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INVESTIGATION ON DRYING OF COCOA BEANS USING A SOLAR DRYER AND THE TRADITIONAL SUNDRYING METHOD

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ABSTRACT

Investigations were carried out on the performance of a partially enclosed solar dryer and traditional sundrying method for drying cocoa beans. The solar dryer attained a significantly higher temperature, lower humidity, faster rate of drying (78 hours compared with 172 hours) and less moldiness, no germinated beans, no insect infestation after drying when compared with the traditional sun drying method. The solar dryer was significantly more efficient, gave better quality product and reduced drudgery than the traditional sundrying. It also gave a benefit of 38. 7% increase in income to the farmer than using the traditional sundrying.

Keyword: Drying, Cocoa beans, solar dryer, traditional Sundrying.

INTRODUCTION

Cocoa ia a very important cash crop in many developing countries producing it. Cocoa beans are produced in many countries of Africa, North Central and South America, Asia and Oceania. The World's total production in 1992/93 was 2,376,200 tones (World Cocoa Directory, 1994/95). Cocoa beans are used to produce cocoa butter, cocoa power and cake paste liquor which are consumed all over the world especially in Europe, America, Asia and Oceania.

Cocoa beans are fermented after harvest. The moisture content after fermentation is approximately 60 percent (Rohan, 1963, Oyeniran, 1978).

The beans must be dried to about 7 percent moisture content for safe storage (Hall, 1970). Moisture content is a major factor usually assessed in the quality grading of the crop. A high moisture content will lead to heavy internal moldiness, germinated beans and insect infestation resulting in very low grade or total rejection of the cocoa beans.

Both natural and artificial drying methods are used for drying cocoa beans. Most cocoa production occurs in small-scale farms averaging 1-2 hectares. Sundrying, in the most elementary form, is still the most popular for drying cocoa and thus dryers that will use solar energy are desirable. For small- scale producers, such a cocoa dryer must be simple to operate, inexpensive to purchase and maintain, require no electricity, be versatile, with spare parts

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readily available and reduce drudgery associated with traditional sundrying. A solar dryer saves costs on fuel and electricity. It also enhances the quality of the final drying product. The increased earning from cocoa will more than offset the cost of applying solar technology. Most of the solar cabinet described have their roofs made of clear window glass which makes them relatively expensive and delicate to handle for farmers. There is the need to find cheaper, less delicate and equally efficient design and materials for the construction. Furthermore, none of the described solar dryers (Khan, 1964; Arinze and Obi, 1984; Djakoto, 1986) has been used for drying cocoa beans, with its peculiarity of requiring to be dried at very high moisture content of about 60% after fermentation to 7 percent for storage. Therefore, the purpose of this article is to report the production of solar dryer satisfying the required conditions and to test its efficiency in drying cocoa beans in comparison with the existing traditional method.

MATERIALS AND METHOD

This work was carried out in Akure, a town located in the high humidity area of Southern Nigeria where the greatest quantity of cocoa is produced in Nigeria. It was started during harvest late in May and continued throughout the month of June.

Solar Dryer

The solar dryer used in this trial was a partially enclosed dryer (see figs 1&2). It consisted of an outer box and an inner box. The dimensions of the outer box were 244cm long, 122cm wide and 22cm deep. The inner box being 225cm long, 105cm wide and 15cm deep. The space between the boxes was packed with sawdust as insulating material. Lower ventilation holes were drilled through the bottom of the boxes. Upper ventilation openings were also provided by cutting slots in the upper edges of the sides of the box. The dryer was raised on four legs, 110cm high to aid ventilation.

The cover was made of simple rectangular wooden frame with a central ridge piece. It was covered with a double layer of polyethylene film. The drying tray was of a wooden frame with perforated iron sheets nailed to the base. The inner dimensions were length 205cm, width 33cm and 9cm deep. All the interior surfaces of the dryer were painted deep black for maximum absorption and retention of heat. The drying tray was placed in the inner box and held the material to be dried. As the drier and its contents became heated, the hot air rose and escaped through the upper ventilation openings and cooler ambient air was drawn in through the lower openings. Air movement through the drier was by convection. It provided a movement of heated air over and through the material being dried. The temperature of the dryer can be controlled effectively by closing or opening the upper ventilation outlets.

Traditional Sundrying

In this trial, galvanized iron sheet, 205cm x 33cm x 9cm deep, similar to the drying tray in the solar dryer was used for the traditional sundrying (fig. 3).

Drying Trials

Fully fermented cocoa beans were divided into two equal portions of 50kg each. One portion was spread in the drying tray of the solar dryer 6cm deep. The other portion was spread on the galvanized iron sheet used in the traditional sundrying at a similar depth of 6cm and placed beside the solar dryer. The beans were usually turned using a flat wood to ensure even drying and to separate the beans that stuck together.

Moisture Content

The moisture content of the fermented bean was determined at the beginning of the trial and at two-hour intervals from 8 a.m to 6p.m daily throughout the drying period. The moisture contents of the samples were determined by drying in a ventilated oven known weights of ground cocoa beans for four hours at 1010C (Corners, 1962). They were determined in triplicate each time.

Temperature

The temperature of drying air in the solar dryer and sundrying were recorded every two hours from 8.00a.m to 6p.m using thermometers.

Relative Humidity

The relative humidity were also recorded at similar intervals for the same period using wet and dry bulb hygrometer.

Moldiness was recorded as the percentage of mouldy beans when 50 were observed externally with a hand lens or cut open and examined for internal moldiness. The mould species found were isolated and identified using malt extract agar.

The beans were also examined for insect infestation and germination beans. These trials were repeated three times using different consignments of cocoa beans harvested at the same time.

The cost/benefit analysis of the solar dryer to the farmer was carried out.

RESULTS AND DISCUSSION

Temperature

The result of the temperatures attained by both the solar dryer and the traditional sundrying are expressed in statistical form in Table 1. The temperatures in the solar dryer were highly significantly higher ($p< 0.01$) than traditional sundrying.

Relative Humidity

The results of the humidity recorded by the solar dryer and the traditional sundrying are shown in table 2. The humidity of the solar dryer was highly significantly lower ($p<0.01$) than the traditional sundrying.

Rate of Drying

The safe moisture content of 7 percent for storage of cocoa was achieved after 78 hours of drying in the solar dryer and after 172 hours in the traditional sundrying (Figure 4). The faster rate of drying in the solar dryer is associated with its higher temperature and lower humidities than the traditional sundrying method. Twice the weight of cocoa beans was dried in solar dryer to traditional sundrying.

Quality

Moldiness

During the drying process, eight (8.0) percent of cocoa beans dried by the traditional sundrying method was mouldy externally compared to 0.4 percent of those dried with solar dryer. This is because those dried by traditional sundrying were exposed directly to the atmosphere or open environment of cool temperature, high humidity, high source of mould infection and slow drying, while that of solar dryer was protected from infection because of the use of polyethylene sheet as cover, has low humidity, warm temperature and high rate of drying. The molds isolated were *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus* sp., and *Mucor pusillus*. Oyeniran (1973) and reported the presence of these molds in cocoa beans. However, there was no internal moldiness in both the solar dryer and traditional sundrying. The external moldiness recorded soon withered off without penetrating into the cocoa beans. Nigerian produce regulation allows a maximum of 3 percent moldiness for grade 1 and 4 percent for grade 2 exported cocoa. No insect or germinated bean was found in the cocoa dried with the solar traditional sundrying.

Cost/benefit analysis of the solar dryer

Drying of cocoa beans takes place for 6 months in the year i.e 180 days.
Solar dryer dries 50Kg in 78 hours or 3.25 days. Traditional sundrying dries 50Kg in 172 hours or 7.2 days.
In 180 days solar dryer will dry

$$\frac{180}{3.25} \times 50 \text{ kg} = 2769.2 \text{ kg or}$$

2.769 ton = 2.8 tonnes

In 180 days traditional drying will dry

$$\frac{180}{7.2} \times 50 \text{ kg} = 1250\text{kg}$$

or 1.25 tonnes.

Difference between solar and traditional = 2.77 - 1.25
= 1.52 tonnes.

Cost of difference at N80,000/tonne. The cost of 1 tonne of cocoa was N80,000.00 at the time of writing

= 1.52 x 80,000
= N121,600.000

If the solar dryer farmer's revenue is N121,600 over traditional sundrying for 6 months, therefore his extra income is the interest on the amount for 6 months at the rate of 21%. Bank lending rate was 21% .

Interest per annum

$= \frac{21}{100} \times 121,600$

= N25,536.00

With traditional sundrying, there will be a watchman to drive away animals etc from soiling the drying cocoa beans. He will earn N2,400 per month.

For 6 months = N2,400 x 6

= N14,400.00.

No need for watchman with solar drying. It is well protected.

Total amount gained in solar drying = Extra income + salary of watchman

= N25,536 = 14,400.00

= 39,936.00

Cost of constructing the solar dryer over traditional sundrying.

Depreciation of solar dryer is 25%

Annual Depreciation is

$\frac{N5,000 \times 25}{100}$

= N1,250.00

Benefit annually

= N9,936.00 - N1,250

= N38,686.00

Normal annual income from traditional dryer

= 1.25 x 80,000

= N100,000

% increase in income as benefit of solar dryer over traditional

$= \frac{38,686}{100,000} \times 100$

= 38.686%

= <u>38.7%</u>

It must be noted that cocoa is a very expensive crop and hence very high cost/benefit to the farmer using solar dryer.

CONCLUSION

The results of these trials show that solar dryer in drying cocoa beans had a significant higher temperature, lower humidity, faster and more efficient rate of drying, no moldiness, no germinated beans, no insect infestation and offers higher financial benefit to the farmer when compared with the traditional sundrying method. The requirements for effective solar drying are that:

(i) The material to be dried and the surrounding air should be heated.

(ii) There is need for maximum possible movement of air over the surface of the material.

(iii) Large surface area of material should be exposed to the air.

It is difficult to attain the first two conditions with traditional sundrying. The partially enclosed solar dryer traps the heat from the sun and has ventilation openings to facilitate air movement through the dryer by convection and control the temperature. Thus high temperature and air movement needed for effective drying in humid climates where cocoa is grown can be attained. Also the solar dryer is covered with polyethylene sheet and therefore rain-proof.

It can be left outside unattended to during rain or sunshine thus reducing the drudgery associated with cocoa drying. The solar dryer being covered offers protection from dirt, dust, attack by insects, birds, rodents and domestic animals. The high temperature attained will kill or make the environment uncomfortable for insect infestation. Solar dryer, unlike artificial dryers, requires no fuel which is getting scarce especially firewood in developing countries where cocoa is produced. It can also be used to dry other crops such as cassava and plantain chips, grains (Adesuyi, 1994) etc. It is therefore versatile. The materials for construction of the solar dryer are readily available and can be fabricated by local people.

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REFERENCES

Adesuyi S. A. (1994). Assessment of a solar drier for drying cassava and plantain chips in humid tropics. Nigerian Journal of solar energy. Vol 10 (in Press).

Anon (1994). World Cocoa Directory, 1994/95. International cocoa Organization. 22 Berners st. London WIP 3DB.

Arinze, E. A and Obi, S.E. (1984). Design and Experimental evaluation of a solar energy crop drying system with heat storage unit. Nigerian Journal Solar Energy. 3: 54 - 70.

Corners, M. A. (1962).Relative Humidity/moisture content equilibria for testa and nibs of main and light crop cocoa. Report, West African stored products Research Unit. pp. 39 - 40.

Djakoto, T. A.(1986), Evaluation of solar collectors for crop dryers. Proceedings of the International Conference Energy, Food Production and Post-Harvest Tech. Africa, Nairobi, kenya.

Halls, D. W. (1970). Handling and Storage of food grains in Tropical and Sub-tropical areas. 350 pp. Rome; Food and Agriculture Organization of the united Nations FAO Agricultural Development paper No 90.

Khan, E. U (1964). Practical devices for the utilization of solar energy. Solar Energy 8(i) : 17

Oyeniran, J. O. (1973). The effect of prolonged fermentation on the internal mouldness of cocoa. Report, Nigerian Stored Prod. Res. Inst. pp. 33 - 37.

Rohan, T. A. (1963). Processing of raw cocoa for the market. 207 pp. Rome. Food and Agriculture Organization of the United Nations, FAO Agricultural Series, No 60.

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Table 1: Analysis of variance of temperatures in the solar dryer and traditional sundrying

S. V.	d. f.	s. s	m. s	F.
Treatments	1	11660.04	11660.04	882.0**
Error	22	290.92	13.22	
Total	23	1195.96		

** = Significant difference 0.01 level.

Table 2: Analysis of variance of humidities in the solar dryer and the traditional sundrying.

S. V.	d. f.	s. s	m. s	F.
Treatments	1	4656.13	4656.13	126.77**
Error	30	1101.75	36.73	
Total	31	5757.88		

** = Significant difference at the 0.01 level.

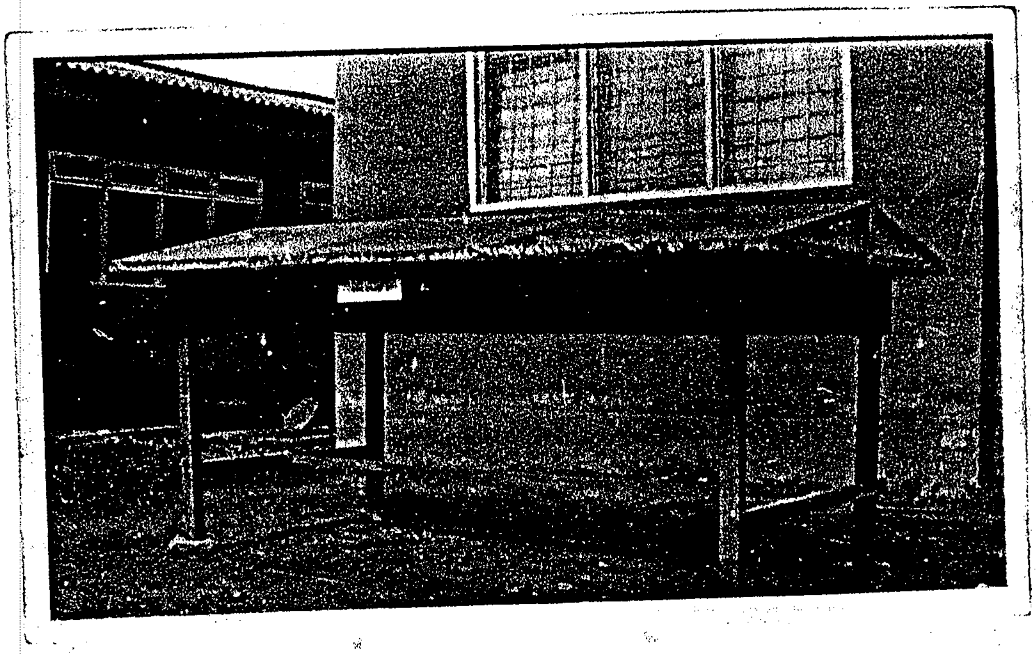

Fig. 1. Partially-enclosed Solar Dryer (Closed Position).

Fig. 2. Partially-enclosed Solar Dryer.
Open Position Showing:
(a) Upper ventilation openings as cut slots in upper edges
(b) Double layer polyethylene film as roof
(c) Four legs on which it is raised
(d) The drying tray inside.

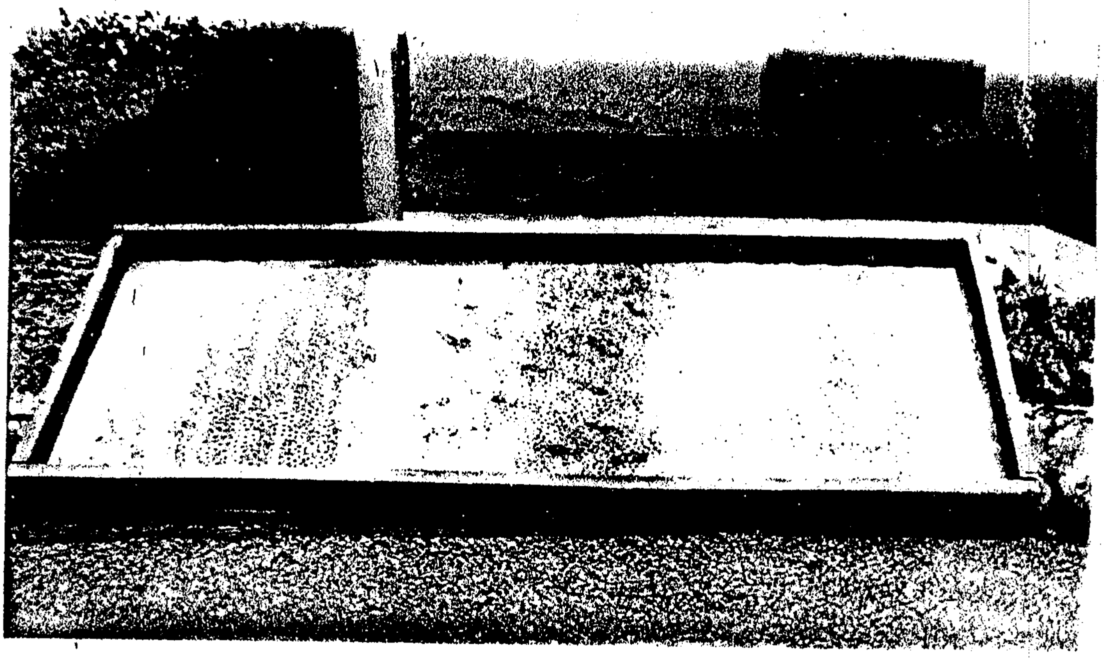

Fig. 3. Drying Tray of the Traditional Sundrying.

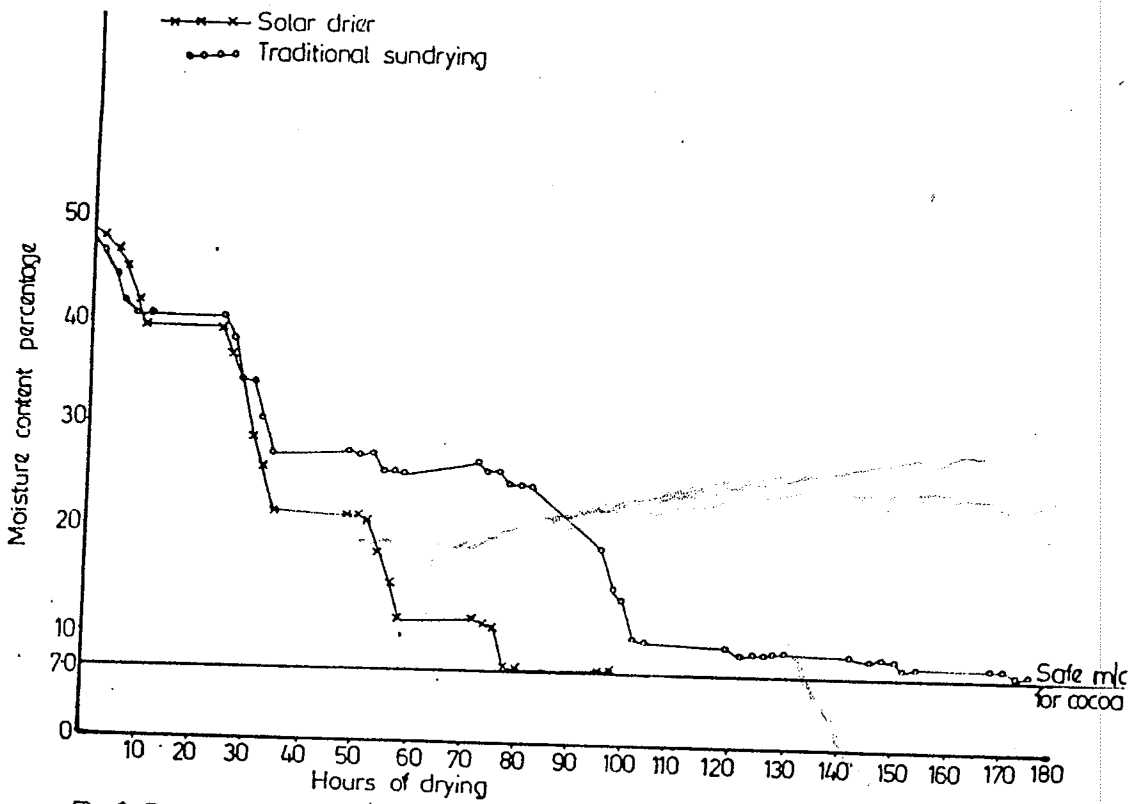

Fig 4 Rate of drying of Cocoa beans using Solar dryer and traditional sundrying.