistance aux particuliers dsireux de mettre sur pied des petites industries. Cette assistance peut couvrir toutes les tapes entre la conception et la gestion effective d'une entreprise.

Les difficults majeures sont :

- **l'absence ou l'irrgularit des matires premires**
- **la pnibilit du travail manuel de prparation du produit scher**
- **la dure de cette opration**
- **la concurrence entre ce travail et les travaux champtres habituels**
- **le manque d'quipements adapts.**

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

5.2. Production of sun dried products for local distribution by development of an integrated technology in Ethiopia

Contents - Previous - Next

- Samu - Negus H. Mariam

INTRODUCTION

Dehydration by sun-drying of various products, notably chillies, on a village or domestic level' is traditional in Ethiopia. The benefits to be derived from improving and extending this ancient method of food preservation were recognised by IAR and following adaptive research' the publication, "Sun-Drying of Fruit and Vegetables in Ethiopia" appeared in 1977. A report on simple methods of storing dehydrated products, followed later.

In spite of the manifest advantages which could secure from sun drying surplus produce from rain fed crops for consumption during the long dry season, these proposals were not taken up and developed by any of the agencies working in rural development, even

though the inputs required are very small.

Recently, a new proposal' as yet unpublished, has been made by HDD; "Appropriate Technology for Dehydration of Vegetables and Fruits". If implemented, this proposal could have a national impact on improving food supplies and there would also be the possibility of developing exports of certain products.

PROPOSED DEVELOPMENT AND WORK PLAN

Briefly, the proposal envisages intergration of two levels of technology in order to combine the best features of both, each being appropriate and complementary.

Many parts of Ethiopia have a prevailing dry atmosphere which is very suitable for open tray sun drying, without the use of solar drying structures. Suitable crops for sun-drying would be grown and sun dried by small farmers. Vegetables can be reduced to a moisture content of 10% by sun drying, at which stage they can be stored at medium temperatures for about 18 months. Such products could be stored for home use by the producers or could be sold locally.

However, in order to convert the farmer's sun dried produce into products of a standard

suitable for national distribution or even for export, some finishing operations are necessary. For this purpose, farmer/sun driers would have the option of soiling their products to a central finishing plant, which could be developed by installation of quite simple equipment at one of the existing agro-industrial processing plants.

The finishing process would consist of drying to a final moisture content of 5-6% for vegetables; grading to produce a standard product' packaging in consumer size packs or bulk; distribution and marketing of the products.

The advantages of this integration of technologies will be readily apparent. Major costs in conventional industrial dehydration are : high capital costs of dehydration equipment and buildings; high transport costs for transporting fresh produce with an average moisture content of 85-90% and average waste of 15%, from field to factory; high running costs for staff and for evaporating about 90% of the moisture in the raw material with non-renewable energy; high cost of discontinuous operation due to shortages of raw material.

By adopting the economical methods of production which are recommended' it should be possible to produce finished products at a low enough price to make them available to a large section of the population as well as to provide highly competitive products for export.

IMPLEMENTATION

It is proposed to confine production initially to only one product, dehydrated onion. Onion has a universal appeal in the Ethiopian diet and it is known from previous work carried out by Institute of Agricultural of Research (IAR), that dehydrated onion is well accepted by consumers. The technique for sun drying onion is a simple one and the dry product has good storage life. There is a good export market for dehydrated onion.

FIELD PRODUCTION OF ONIONS AND SUN-DRYING

It is proposed that in the first season' 100 farmers should each grow 0.25 ha of onion under irrigation and sun dry the crop. Ma, serial inputs for growing the crop and sun-drying it would be provided by the project. Seasonal inputs would be repayable at the end of the season and capital inputs over 3 seasons. Inputs are detailed in Appendix 1.

Sun dried produce which is purchased by the finishing plant should be priced according to the formula:

Agreed contract farm gate price x 10 plus 0.75 Birr/kg (labour of sundrying)

Thus, if the farm gate price is 0.20 Birr/kg, the price paid to the farmer for sun dried onion would be 2.75 Birr/kg. (U.S. $ 1.00 . 2.07 Birr).

It is estimated that with good husbandry' the yield from 0.25 ha would be 4,000 kg. After sun-drying, gross return to the farmer would be 1,100 Birr from 1/4 of a hectare.

One suitably trained field agent would be required to supervise the production of onions and sun-drying of the crop.

In the second season, production should be extended to 200 growers and double the production of sun dried onion.

THE FINISHING PLANT

It is proposed that production and sun-drying should be undertaken within transport range of the merti Processing Plant so that finishing could be undertaken as a subsidiary operation there. A flow sheet of the finishing operation is shown in Appendix 1.

The plant is design d for 180 day operation so that maximum advantage can be taken of solar energy for bin drier operation during the dry period of the year. Solar heat is utilised by passing the intake sir of the bin drier through the double akin roof of the building and forged draught is provided by electric fan. The bin drier can be built locally of sheet metal and timber. It should have an initial capacity of 50 kg input/12 hours, divided into 2 sections of 25 kg each.

The flow sheet B for local market grade dehydrated onion, packed in plastic pouches of 100 g, is vary much simpler than the flow sheet recommend d for export grade. This should result in an attractive price to the consumer.

PRIORITY AND DURATION

The priority of this project has to be discussed. It is a long term project but continuation must depend on assessment of the first season's results.

ACKNOLEDGEMENT

Thanks of acknowledgement goes to Mr. T.H. Jackson, Export in the Horticulture Development Department for the original idea.

Appendix 1

Finishing Plant

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

5.3. Expose sur les possibilites d'amlioration du schage solaire des fruits, tubercules, lgumes et pices au Gabon

Contents - Previous - Next

- Jean Ngoua-Mba

En matire de schage traditionnel de fruits, tubercules, lgumes et pices, notre contribution la prsente session d'tude ne rpondra pas ce que les Honorables Participants attendaient ou taient en droit d'attendre :

Premirement, parce que le temps dont nous avons dispos aprs confirmation de notre participation ne nous permettait pas de fournir le travail de recherche que nous aurions souhait prsenter.

Deuximement, parce qu'en ce qui concerne les fruits et lgumes schs, dans notre pays l'on peut sans grand risque d'erreurs affirmer que ces deus catgories de produits ne sont pas rentrs dans une vritable conomie de march, les schages qui sont faits n'tant pas destins une consommation commerciable grande chelle.

Troisimement, les habitudes alimentaires des populations gabonaises sont concentres dans la consommation l'tat frais, y compris des tubercules.

Pour illustrer le 3me point, qu'il me suffise de dire que les femmes et les hommes qui pratiquent les cultures vivrires font une plantation chaque anne et n'attendent mme pas de rcolter toute la production de tubercules en terre pour commencer rcolter dans les nouvelles soles qu'elles ont plantes. C'est pour cette raison d'ailleurs qu'en matire de

manioc environ 30% de la production ne a ont pas perdus par le fait des ennemis de cultures mais par l'itinrance des plantations conscutives l'abondance des terres, telle enseigne que les Services Agricoles de l'poque coloniale conseillaient des jachres allant jusqu' 10 annes.

Si dans certaines provinces du Gabon et notamment le MoyenOgoou et l'Ogoou-Maritime, les habitants consomment le manioc sous diffrentes formes sches, il convient de retenir que dans ces provinces maritimes les populations ont eu depuis longtemps une tradition de voyageurs et ont prouv assez vite le besoin de conserver certains produits de base pour leur consommation dans les ampements de pche ou do chasse.

D'une manire plus gnrale, l'on peut dire que le schage traditionnel au Gabon n'a pas permis le dveloppement d'une technique quel-que aussi sommaire soit-elle, C'est l'exposition au soleil qui a t et gui reste jusque l la sule pratique de schage en milieu paysan et ce en rapport avec le peu d'impact gu'ont le produits schs de ce type sur le march de consommation. Parmi ces produits schs nous tenterons de prsenter ceux gui sont couramment consomms par une grande partie de la population et gui pourraient ventuellement tre envisags pour une production de march.

LES TUBERCULES DE MANIOC

Dans ce cas prcis, le schage du manioc fait suite une fermentation pralable dans l'eau des rivires et gui a pour but d'liminer l'acide cyanydrique responsable du got amer de la varit utilise. L'opration permet l'obtention de tubercules schs ou de la farine.

OBTENTION DE TUBERCULES SECHES

La technique utilise est simple: le manioc une foie ramolli est dbarrass de sa pellicule et les tabercules entiers sont mis sur des claies pour gouttage et schage au soleil. Ce premier schage dure de deus trois jours. La seoonde tape du schage qui a pour but de donner certaines proprits organolaptigues au produit par funage se fait par la suite sur des claies. suspendues au-dessus des feux de cuisine (feux de bois). A ce niveau la dure de schage importe pou, le manioc sch reste sur les claies et est consomm au fur et mesure des besoins. Il pr ente l'avantage d'un transport facile pour les campagnes de pche, de chasse, etc...

OBTENTION DE LA FARINE

Les tubercules schs obtenus par l'opration prcdente peuvent tre rduits en farine par crasement dans des mortiers. Cette pratique est rencontre rarement et est souvent le fait de personnes ayant voyag dans des paya voisins et qui prouvent parfois le besoin de retrouver certaines pratiques alimentaires inhabituelles dans le paya.

EPICES ET LEGUMES

Leur disponibilit continue sur l'anne et leur consommation l'tat frais en gnral limite toute possibilit de schage. Pour ces produits la pratique de schage rencontre concerne essentiellement la conservation des semences et galement des plantes mdicinales utilises en pharmacope traditionnelle.

LES FRUITS

Dans ce cas, le schage est pratiqu pour les fruits prsentant un caractre saisonnier. C'est par exemple le cas des noisettes dites sauvages et du chocolat indigne courants sur nos marchs.

LES NOISETTES SAUVAGES

Il n'y a pas pour ce cas' d'opration de schage excut par les paysans, les fruits tombs schent au soleil au pied de l'arbre et sont ramasss pour tre casss aux fins d'extraction des noix. On peut parfois parfaire le schage des noix en utilisant la technique des claies vue dans le cas du manioc.

LE CHOCOLAT INDIGENE

Ce produit trs consomm dans les agglomrations urbaines du pays est d'un emploi facile pour la mnagre qui y trouve un moyen d'offrir rapidement des mts gnralement apprcis par tous.

Il est obtenu partir du fruit d'un arbre de la famille des Irvingiaces, l'Irvingia gabonensis couramment dsign sous le vocable local de Odika.

Le schage dans ce cas prsente plusieurs tapes et demande une certaine organisation. Il peut se rsumer de la manire suivante :

1. **rcupration des amandes extraites des mangues aprs fente longitudinale du fruit;**
2. **schage au soleil et/ou dans des fumoirs traditionnels suspendus au-dessus des feux de cuisine;**
3. **broyage des amandes au pilon dans des mortiers de bois;**
4. **mise en forme du broyat dans des rcipients;**
5. **exposition au soleil pour schage**

    - **il y a exsudation des graisses**
    - **et durcissement;**

6. **dmoulage des pains ou blocs de chocolat indigne obtenus qui sont envelopps dans des feuilles et suspendus prs des feux de cuisine pour assurer une longue conservation et viter galement le rancissement de la matire grasse dont ce produit est riche.**

La consommation se fait au fur et mesure des besoins. Par rpage des blocs, on obtient une fine poudre couleur chocolat qui sert de liant pour les sauces tout en leur procurant un arme particulier.

Sur un plan de recherche pure, les efforts de nos instituts do recherche ne se sont pas orients vers le type de produits que nous venons de voir. Notre recherche a travaill sur

d'autres produits schs tel le poisson pour lequel l'IRT a mis rcemment au point un appareil d'usage simple et facile construire en milieu rural.

Nous sommes convaincus que la somme des techniques de schage mises au point dans les autres continents peuvent nous permettre d'aboutir une technologie polyvalente en la matire' c'est en cela que rside notre intrt la participation ce sminaire et c'est dans cet espoir que nous pensons prendre part aux diffrents dbats qui suivront ces travaux

Nous remercions les honorables participants pour leur aimable attention.

Contents - Previous - Next

Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw

5.4. African workshop for improvement and development of drying fruits in Ghana

Contents - Previous - Next

- E. Gyabaah - Yeboah

INTRODUCTION

The demand for vegetables, fruits, tubers and spices and the importance of these crops in the diet of the average Ghanaian cannot be over emphasised. Their demand especially out of season has led to the exploitation of methods of preservation. One feature of the distribution of these highly perishable food crops in Ghana throughout the year is that it is highly skewed. Soon after the harvest the local markets become flooded with the commodities over and above the demand for consumption. Excess supply available at the time of harvest could be preserved and stored against the lean season. The lopsided fashion of preservation and storage of such perishable food items make their prices fluctuate considerably in the periods between two successive harvests of these crops. It is estimated that Ghana looses 15% - 30% of her cereal crop and 30% 40% of the starchy crops and vegetables annually because of lack of storage and preservation facilities. Reduction of these losses through appropriate preservation methods could increase the domestic shortfall in food supply by 20% - 30%.

The excess supply at time of harvest' which are left to rot' can be preserved against the

periods of lean supply. The various methods of preservation of these crops are drying or dehydration (air' sun' fire) bottling and canning. Sun-drying is however, the oldest traditional method of food preservation in Ghana. The advantage of such preservation methods lies in the fact that since the items are treated in a natural condition' they are not very different in appearance and flavour from the fresh items when served. An added advantage of sun-drying is that a lot of the produce can be dried at a time.

SITUATION OF SUN-DRYING IN GHANA

Sun dried vegetables, spices and tubers feature prominently in the Ghanaian diet during the lean season. Since sundrying especially of vegetable is the most popular preservation method' it is undertaken in all the regions of the country. Ideally all vegetables intended for sun drying must be fully mature at harvest time. In most cases all defective items are discarded and vegetables' fruits and spices at different stages of maturity are never mixed. The crops are then washed' trimmed and cut into pieces according to the type of fruit or vegetable. In spices' the stalks and calyx are removed. Spices are subjected to blanching' that is hot water or steam treatment to improve the storage qualities and preserve the natural qualities. Traditionally tubers are not blanched before drying.

The traditional method of sun-drying in Ghana has no definite methods nor special equipment. Products for Bun-drying are spread on rooflope' on concrete constructions, along roadsides and in courtyards. There is a disadvantage of the products being subjected to contaminations from dust' flies' and even human beings.

MARKETED SUNDRIED VEGETABLES, FRUITS, TUBERS, SPICES

The moat important marketed sundrier vegetables, fruits, tubers and apices are tabulated below:

i. Vegetables:

Okro, (Hibiscus esculentus), tomatoes (Lycopersicum esculentum) shallots (Allium ascalonicum and on a smallscale leafy vegetables).

ii. Fruits

Plantain, (Muse) bananas (muse) palm fruits (Elaeis guineensis) groundnuts (Arachis hypogen)

iii. Tubers

Cassava (Mahihot esculenta) yam (Dioscorea Alata)

iv. Spices

Various types of pepper (Capsicum annum spp.) - hot pepper, black pepper.

PROBLEMS OF SUN-DRYING IN GHANA

i. **One of the major problems of sun-drying in Ghana has been contamination. This has already been mentioned as a disadvantage but it can be a serious problem because in most cases the dried products are ground into powdery form to economise storage space. In this way items cannot be washed before use.**
ii. **Another problem is that, if the products are not spread evenly or trimmed as uniform as possible, drying may not be even. This means some will dry faster that others while others may have higher moisture content and be of poor storage quality. In this case the poet-harvest losses which is being prevented is aggravated since in worse cases 50% of the produce can go bad.**

iii. **A third problem is browning of some of those fruits and vegetables when exposed to air. This is especially so with plantain, banana and to a lesser extent cassava Along the coast where salt is abundant such products are immersed in salt solution to reduce browning.**

IMPROVEMENT OF SUN-DRYING IN GHANA AND RELATED RESEARCH

The subject of improvement of traditional sun-drying methods for food preservation has engaged the attention of scientific work era especially at the Food Research Institute of the Council for Scientific and Industrial Research and the Ghana Atomic Energy Commission. Some of the improvements proposed are discussed below:

i. **That there should be an exclusive drying yard which could be constructed with local materials. The drying yard should be equipped with a cutting and trimming table with a hardwood top. The shed will be reserved exclusively for grading' cutting' trimming and spreading on drying trays.**
ii. **Where bamboo and other boards are available, raised platforms (similar to those used for cocoa) could be construct d to minimise contamination. Another sun drying unit which may be ideal is the sun-drying cabinet which consists of a rack with**

trays; each tray measuring 3 feet by 3 feet. Two of the trays can be held together by two hinges to allow them to be stretched out to form a 6 feet by 3 feet drying surface.

iii. **Improvement in packaging and storage are a prerequisite for better handling. Packaging should follow immediately after cooling the dried products. Large quantities could be packed in either high density polythene bags or in polythene lined juge bags. It has been observed that plastic bags and jute bags are also susceptible to insect and animal attacks. The packed products should be kept in a cool dry place to avoid deterioration. Alternatively, the dried products could be ground and packaged in tightly closed tins especially when the product is to be stored for a long period. This is especially true of garden eggs and the various species of spices.**

iv. **Simple methods of sun-drying of specific vegetables, fruits, tubers and spices, clearly indicating the blanching temperature, duration of blanching to get the right moisture contort with the drying ratios have been devices as an improvement on the traditional sun-drying methods.**

A specific example of such methods of sun-drying is the case of garden eggs. Hitherto, sun-drying of this particular vegetable was not popular. In recent years as a result of this simple but important research' sun-drying of vegetables has been popularised.

Method of sun drying of garden-eggs: Garden eggs tend to have worms in them as a result of over-maturity. This fact is evidenced by small holes in the vegetables. All those vegetables with such worms should be discarded. The rest should then be graded as to colour and size, and trimmed by removing the stalks and calyx, The garden eggs are then cut into four equal sizes and immersed in 10 tablespoonsful vinegar to a gallon water for 25 minutes. The cut pieces are blanched in water containing sodium carbonate (baking soda) at 90 C for three minutes, drained and then dried to a moisture content of 8% - 10%. The drying ratio is 10:1. The dehydrated garden eggs should then be ground into powder and stored in tightly covered tins.

v. **Another suggestion is the use of preservatives to improve the colour and storage quality of the final dry products especially leafy vegetables. However this has not caught on well with producers since such chemicals are difficult to obtain.**

ON-GOING PROJECTS

i. Food Preservation by Solar Drying

The major on-going project at finding alternative to traditional sun-drying in Ghana is

solar drying. The Project is being undertaken by the Food Research Institute of the Council for Scientific and Industrial Research of Ghana.

ii. Food Preservation by Irradiation

Research into perishable food preservation by radiation is still in its infancy in Ghana. Most of the work done to date is at the exploratory stage. The Ghana Atomic Energy Commission is responsible for this type of Research.

Preliminary work has, however, demonstrated the potential of ionizing radiation in prolonging the shelf-life of onions, yams, fruits and vegetables.

OTHER AREAS OF RESEARCH

In the short term, research is being conducted to reduce the length of the drying time for all the vegetables and fruits through the development of new drying trays and improved blanching methods.

Contents - Previous - Next