DEVELOPMENT OF A PROTOTYPE SOLAR AUTOMATED COCOA SEED DRYER

(Theoboma cacao)

By:

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CHAPTER ONE

1.0INTRODUCTION

1.1 Background to the study

Cocoa bean is a highly valued commercial export commodity of global interest with a significant economic impact in many of the tropical countries where it's being produced (Afoakwa et al., 2013). World production of cocoa beans for the year 2017/2018 was estimated to be about 4.6 million tonnes with Africa holding about 73% of the production shares (International Cocoa Organization, 2019; World Cocoa Foundation, 2012). Most of the cocoa bean produced in Africa goes into the export market and as such cocoa beans meant for the export market are grade 1: free of contamination, mold infestation, insect damage, and pesticides residues. The quality of dried cocoa bean ready for ex-port is influenced by prevailing climatic conditions during its post-harvest processing (Afoakwa et al., 2013; Manoj & Manivannan, 2013).

Most of the cocoa bean produced in Africa goes into the export market and as such cocoa beans meant for the export market are grade 1: free of contamination, mold infestation, insect damage, and pesticides residues. The quality of dried cocoa bean ready for ex-port is influenced by prevailing climatic conditions during its post-harvest processing (Afoakwa et al., 2013; Manoj & Manivannan, 2013). Cocoa beans are produced in humid tropics with an-nual mean temperature of over 24°C, high relative humidity levels and varied annual rainfall ranges be-tween 1500 and 3000mm. In Africa, where most of the cocoa beans are processed for export, seasonal variations in weather conditions (i.e. unpredictable duration of dry and wet seasons in tropical region) may impact the quality of the dried and the overall production yield. For example, dry weather patterns experience across West Africa in the early part of year 2011/2012 led to a forecast of production short-falls that year; although, increase in rainfall experienced later in the year and through March 2012, made up for the production deficit (World Cocoa Foundation, 2012).

Fermentation and drying processing steps are very key to the overall quality of the final dried cocoa bean product (Zahouli et al., 2010). The fermentation process is necessary for improving the flavor and amino-acid profile of the cocoa beans and to break down the mucilaginous pulp surrounding the bean, thereby leading to reduced bitterness and astringency (Adeyeye et al., 2010; Afoakwa et al., 2008; Rodriguez-Campos et al., 2011; Thompson et al., 2013).

The natural drying methods allows slow removal of moisture, continuous fermentation and flavor development leading to a high-quality cocoa bean product; while artificial drying method causes rapid moisture removal, with high content of titratable acid, propionic acid, butyric acid, isobutyric, and isovaleric acids all of which are useful in making a low-quality chocolate (Dina et al., 2015).

However, irrespective of the drying methods or equipment used to process the cocoa bean, the seasonal variation in the climatic conditions (i.e. changing temperature and relative humidity) has been identified as major factors that affect fermentation and drying process and consequently the overall quality of the dried cocoa bean (Afoakwa et al., 2013), hybrid (or mixed mode) solar dryer circumvents this challenge in that, it has the capacity to store energy during the active drying period and release it at night during resting period to support continuous drying, thereby providing a better quality of cocoa beans (Dina et al., 2015).

1.2 Problem statement of the study

Cocoa seed drying, a critical step in cocoa processing, is often hindered by unreliable and inefficient traditional drying methods, resulting in poor quality cocoa beans, reduced yields, and economic losses for small-scale cocoa farmers, thereby necessitating the development of a sustainable and energy-efficient drying solution."

1.3 Aim and objectives of the study

The main aim the project is to design and develop an innovative solar –powered cocoa seed with automated temperature control and battery backup While:

Specific Objective

This study objectives are to evaluate the quality of cocoa beans after continuous drying, investigate the effects of continuous drying on cocoa's physical, chemical, and sensory properties, and identify the optimal continuous drying conditions for maintaining high-quality cocoa beans.

1.4Scope of the study

The scope of this study is to design and develop a solar-powered cocoa seed dryer with temperature control and battery backup, and to evaluate its performance in terms of drying time, energy efficiency, and cocoa seed quality.

1.5Justification of the study

The justification for this study is multifaceted, driven by the need to improve cocoa quality, address energy poverty, enhance sustainability, support small-scale farmers, and fill a knowledge gap in the use of solar-powered dryers in cocoa production, ultimately contributing to the development of a reliable and efficient solar-powered cocoa seed dryer with temperature control and battery backup.

2.0CHAPTER TWO

CHAPTER THREE

3.1MATERIAL AND METHOD

The following materials will be used for the fabrication of an Automated Solar powered Cocoa Seed Dryer

1. Solar Collector (Glass)

The solar collector, constructed using glass, is responsible for capturing solar energy to heat the drying chamber. The glass material allows maximum transmission of solar radiation, ensuring the collector absorbs sufficient heat from the sun. The energy captured by the solar collector is transferred to the drying chamber to facilitate the drying of cocoa seeds.

2. Drying Chamber

The drying chamber serves as the primary enclosure where the cocoa seeds are dried. This chamber is designed to maintain optimal temperature and humidity conditions for the drying process. The internal design ensures even distribution of heat throughout the space, thereby enhancing the efficiency of the drying process. The chamber is constructed to accommodate different volumes of cocoa seeds, depending on the capacity of the dryer.

3. Drying Chamber (Loading and Unloading Unit)

The loading and unloading unit of the drying chamber is designed to allow for the easy insertion and removal of cocoa seeds. This system is essential for the smooth operation of the dryer, enabling continuous drying without disrupting the flow of materials. It can be manually or automatically operated, depending on the design of the drying system.

4. Stainless Steel Trays (3 Layers)

Stainless steel trays, arranged in three layers, are used to hold the cocoa seeds during the drying process. Stainless steel was chosen for its durability, resistance to corrosion, and ease of cleaning. The three-layer tray design allows for multiple batches of cocoa seeds to be dried simultaneously, thereby increasing the overall capacity of the dryer.

5. Blower

The blower is employed to circulate air within the drying chamber. Proper air circulation ensures that heat is evenly distributed around the cocoa seeds, preventing uneven drying and promoting efficient moisture removal. The blower also assists in regulating temperature and humidity within the chamber, contributing to the control of drying conditions.

6. Chimney

The chimney is used to expel hot air and moisture from the drying chamber. This is essential for maintaining optimal drying conditions and preventing excess humidity from compromising the drying process. The chimney ensures that the drying chamber remains well-ventilated, facilitating the expulsion of moisture and heat.

7. Support Stand (Frame)

The support stand, or frame, provides the structural integrity of the entire drying system. The frame holds the solar collector, drying chamber, blower, and other components in place, ensuring the system remains stable during operation. It is designed to withstand the mechanical stresses of daily use and provide a robust foundation for the dryer.

8. Thermohygrometer Sensor for Automation

The thermohygrometer sensor is an integral component of the automated system, used to monitor the temperature and humidity levels within the drying chamber. The data collected by the sensor allows for real-time adjustments to the drying conditions, ensuring that the cocoa seeds are dried under optimal temperature and humidity. This automation helps maintain consistent and controlled drying conditions, improving the overall efficiency of the drying process.

9. Variable Speed Control

The variable speed control system is used to adjust the speed of the blower. By regulating the airflow within the drying chamber, the speed control ensures that the drying conditions remain consistent. The ability to fine-tune the blower speed allows for adjustments based on the moisture levels of the cocoa seeds, optimizing the drying process for different batches.

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