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FACULTY OF ENGINEERING

DEPARTMENT OF AGRICULTURAL MECHANIZATION AND IRRIGATION ENGINEERING

DESIGN AND CONSTRUCTION OF A SOLAR – BIOMASS HYBRID DRYER FOR COCOA BEANS

By

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ABSTRACT

In Uganda, cocoa has been grown for all the years and farmers have always relied on open sun drying as the main drying method however, this method has proven to ineffective during rainy season since high yields of Cocoa pods are normally received during rainy seasons, and also associated with a serious risk of contamination with wind-borne dirt and dust, dead insects and animal droppings thus lowering the quality of the cocoa beans produced.

Innovations of solar dryers have been made and put on market to reduce losses related to drying of grains and also improve the drying conditions of agricultural products. But these systems also face similar challenge as the open sun drying due to dependency on weather conditions and lacking a means of regulating temperatures within the drying chamber with low drying effectiveness factor.

This project aims at design and construction of a solar – biomass hybrid dryer using locally available materials at relatively low cost. The dryer is composed of solar collector for optimizing the amount of solar energy for drying, back-up heater which acts as the backup energy source to enable drying to continue till the night hours and reduce on the drying period, airflow system for carrying heat energy to the drying chamber and a temperature regulating system, this controls the heat energy inside the drying chamber automatically.

The design was based on the study area of Imanyiro sub county located Mayuge district, where cocoa is being grown by many farmers. The average ambient conditions were; 25°C air temperature and 75% relative humidity with daily global solar radiation incident on horizontal surface of about 5 MJ/m^2/day. A minimum of 0.2m^2 solar collector area was required to dry a batch of 6kg of cocoa beans in 26h with the dryer from the initial moisture content of 50.8% to final moisture content of 7.75%. The system has an effectiveness factor of 1.52 which makes is 52% more effective than the open sun drying and a drying efficiency of 11.6% which is low because of the non-uniform drying temperature on the trays due to un even distribution of heat, heat losses though the joints, heat loss due to poor insulating material and also the heat obtained by burning the biomass does not directly come in contact with the cocoa beans, but instead heats the air duct which in turn heats the drying air. However, preventing leakage in the air supply system, use of better lagging (insulating) material, and increasing the size of the flat plate collector will increase the efficiency of the system.

DECLARATION

I, **Zirete Daniel** hereby declare to the best of my knowledge that this report is my own work towards the B.Sc. in Agricultural Mechanization and Irrigation Engineering and, it has not been published by another person for the award of any other degree in any University, except where due acknowledgment has been made in the text.

Signature: ……. Date: ……

APPROVAL

This work was authenticated by the following Supervisors;

Name: Mr. Ashababahebwa Ambrose **Signature:** ……...…. **Date:** …..……

Name: Mr. Sserumaga Paul **Signature:** ……..……. **Date:** …...…...…...

DEDICATION

I dedicate this report to my precious and loving mother **Namutibwa Irene** for all the tremendous support that she has always given to ensure that I reach this academic level.

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I start by extending my word of thanks to the Almighty God for breath of life, courage and strength that He has given to me.

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1 INTRODUCTION

1.1 Background

In Uganda organic cocoa is grown mostly in Bundibugyo, Mukono, Jinja, Kamuli, Buikwe, Masindi, Mayuge, Iganga and Kayunga districts on a small scale with an estimate of about 15,000 farmers are involved cocoa growing (Wetala, 2014)

Cocoa is one of the most profitable crops for smallholder farmers in Uganda (Kraybill and Kidoido, 2009) and because Ugandan cocoa is reputed to have special aromatic properties that are favored by chocolates manufacturers, it has increased the demand of cocoa by the large chocolate companies that manufacture special flavour chocolates. Cocoa beans are used for production of chocolate, and beverages.

In Uganda, Farmers normally receive high yields of Cocoa pods during rainy seasons (Feb - April and Sept. - Dec) which season offers Poor drying weather conditions leading to slow drying rate, which results into negative realization of bio-chemical degradation and browning reactions of cocoa beans resulting in strong acidic flavor, weak 'chocolate' flavour, possession of other off-flavour and development of moulds. Since the inception of cocoa growing, Open sun drying has been the predominant method of drying cocoa beans, which is associated with a number of limitations like; dependence on weather conditions, labor intensive, unhygienic, unreliable, time consuming, non-uniform drying and requires a large area for spreading the produce out to dry which compromise the quality of cocoa beans produced.

Innovations of solar dryers have been tailored to reduce losses related to drying of grains and other agricultural products. However, most standalone solar dryers have proven inefficient for drying cocoa beans most especially during the rainy season.

Therefore, this project is focused to the development of a solar – biomass hybrid drier that is able to dry cocoa in a more closed and controlled environment to achieve the highest quality of dried cocoa beans without being much affected weather conditions.

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