UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A SOLAR DRYING UNIT FOR THE COCOA SMALLHOLDERS IN MALAYSIA

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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To all the cocoa growers in Malaysia

Abstract of the thesis presented to the Senate of the Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

DEVELOPMENT OF A SOLAR DRYING UNIT FOR THE COCOA SMALLHOLDERS IN MALAYSIA

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December 2003

Chairman : Associate Professor Russly Abdul Rahman, Ph.D.

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Sun drying is the most popular method used by the Malaysian smallholders to dry cocoa beans during the harvesting season. However, various limitations have been associated with this traditional practice particularly due to unpredictable weather conditions. The sun dryer is usually without any means of protection in the event of rain unless labour is available to look after the dryer. In situations where no other alternatives of natural drying are available, the smallholders will either continue using the sun dryer or sell wet beans at a lower price.

This study was carried out to develop a small-scale solar dryer to provide an additional option to the smallholders in cocoa drying. The concept of direct solar drying was adopted where the product is dried inside a transparent enclosure using direct sunlight. Overall dimension of the solar dryer prototype measured 1565 mm x 912 mm x 1375 mm (L x W x H). Most of the structural components were constructed using 'Chengal' hard wood. The side panels and drying platform were constructed from plywood and transparent Ultra Violet Stabilised Polyethylene film was used to form the enclosure. Air enters through the perforated platform (about

15% perforation) and the side air gaps (measuring 1365 mm x 40 mm) and the humid air exits through the apertures (measuring 159 mm x 1565 mm) at the apex. Two removable windows (measuring 1565 mm x 600 mm) were made at both sides of the dryer to facilitate loading, unloading and mixing. Individual part of the prototype was connected using bolts, nuts and screws to ease assembling and dismantling on farm. The total material cost of construction for a unit of solar dryer was RM 156.76.

Quality of the dried cocoa beans was assessed in terms of acidity (pH and titratable acidity), degree of fermentation (cut test and fermentation index), surface mould, odour and sensory evaluation. The performance of the solar dryers was also assessed in terms of bean moisture content reduction, bed and air temperatures. Two trials were carried out to determine the effect of loading on solar drying and to compare between the solar dryer and sun dryer. From the studies, the solar dryer is recommended to the smallholders for 20 kg wet beans using perforated drying platform. The performance of the solar dryer and quality of the beans showed no significant difference ($p>0.05$) as compared to sun drying. This would be an added advantage to the smallholders as protection of the beans could be achieved through solar drying.

Based on the recommendation, the solar dryer was able to produce beans with good external appearance, extremely light in surface mould, high in degree of fermentation and acceptable in terms of odour and sensory evaluations. The drying period was shorter at this loading (20 kg) which could eliminate the risk of mould growth due to prolong drying and the beans temperatures were well below the limit detrimental to the quality.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN UNIT PENGERING SURIA UNTUK PEKEBUN KECIL KOKO DI MALAYSIA

Oleh

HII CHING LIK

Disember 2003

Pengerusi : Professor Madya Russly Abdul Rahman, Ph.D.

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Pengeringan matahari merupakan teknik yang paling popular digunakan oleh pekebun kecil di Malaysia untuk mengeringkan biji koko semasa musim penuaian. Walaupun demikian, beberapa kekurangan telah dikenalpasti melalui cara tradisional ini terutamanya ketidaktentuan keadaan cuaca. Alat pengering matahari yang biasa digunakan tidak mempunyai sebarang sistem perlindungan terutamanya semasa hujan kecuali tenaga pekerja boleh didapati dan menjaga alat tersebut. Dalam keadaan tanpa sebarang alternatif pengeringan semulajadi yang lain, pekebun kecil akan terpaksa menggunakan alat pengering matahari atau menjual biji koko basah pada harga yang lebih rendah.

Kajian ini telah dijalankan untuk membangunkan alat pengeringan suria bersaiz kecil agar pekebun kecil mempunyai alternatif untuk pengeringan koko. Konsep pengeringan suria secara terus telah digunakan di mana produk dikeringkan dalam kebuk lutsinar dengan menggunakan sinaran matahari. Dimensi keseluruhan prototaip pengering suria tersebut berukuran 1565 mm x 912 mm x 1375 mm (P x L x T). Kebanyakkan komponen struktur dibina daripada kayu keras jenis Chengal.

Panel tepi dan pelantar pengeringan dibina daripada papan lapis dan filem lut sinar Polietilena Terstabil Ultra Ungu telah digunakan sebagai kebuk. Udara masuk melalui pelantar berlubang (lebih kurang 15% berlubang) dan ruang udara tepi (berukuran 1365 mm x 40 mm) dan udara lembap keluar melalui bukaan di atas (berukuran 159 mm x 1565 mm). Dua tingkap mudahalih (berukuran 1565 mm x 600 mm) dibina pada kedua-dua tepi alat pengering untuk memudahkan kerja-kerja memasuk dan mengeluarkan muatan dan pembalikan. Bahagian individu prototaip disambungkan dengan menggunakan selak, nat dan skru untuk memudahkan pemasangan dan pembukaan di ladang. Jumlah kos pembinaan seunit alat pengering suria adalah RM 156.76.

Kualiti biji koko telah dinilai dari segi keasidan (pH dan asid tertitrat), tahap fermentasi (ujian belahan dan indeks fermentasi), perkulatan pada permukaan, bau dan penilaian deria rasa. Prestasi alat pengeringan suria juga telah dikaji dari segi penurunan kandungan kelembapan, suhu lapisan dan suhu udara. Dua kajian telah dijalankan untuk melihat kesan kuantiti ke atas pengeringan suria dan perbandingan diantara pengeringan suria dan matahari. Daripada kajian, pengeringan suria adalah dicadangkan kepada pekebun kecil untuk 20 kg biji basah dengan menggunakan pelantar pengeringan berlubang. Prestasi alat pengering suria dan kualiti biji koko telah menunjukkan perbezaan tidak ketara ($p>0.05$) berbanding dengan cara pengeringan matahari. Ini adalah satu kebaikan tambahan kepada pekebun kecil di mana biji koko mendapat perlindungan dengan pengeringan suria.

Berdasarkan kepada cadangan yang dikemukakan, alat pengering suria tersebut dapat menghasilkan biji koko yang mempunyai permukaan luar yang baik, sangat kurang

dalam perkulatan luar, mempunyai tahap fermentasi yang tinggi dan boleh diterima dari segi bau dan penilaian deria rasa. Tempoh pengeringan pada muatan ini (20 kg) adalah pendek dan dapat mengelakkan pertumbuhan kulat akibat pengeringan yang berpanjangan. Suhu biji koko yang digunakan adalah di bawah had yang merbahaya kepada kualiti.

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I certify that an Examination Committee met on 23rd December 2003 to conduct the final examination of Hii Ching Lik on his Master of Science thesis entitled "Development of a Solar Drying Unit for Cocoa Smallholders in Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

HII CHING LIK

Date: 26/3/04

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LIST OF ABBREVIATIONS

Anova	Analysis of variance
CTS	Cut test score
cm	Centimeter
C_2	Carbon 2
C_5	Carbon 5
FI	Fermentation index
ft	Feet
g	Gram
kg	Kilogram
L	Lebar (Width) or Length
Meq	Miliequivalent
m	Meter
m/s	Meter per second
mm	Milimeter
m^2	Meter square
n.s.	No significant
P	Panjang (Length)
P0	Platform without perforation
P1	Platform with perforation
SU	Sun drying
SL	Solar drying
SUP1	Sun dryer with perforated platform at 20 kg loading
SUP0	Sun dryer with non-perforated platform at 20 kg loading

SLP0	Solar dryer with non-perforated platform at 20 kg loading
SLP1	Solar drying at 20 kg loading using perforated platform
SAS	Statistical Analysis System
T	Tinggi (height)
TA	Titratable acidity
W	Width
w.b.	Wet basis
°C	Degree Celsius
%	Percentage

CHAPTER 1

GENERAL INTRODUCTION

In general, the primary production sector of the Malaysian Cocoa Industry can be categorized into the estate and the smallholder sectors. Farm size of more than 40.5 hectare is considered as estate plantations while those less than 40.5 hectare is considered as smallholders (Masarudin and Omar, 1998). In the early 80's, the estate sector dominated more than 60% of the national cocoa planting area. However, it has been gradually replaced by the smallholder sector in the 90's and made up to about 69% of the national cocoa planting area in year 2000 (Anon, 2000).

Productivity of the smallholders usually varies and ranges between 184 and 819 kg of dried cocoa beans per hectare per year (Mahmod, 2001). However, some established farmers in Pahang and Sabah could produce about 3-5 tonne of dried cocoa beans per hectare per year using proper agronomy practices (Masarudin and Omar, 1998). Many smallholders were found having limited knowledge in the cultural and agronomic practices of cocoa. Furthermore, lack of knowledge in post harvest processing technology, such as fermentation and drying, resulted in smallholders selling fresh beans or low quality dried beans. This has prevented the smallholders from earning better income, as the price of dried cocoa beans is usually three times the price of fresh cocoa beans.

The processing of fresh cocoa beans begins with fermentation and the fermented product is then dried to reduce the moisture content to less than 7.5 % w.b. prior to storage. Proper drying must be performed in order not to deteriorate the quality of a

well-fermented batch of cocoa beans. A common quality defect in cocoa beans is due to mould contamination, either externally or internally which happens mostly due to poor drying conditions. Nevertheless, sun drying is the most popular technique used by the cocoa smallholders other than artificial drying (Mahmod, 1999).

During the drying of cocoa beans, labour is engaged in loading and unloading, mixing and protecting the beans from external threats such as rain, dew, dusts and even animals. A national survey among the cocoa smallholders showed that 61% of the interviewed respondents are not full-time cocoa farmers. They are either involved in non-agricultural based activities or practice multi-crop planting (Mahmod, 1999). Furthermore, the cocoa harvesting period in Malaysia normally coincides with the rainy season. Therefore, most smallholders are not interested in drying cocoa beans to avoid the labourious activities involved due to interruptions by rain.

Studies are therefore carried out by the Malaysian Cocoa Board to develop a dryer suitable to the smallholders. This is also to encourage the smallholders to obtain better income through selling of dried cocoa beans. Hence, the concept of a direct solar dryer was proposed as an alternative to the conventional sun drying technique. The design of the dryer is such that the fermented cocoa beans are placed inside a transparent enclosure and dry primarily using direct sun light. This type of dryer is cheap and easy to construct using locally available materials, capable of drying small quantity materials, easy to assemble and dismantle, portable due to its simple design and small size, easy to use and maintain as no complicated equipments are involved, thus making it very suitable to the smallholders. A distinct advantage of the dryer is the transparent cover whereby the product is protected against rain droplets. This will

be an added advantage to the conventional sun drying technique and directly assist the smallholders since the labour involved in protecting the beans is eliminated. Therefore, research studies were conducted with the following objectives:

i. To design and construct the prototype of the solar dryer
ii. To evaluate the performance of the solar dryer prototype at different loading
iii. To compare the performance of the solar dryer prototype against the sun dryer

The first objective was carried out to obtain a suitable design for the solar dryer prototype which can be constructed using locally available materials into a kit where its individual parts can be easily assembled and dismantled by the smallholders. The second objective was conducted to select the most suitable loading for the solar dryer prototype and finally, the third objective was to compare the performance of the solar dryer prototype against the sun dryer based on the selected loading.

CHAPTER 2

LITERATURE REVIEW

Commercial cocoa beans are from cocoa tree of type *Theobroma cacao* which is the only one cultivated widely for production (Suhaimi, 1996). Cocoa beans from this species are subjected to fermentation and drying, which often referred as "curing", in order to develop the necessary flavour precursors required in roasting of cocoa beans (Forsyth and Quesnel, 1963). The curing process is usually carried out at the fermenteries situated at the farms or estates immediately after harvesting and pod splitting. The cocoa pods harvested should be ripe or slightly overripe and diseased pods are separated from the healthy pods.

The fermented cocoa beans must also be dried to moisture content less than 7.5 % w.b. by suitable means of drying methods. Inferior quality dried cocoa beans produced due to improper curing practices is rejected in downstream processing to avoid flavour deterioration in the finished products. Therefore, careful monitoring of the processing parameters during fermentation and drying are vital to ensure only good quality dried cocoa beans are produced. Figure 2.1 shows the process flow of the cocoa beans after harvesting and during downstream processing (Anon, 1997).

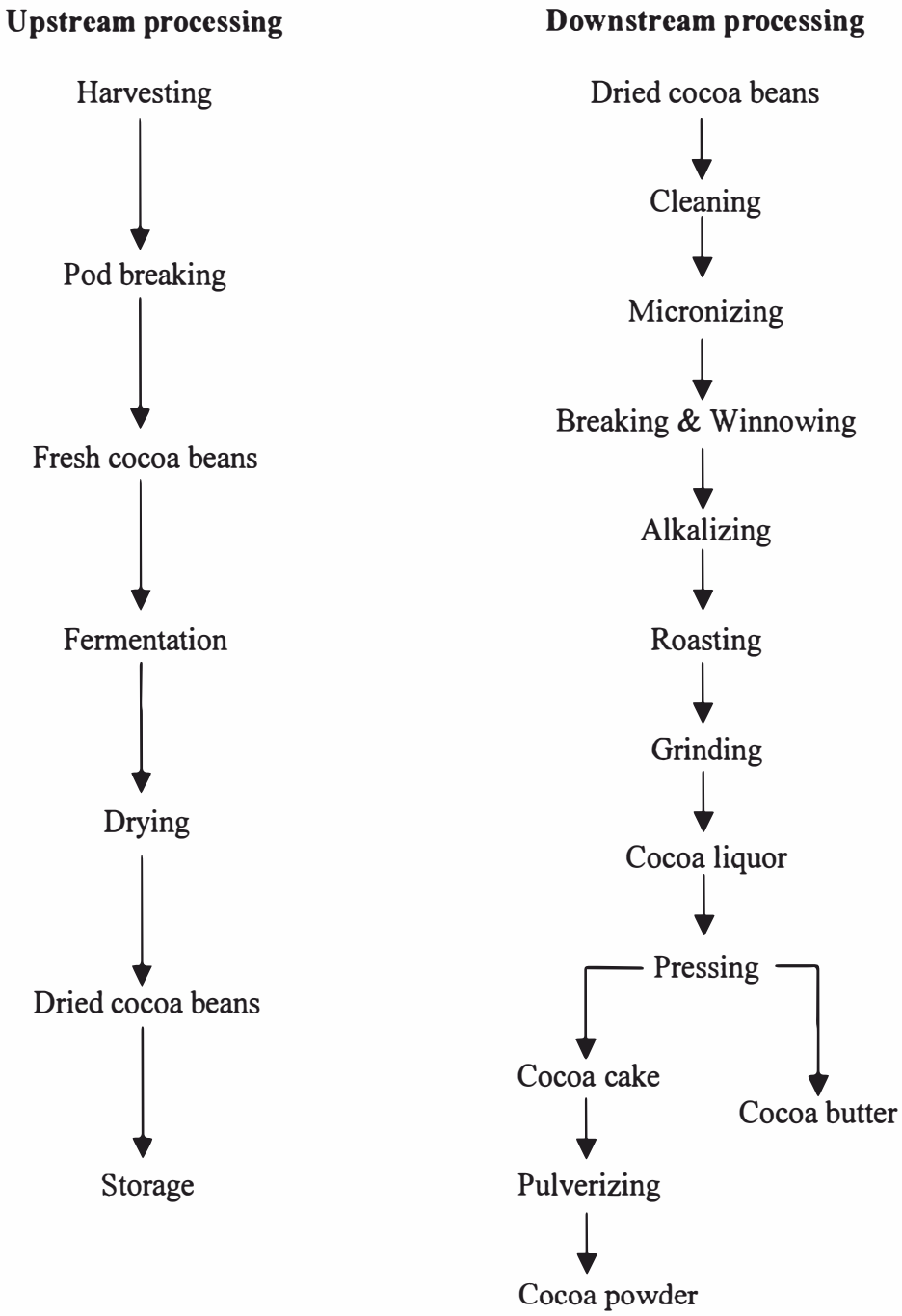

Figure 2.1: Upstream and downstream processing of cocoa beans (Anon, 1997)