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A Study on the Evaluation of Driers for Cashew Processing in Sri Lanka

Prepared by

Agro Enterprise Project in collaboration
with the Export Development Board
and Sri Lanka Cashew Corporation

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SUMMARY

The AgEnt Project in Association with the Export Development Board and Sri Lanka Cashew Corporation has initiated a programme to improve the quality of cashew nuts produced in Sri Lanka. Among other things, it hopes to assist the cashew processors in improving their product by investing in suitable driers for processing of cashew nuts. For this purpose, an evaluation of the locally available driers was required.

Three locally produced driers were identified by the Sri Lanka Cashew Corporation for evaluation. The first, was an electrically operated drier manufactured by the National Engineering Research & Development Centre (NERD) and the second, was a saw-dust fired drier promoted by the Intermediate Technology Development Group (ITDG Sri Lanka). The third drier was one manufactured by a local enterpreneur from Makewita in the Gampaha District.

Of the three driers evaluated, the NERD drier was the most suitable. It was efficient, cost - effective and had the multiple use capability. However, it operates on electricity and therefore may have limited use in rural areas. Few modifications if incorporated, may improve its performance further.

The ITDG drier comes second in the evaluation & has many strengths. It is easy to operate & maintain, ideally suited for rural area, and is presently in use. In spite of these advantages, it needs further improvement to make it more cost effective, efficient and suitable for multiple use. The technology however blends well with the moral atmosphere.

The third drier which is of the traditional type, has many shortcomings. The needs major changes in design if it is to be made efficient & reliable. It is not economical for use, the quality of it's product cannot be guaranteed and its operation & maintenance is comparatively difficult. The major advantage it has is the use of cashew nut shells to produce heat energy. Multiple use of this drier is not possible and this drier cannot be recommended for use.

EVALUATION OF CASHEW NUT DRIERS IN SRI LANKA

1. THE BACKGROUND

A major share of the cashew nut processing in Sri Lanka is in the hands of the small scale entrepreneur. These processors employ women in rural areas to shell, peel and prepare the nuts to the standards required by the local market. However, their processing techniques need to be greatly improved, if they are to achieve the quality standards demanded by the export markets.

AgEnt Project has identified this need to improve the quality of cashew nuts processed in Sri Lanka. It believes that it could assist these small scale cashew processors to improve their processing capabilities to attain international standards.

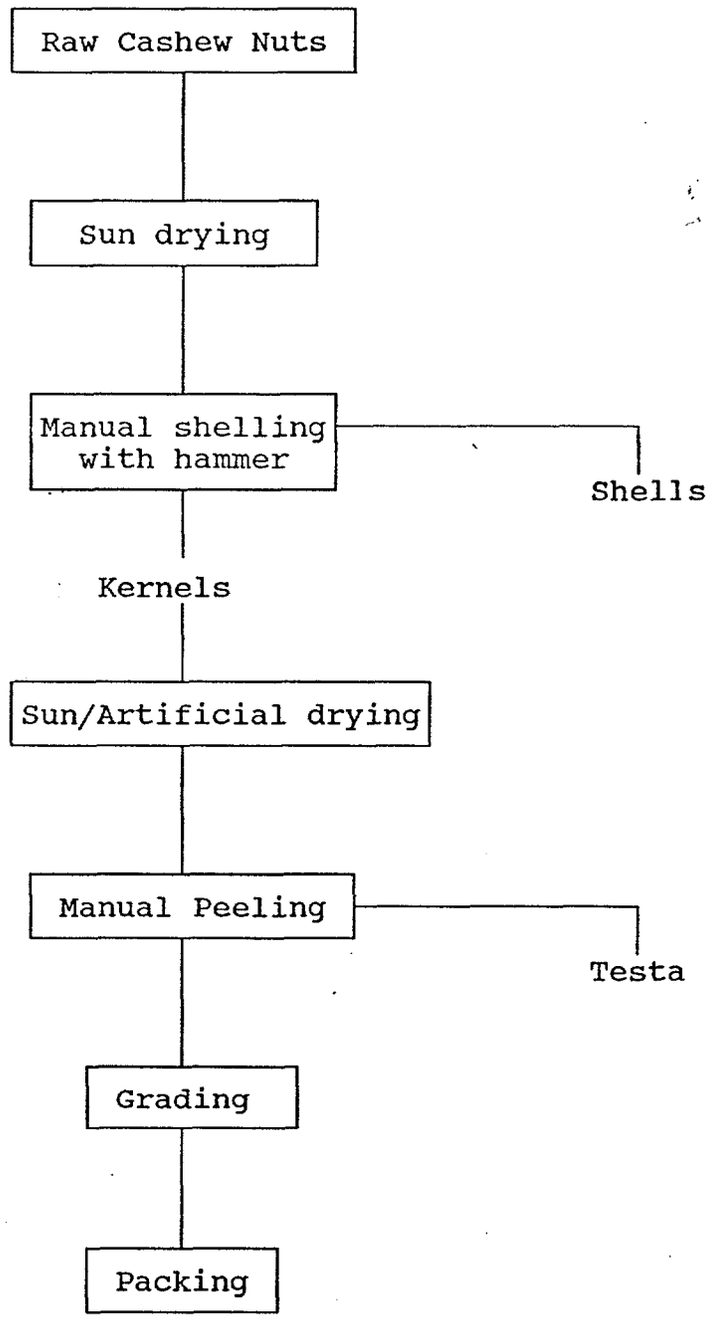
As an initial step in this direction, AgEnt commissioned this study to identify the most efficient and appropriate drier suitable for the small scale entrepreneur. Three locally fabricated cashew nut driers were evaluated for this purpose as per TOR given in Annexure 1. This report outlines the findings of this study.

2. PROCESSING OF CASHEW NUTS

One needs to understand the common methods of processing of cashew nuts in Sri Lanka before any attempts are made to compare the merits and demerits of the driers in question. Hence, the prevailing processing methods are discussed first.

Many methods are employed to process cashew nuts. In countries where cashew nut shell liquid (CNSL) is extracted, methods such as moisture conditioning, open pan and drum roasting or oil bath roasting are practiced. However, in Sri Lanka, only two methods are common. They are the 'traditional' method, which is practiced in the rural areas by small scale entrepreneurs and the 'Steaming Process' practiced by the two factories of the Cashew Corporation and few large scale cashew processing companies. The difference in technique of these two methods is discussed below.

TRADITIONAL METHOD OF PROCESSING



2.1 Harvesting

The first step in the processing operation is harvesting. In all cashew growing countries, the harvesting of cashew nuts from trees is not practiced. Instead, the ripe fruits are allowed to fall to the ground and collected. The nuts are then detached from the fruit by hand with a twisting action. They are usually gathered daily to avoid damage by high humidity, insects and pests. At the time of harvest the moisture content of the nuts may be as high as 20%. For this reason they are sun-dried for 3-4 days to stop fungal infestation and enhance the keeping quality.

To sun dry, the nuts are evenly spread on concrete floors or mats that are laid on the ground. Even drying is obtained by raking and re-spreading the nuts after every two hours. In the evening nuts are collected, heaped up and left covered during the night to be re-spread in the morning for drying again. Sometimes individual farmers dry the nuts for a day and sell them to the cashew processors who in-turn dry the nuts for 2-3 days more & prepare them for processing or storage.

This sun-drying process will bring the moisture level down to about 6-8% . To determine the correct level of drying, few nuts are taken from the drying floor, clasped between the two palms of the hand and shaken. If the kernel is heard rattling inside the nut, the drying is considered to be adequate. No measurement of the moisture content is performed, but the above practice seems to be fool-proof and is continued at present.

3. THE TRADITIONAL METHOD OF PROCESSING

3.1 Shelling

In the traditional method, the shelling of cashew nuts is done manually. It is performed by holding the cashew nut with its convex side resting on a stone or a hard surface and striking the broad end of the nut, perpendicular to its natural line of cleavage, with a shelling mallet. A second blow on the reverse side may sometimes be necessary to complete the shelling.

To protect the fingers of the sheller from CNSL, the hands of the sheller and the nuts are frequently dusted thoroughly with wood ash. The ash absorbs any CNSL remaining on the shell, preventing it from damaging the workers' hands or contaminating the kernels.

Once the nuts are cracked, the two halves of the shell are separated by inserting a pointed tool in the crack and twisting it, taking care not to split or damage the inner kernels. The whole kernel is then pushed out using the same tool. Usually flattened nails, bamboo knives or sharpened hack-saw blades are used as tools for this purpose.

Mostly, rural women do the shelling of cashew nuts. An experienced woman worker can shell about 3000 nuts in an 8 hour working shift and is paid Rs. 35/= per 1000 nuts shelled.

3.2 Drying

Once the kernels are separated from the shell, they are more susceptible to insect damage and fungal attack. Therefore, every attempt is made to dry the kernels without delay.

Drying also facilitates the removal of the skin or the 'testa' from the dried kernel. The shelled cashew kernels have a moisture content of about 6~8% before drying.

The kernels can be sun dried or machine dried. In sun drying, as in the case of nuts, they are spread evenly in thin layers on mats and allowed to be in strong sun light till the testa can be removed by hand. This process may take 2-3 days, but there is no risk of scorching of the kernels. Artificial drying on the other hand is quicker and may take only 5-6 hours.

Traditional driers in Sri Lanka are fired by burning cashew shells or any other combustible material such as fire wood, paddy husk, saw dust or coconut shells. They are usually metal boxes fitted with racks to accommodate loading trays filled with kernels. Kilns made of fire bricks are built around these boxes as double walled structures with provision for fire places at the bottom. The flue gases from these fires move upwards through the double walled passage, heating the box from outside and escaping through the chimney.

The temperatures inside such driers are difficult to control. However, long usage and experience of operators ensure minimum scorching of kernels. The trays are moved from bottom to top periodically to ensure even drying as there is a wide variation of temperature within. Over the years many modifications have been incorporated in these driers to improve the quality of the dried kernels. Some attempts have been successful.

3.3 Peeling

The process of the removal of the testa from the dried kernel is known as 'peeling'. Artificial or sun drying shrinks the kernel so that the testa is now loosely adhered to it and therefore can be removed by hand or with the aid of a wooden or metal knife.

Peeling is usually performed by children. They are paid Rs. 15/- per kilo peeled. In the peeling operation it is important that the kernel is not damaged by cuts or blemishes. Moreover, the dried kernel is brittle and will break easily. Careful handling is critical at this stage. For this reason, the peeled kernels are immediately graded and packeted. If there is to be a delay in the grading, they are temporarily packed in to large polythene bags and sealed, to prevent mould infestation and absorption of moisture.

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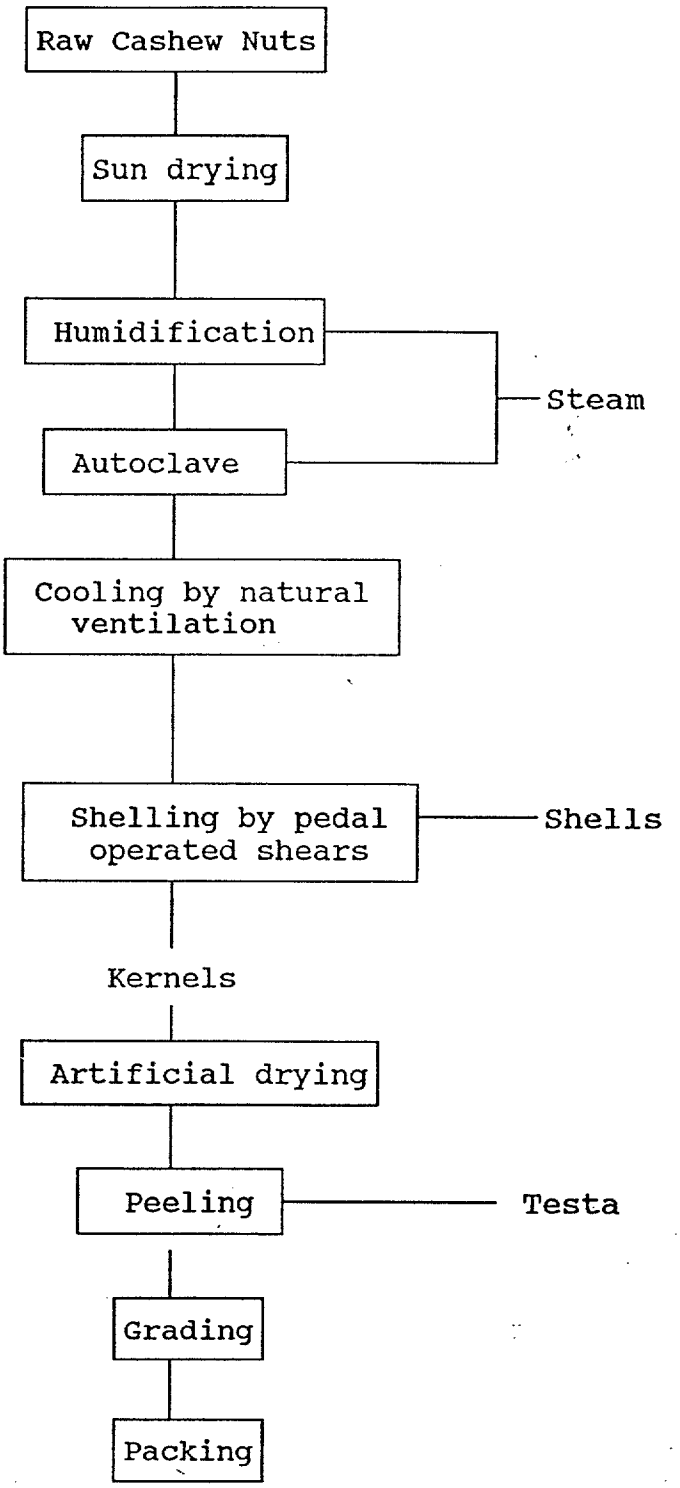
THE STEAMING METHOD OF PROCESSING



4. THE STEAMING PROCESS

4.1 Drying

The nuts are sun dried as before for about 3-4 days to reduce moisture content and ensure safe storage. They are then stored in suitable buildings in 40-50 kg gunny bags using dunnage at the base to avoid seepage of moisture from the floor.

4.2 Steaming

In this method, a pressure vessel, usually termed an autoclave is used to steam the nuts. This vessel can be loaded from the top with cashew nuts using a conveyer system. Once loaded, the lid of the vessel is closed and steam is supplied from a boiler through a perforated pipe at the centre of the vessel.

The boiler is fired first and steam is allowed to be generated till the pressure rises to 100psi. The fuel for the boiler may be diesel, kerosene or cashew nut shells. Once the pressure reaches 100 psi, the control valve is opened to allow the steam to fill the pressure vessel where about 350 kg of cashew nuts had been loaded for treatment. After 10 minutes of steaming the outlet valve of the autoclave is opened.

The pressure in the vessel will then drop down to around 5~15 psi. However, the steam is continuously supplied for about 15-20 more minutes before the cashew nuts are unloaded. The steamed nuts are then spread on the concrete floor of a well ventilated building and allowed to cool gradually. After 24-36 hours the nuts are ready for shelling.

4.3 Shelling

The shelling of nuts is done by pedal operated machines. The shellers pick the nuts one by one and place them between the upper and lower cutter blades of each machine. A pedal when operated, cuts the nut without damaging the kernel, which is left intact. The skill of the operator is vital to obtain the kernel without cuts or blemishes. The shellers themselves or additional helpers working with them, push the kernel out of the split nut, manually.

4.4 Drying

The kernels are transferred to electrically operated driers which dry them to a moisture content of about three percent. The kernels are not allowed to remain long after shelling, as they are prone to gain moisture and are susceptible to fungal attacks. Therefore, the nuts are shelled in batches to feed the dryers.

The drying is done in wooden trays fitted with wire meshed bottoms. Each tray accommodating a layer of kernels of about 25mm thick. The temperature of the dryer is maintained between 70-80°C by means of a thermostat and air-control flaps. Usually it takes 4 1/2~5 hours to dry one batch of kernels.

4.5 Peeling

The peeling is done manually after the dried kernels are allowed to cool to room temperature. Alternatively, they can be left in the drier (after switching off the power supply) if they are to be peeled the following day. Packing in air-tight baskets will keep the kernels in good condition for a day or two, if there is a delay in the peeling operation.

The peeled kernels are then graded as follows.

a. White wholes
b. Scorched wholes
c. White pieces
d. Scorched pieces
e. Refuse

Grading of kernels for export is different. Here more stringent standards are followed.

5. GRADING OF CASHEW KERNELS TO QUALITY STANDARDS

Cashew kernels are graded for export according to the size and number of kernels per pound. The most common count is 300 ~ 320 per lb. followed by 400 ~ 450 ; 220 ~ 240 and 200 ~ 210. They are also classified as wholes, chips, splits, butts or baby bits. The colour of the kernel is another quality parameter. The white and ivory coloured kernels fetch a better price than the brown ones which are termed 'scorched' kernels. The scorched kernels are those slightly burnt due to over-roasting.

The standards also specify that the kernels should be without blemish, free from infestations, insect damage, mould, rancidness, testa residues and extraneous materials. The white kernels which are not whole are graded according to the way they have broken. Thus, splits are those broken along their natural line of cleavage, butts are the ones that are broken cross- wise which have not split. The chips or pieces are those broken into many parts.

Further classification is sometimes made as large white pieces (lwp) and small white pieces (swp) and baby bits (bb). The ISO 6477 standard specifies the grades in detail and is followed by all cashew exporting countries. There is also a maximum tolerance concerning moisture and the number of lower quality kernels in a lot. Normally up to 5% of the lower grade is accepted.

The highest price is generally paid for the better quality, large and heavier, whole kernels. Therefore, processing techniques should always aim for the maximum recovery of unblemished white whole kernels.

6. EFFECT OF ARTIFICIAL DRYING ON QUALITY

In the artificial drying of cashew kernels, heat is necessary to evaporate the moisture from the kernels and a flow of air is needed to carry away the evaporated moisture. There are two basic processes involved here; the migration of moisture from the interior of a kernel to the surface and the evaporation of moisture from the surface to the surrounding air. The rate of drying is determined by the initial moisture content, the temperature of the kernels and the temperature, relative humidity and the velocity of the air in contact with the kernels. Therefore, a good flow of heated air is critical in a drier.

The drying operation is not merely the removal of moisture. There are many quality factors expected in the dried kernels, such as:

* Low and uniform moisture content after drying
* Low susceptibility to stress cracking and breakage
* No mould growth
* No loss of nutritive value
* Good appearance

6.1 Moisture content

The moisture content of the kernels after drying should be suitable for long term storage. It is also important that the range of moisture levels in a batch dried be uniform. Under-dried kernels can lead to fungal infestation where as over-dried ones can cause loss of revenue due to excess breakage in handling.

6.2 Stress cracking and breakage

In drying with heated air, excessive exposure can lead to stress cracking and more broken kernels. The extent of stress cracking is related to the rate of drying. Rapid cooling too should be avoided. The recommended moisture content suitable for packing (after drying) is 5% . However, most driers bring the moisture content of kernels down to about 2-3% , making and them brittle and more susceptible to breakage before packing.

Un-even and slow drying of kernels may occur due to restricted movement of hot air or inadequate rates of flow. Alternatively, quick drying of kernels with high air velocities will tend to case harden the kernels. Here, the moisture on the surface of the kernel will evaporate at a rate higher than the rate of migration of moisture from the interior of the kernel to the surface. Thus, creating a barrier for the free flow of moisture from interior.

6.3 Mould growth

The rate of development of mould growth and micro-organism is dependent on the moisture content, temperature and degree of physical damage to kernels, The mould growth can only be detected fully at the time of final roasting of nuts (in vegetable oil) for consumption. At this stage the kernels which have been attacked by mould growth will not brown evenly but show light and dark patches. This is termed 'spotting' and such kernels are unacceptable.

Available literature specifies a moisture content of less than 6% as a safe limit to prevent mould growth. Packing of kernels for export at 5% moisture content is therefore recommended by many countries.

6.4 Nutritive value

The constituents such as proteins, sugars and vitamins may be adversely affected if the kernels are heated to excessive temperatures. On the other hand, their feeding value may be lowered if the kernels are inadequately dried.

6.5 Appearance

The appearance and colour of kernels is an important parameter. Less attention paid during the peeling operation is liable to produce kernels with cuts and blemishes. These kernels when roasted in vegetable oil do not roast to an even colour since the damaged parts will show up lighter in colour. Such discoloured kernels are valued less.

The Sri Lanka Standards (SLS 1003/93) specifies drying of kernels around 70 °C for about 6 hours to reduce the moisture content to around 3 percent in it's code of practice for processing of cashew nuts. Grading and packing standards of are in accordance with SLS 405.

7. THE DRIERS CHOSEN FOR EVALUATION

In this study, three locally fabricated driers were selected for comparison. The first one was an electrically operated drier manufactured by the NERD centre of Sri Lanka. The second was the saw dust fired drier promoted by the Intermediate Technology Development Group (ITDG). The third was a drier made by one of the small scale producers, namely, Mr. Ranjith Perera of Makewita.

Their constructional features, methods of operation and performances are discussed below. Reference is made here to the test results obtained during the trials conducted with each machine as given in Annex II.

8. THE NERD DRIER

8.1 The Construction:

The NERD Drier is made of double walled G.I. sheeting with a wooden frame work in the middle. It consists of four sections. The top chamber, the drying chamber, the back chamber and the bottom chamber. The drier is electrically operated and works on the normal 220 V single phase 50 hz supply. Its' outside dimensions are 620 mm X 1010 mm X 1800 mm. The drier chamber occupies the central section of the drier. It has a lockable single door, opening to the front of the drier and hinged on one side as shown in fig. 1 (See photos 1 & 2).

The trays are made of wooden frames with wire-meshed bottoms and of dimension 745mm X 520 mm. Aluminium rails fitted 102 mm apart from one another accommodates these trays. Each tray can hold about 3 kg of cashew kernels for drying.

Three heater coils of 1500 watts each, connected in parallel as shown in fig. 2, supply the heat to the dryer. The air is supplied by means of a blower of capacity 1/2 hp which is mounted as shown. The ambient air drawn by the blower is passed over the heater coils mounted on the back chamber, which is partitioned from the drying chamber as shown in the figure.

This air enters the drying chamber from its' bottom. The hot air then moves upwards through the drying trays, carrying with it the moisture of the material being dried and moves to the top chamber above the trays.

FIGURE 2 - NERD CENTRE DRIER

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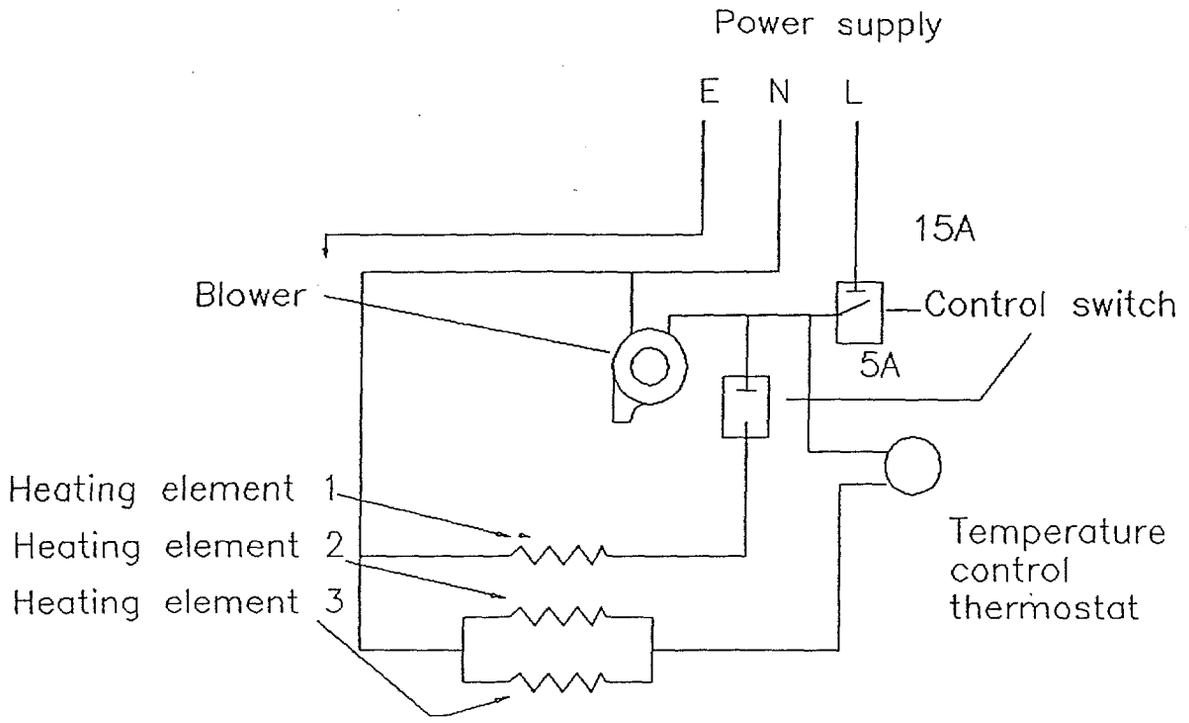

ELECTRICAL CIRCUIT

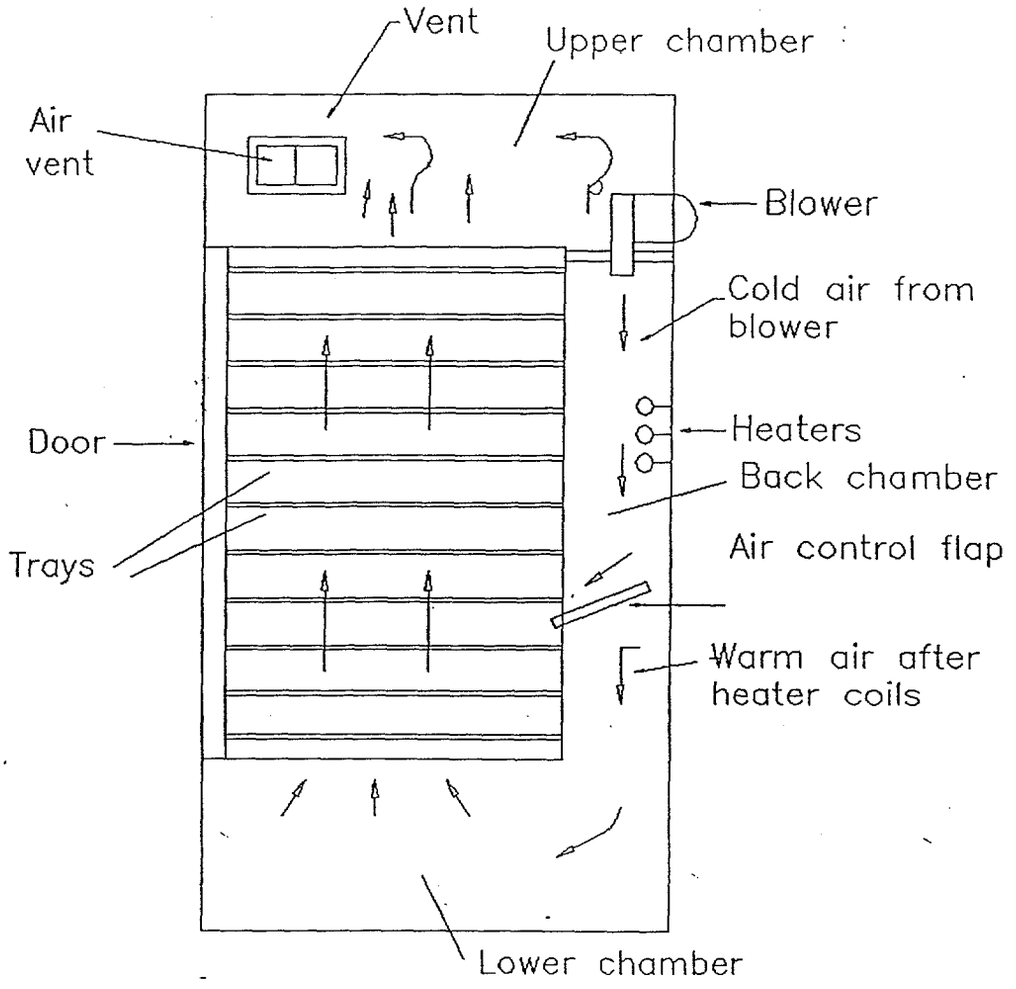

FIGURE 3 - OPERATIONAL LAYOUT INDICATING AIR FLOW

Subsequently, it escapes through two vents located on the two sides of the dryer. These vents can be opened or closed as required by moving two flaps as shown in fig. 3.

A dial type thermostat is provided. It regulates the power supply to the heater coils as shown in the electrical circuit . The thermostat can be set at any temperature between 30°~110° C. Visual observation is provided by means of an indicator lamp incorporated in the thermostat.

8.2 The operation

The trays are filled with an evenly spread layer of cashew kernels of about 20-30 mm thick and weighing about 3 kg per tray. They are then loaded into the drier and the door closed (Photos 3 & 4). The drier is initially run with the two vents fully closed and the thermostat set at about 55°C. In this manner the drier is operated for 45 minutes. Once this temperature has reached, the thermostat setting is increased to 75° C and the two vents thrown open.

This is done to conserve heat. Initially, the cashew nuts and the drier body will absorb an appreciable quantity of heat before their temperatures begin to rise. If the vents are kept open from the start, a major share of the heat will escape through the vents, resulting in a considerable loss of heat. After setting the temperature to 75° C the drier is left to run without opening the door until the time of unloading of cashew nuts. The condition of the kernels can be checked at any time by inserting one's hand through a vent and picking up a few kernels. One person can easily handle the whole operation. 36 kgs of cashew kernels can be dried during a period of 4 1/2-5 hours.

The blower and one or more of the heater coils will operate continuously during the period of drying. The provision of the thermostat limits wastage of heat energy. Good insulation provided inside conserves heat energy. However, it is electrically operated, and a 230 V single phase power supply is essential for the operation of this drier.

The test results of this drier are given in pages 4-10 of Annex II. The following observations can be made on its performance.

8.3 The Strengths

1. The inside temperature of this drier stabilizes after two hours of operation. The temperature difference between the front and rear of each tray is less than 2°C. The temperature gradient from top to bottom is only 5°C. Thus, it can maintain a good distribution of heat inside the drier, which will ensure even drying of kernels.

2. There is no need to unload the trays at different times. Once the trays are loaded, they can be unloaded in one operation after 4 1/2 hours of drying.

3. Scorching is prevented as the temperature is successfully controlled by the thermostat.

4. Once the drier is loaded, there is no need to open the door frequently to check the condition of the kernels as the temperature is automatically set. However, if necessary, provision is available to check the condition without opening the door.

5. The drier can be operated by one person. Therefore, its cost of operation is comparatively low even though it works on electricity.

6. It needs little maintenance. No soot, burnt material or smoke is generated. The machine can be installed inside any closed building that has adequate ventilation.

7. The air flow rate is good. The anemometer recorded values of 0 - 3.5 m/s even after the trays were loaded with kernels. Thus, it ensures successful removal of moisture. However tables 7 & 8 show that there is still an uneven air flow across the trays and occurrence of turbulence at some points, which is a factor that needs correction.

8. The thermostat control allows the drier to be operated at any temperature in the range 30° -110°C. Therefore it has the multiple use capability. The above temperature range and the recorded air flow rates are adequate for drying of fruits, vegetables and grain legumes.

8.4 The Weaknesses:

1. The technology is more suited for urban areas where electrical power is freely available. No alternative fuel can be used.

2. The maintenance work, although minimum, needs the services of a skilled electrician.

3. The workmanship of the machine needs improvement. Few modifications are necessary to upgrade its performance.

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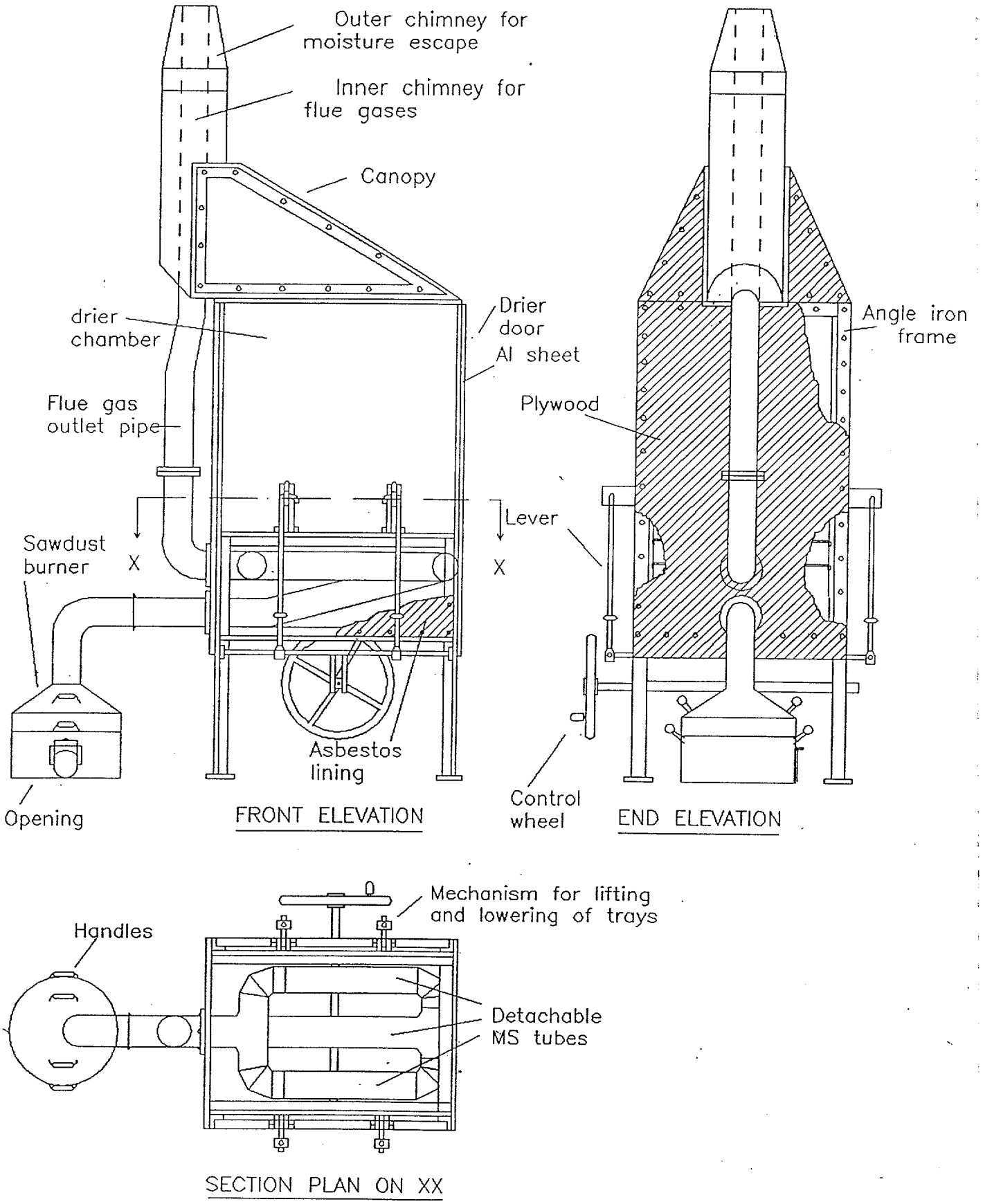
FIGURE 4 - I.T.D.G DRIER



9. THE ITDG DRIER

9.1 The Construction

This drier is made of plywood, G.I. and asbestos sheets and is mounted on an angle iron frame work as shown in Photos 5 & 6. The fuel used is saw dust. The saw dust is burnt in a separate stove which is connected to the dryer by means of a mild steel duct of diameter 120mm.

The flue gases from the stove passes through a heat exchanger consisting of a horizontally fixed network of tubing as shown in the figure 4. These gases exit through the chimney at the top. The incoming air from the open bottom of the drier gets heated by the heat radiating from the exchanger. This hot air then moves upwards through the trays of the drying chamber, carrying with it the moisture of the material being dried. A co-axial outer tube surrounding the chimney facilitates moist air removal.

The drier can accommodate six trays. These trays are made of wood with wire-meshed bottoms. Each is of size 710mm x 970mm having a height 140mm. The frames are made of 15mm thick wooden planks (Photo 7)

A simple lever mechanism operated by a handwheel as shown (in the plan) allows raising and lowering of the trays. With the aid of this mechanism the bottom tray can be taken out at any instance without disturbing or bearing the weight of the trays above it.
The heat exchanger tubes are fabricated and fitted to each other by slide-fit.
This allows easy detachment and cleaning of all tubes without difficulty (Photo 8). The exhaust tubes of the chimney are fitted in parts for easy maintenance and removal. The end of the outer tube of the chimney is tapered to create a venturi effect.

The enclosure of the heat exchanger is made of asbestos sheeting to conserve heat. The drier chamber itself is made of aluminium covered with chip board to ensure an even temperature distribution inside the chamber and to reduce the loss of heat to the outside.

The door consists of three sections. The one, at the top front end of the drier, can be opened down as a flap. The main door can then be opened side ways to allow loading and unloading of trays. The lower section can be opened down as another flap.

A removable dial type thermometer is inserted through a hole in the flap at a level just above the lowest tray to monitor the temperature of the drier.

9.2 The Operation

The stove is filled with saw dust. It is packed thoroughly, leaving a cylindrical opening at the centre (which is vertical) and a cylindrical opening extending horizontally and radially, at the bottom.
This is achieved by inserting two 75mm diameter GI pipes to the stove body and packing the body of the stove with saw dust. Once the packing is complete the two GI pipes are pulled out carefully, creating two tunnel shaped openings.

The stove is ignited by dropping a few pieces of coconut husk or wood chips from the top opening and pouring kerosene oil on it before applying a match stick. A single piece of wood is inserted in the horizontal tunnel which burns continuously facilitating the increase or decrease of heat at will.

Once fired, the lid of the stove is closed and it is pushed in to position (Photo 10). The stove will then supply heat to the drier for about 4-5 hours. Each batch of kernels dried will require one filling. A maximum of three batches of kernels can be dried per day.

There are 6 trays in the drier. Each tray can accommodate 5-6 kg. of kernels for drying. The stove holds 20.3 kg. of sawdust when fully packed and each filling is capable of drying 36 kg. of cashew kernels in a period of 4 1/2 - 5 hours.

Once the trays are in position, the door of the drier is closed and a dial type thermometer with a probe is inserted at a level little above the bottom-most tray. The reading of this thermometer is maintained just below 80°C at all times. If the reading tends to rise above 80°C, the piece of firewood in the stove is withdrawn allowing the temperature to drop. The top flap on the door can also be opened if the temperature has to be brought down quickly. However, in most instances, by just withdrawing the burning piece of firewood, one can easily maintain the temperature below 80°. This drier was tested in the manner given in pages 10 to 14 of Annex II. It's performance can be outlined as follows.

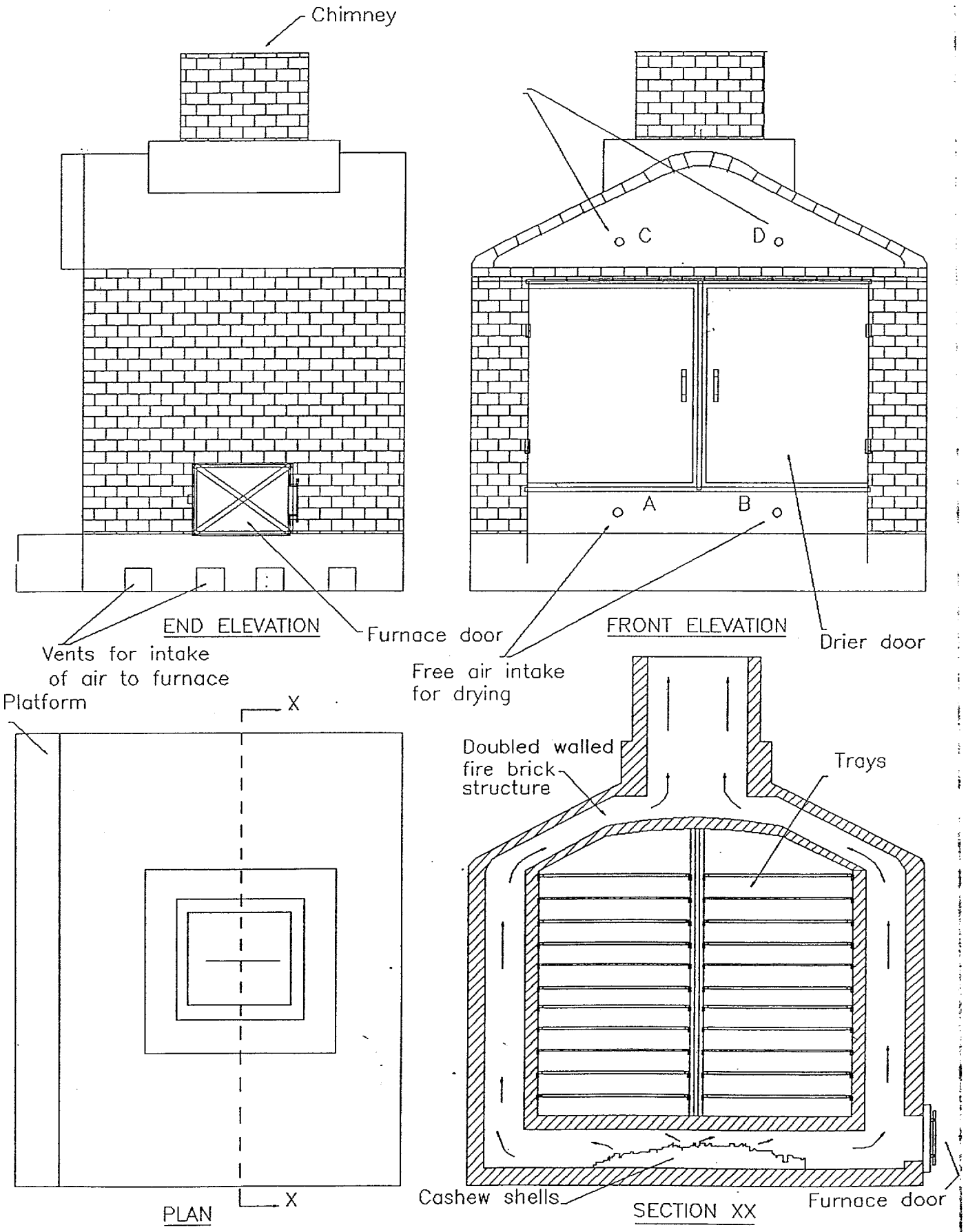
9.3 The Strengths:

1. This technology is suited for rural areas. At Rs.5.00 per stove filling, the fuel costs are comparatively low. Moreover, saw dust is freely available anywhere. Alternative fuels such as rice husk or coconut shells can also be used if necessary.

2. The maintenance cost is fairly low. Maintenance is easy and can be performed by women. No special skills are required.

3. Two women workers can handle the operation of the drier with ease. Already it is successfully utilized by women in cashew processing areas.

FIGURE 5 - Mr. RANJITH PERERA'S DRIER



4. Any part of the drier if broken or damaged, can be repaired in the village itself with the local welding and blacksmith skills.

5. The temperature inside the drier can easily be controlled to remain below 80°C. Therefore, with due care scorching can be avoided.

6. The capacity of the drier is well suited for the people in rural areas. 120 kg per day is a manageable quantity to process.

9.4 The Weaknesses:

1. The temperature variation across each tray at any instance is less or equal to 3°C, which is not a problem. However, the variation from top to bottom is about 30°C. This necessitates unloading of trays at different times of drying.
2. The inlet temperature of the flue gases is in the range 317-391°C and the outgoing flue gases recorded temperatures in the range 147-165°C. A lot of heat is thus wasted. Furthermore, the high inlet temperatures make the mild steel pipes red hot and less durable.

3. The air flow rate is inadequate for proper drying. The rates recorded are from 0 - 2.0 m/s for the empty drier. No readings could be obtained when the trays were loaded with kernels. In addition, the distribution of the flow rates is uneven as seen from Table 12. The rate of flow is greater on the rear end of the drier than at front.

4. It is seen that the temperature can be kept without exceeding 80°C. However, the drier cannot be set to operate at lower values of temperature, such as at 50°C. Therefore, the drier is not suitable for multiple use in it's present form.

10. MR. RANJITH PERERA'S DRIER

10.1 The Construction:

This drier is made of fire-bricks as shown in figure 5. It is rather a kiln than a drier. The furnace is at the bottom and is fired by burning cashew nut shells. The drying chamber is totally lined with fire bricks and the flue gases pass through the double walled heating chamber surrounding the drying chamber and escape via the chimney. The fumes from the burning cashew nut shells heat the bottom, the three sides and the top of the drying chamber on its way up before escaping through the chimney. The front is not heated as it occupies the two doors and the opening for inserting the trays.

There is no direct contact of the flue gases with the material to be dried. The intake air for drying is through two metal perforated pipes A and B extending across the floor of the drier from front to the back of it. This air gets heated due to the radiated heat from the firebrick walls and the floor. Then it moves upwards, carrying with it the moisture of the material that is dried and escape through the openings C & D. There is no forced convection of air.

Twenty four trays of size 700 mm x 900 mm are loaded to the drier leaving gaps between them at 100 mm. when pushed into position. Wire-meshed wooden frames are used as trays. The door is made of angle iron construction with a mild steel sheet welded on to it. There are no locks, but the two halves of the door can be pushed into position firmly (Phot 11 & 12).

10.2 The Operation

About 50-100 kg of Cashew nut shells are loaded into the furnace in the morning and ignited. At this stage the drier is empty, with the doors closed. It is heated for about 2 1/2 hours in this manner (Photo 13).

The drier doors are opened when all the kernels are burnt and the flames die down. The trays are then loaded into it. Each tray accommodates about 4.5kg of kernels, to a layer of thickness of about 25 mm. Twenty four trays are pushed into position in two columns of twelve trays each.

The design of the drier is such that the top portion of the drier gets heated more than the bottom. To counteract this problem, the trays are moved up or down in a sequence to maintain even drying.

The operation is as follows. The top three trays on each side are moved to the bottom and the bottom ones moved to the top after some time. In another one and half hours the remaining six on each side is shifted as before, with the lower middle three trays occupying the upper middle positions and vice versa.

The condition of the kernels is frequently checked by opening the door and feeling the surface of the cashew kernels to prevent over heating. Two women workers check the trays every hour or so, to ensure proper shifting of trays and avoid scorching. In a period of 4 hours after the initial loading and shifting of trays, the temperatures inside the drier stabilize. However, it is allowed to stay and cool slowly with the loaded kernels till the following day.

The drier doors are opened in the morning by which time its temperature has fallen to about 5°C above room temperature. Thus, a load of 100 kg. of kernels will take about 24 hours for drying by this method.

The test results of this drier are shown in page 15 of Annex II. The following inferences can be made on its performance and efficiency:

10.3 The Strengths

1. Cashew nut shells are used as fuel, which is a by-product. The fuel costs are therefore comparatively low. However, the shells can be readily sold in the open market for Rs. 2/50 a kilo, if needed.

2. The maintenance costs of this drier are low. No major skill or maintenance knowledge is required to keep the drier in good operational condition. However, daily cleaning, removal of unburnt shells and ash need to be done.

3. Two women workers can operate the drier when trained. People in rural areas can easily adopt this technology.

10.4 The Weaknesses

1. The capacity of the dryer is 100 kg for a 24 hour period, which is inadequate. The other driers can process 100 kg in 4 1/2 hours.

2. The drying of kernels is un-even. There is no temperature monitoring device or a mechanism to control the flow of heat. This results in a temperature gradient from top to bottom, as well as an uneven distribution from one end of the drier to the other.

3. The inlet air for drying is drawn through the <u>two</u> perforated tubes only. This method is unsatisfactory. The kernels above these openings dry more quickly than those distant from the tubes. Similarly, the small openings at the top create a concentration of heat in these locations. This shortcoming can lead to case hardening of kernels.

4. The drier does not allow for the free removal of the moisture released from the kernels. This drawback leads to an oven-effect rather than a drying technique. The kernels tend to get cooked slightly before there is a drop in moisture content to the levels required for peeling.

5. There is no provision available for checking the inside temperature the drier at any stage of its operation. There is no way to control its temperature.

6. As seen from table 14 of the test report, at the start (10.00 hrs.), the temperature of the top left hand side of the drier is 145°C, where as the top right is 85°C. At this time, the bottom ones are 53°C and 49°C respectively. The differences remain till the end of the drying period although they narrow down by evening. The operators when questioned about this discrepancy informed that

sometimes the upper two trays are not filled with cashew nuts, to avoid scorching. This clearly shows that the hot air does not escape through the tubes freely but converges on one side of the drier.

7. The rate of flow of air is very poor. The anemometer could not record any readings, even when the drier was tested without kernels.

8. Multiple use of this drier cannot be recommended as the air flow rate is inadequate, uneven temperatures prevail inside and no mechanism is available to control the heat or the rise of temperature. Fruits & vegetables, for example, require temperatures around 50°C for drying. Grains on the other hand will require increased air flow rates for drying. Therefore, multiple use of this drier is not possible.

11. DISCUSSION:

The processing techniques in the cashew industry should aim at the maximum recovery of whole white kernels of exceptional quality. The specifications outline in detail, the stringent standards to be maintained in the production of nuts for export. Therefore, not only at the processing stage, but great care should be exercised in the subsequent handling, storage, packing and transport of kernels as stipulated in the USA standards shown in Annex III.

Artificial drying is only a link in this chain. However, every effort should be made to maximize the recovery of quality whole white kernels in the drying process too. The cashew processors when questioned as to their priorities in selection of a drier for use, expressed that they would look for characteristics such as:

1. The capability of the machine to produce whole white kernels with minimum scorching, case hardening, breakage or spoilage due to other factors.

2. A machine of manageable capacity which is fairly efficient and cost effective.

3. Women should be able to operate the machine as their services are already available for the other tasks in the processing cycle.

4. The machine should be easy to repair and maintain, preferably, using the local skills and facilities available.

5. The machine is capable of drying other food stuffs during the off season.

In addition, the village level processors expressed their desire for a machine of a capacity of 30-50 kg/hr. where as, medium scale processors opted for a capacity of 200-500 kg/hr. Both categories were of the view that the machine would remain idle for about three to four months, during the period of January to April of each year.

The exporters who were questioned on the quality of the product were mostly worried about the problem of 'spotting'. The scorching and case hardening were not a major problem as they conducted their own grading at the final stage of packing and the prices for the kernels were paid accordingly.

On the average, the exporters have experienced about 5-12% of kernels affected by 'spotting' in their shipments. Although there is no fool proof method to detect 'spotting' at the stage of processing, the problem could be minimized by adhering strictly to the recommended processing techniques, moisture contents and taking adequate precautions during peeling and packing. The steaming process tend to give lesser percentage of spots. This may be due to less damage to the kernels during the peeling operations after machine shelling.

The comparison of the three driers evaluated is shown in the chart in Annex IV. Their strengths and weaknesses were discussed earlier. All three machines have their unique characteristics. They differ from each other in their capacities, fuel used, utilizations of energy, cost effectiveness and methods of operation. There are other differences too. Mr. Ranjith Perera's drier and the ITDG drier use cashew nut shells and saw dust respectively as fuel. Such items are freely available in any village locality in cashew processing areas.

These driers are already in use and are managed by women. They blend well with the rural environment. The maintenance is easy and can be handled by the women themselves. Moreover, any major repair if necessary can be effectively taken care of, by the village carpenter or the blacksmith.

If one were to consider the efficient utilization of energy by these driers, it is very low. Most driers of such rural based technology are not efficient. Their efficiencies fall below a meager 10%. The flue gases carry away most of the heat as seen from the high outlet temperatures of the gases. However, the fuel used is cheap and available in abundance and this factor off-sets the above disadvantage. The specific recommendations are given below.

11.1 Mr. Ranjith Perera's Drier

This drier has many shortcomings. It cannot be recommended for use and to guarantee the production of quality cashew kernels. The reasons are as follows.

1. The large difference in temperature at different locations inside the drier will lead to many scorched kernels. In fact, the topmost trays are not loaded in many instances to overcome of this problem.

2. There is no appreciable movement of air inside the drier. This amounts to cooking of kernels in a humid atmosphere. The prolonged drying period (24 hours) is due to the non-removal of moist air as needed for continuous drying. A major modification to the design is necessary to correct this fault.

3. This is a technology which was practiced in India in the 1930's. If cashew nut shells are to be used as fuel, it may be worthwhile to burn the shells to generate steam and use humidification to process the nuts.

4. The kiln is a permanent structure which needs to be erected outdoors. Large quantities of burnt shells and ash need daily cleaning and maintenance. This is exhaustive work for women. Two workers are needed. The labour component cannot be reduced. This fact makes it not very cost-effective when compared with the others.

11.2 The ITDG Drier

The performance of the ITDG drier is better than that of the Mr. Ranjith Perera's drier. The main difference in performance results from the fact that the ITDG drier does not get over- heated as its temperature can be kept below 80° at all times. Thus scorching can be prevented. The cost of operation is equal in both cases, but, this design has many advantages over the former. The technology is ideally suited for the rural areas as it is simple in operation, repair maintenance is easy and raw material availability and costs (Rs. 5/= per batch) are minimum. The particular drier that was tested in this study has been in use for two years and the women who operate the machine were doing a thoroughly professional job. Two women handle the entire operation. A charge of Rs. 5/= per each kilogram of kernels dried has been levied to recover the overheads. As shown in the test report, the capital cost of the machine can be recovered in twelve months.

In spite of the above positive features, the drier cannot be recommended in its present form for production of quality kernels. It is true that the kernels dried by this drier is presently exported by one of the leading Cashew Exporters. However, few improvements should be incorporated in the present design if one were to certify it's performance as worthy enough for commercial exploitation. The following shortcomings need correction.

1. The major drawback in the ITDG drier is it's inadequate air flow. As seen from the test report, there is only a feeble flow of air when the drier is tested without any load. Once the kernels are loaded, the flow reduces to a level that cannot be recorded by the anemometer.

2. A modification must be done to correct this shortcoming. The uneven flow across the base of the drier can be corrected by installing a set of metal louvers or a grill between the lowest tray and the combustion chamber.

3. The rate of flow of air is inadequate. This should be corrected by either having forced convection of air by means of an electrically operated fan or create a suction effect by incorporating a ventilator at the top of the chimney. As the above drier is more suitable for rural areas, the second option is more relevant. A ventilator can be designed and installed on the chimney which would rotate by the outgoing exhaust fumes and made to suck the moist air from the outer tube of the chimney.

Along with the above modifications few minor changes are necessary as given below to improve it's performance further.

i. Reduction in the weight of the loading trays and the height of the drying compartment from the ground, to facilitate loading.

ii. Provision of more thermometers at different locations.

iii. Improve the mechanism for lifting of trays and make it smoother in operation.

Such changes if incorporated will reduce the requirement of labour to only one person per day. This drier would then be more efficient, cost effective and suitable for commercial production.

11.3 The NERD Drier:

The NERD drier qualifies well for immediate commercial use. Few shortcomings are there, but these could be corrected without any major modification. This drier is easy to operate and maintain, cost effective, produces a clean product in a better working environment and can be adjusted to the needs of temperature and heat of the material dried. It however, needs the following modifications to incorporated, enhance it's performance.

1. As seen from the trials on pages & of the test report, the air flow rates are not uniform over the drying chamber. Air turbulence is created in some corners. The air control flap provided is not effective. As a corrective measure, a series of metal plates should be installed at the bottom end of the drier to direct the air flow where necessary. These plates should be hinged at the middle and be capable of being adjusted to obtain equal anemometer readings at the four corners of the bottom

chamber. Once this is achieved, the plates can be welded into position. Such a modification will ensure even flow of air up the trays.

2. The two vents provided on the sides of the top chamber allow removal of moist air. However, these small openings create convergence of escaping air, thus creating hot spots. To avoid this effect, the vents should be made in the form of a grill or louvers extending along the sides which can be closed or open by means of a lever or knob from outside. Concentration of heat can be avoided thus.

3. In the present machine the probe of the thermostat is not properly located. Therefore, the dial indicates a higher value than the actual temperature inside the drying compartment. The dial may remain in the present position, but, the probe should be moved closer to the centre of the drying chamber.

4. The workmanship of the drier is poor. It should be improved. The door beading is already peeling off. The lock does not fasten properly and the air vents need improvement.

12. CONCLUSION

The NERD drier can be recommended for use in urban areas if the above improvements are affected. These changes would cost about Rs.2,000/= and can be easily incorporated. The present capacity of the drier is ideal for the very small scale processors. However, medium scale processors, for example, those in areas such as Nedagamuwa, Gampaha and Makewita, will require a bigger version of this machine which can process about 200-250 kg. per shift.

The ITDG drier can be modified to the above standard at a cost of about Rs.5,000/=. Its' capacity is adequate as it will be used only in the villages by small scale processors or individual farmers. This technology is needed in the rural areas. However, the modifications outlined in this report should be incorporated in the machine before it is recommended for commercial use.

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TERMS OF REFERENCE

POST TITLE : Consultant on evaluation of driers/ ovens for Cashew Processing in Sri Lanka.

PROJECT TITLE : Study on evaluation of driers/ ovens for Cashew Processing in Sri Lanka.

DUTY STATION : Colombo, with possible visits within the Country.

DURATION : Two (2) weeks

STARTING DATE : January 1996

BACKGROUND : AgEnt in association with EDB, Intermediary Technology Development Group (ITDG), Sri Lanka Cashew Corporation and Peoples' Bank is implementing a programme to improve quality of Cashew. Under this programme processors are to be provided with intensive training on processing of good quality Cashew. At the end of the training period it is envisaged that each of these processors will invest in a drier/ oven either through their own funds or loan funding. An evaluation of the available driers/ oven is required to enable these processors to decide on the appropriate drier. The programme will be implemented mainly in Cashew growing/ processing areas such as Puttalam in villages with different levels of infra-structure development. The objectives of the proposed programme are as follows:-

- Upgrading of quality of Cashew
- Higher value addition
- Increase investment in appropriate technology through loan funding.
- Better price and increase income to the processor.

TASKS :

1. The consultant in collaboration with ITDG and Cashew Corporation will survey the present availability of Driers/ Ovens in Sri Lanka and evaluate their merits and demerits with a view to determine inter alia the following:-

Cont'd...2/-

(a) The nature of the existing technology, its efficiency, capacity and ancillary needs. Assess the ability of the equipment to perform to produce the output of the required quality, based on feed back from the markets. Should be able to address problems such as case hardening, over roasting, black patches etc.

(b) Capacity required to meet sales forecast.

(c) Can small increments of capacity be readily added subsequently.

(d) Can the processing equipment investment/ cost be minimised.

(e) How much maintenance will the equipment require.

(f) Are the local maintenance personnel with the requisite skills available.

(g) How much idle capacity will occur due to seasonality factors.

(h) Can the technology permit multiple uses of the equipment to enable processing different raw materials.

(i) What would be the additional investment requirements to achieve this multiple use flexibility.

(j) Description of the process indicating material and energy requirements and the normal duration of the process.

(k) Accessibility of the equipment by
- people in rural areas
- women in cashew processing areas

(l) Cost effectiveness

2. On completion of the study, the Consultant will furnish a technical report to the AgEnt embodying his findings and recommendations.

Annex II

TEST REPORT

THE OBJECTIVE

To test the performance of three driers used for processing of cashew nuts, with the intention of selecting the most appropriate one for the small scale cashew processors.

MATERIALS AND METHODS

The following parameters were measured to evaluate the performance of each machine with the equipment listed below.

1. The weight of the cashew kernels dried per batch.

2. The moisture content of the cashew kernels before and after drying.

3. The pattern for air flow through the drier.

4. The inside temperature of the drier at various locations at 1/2 hour intervals.

5. The energy consumption during the drying operations.

6. The temperature of the surroundings and outlet temperature of the flue gases.

EQUIPMENT USED (See Photos 15, 16,17)

Parameter measured	Instrument used	Type and Model	Measuring range	Accuracy
1. Temperature	Probe thermometer	Kyowa/Japan	0-1000°c	± 0.1%
2. Elec. Power	Digital Multi-meter	Kyowa/Japan	0-500v 0-20 Amp.	± 0.1%
3. Moisture	Digital Moisture tester	Seed Buro equip company U.S.A. Burrow 700	Best 5%~ 35%	± 0.1%
4. Air flow rate	Thermistor Anemometer	Ogawa Seiki Co. Ltd. Japan OSK 7124-A	0-5-40 m/s 0 - 120° C	± 3% ± 0.5 °C
5. Weight	Weighing scale	Waymaster U.K. 911 D	0-5 kg.	± 2 %

THE TYPES OF DRIERS TESTED

Three types of dryers were tested as requested by the Cashew Corporation, namely;

1. The Drier manufactured by the National Engineering Research and Development Centre, Ekala (NERD drier)

2. The Drier manufactured by the Intermediate Technology Development Group (ITDG drier)

   and

3. The drier belonging to Mr. Ranjith Perera of Makewita.

The driers were tested in the exact manner in which they are used normally during the season to dry cashew kernels. This includes the use of skilled workers who operate the machine, observing same operating times and maintaining the exact loading and unloading procedures.

It was originally planned to carry out at least 3 trials per machine, but due to the limited supply of nuts available, the number of trials was restricted to a total of five.

Two trials on the NERD drier and two trials on the ITDG drier were carried out. The third drier was tested only once as it required 100 kg. of cashew nuts per trial. Moreover, it was felt that a second trial on this drier was not necessary as it's performance was far below that of the other two. Few obstacles were encountered during the measurement phase as follows:

1. There was no provision in the driers for measuring the temperature above each of the trays. Therefore, the temperatures at the level of the top, bottom and middle trays were measured.

2. The air flow rates in some instances were of very low values and the anemometer could not record them.

3. It was not possible to measure the inlet or exhaust temperature of the flue gases in some driers.

THE TESTING PROCEDURE

1. Each drier was put into operation in the exact manner as it is used in normal day to day operation.

2. The cashew kernels were weighed and equal quantities were put into the trays of the drier.

3. The initial moisture content of the cashew kernels was recorded by taking three random samples each from the trays before they were loaded to the drier. A sample size of 250 gms. of kernels was used in the Burrows digital moisture meter for measurement.

4. The ambient temperature, initial temperature inside the drier and the temperature of the exhaust fumes were recorded with the probe thermometer.

5. The trays filled with kernels were then loaded into the drier and the doors closed.

6. The temperatures of the air in the vicinity of the bottom, middle and top trays were noted by inserting the probe of the thermometer through openings provided in the drier. The instrument was held in the hand while the probe stayed inside the drier. Care was taken to record the reading when it became stabilized. These temperature readings were noted for every 30 minutes of operation.

7. The air flow pattern in each tray was noted immediately after temperature measurement. This was done by means of the anemometer probe. The probe was moved to the four corners of the drier for measurement and the values recorded. The anemometer probe can also be used with change of switch control position to measure the temperature and it served as a double check of the temperatures recorded earlier.

8. The trays were shifted during drying in the same way as practised during a normal days operation of the dryer. This operation was not necessary in the case of the NERD drier.

9. The trays were unloaded at the specific times of unloading relevant to each drier and the moisture content of kernels checked as before, taking three samples each from the same trays listed above. The measurement was taken after the kernels have cooled down to ambient temperature.

10. The energy consumption in each drier was checked by measuring the quantity of fuel burnt. In the case of the NERD drier, the continuous recording of the current drawn and the voltage supplied was carried out ascertain the power consumption.

THE RESULTS

TABLE - 1

NERD DRIER - MEASUREMENT OF TEMPERATURE AT HALF-HOUR INTERVALS - (TRIAL 1)

1.	Max Capacity of drier	= 60 kg
2.	No. of trays	= 12
3.	Wt. of cashew nuts/tray	= 03 kg
4.	Total wt of cashew nuts	= 36 kg
5.	Starting time	= 9.00 hours
6.	Stopping time	= 13.30 hours

Time	Amb temperature (°c)	Drier temperature (°c)						Outlet temperature (°c)
		Top tray		Middle tray		Bottom tray		
		Front	Rear	Front	Rear	Front	Rear	
9.00	30	30	30	30	30	30	30	-
9.30	30	43	43	45	45	49	49	43
10.00	31	45	45	49	49	60	60	47
10.30	31	57	57	62	62	66	66	56
11.00	31	61	61	61	61	66	66	58
11.30	32	61	61	61	61	66	66	58
12.00	32	62	62	63	63	66	66	60
12.30	33	64	64	65	65	68	69	60
13.00	33	63	63	64	64	67	67	61
13.30	33	63	63	63	63	67	67	62

TABLE - 2

NERD DRIER - MEASUREMENT OF TEMPERATURE AT HALF-HOUR INTERVALS - (TRIAL 2)

1. Max Capacity of drier = 60 kg
2. No. of trays = 12
3. Wt. of cashew nuts/tray = 03 kg
4. Total wt of cashew nuts = 36 kg
5. Starting time = 9.00 hours
6. Stopping time = 13.30 hours

Time	Ambient temperature °C	Oven temperature (°c)			Outlet temperature (°c)
		Top shelf	Middle	Bottom	
9.00	30	30	29	29	-
9.30	31	48	42	38	37
10.00	32	60	48	40	42
10.30	32	65	58	53	53
11.00	32	65	61	56	58
11.30	32	66	62	58	59
12.00	32	66	64	59	60
12.30	32	66	64	61	61
13.00	32	66	64	61	60
13.30	33	67	63	62	60

TABLE - 3

NERD DRIER - POWER CONSUMPTION - (TRIAL 1)

T = Time I = Current in Amps. V = Voltage in volts.

T	9.00	9.10	9.12	9.15	9.16	9.17	9.18	9.20	9.22
I	10	4	10	4	10	4	10	4	10
V	211	219	214	217	210	217	210	219	212

T	9.25	9.29	9.31	9.37	9.38	9.51	10.35	10.40	10.41
I	4	10	4	10	4	10	4	4	10
V	219	211	220	210	219	214	216	218	210

T	10.45	10.46	10.48	10.50	10.54	10.55	10.59	11.00	11.03
I	10	10	4	10	4	10	4	10	4
V	211	211	220	219	219	212	220	212	220

T	11.05	11.07	11.09	11.11	11.14	11.15	11.18	11.20	11.22
I	10	04	10	04	10	4	10	4	10
V	206	213	208	213	208	216	209	216	210

T	11.24	11.27	11.29	11.31	11.33	11.41	11.42	11.44	11.46
I	4	10	4	10	4	10	4	10	4
V	216	211	215	208	215	209	216	211	215

T	11.48	11.50	11.52	11.55	11.57	11.59	12.02	12.04	12.06
I	10	4	10	4	10	4	10	4	10
V	209	212	206	216	212	222	216	224	214

T	12.09	12.11	12.13	12.16	12.18	12.22	12.23	12.28	12.31
I	4	10	4	10	4	10	4	10	4
V	224	216	222	221	223	218	225	219	216

T	12.34	12.37	12.39	12.41	12.45	12.47	12.51	12.52	13.05
I	10	4	10	4	10	4	10	4	4
V	211	212	209	218	210	217	209	213	211

T	13.07	13.18	13.20	13.25	13.30	13.33	13.35		
I	4	4	10	4	10	4	10		
V	222	222	222	222	222	220	216		

TABLE - 4

NERD DRIER - POWER CONSUMPTION - (TRIAL 2)

T = Time I = Current in Amps. V = Voltage in volts.

T	9.00	9.07	9.12	9.15	9.17	9.20	9.25	9.27	9.30
I	10	4	10	4	10	4	10	4	10
V	219	214	211	217	210	217	219	212	218

T	9.33	9.37	9.38	9.40	9.45	9.47	9.55	9.59	10.00
I	4	10	4	10	4	10	4	10	4
V	210	213	213	216	220	212	218	212	211

T	10.11	10.15	10.17	10.25	10.31	10.40	10.46	10.48	11.00
I	10	4	10	4	10	4	10	4	10
V	217	209	216	224	216	218	219	218	220

T	11.05	11.11	11.15	11.18	11.22	11.28	11.33	11.46
I	4	10	4	10	4	10	4	10
V	218	220	209	216	219	220	216	220

T	11.52	11.55	11.57	12.02	12.04	12.08	12.16	12.17
I	10	4	10	4	10	4	10	4
V	217	211	225	216	211	209	224	220

T	12.28	12.34	12.37	12.40	12.42	12.45	12.48	12.50
I	4	10	4	10	4	10	4	10
V	211	209	220	217	213	214	218	218

T	13.05	13.07	13.15	13.18	13.20	13.25	13.30	
I	4	10	4	10	4	10	4	
V	220	222	210	218	220	218	220	

TABLE - 5 **NERD DRIER - MOISTURE CONTENT OF CASHEW KERNELS BEFORE & AFTER DRYING - (TRIAL 1)**

No. of Sample	Top tray		Middle tray		Bottom tray	
	Before drying	After drying	Before drying	After drying	Before drying	After drying
1	5.8	2.4	5.8	2.4	5.8	2.4
2	5.8	2.4	5.8	2.4	5.8	2.5
3	5.8	2.4	5.7	2.4	5.8	2.3

TABLE - 6 NERD DRIER - MOISTURE CONTENT OF CASHEW KERNALS BEFORE & AFTER DRYING - (TRIAL 2)

No. of Sample	Top tray		Middle tray		Bottom tray	
	Before drying	After drying	Before drying	After drying	Before drying	After drying
1	5.8	2.6	5.8	2.6	5.0	2.7
2	5.8	2.6	5.9	2.6	6.0	2.6
3	5.8	2.7	5.9	2.5	5.8	2.7

TABLE - 7 NERD DRIER - AIR FLOW RATES (m/s) - (EMPTY DRIER)

Level of Measurement	Front Left Corner	Rear Left Corner	Front Right Corner	Rear Right Corner
Top Tray	4.5	1.0	5.0	5.0
Middle tray	1.5	2.0	2.0	2.0
Bottom tray	2.5	1.0	0	3.0

TABLE - 8NERD DRIER - AIR FLOW RATES (m/s)-(LOADED WITH KERNELS - 36 kg)

Level of Measurement	Front Left Corner	Rear Left Corner	Front Right Corner	Rear Right Corner
Top tray	1.1	0.8	0.5	
Middle tray	0.3	3.5	3.5	
Bottay tray	0.4	1.0	3.5	

NERD DRIER - COST OF OPERATION

1. Capital cost = Rs. 32,000/=
2. Maintenance cost = Rs. 2000/= per year
3. Cost of Electricity = Rs. 4/= per unit
4. Cost of labour = Rs.150/= per hea

Assumptions

* The drier has a capacity of 60 kg per shift.
  It is possible to work two shifts per day.

* No. of days of operation per year is 200

* Only one worker is required to operate the machine.

* Drier has 5 yrs of trouble free operation and no salvage value.

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Calculation

Capital + maintenance cost per day = $\frac{\text{Rs. } 32{,}000+2000\text{x } 5}{200 \text{ x } 5}$

= Rs. 42

Cost of Electricity per day = $\frac{\text{Rs. } 7 \text{ x } 220 \text{ x } 9 \text{ x } 4}{1000}$

= Rs. 56

Labour cost per day = Rs. 150
Total operation cost per day = Rs. (150+56+42)

= Rs. 248/=

Cost per kilo = $\frac{\text{Rs. } 248}{120}$

= Rs. 2.06

Return on Investment

Charge for drying = Rs. 5 per kilo

Hence Income per day = Rs. 5/= x 120

= Rs. 600/=

Net profit per day = Rs. (600 -248)
= Rs. 352

Net profit per year = Rs. 352 x 200
= Rs. 70400

The capital and yearly maintenance cost amount to **Rs. 34,000**

Therefore, the pay back period is approximately 6 months.

TABLE - 9

ITDG DRIER - MEASUREMENT OF TEMPERATURE AT HALF-HOUR INTERVALS - (TRIAL 1)

1. Max Capacity of drier = 36 kg
2. No. of trays = 6
3. Wt. of cashew nuts = 4.545 kg per tray
4. Starting time = 10.00 hrs.
6. Stopping time = 14.30 hrs.
7. Weight of saw dust = 20 kg.

Time hrs.	Amb Temp c°	DRIER TEMPERATURE C°						Flue gas Temperature c°	
		Bottom Shelf		Middle Shelf		Top Shelf			
		Front	Rear	Front	Rear	Front	Rear	Inlet	Exhaust
10.00	34	34	34	34	34	34	34	36	36
10.30	34	73	76	48	51	42	44	345	165
11.30	35	76	79	44	45	36	38	356	172
11.30	36	80	82	48	50	41	42	370	186
12.00	36	80	80	50	52	45	46	360	158
12.00	35	70	71	54	56	44	46	358	176
13.00	36	80	81	51	52	45	46	391	220
13.00	33	73	74	53	55	43	46	374	187
14.00	34	76	80	54	54	48	50	349	176
14.30	35	80	81	56	57	49	52	352	180

Mr. Ranjith Perera's Drier - cost of operation

1. Capital cost = Rs. 15,000
2. Maintenance cost = Rs. 1,000
   (Re-lining of furnace compte replacement of iron pipes)
3. Cost of cashew shells = Free
4. Cost of labour = Rs. 150 x 2

Assumptions

* The drier can process 100 kg of kernels per day
* 200 days of operation per year
* 2 workers are required to operate the driver
* Life of driver to be 5 years without major overhaul and no salvage value thereafter.

Calculation

Capital + Maintenance cost per day = Rs.15,000 ± 5 x 1000 / (5 x 200)
= Rs. 20

Cost of labour per day = Rs. 150 x 2
Cost of cashew shells per day = Rs. 300
= Free
Total operation cost per day = Rs. (300 + 20)
= Rs. 320/=

Cost of operation per kilo = Rs. 320/100
= Rs. 3.20

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Note

No air flow readings could be obtained in the case of this drier as the air velocities were very low. The Anemometer did not register any readings even without any load.

TABLE -10

ITDG DRIER - MEASUREMENT OF TEMPERATURE AT HALF-HOUR INTERVALS - (TRIAL 2)

1. Max Capacity of drier = 36 kg
2. No. of trays = 6
3. Wt. of cashew nuts per tray = 6 kg
4. Starting time = 14.30 hrs.
6. Stopping time = 19.00 hrs.
7. Weight of saw dust = 20 kg.

Time hrs.	Amb Temp c°	DRIER TEMPERATURE C°						Flue gas Temperature (c°)	
		Botton Shelf		Middle Shelf		Top Shelf			
		Front	Rear	Front	Rear	Front	Rear	Inlet	Exhaust
14.30	34	34	34	34	34	34	34	34	34
15.00	34	73	76	60	61	41	44	317	147
15.30	34	76	79	43	45	36	38	325	149
16.00	33	80	2	48	50	40	42	370	203
16.30	32	79	80	51	52	45	46	358	180
17.00	31	68	71	55	56	44	46	328	134
17.30	31	80	81	50	52	45	46	368	293
18.00	31	73	74	54	55	45	46	330	171
18.30	31	78	80	51	54	48	50	360	198
19.00	31	82	74	54	57	49	52	362	187

TABLE - 11

ITDG DRIER - MOISTURE CONTENT OF CASHEW KERNELS BEFORE & AFTER DRYING - (TRIAL 1)

No. of Sample	Top tray		Middle tray		Bottom tray	
	Before drying	After drying	Before drying	After drying	Before drying	After drying
1	6.2	2.3	6.0	2.1	6.0	2.3
2	6.1	2.2	6.3	2.1	6.3	2.4
3	6.2	2.3	6.2	2.1	6.1	2.5

TABLE - 12

ITDG DRIER - MOISTURE CONTENT OF CASHEW KERNELS BEFORE & AFTER DRYING - (TRIAL 2)

No. of Sample	Top tray		Middle tray		Bottom tray	
	Before drying	After drying	Before drying	After drying	Before drying	After drying
1	6.0	2.1	6.0	2.3	6.0	2.4
2	6.1	2.2	6.0	2.4	6.2	2.4
3	6.0	2.1	6.0	2.4	6.1	2.6

TABLE - 13

ITDG DRIER - AVERAGE AIR FLOW RATES (m/s) - (EMPTY DRIER)

Level of Measurement	Front Left Corner	Rear Left Corner	Rear Right Corner	Rear Right Corner
Top tray	0	0	0	0
Middle tray	.05	0.1	.05	0.1
Bottom tray	0.1	0.2	0.1	0.2

TABLE - 14

ITDG DRIER - AVERAGE AIR FLOW RATES (m/s)

Level of Measurement	Front Left Corner	Rear Left Corner	Rear Right Corner	Rear Right Corner
Top tray	0	0	0	0
Middle tray	0	0	0	0
Bottom tray	0	0	0	0

(WHEN LOADED WITH KERNELS)

ITDG DRIER - COST OF OPERATION

1. Capital cost = Rs. 25,000/=
2. Maintenance cost = Rs. 1000/= per year
   [Replacement of M.S. pipes and the burner each year]
3. Cost of sawdust = Rs. 800/= per cube
   = Rs. 24 per filling
4. Cost of labour = Rs. 150 per head

Assumptions

* 36 kg. of kernels can be dried in a shift. Three shifts per day can be done.

* The expected number of days of operation per year is 200.

* Two workers are required to operate the drier.

* The drier is considered to withstand 5 yrs of trouble free operation. No salvage value thereafter.

Calculation

Capital and maintenance cost per day	$= \frac{25000+1000 \times 5}{200 \times 5}$
	= 30
Cost of labour per day	= Rs. 150 x 2 = Rs. 300/=
Cost of saw dust	= Rs. 5 x 3 = Rs. 15/=
Total operational cost per day	= Rs. (30+300+15)
	= Rs. 345/=
Cost / kilo	= Rs. 345/108 = 3.20/=

Return on Investment

Present charges levied for drying	= Rs. 5/= per kilo
Hence income per day	= Rs. 5 x 108 = Rs. 540
Net profit per kg.day	= Rs. (540/= - 402)
	= Rs. 138/=
Net profit per year	= Rs. 138 x 200
	= Rs. 27600/=

The capital and the 1st years maintenance costs amount to **Rs. 26,000/=**. Therefore, the payback period in approximately one year.

TABLE - 15

MR. RANJITH PERERA'S DRIER - MEASUREMENT OF TEMPERATURE AT HALF-HOUR INTERVALS - (TRIAL 1)

1.	Max Capacity of drier	= 100 kg
2.	No. of trays	= 24
3.	Wt.of cashew nuts/tray	= 4.545 kg
4.	Starting time	= 8.00 a.m.
5.	Stopping time	= 4.30 p.m.

Note:

* Furnace is fired at 8.00 a.m., but the cashew kernels are loaded to the drier at 10.00 a.m.

* The temperature stabilize after 4-5 hours but the unloading of kernels is done only the morning after.

Time	Ambient temperature °C	Oven temperature in (°c)			
		Bottom Right	Bottom Left	Top Right	Top Left
10.00	33	53	49	85	145
10.30	33	49	49	80	128
11.00	34	44	49	75	115
11.30	34	44	46	70	102
12.00	34	43	44	68	95
12.30	34	43	44	66	90
13.00	34	43	43	64	86
13.30	34	43	43	63	85
14.00	35	42	42	60	84
14.30	34	42	42	60	84
15.00	34	42	42	60	84
15.30	34	42	42	60	84
16.00	33	42	42	60	84
16.30	33	42	42	60	84

No. of Sample	Top tray		Middle tray		Bottom tray	
	Before drying	After drying	Before drying	After drying	Before drying	After drying
1	5.5	2.7	5.7	2.4	5.5	2.3
2	5.6	2.7	5.6	2.3	5.5	2.3
3	5.4	2.5	5.6	2.4	5.6	2.2

Annex III

STANDARDS AND SPECIFICATIONS-USA
Adopted by the Nut & Agricultural Products Section of the American Association of Food Industries, February 1990

General Requirements
Each shipment inspected or released by FDA shall be of good quality, cleared by customs, and stored in accordance with good commercial practice.

The cashews shall be packed in new, clean, dry, leak proof containers with an airtight (hermetic) seal and without internal paper liners. Packaging shall be of sufficient strength to assure the integrity of the product during normal shipment and storage.

The outer container shall be constructed of a new cardboard, free of infestation and visual mold, and sealed without staples, unless otherwise specified by the end user. Moisture levels of the cashews should be in the range of 305 per cent.

All cartons shall be clearly marked on each end with the following:
1. Name of the product and trade name or brand name, if any
2. Name and address of producer or packer
3. Grade
4. net weight
5. Country of Origin
6. Buyer's name or marks
7. Destination
8. Crop year, and date of packing (if known)
9. Reference to AFI specifications

Bill of Lading must list the number of cartons, source of origin, and the marks that are on the cartons.

Preclude quality deterioration of nuts
All handling, processing, storage and transporting operations shall be conducted under those conditions of temperature and humidity necessary to preclude quality deterioration of the nuts. Fluctuations in temperature and relative humidity should be avoided to protect the integrity of the product. Fumigation is permitted in conformity with FDA regulations, except that methyl bromide & EDB may not be used.

Damage - any defect described in the specifications which materially detracts from the appearance of a kernel or of a lot, and lessens their marketing quality.

Shriveled - the kernel is materially shrunken, wrinkled, and tough.

Fancy Cashew Kernels - Whole, First Quality

ıdian/African ıaracteristics ɜsignation	Brazilian Grade Designation	Counter Per Lb. Size Description	General Characteristics
ı80	SLW1	160-180	Cashew kernels have been obtained through shelling and peeling cashewnuts. (Anacardium occidental) shall have the characteristic shape; shall be white, pale ivory or light ash in colour, reasonably dry, and free from insect damage, damaged kernels and black or brown spots. They shall be completely free from rancid kernels. The kernels shall have a reasonably uniform appearance when roasted.
	LW 1	180-210	
210	-	200-210	
240	W1-240	220-240	
320	W1-320	300-320	
450	SW or W1-450	400-450	
-	W1	mixed sizes	

'olerance: Broken kernels and kernels of the next lower grade, if any, shall .ot together exceed 5 percent at time of packing. Broken kernels shall not :xceed 10 percent at port of entry/discharge.

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Tolerance : Broken kernels and kernels of the next lower grade, if any, shall not together exceed 5 percent at time of packing. Broken kernels shall not exceed 10 percent at port of entry/discharge.

Fancy Cashew Kernels - Broken, First Quality

Indian African Desig.	Brazilian Grade Designation	Trade Name	Blemish	General Characteristics
FB	B1	Butts	Kernels broken crosswise and naturally attached	Cashew kernels shall have been obtained by shelling and peeling cashewnuts (Anacardium occidental), shall be white, pale ivory or light ash in color, reasonably dry, and free from insect damage, damaged kernels and black spots. They shall be free from rancid kernels. The pieces shall be free from testa, and reasonably uniform in sizes.
FS	S1	Splits	Kernels split naturally lengthwise	
LWP White	P1 broken	Large Pieces	Kernels into more than two pcs. and not passing through a 4 msh 16 SWG sieve.	
SWP	SP1	Small White Pieces	Broken kernels smaller than those described as LWP but not passing through a 6 mesh 20 SWG sieve.	
	SSP1	Small Brazil-ian pieces	Broken kernels smaller than those described as SWP or SP1 but not passing through an 8 mesh 20 SWG sieve.	
BB	G1	Baby Bits or Granu-les	Plemules and broken kernels smaller than those described as SWP or SP1.	

corched Cashew Kernels - Broken, Second Quality

ian ican de ignation	Brazilian Grade Designa-tion	Trade Name	Description	Blemishes	General Characteristics
		Dessert Pieces	Kernels broken into pieces but not passing through 4 mesh 16 SWG sieve	More shrivelled than those described as SPS and deeply scorched and may be black spotted.	Cashew kernels shall have been obtained by shelling and peeling cashewnuts (Anacardium occidental), shall be reasonably dry, and free from insect damage
		Small Dessert	Kernels of the same description as above but smaller than DP and not passing through 6 mesh 20 SWG sieve.	Same as DP	be deep brown, or deep bl in color. They shall be free from rancid kernels. Pieces shall be reasonably uniform in size.
		Dessert Butts	Kernels broken crosswise and naturally attached.	Same as DP	
		Dessert Splits	Kernels split naturally lengthwise.	Same as DP	

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ANNEX IV

CHART 1 COMPARISON OF PERFORMANCE OF THE THREE DRIERS

ITEM	NERD CENTRE DRIER - A	ITDG DRIER - B	Mr.RANJITH PERERA'S DRIER C	RATING
a 1 Nature of Technology	More suited for urban areas	Rural Based	Rural based	
2 Capacity	12 kg/hr	9kg/hr	5 kg/hr	
3 Ancillary needs	230v, 50hp A. C supply	Rice husk/saw dust as fuel	Cashew shells as fuel	A ****
4 Quality of product	Good	Good	Fair	B ***
5 Problems	None	Insufficient air flow	Un-even drying of material	C *
6 Scope for improvement	Yes	Yes	Yes	
7 Overall performance	Very good	Good	Poor	
b Capacity Required to meet sales forecast	200 kg/day	200 kg/day	200 kg/day	
c Can small increments of capacity be subsequently added	No	No	No	
d Can processing equipment investment cost be minimized	No	No	No	
e Maintenance requirement	Minimum	Easy but needs to be done daily	Comparatively difficult needs to be done daily	A *** B ** C *
f Local maintenance skill available or not	Yes - but an electricians service is necessary	Yes	Yes	
g How much idle capacity will occur due to seasonality factors.	3 Months max.	3 Months max.	3 Months max.	
h Possibility of multiple use of present technology	Yes for drying of fruits, vegetables and grain legumes	Yes-with modification for drying of fruits & vegetables	Not possible	A *** B *** C -
i Additional investment required to achieve multiple use	Rs. 2000	Rs. 5,000	Not possible	
j Cost to process 100kg of cashew kernels				
i Energy requirement	Rs. 47	Rs. 14	Rs. 0 (Cashew shells)	A ***
ii Man power requirement	Rs. 125	Rs. 278	Rs. 300	B **
iii Overheads	Rs. 35	Rs. 28	Rs. 20	C **
iv Total	Rs. 207	Rs. 320	Rs. 320	
k Accessibility of equipment by:	Limited			A **
- People in rural areas	Only if electrical power	Yes	Yes	B ***
- Women in cashew pr areas	is available	Yes	Yes	C ***
l Cost effectiveness	Very efficient	Efficient	Fair	A **** B *** C **

Rating: **** - Very good *** - Good ** - Fair * - Poor

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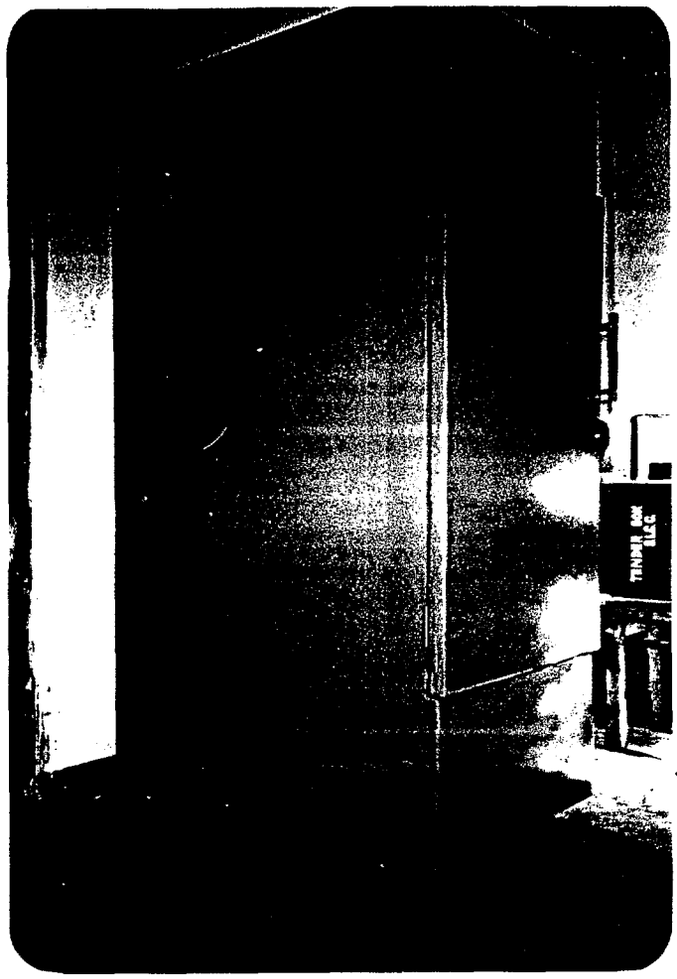

Photo 1 The NERD Drier with the control panel in view

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Photo 2. The NERD Drier when empty

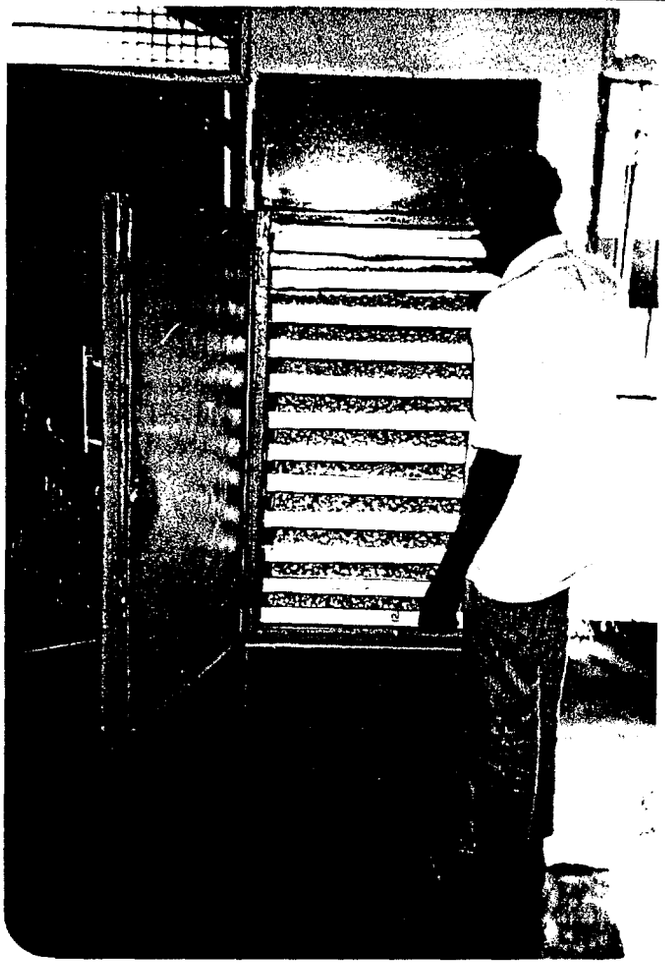

Photo 3 Loading of trays to the NERD Drier

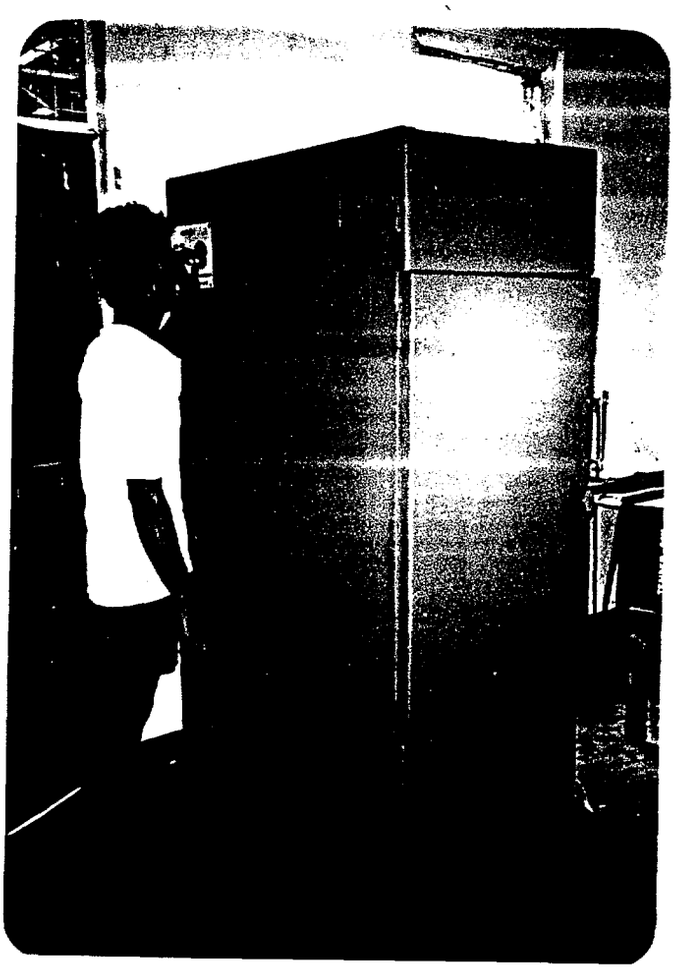

Photo 4. The NERD Drier with all trays loaded

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Photo 5 The ITDG Drier - Side View

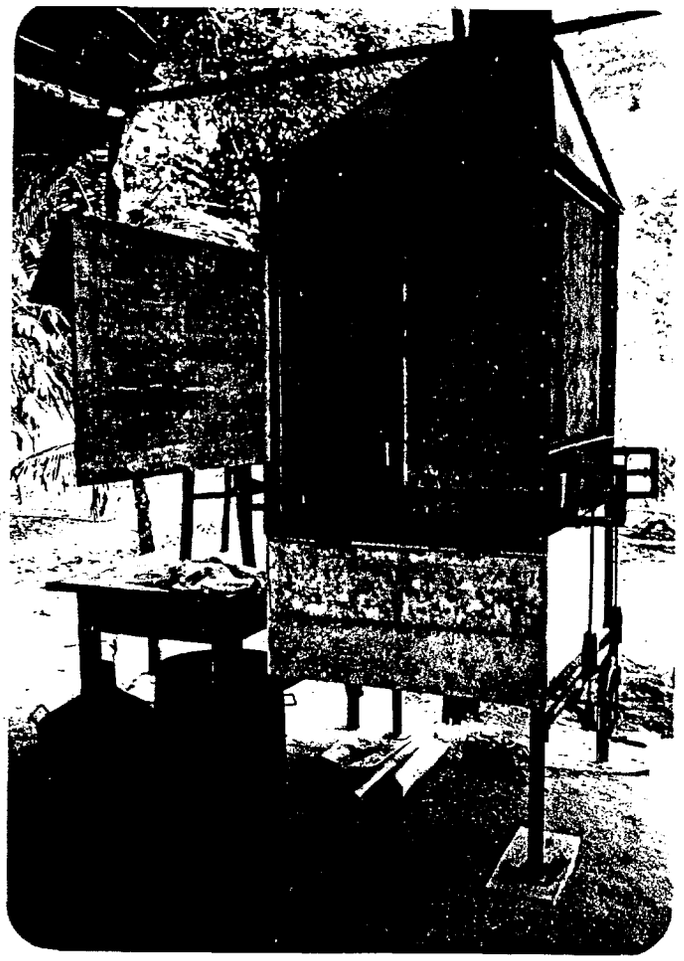

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Photo 6. The ITDG Drier - with door and flaps open

Photo 7 The ITDG Drier with only five trays loaded

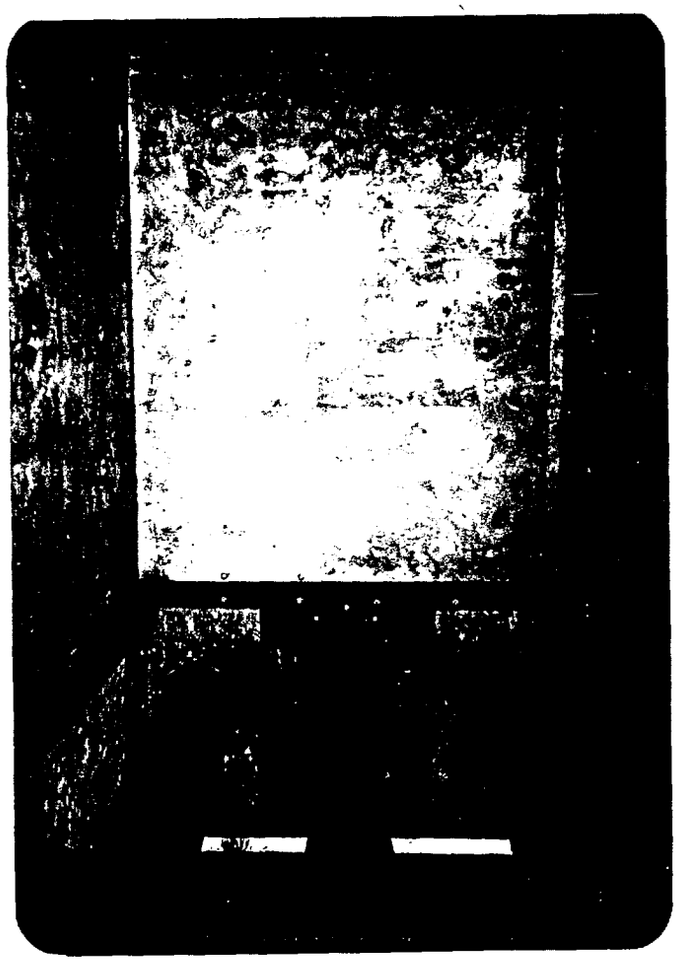

Photo 8. The heat exchanger tubes of the ITDG Drier

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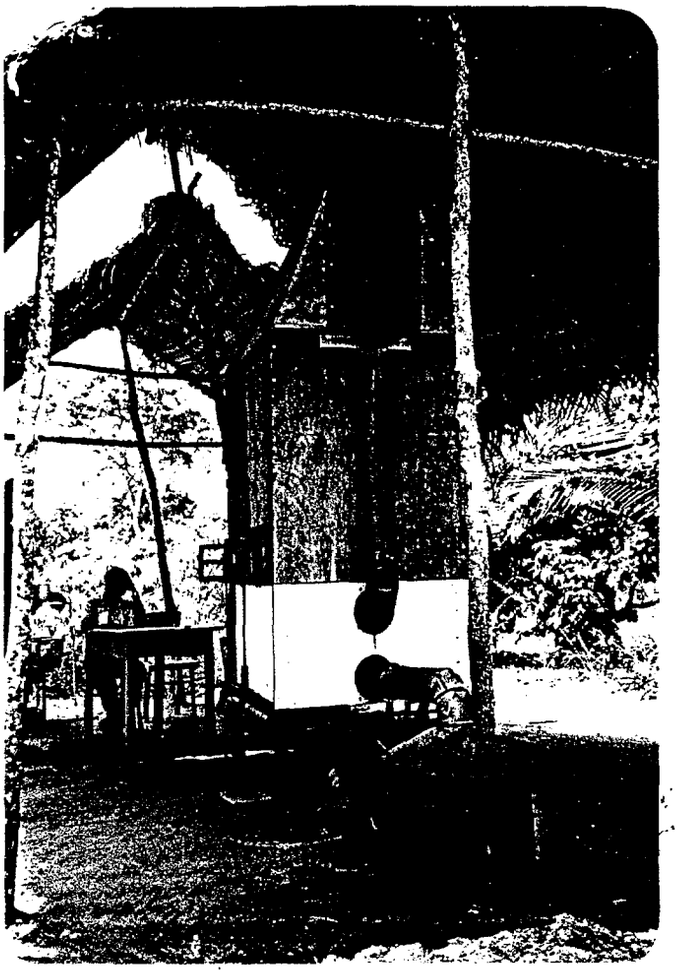

Photo 9 The ITDG Drier back view and stove

Photo 10 The stove and its lid

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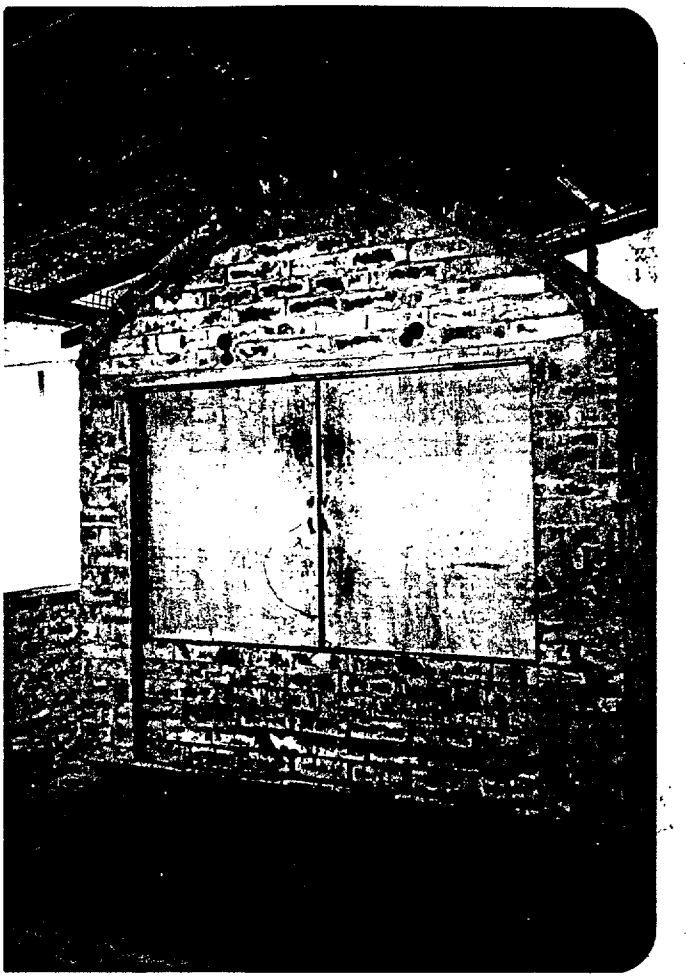

Photo 11 Mr. Ranjith Perera's Drier

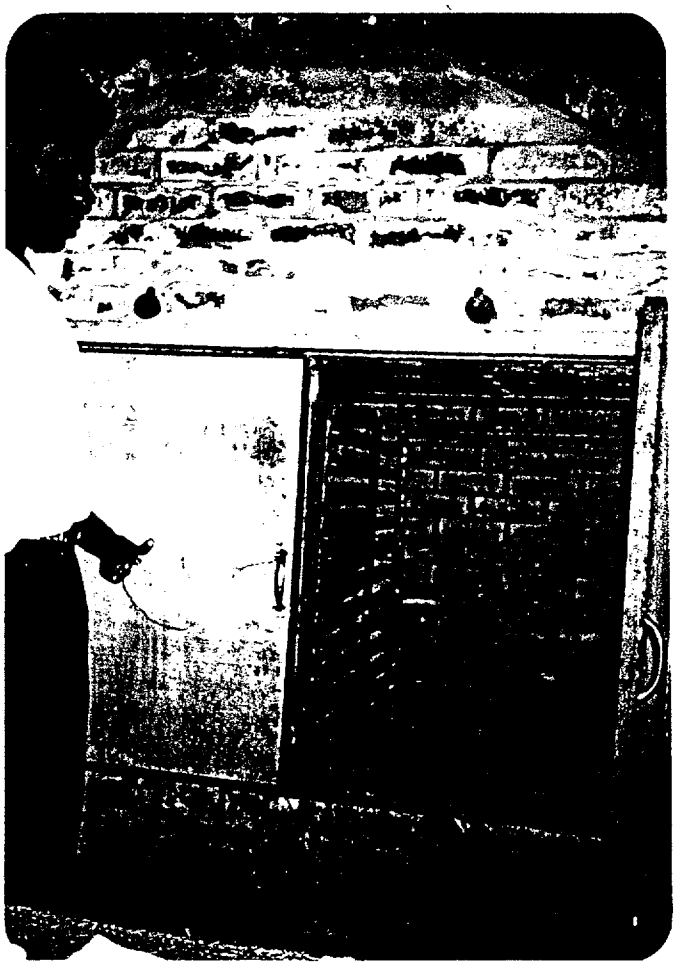

Photo 12 The inside of Mr. Perera's Drier

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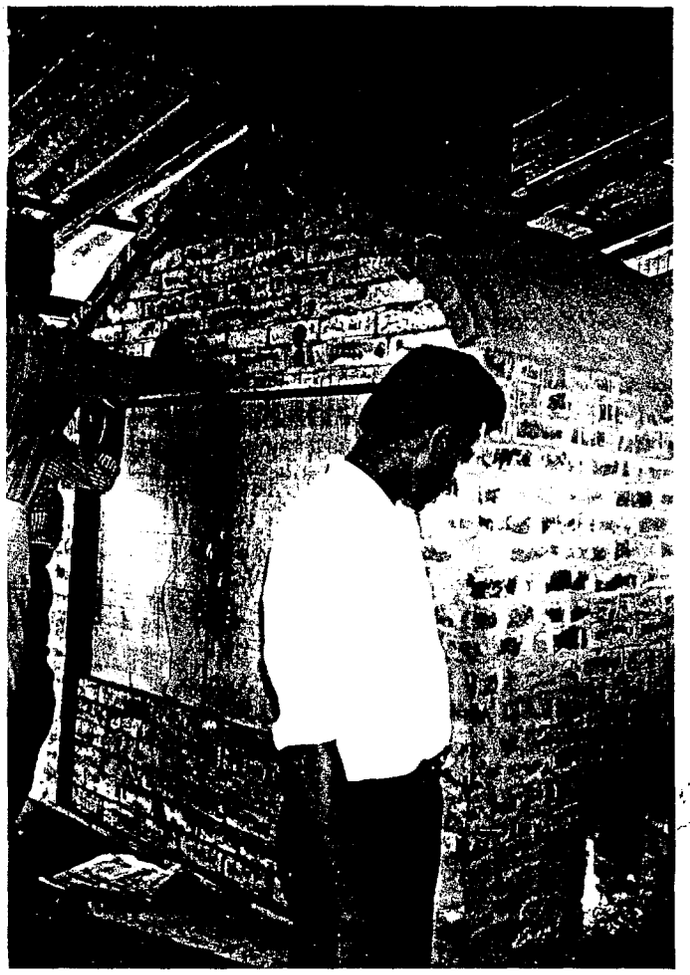

Photo 13 View of the furnace of Mr. Perera's Drier

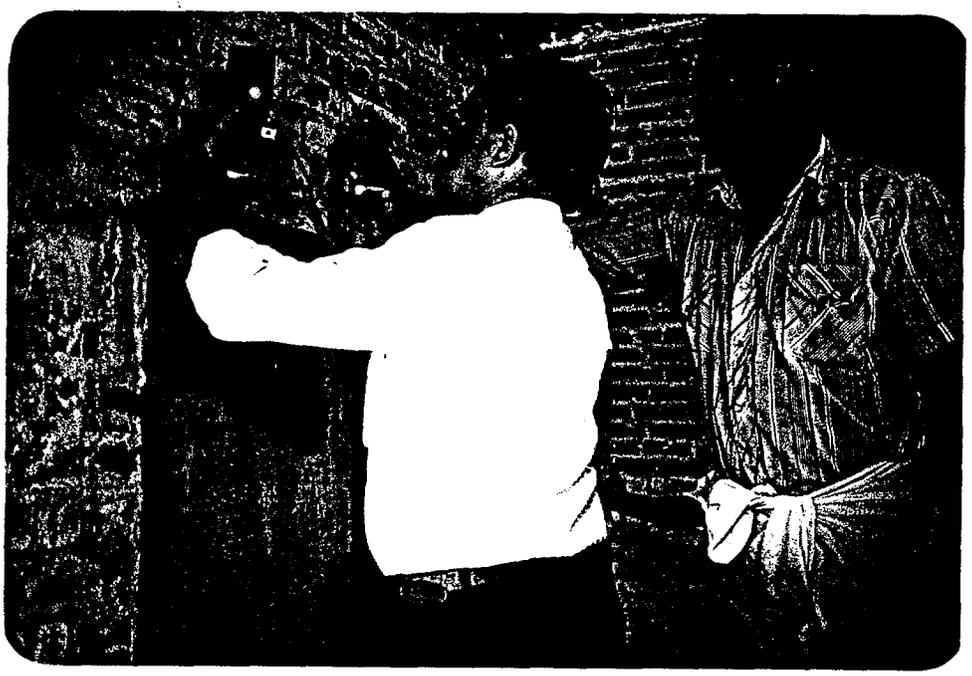

Photo 14. Measuring of temperature of Mr. Perera's Drier

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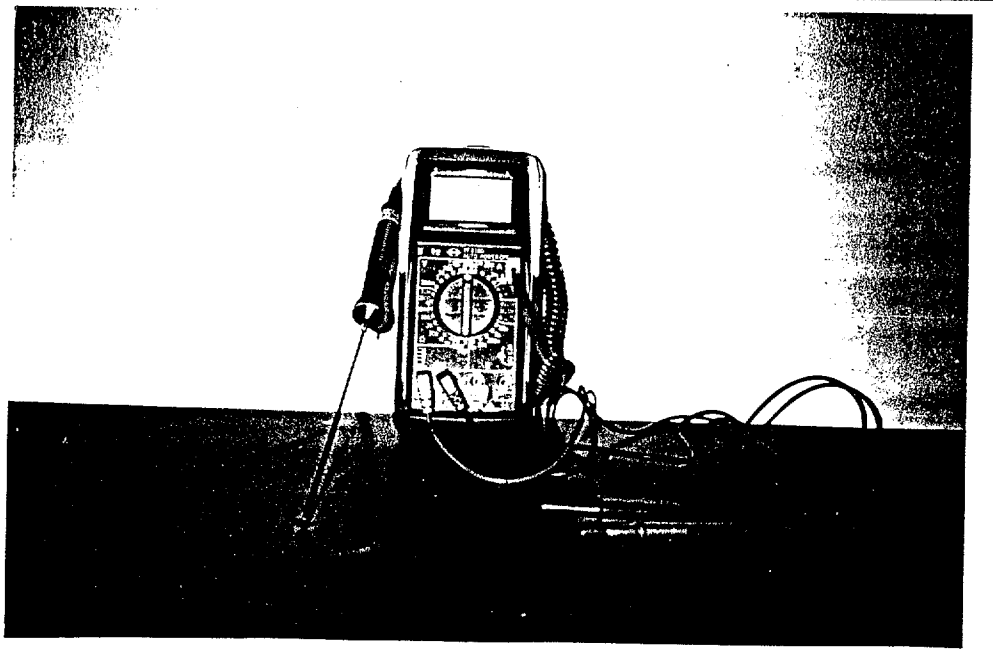

Photo 15. The Multimeter

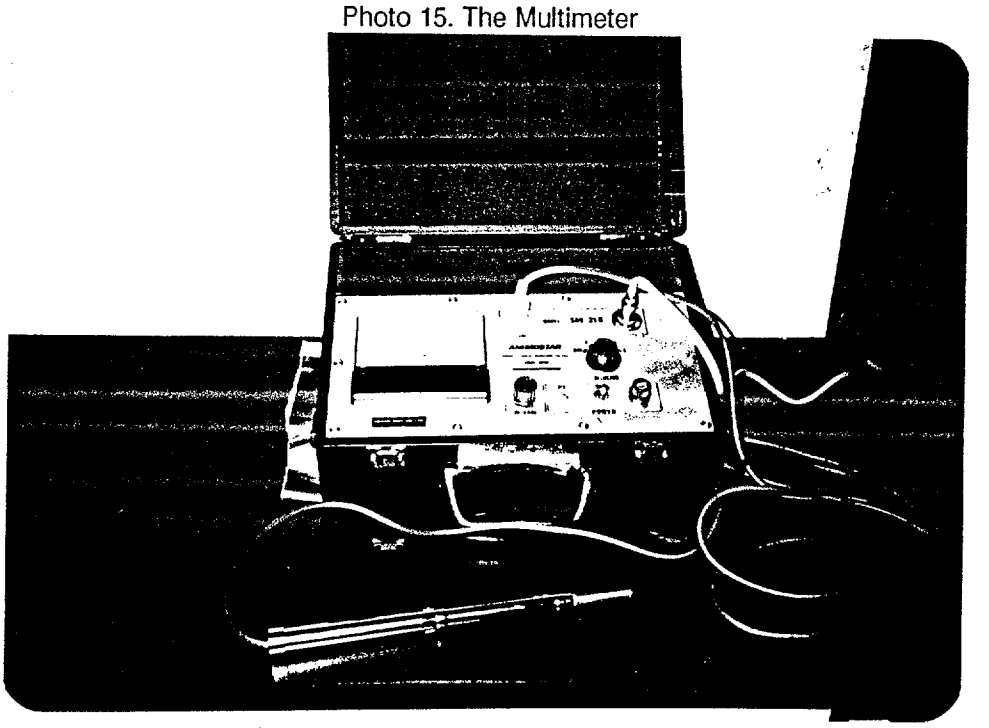

Photo 16. The Thermistor Anemometer

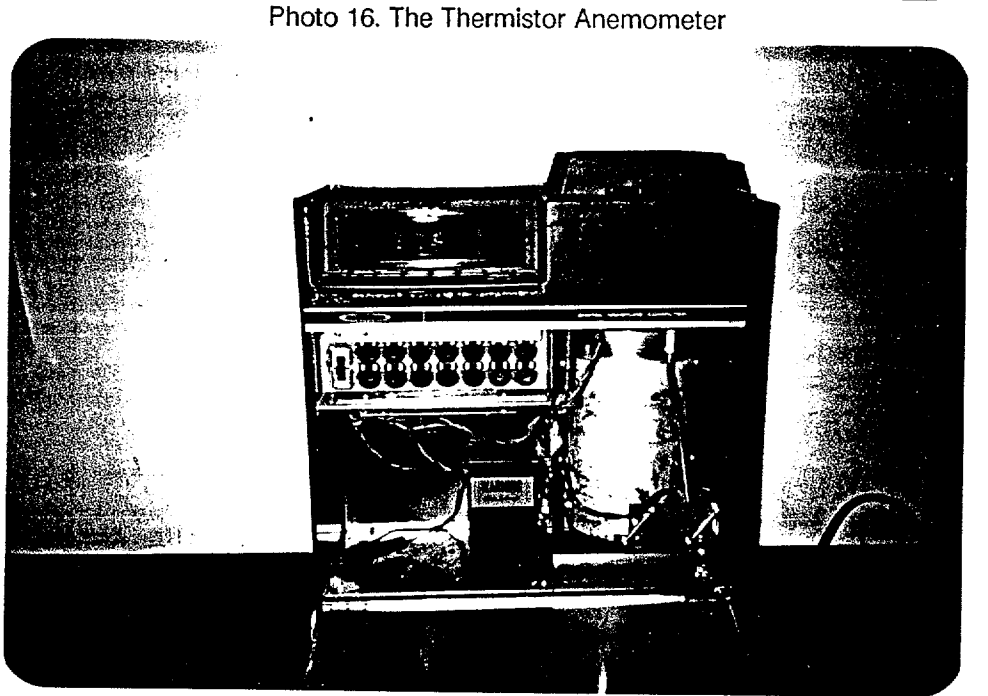

Photo 17. The Moisture Meter

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