Dried fruit and vegetables

Drying produce in the sun is simple and has the advantage of being a traditionally-understood technology with little or no fuel and equipment costs.

Drying removes water from the surface of the food by the combined effects of air flow, air temperature, and air humidity. The relationship between the three is important if drying is to be successful. When the moisture content is lowered below a certain level, micro-organisms cannot grow, and the produce is preserved.

In humid climates, dried products must be packaged well in order to prevent moisture uptake and protect against spoilage.

Air-dried products

These are the most common type of dried fruit and vegetables. Some products may be blanched or sulphured/sulphited to protect the natural colour and aid preservation. Dried fruit pulp is often named 'fruit leather'.

Dried and fried products

These are products which are partly dried, and then deep-fried, to produce a snack food. Examples include banana chips and bombay mix.

Osmotically dried fruits

These are fruits which are soaked in hot concentrated sugar syrups to extract some of the water prior to drying.

Production stages for dried fruits and vegetables

Process/product	***Air-dried fruit***	***Air-dried vegetables***	***Fried/dried product***	***Osmotically dried fruits***
Prepare raw materials	*	*	*	*
Blanch		*		
Sulphuring/sulphiting	*Some	*Some		
Prepare sugar syrup				*
Soak in syrup				*
Pulp	*Some (e.g. fruit leathers)			
Strain/filter	*Some (e.g. fruit leathers)			
Boil	*Some (e.g. fruit		*	

	leathers)			
Pour into thin sheets	*Some (e.g. fruit leathers)			
Dry	*	*	*	*
Deep-fry			*	
Pack	*	*	*	*

Equipment required

Processing stage	*Equipment*	*Section reference*
Prepare raw material	Fruit and vegetable cleaners	14.1
	De-stoners	21.0
	Peeling machinery	51.0
	Fruit and vegetable choppers	12.1
	Cutting, slicing and dicing machinery	17.0
Blanch	Steam blancher 01.0 or boiling pan	48.0
Sulphur/sulphite	Weighing and measuring equipment	64.1 and 64.2
	Sulphur cabinet	
Prepare sugar and syrup	Weighing and measuring equipment	64.1 and 64.2
	Boiling pan	48.0
	Heat source	36.0
Soak in syrup	Boiling pan	48.0
	Food grade tank	03.1
Pulp	Pulper/juicer	55.0
Strain/filter	Muslin cloth	
	Stainless steel strainer/filter	29.0
Dry	Solar dryer	23.1
	Fuel-fired dryer	23.2
	Electric dryer	23.3
Deep-fry	Fryers	33.0
Pack	Sealing machinery	47.1

Processing notes

During drying, many fruits and vegetables experience some changes in colour. These can be lessened by carrying out some simple processing stages prior to drying (for example, blanching, sulphuring, and sulphiting).

Blanching is a short heating treatment in water or steam, and is often a necessary processing stage. It has many functions, but essentially it destroys enzymes which are responsible for causing browning, and reduces the total number of micro-organisms in the food.

For production on a small scale, the produce can either be wrapped inside a muslin cloth or in a wire basket, and immersed into boiling water. As the food is in direct contact with the water there is some loss of water-soluble vitamins. Steam blanching can be carried out by placing the produce in a strainer, which is then fitted over a pot of boiling water and covered with a lid to prevent the steam escaping. Steaming takes a few minutes longer than the water method but it has the advantage of losing fewer nutrients, as vitamins are not leached into the water. For larger production, a tray blancher can be purchased.

Sulphuring/sulphiting

With some dried products, the use of chemical preservatives will improve the colour and increase the shelf-life. The most commonly used preservative is sulphur dioxide. There are two methods: sulphuring and sulphiting. Sulphuring is more commonly used for fruits, and sulphiting for vegetables.

Sulphiting involves the use of sulphite salts, such as sodium sulphite or sodium metabisulphite. They may be either added to the blanching water or more commonly used by soaking the food in a solution of the salts.

The strength of a sodium metabisulphite solution is expressed in 'parts per million' (ppm) and the strength used will depend both on the final product required and the legal standards set in any particular country.

Sulphuring is achieved by burning sulphur in a sulphur cabinet. This can be made from locally available materials. The amount of sulphur used and the time of exposure depend on the commodity, its moisture content, and the levels permitted in the final product. The food is placed inside the cabinet and sufficient sulphur is placed in a container near the trays. For most vegetables 10-12 g of sulphur (22½ level teaspoons) per kg of food is adequate. The sulphur is ignited and allowed to burn in the enclosed cabinet for 1-3 hours.

Drying techniques

The simplest method of drying is to lay the foods in the open air, either on mats, or on raised platforms. Although this is effective, there is limited control over the drying process which results in a variable product quality and a greater risk of contamination. To give more control over these aspects, solar dryers have been designed which protect the product from dirt and insects and increase the rate of drying.

Solar dryers fall into two categories - direct or indirect. In a direct dryer, the product is exposed to the sun's rays. This exposure results in vitamins being lost and a darkening in the colour of some foods. This colour change is desirable for products such as dates, but for lighter fruits, such as papaya and apricots, it is a problem.

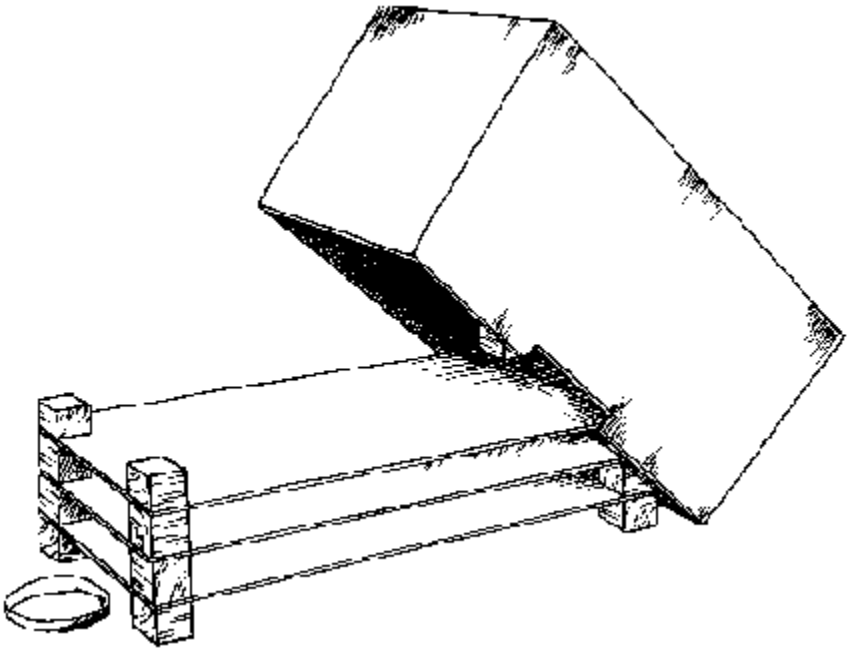
Indirect dryers shelter the product from the sun. The heat from the sun is collected in a separate connected chamber and the heated air is passed over the food in an enclosed dryer.

Designs are also available for combined dryers. These are fitted with both a heater unit and a solar collecting chamber. When there is plenty of sunshine, the solar collector can be used, but the heater can also be used in poor weather conditions and at night.

There have been numerous designs for solar dryers, but most have met with a very poor response from rural producers. Most rural consumers are not willing to pay more for a slightly improved product quality and the investment in a dryer may not prove to be economically advantageous. In addition the relatively poor control over drying conditions compared to that for fuel-fired or electric dryers, means that they are largely unsuitable for high-value products such as spices, where an improvement in quality does generate higher income.

There are also a large number of designs of fuel-fired dryers. These have better control over drying conditions and therefore produce a higher quality product. They are able to operate at all times of the day and year, and in most cases produce a higher rate of drying. However, these benefits must be evaluated against higher capital and operating costs.

Sulphur cabinet



Packaging

Traditional packaging materials such as baskets, jute sacks, and wooden boxes have long been established for packaging dried foods such as fish and vegetables. They are for commodities which are transported in large quantities to a central marketing place and then sold loose. These packages can be used several times and are usually cheap.

Traditional packaging is only suitable provided the climate does not cause an increase in the moisture content of the food which will result in mould growth. If the climate is not suitable, dried foods should not be transported in this way. Boxes are used to prevent crushing of dried foods, and in humid climates, moisture-proof flexible films can be used (see Packaging chapter).

Some semi-moist foods such as osmotically dried fruits have special needs to prevent the reabsorption of water. Since dried fruit is a valuable product, it may be worth spending more on the package, such as a moisture-proof sealed bag. A wide range of flexible packaging materials is also available, but the use of many of these is limited due to high costs. Low-density polyethylene is a moderately good moisture barrier and cheaper than other films. It can be easily sealed using a powered bar-sealer.

Flexible materials may be used as the sole component of a package, but for most foods, a sturdy outer container is also needed to prevent crushing or to exclude light.

Suitability for small-scale production

It is technically feasible to make most fruit and vegetable products on a small scale using simple machinery, but it is likely that a group starting up in business will require substantial advice.

A common problem for small producer groups is the lack of market research. Such enterprises are often production-led, and products may be manufactured in order to use up a glut before a definite need or market for the product has been identified. Therefore, marketing will require special emphasis as this is often the most serious problem facing a new business. Rural production of value-added fruit products for urban or middle class markets has the added complication that the markets may be a long way from the producer group which may cause difficulties in negotiations and language problems, packaging supplies, and high distribution costs.

It is a common mistake to assume that poor-quality fruits and vegetables can be used to make high-quality goods. It is only possible to use rejected produce if it has been rejected for cosmetic reasons (e.g. the wrong size or slight blemishes).

For year-round production, it may be necessary to part-process raw materials into a form that can be stored in readiness for future production. Alternatively, a sequence of fruits or vegetables can be processed throughout the year in some regions. Both methods can help overcome the highly seasonal nature of fruit and vegetable crops. Despite this, in many cases processors will need a high working capital to buy the majority of raw materials in mid-season when prices are at their lowest.

A constraint in the production of preserves is that they require a large quantity of sugar. In many cases, refined white sugar has to be brought from urban centres, and may be expensive.

These points are not meant to discourage anyone from starting such a venture, but the problems should not be under-estimated, and it is best to seek advice first from a qualified technical source.

23.0 Dryers

23.1 Solar dryers

Drying foods in the sun is probably the oldest method of food preservation. At the simplest level, the food is spread on the ground or on mats, and the moisture at or near the surface of the food is heated and vaporized by heat from the sun and ambient air. However, there are a number of disadvantages with sun drying. These include: the intermittent nature of solar energy throughout the day and different times of the year; the possible contamination of the food material by dirt, or insects; exposure to the elements (such as rain and wind), causing spoilage and losses; and the exposure of the crops to rats, chickens and other pests.

Most solar dryers incorporate a platform, raised above the ground, and often some kind of covering to combat the problems mentioned above. The purchase of a solar dryer may require a high capital investment initially, but it is argued that the gains from producing a higher-quality product will quickly offset these costs. A careful assessment of the requirements of the producer is therefore necessary to establish whether higher income can be obtained from better quality products. Solar dryers may be more suitable if processing high value foods rather than low-value staple crops. In addition, the introduction of combination solar/fuel fired dryers may be a desirable option to overcome the problems of intermittent sunshine that often adversely affects solar drying.

SOLAR FOOD AND CROP DRYER

This dryer is not commercially available. Two wooden boxes are made, one to fit inside the other. The inner box should have a 6cm gap all the way around for holding insulation. A few trays, with mesh bases are required to hold the material for drying, and ventilation holes are required all around the sides of the box. Plastic sheeting is used to form a clear lid over the dryer which retains heat inside the unit. Dimensions: 2.6 x 1.2 x 0.4m. Information available from:

ILO - SDSR
P.O. Box 60598
NAIROBI
KENYA

FORCED CONVECTION SOLAR CROP DRYER

This dryer is not commercially available. It has a centrifugal/axial flow fan to blow air through the drying chambers. Gas, electric and firewood heaters are also available for combination dryers. Information from:

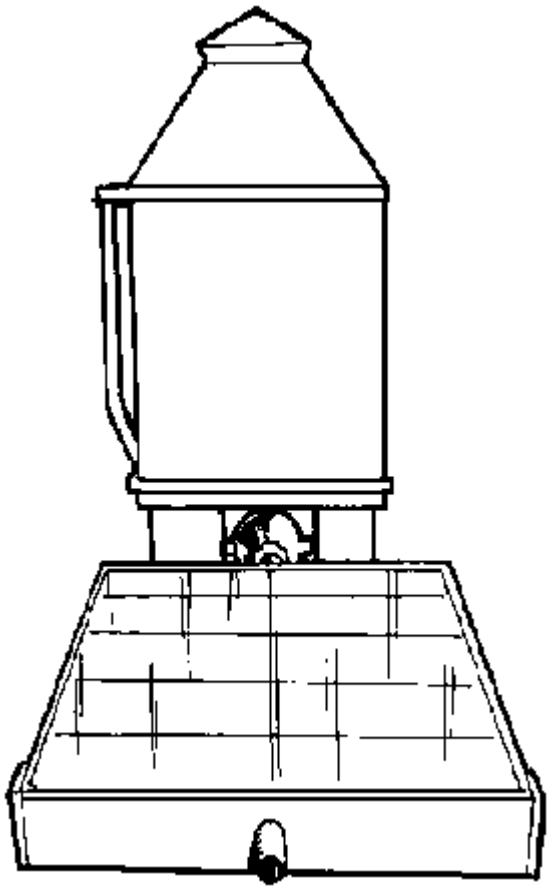
INSTITUTE FOR AGRICULTURAL RESEARCH
Samaru, Ahmadu Bello Uni
PmB 1044
ZARIA
NIGERIA

TRIPLE PASS SOLAR COLLECTOR/DRYER

This dryer can be Used for cereals and tubers and consists of a flat plate collector, drying cabinet and dehumidification chamber. These units result in high heat-gain through the collector, and sustained and Uniform drying for both day and night-time.

PRICE CODE: 2

TRIPLE PASS SOLAR COLLECTOR/DRYER



DEHUMIDIFIED AIR SOLAR-HEATED TRAY DRYER

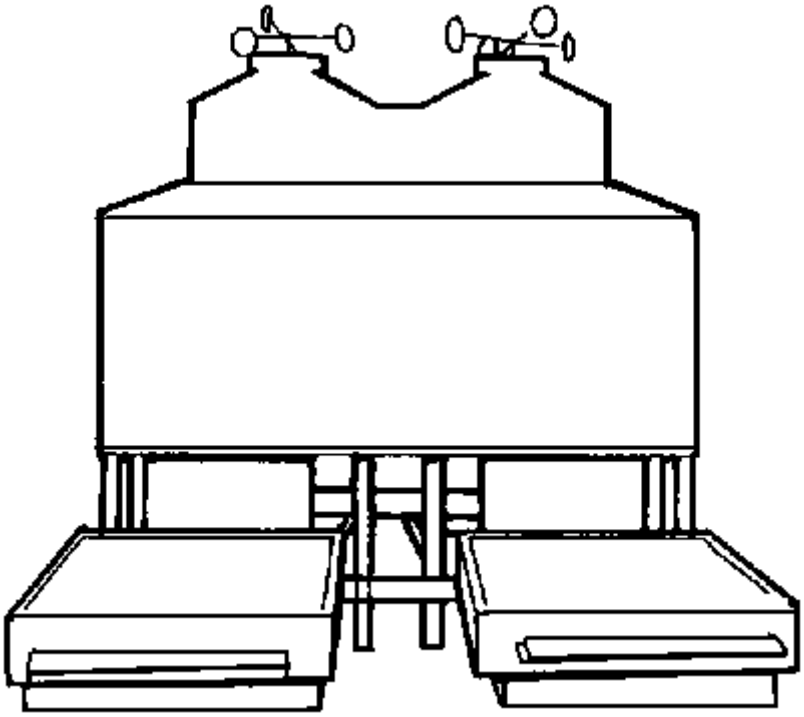
This dryer comprises several built-in modules each consisting of a flat plate collector, dehumidification chamber and drying cabinet. All major components are detachable and so can

be added to, increasing the overall capacity. A wind-operated suction pump draws air through, and temperatures of up to 90°C can be reached. Throughput: 200kg (fish), in four days.

PRICE CODE: 3

DEPARTMENT OF AGRICULTURAL ENGINEERING
Faculty of Engineering
University of Nigeria
NSUKKA
NIGERIA

DEHUMIDIFIED AIR SOLAR-HEATED TRAY DRYER



Solar dryers also manufactured by:

SCIENTIFIC INFORMATION DIVISION
Pakistan Research Council of
Scientific & Industrial Research
39 Garden Rd
KARACHI 0310
PAKISTAN

M/S DALTRADE (NIG) Ltd
Plot 45 Chalawa Indust. Est.
P.O. Box 377

KANO
NIGERIA

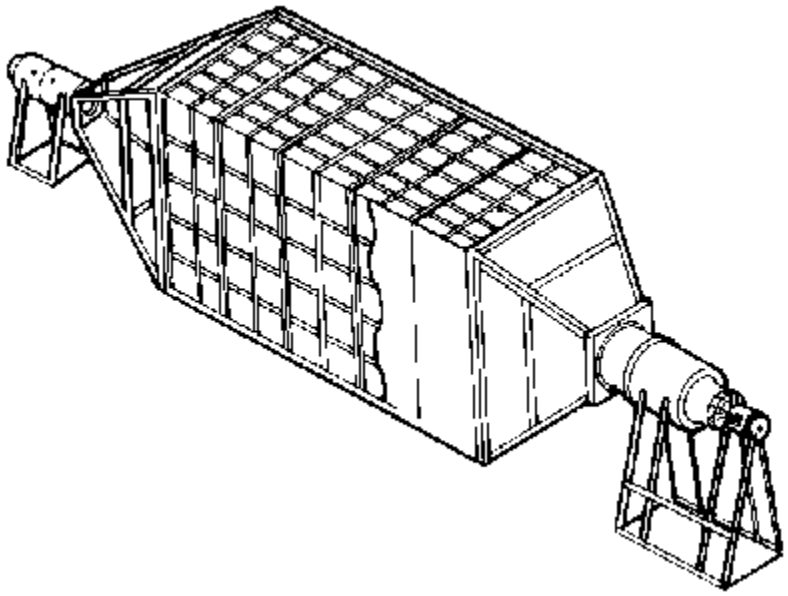
23.2 Fuel-fired dryers

CARDAMOM DRYER

This machine comprises a drying bin, and a heating chamber powered by an electric fan which requires motors, 0.55kW (0.74hp) 1500rpm single-phase. The heaters require 8kW. Capacity: 1000kg per charge. Dimensions: 930 x 350 x 250cm.

The cardamon dryer is not commercially available. Information from:

CARDAMOM DRYER



TANZANIA ENGINEERING & MANUFACTURING DESIGN ORGANIZATION
P.O. Box 6111
ARUSHA
TANZANIA

KILN DRYER

This kiln dryer comprises a drying bin, furnace, and air circulatory systems, and will run continuously for 24 hours. It is used to dry onions at a throughput of 3.3 tonnes/3 days. Dimensions: 360 x 327 x 488cm.

PRICE CODE: 4

FOREST PRODUCTS & RESEARCH DEVELOPMENT INSTITUTE
Officer in Charge, Packaging Prg
LAGUNA
PHILIPPINES

DRYER

A general-purpose dryer (for paddy and other grains) can be manufactured locally. The power source can be a petrol/kerosene engine, electric motor or a rice-husk burner. This dryer is not commercially available. Capacity: 1 tonne.

INTERNATIONAL RICE RESEARCH INSTITUTE
PHILIPPINES

BATCH DRYER

A rice dryer, based on an IRRI design, uses a 3hp (2.2kW) petrol engine or a 1.5kW (2hp) motor to drive a 47cm diameter vane-axial type fan and to supplement heating. Primary heat is provided by a rice-hull furnace or kerosene burner. There is an automatic safety burner shut-off mechanism. The weight (without engine) of the burner and fan is 40kg. Airflow is 1800 cfm at 2200 rpm, with a static pressure of 20mm water. Temperature: 43°C. Fuel consumption: 0.75 litres per hour petrol + 2.0 litres per hour kerosene or 3.4kg/h rice-hull. Drying bin dimensions: Length 277cm, width 190cm, height 92cm. Drying rate 23% moisture (w.b.) paddy (1 tonne) to 14% in 5-6 hours.

PRICE CODE: 3

VERTICAL BIN BATCH DRYER

This rice dryer is constructed of wood and steel and uses a 2.2kW (3hp) motor or a 3.7kW (5hp) engine. Heat is supplied by a kerosene burner. Consumption: 1.5 litres per hour petrol + 2.7 litres per hour kerosene. Air at 43°C is blown by the blower (2000 rpm) through a grain bed 46cm thick at a flow rate of 1612 cubic metres per hour (3600 cfm) and 3cm water static pressure. Weight with engine: 364kg. Dimensions: length 344cm, width 173cm, height 158cm. Capacity: 2 tonnes paddy per load. Drying rate: 2% per hour.

PRICE CODE: 3

JCCE INDUSTRIES
242 Mayondon
Los Banos
LAGUNA
PHILIPPINES

MULTI-CROP DRYER, TILTING BED TYPE

This tilting bed dryer is manually-operated and uses rice husk as a fuel. The 1500 rpm multi-vane centrifugal fan gives an airflow of 3500cfm. In addition, a fixed-flat bed type is available (Model FS 35).

PRICE CODE: 2

MULTI-CROP DRYER, FIXED TWIN-BED TYPE

This dryer is indirectly heated from rice husk. It comprises a burner, blower and two holding beds totalling 90-100 cavans. Each bed can be operated simultaneously or alternately. Model FD50 has a capacity of 45-50 cavans/bed x 2. Throughput: 1517 cavans per hour. Size range: 30-35 cavans/bed x 2. (Model FD35)

PRICE CODE: 0

MARINAS MACHINERY
MANUFACTURING CO. INC.
Rizal Street
Pila
LAGUNA
PHILIPPINES

TRAY DRYER

This dryer has proved successful in drying many products, particularly the higher value foods such as fruit and herbs.

It consists of sixteen trays, each measuring 3ft by 4ft. The capacity of the dryer varies according to the product being dried, but as an example, it will dry 300-400kg of herbs (net weight) per day.

The heat source can be powered by diesel, gas or electric. The dryer requires 1200 cubic feet of hot air per minute.

Work is continuing on the dryer in an effort to reduce the cost of the forced hot air system.

Plans, construction guide and a video (in Spanish) are all available from ITDG.

TRAY DRYER

ITDG
Myson House
Railway Terrace
RUGBY
Warwickshire CV21 3HT
UK

Fuel fired dryers also manufactured by:

ARMFIELD TECHNICAL EDUCATION CO. LTD
Bridge House
West Street
RINGWOOD BH24 1DY
UK

CECOCO
P.O. Box 8
Ibaraki City
Osaka 567
JAPAN

TECHNOLOGY DEVELOPMENT OFFICE
S & T Comm'n of Liaoning Province
1-2 San Hao Street
He Ping District
SHENYANG
CHINA

AGRICULTURAL MECHANIZATION
DEVELOPMENT PROGRAMME
AMDP, CEAT, UP Los Banos College
LAGUNA, 4031
PHILIPPINES

C.V. KARYA HIDUP SENTOSA
Jl. Magelang 144
YOGYAKARTA, 55241
INDONESIA

P.T. RUTAN MACHINERY TRADING CO.
P.O. Box 319
SURABAYA
INDONESIA

23.3 Electric dryers

SUN PANTRY OVEN DRYER

This drier is designed for small-scale drying, and uses heat from an oven (temperature range of 41°71°C). The individual trays can also be used for sun-drying. The dryer is made from hardwood and comes with four drying trays which have aluminium screens, covered in acrylic for safe contact with the food. Drying space: 4955cm². Dimensions: height 17 x weight 43 x depth 33cm.

PRICE CODE: 1

LEHMAN HARDWARE & APPLIANCES INC.
P.O. Box 41
4779 Kidron Road
Kidron, OHIO 44636
USA

DRYER

This electric or gas dryer, can be made to order. It is made of stainless steel and has double doors at the front.

PRICE CODE: 2-3

KLAUY NAM THAI THOW OP
1505 07 Rama 4 Rd. Wangmai
Patumwan
BANGKOK 10330
THAILAND

Electric dryers also manufactured by:

LEHMAN HARDWARE & APPLIANCES INC.
P.O. Box 41
4779 Kidron Road
Kidron, OHIO 44636
USA

23.4 Vacuum dryers

ROTARY VACUUM DRYERS

This vacuum dryer is suitable for producing granular, powdery materials. It has a capacity of 250 litres and gives low temperature, uniform drying.

PRICE CODE: 4

DALAL ENGINEERING PVT LTD
36-37 Jolly Maker Chambers II
Nariman Point
BOMBAY 400 021
INDIA

23.5 Spray dryers

SPRAY DRYER

This dryer produces powdered foods and is designed for product testing or small-scale production of high-value foods. The concentrate feed-rate may be varied using a peristaltic pump, and the temperature of the drying air is controlled by a 3kW heater.

PRICE CODE: 4

ARMFIELD TECHNICAL EDUCATION CO LTD
Bridge House
West Street
RINGWOOD BH24 1DY
UK