Coco peat Drying Techniques: A Review

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[1]***Abstract -*** Coco peat is a light soil-like material that is created as a by-product of the extraction of coco coir from coconut fibre. When wet, coco peat is a bulky material and possess a challenge in transportation. Drying removes moisture in the coco peat which then is compacted into bricks thus offering a solution to transportation. Different drying techniques for coco peat are used all over the world. This then serves as the foundation for this review, as the goal of this research is to comprehend and explain the various techniques used in the drying of coco peat. The coir industry is gradually expanding, and coco peat as a by-product is in high demand. This has resulted in an increase in the global valuation of the coco peat market; therefore, this review will concentrate its discussion on the existing methods used in coco peat drying, such as open-air sun drying, solar dryers and their various models, and will also analyse the existing peat drying machines manufactured for industrial or commercial purposes.

Keywords: Coconut husks, Coco peat, Drying, Solar, Technique.

I. *INTRODUCTION.*

Coco peat is a spongy and light weight ligno-cellulose material which is a by-product generated from coconut husks by extracting a fine soil-like product as illustrated in figure 1. The demand for coco peat is extensively growing especially in the horticultural industry. This demand for coco peat is brought by its ability to provide an excellent medium for growth due to certain significant characteristics such as its high ability for water retention and also its micro and macro nutrients content hence improving fertility [1]. The global coco peat market as of 2020 had a valuation of over US$2.4bn and is estimated to expand at a Compound Annual Growth Rate (CAGR) of 4.4% between 2021 and 2031 to cross a valuation of US$3.8bn towards the end of 2031 [17]. Kenya heavily relies on the importation of coco peat from Sri Lanka and India while at any given year the Kenyan coast produces 20,000 MT of coconut husks which is either dumped, burnt or drained into rivers or oceans [9]. In coco peat production drying plays a significant role, it is a phenomenon during which a transfer of heat and mass occurs between the coco peat product and dry air [1]. When wet, coco peat is a bulky material and transportation can become a problem. Drying of the peat reduces its moisture content from around 30% to between 15% - 20% (w/w, dry basis). The percentage can be adjusted according to the needs of the consumer. In this article, different techniques are reviewed so as to identify the most appropriate drying method to adopt for coco peat drying.

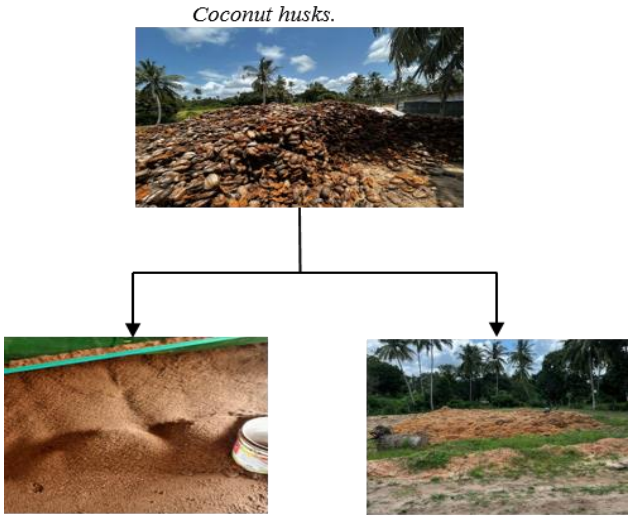

Fig. 1.Coconut husk by-products.

II. *DRYING TECHNIQUES.*

There are various methods that have been introduced with regards to the drying of coco peat from coconut husk. Solar drying technologies are classified on different basis, this can be done on the basis of the mode of drying i.e., direct solar drying, indirect solar drying and mixed mode solar drying [2]. Ashish and Prof. Sanjay (2014) [2] further opine that this classification can also be done based on the design of a dryer machine i.e., depending on the type of solar dryer. Different drying techniques have been rapidly introduced over the years for example flash drying [18], a technique by which water evaporation is caused by the heating of coco peat using hot air at atmospheric pressure to cause partial dehydration and when the desired temperature is achieved an application of rapid pressure reduction is used to cause evaporation. Other techniques such as open-air sun drying, by use of commercial dryers, which are large scale dryers used for industrial purpose, as well as solar dryers. This then will form the basis of our discussion in this review.

A. *Solar Drying Techniques.*

Conventional drying techniques have been widely applied dating back to the eighteenth century and despite the

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development of modern drying techniques, drying by means of exposure to direct solar radiation remains to be the most widely adopted method in the drying of coconut by-products worldwide [14]. Solar drying techniques use solar energy in one of two ways, either as the sole source of heat or as a supplementary source while the air flow is generated either by means of natural or forced convention. Solar drying will be discussed from two dimensions in this review; open-air solar drying and solar dryers. This are the two main methods in which solar energy is utilized in the drying of coco peat.

a. Open-air Solar Drying Technique

Farmers have traditionally used open-air sun drying or natural drying techniques to achieve this by utilizing solar radiation, natural wind, relative humidity, ambient temperature, and air temperature [14]. This technique as shown in figure 2 involves spreading the product in a thin layer on large surfaces or concrete floors in an outdoor threshing environment, then drying it while turning it from time to time to allow trapped moisture to escape. According to Atnaw *et al.,* (2017) [3], there are various benefits and drawbacks to using this technique to dry the product. The advantages to this technique are such as the fact that it does not require investments to implement and does not require fuel to be effective; however, this method has several disadvantages.

Fig. 2.Open air sun drying of coco fiber.

These disadvantages are well portrayed by the difficulties encountered while drying, as there is an exposure to certain risks such as dust, birds and animals such as rodents that damage crops, rain, quality degradation due to radiation exposure, severe weather, or an increase in moisture content from dew. This method is also time-consuming and labor-intensive due to the extensive human involvement; however, failure to dry uniformly may result in pest and insect infestation [16]. According to a study conducted by Fernando and Amarasighe (2016) [6], open sun drying can achieve a moisture content of 16-17% (w/w, dry basis) under temperatures of 29 ± 2^0 c, a relative humidity of $60 \pm 5\%$ and a solar intensity of 13-15 MJ/m^2; however, this takes the longest time of approximately 668 minutes. This alone demonstrates how time-consuming the open-air drying process could be in order to deliver the required moisture content.

b. Solar Dryers

Traditional drying techniques need to be improved; solar dryers have the potential to significantly reduce the disadvantages associated with open-air drying techniques. Solar dryers use air collectors to harness solar energy [14]. The dryers are designed to provide more heat to a product than is naturally available. This effectively raises the vapor pressure of the coir's moisture content while also significantly lowering the relative humidity of the drying air. Solar dryers have numerous advantages, including the fact that they are environmentally friendly, inexpensive, and simple to maintain.

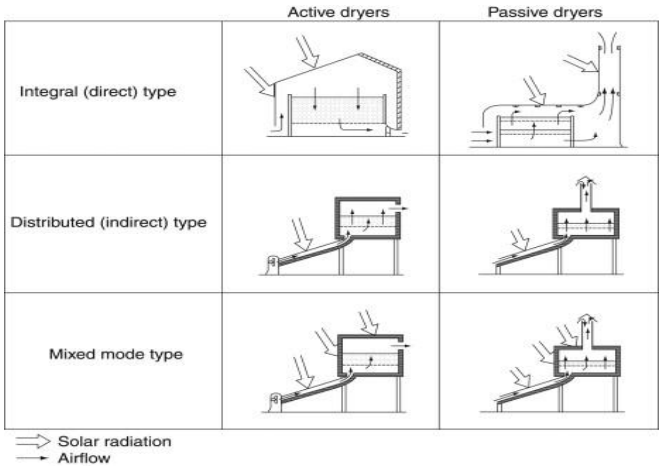

Fig. 3. Variations of Solar Drying Modes in Cabinet dryers.
Source; [12]

Solar driers are best suited for small-scale farmers with limited income and a low investment budget [3]. They are classified under two categories, based on their drying modes and based on the dryer designs. Classification under the drying modes include both direct and indirect solar dryers and the mixed mode solar dryers as illustrated in figure 3. Solar utilization for coco peat drying is appealing and regarded as an economical solution [7]. According to the Fudholi *et al.,* (2010) [7], solar dryers for marine, coco pith and other agricultural products are classified primarily based on dryer size, system design, and solar energy consumption mode. Figure 4 depicts active, passive, and hybrid solar-powered dryers based on their different air circulation techniques, such

as forced or natural, and heat transfer methods, such as direct or indirect.

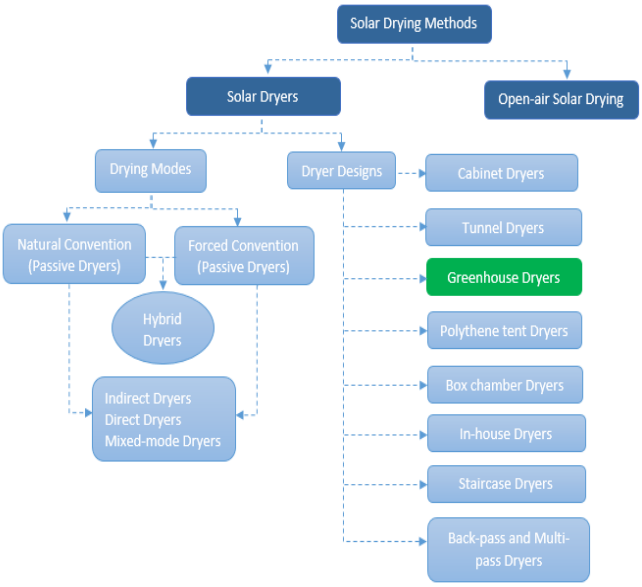

Fig. 4. Categorization of solar-powered dryers.
Source: [8]

Solar Dryers can equally be categorized on the basis of dryer designs as equally depicted in Figure 4.

Solar cabinet Dryers

The solar cabinet drier is more efficient than natural drying (open air drying) in drying coconut coir, according to Atnaw *et al.,* (2017) [3], three random samples of coco peat were tested on loss of moisture content under solar cabinet dryers for a period of 3 days. From the samples, sample 1 had an initial mass of 23.4875g while sample 2 had an initial mass of 27.4722g and sample 3 initial mass was 19.1242g. After the test sample 1 had a final mass of 15.6826g representing 33.23% MC loss while sample 2 and 3 had a final mass of 19.5932g and 12.9164g representing a moisture content loss of 28.68% and 32.46% respectively.

On average all samples had an average of 31.46 percent moisture content removed at temperatures of 107^0c within a 24hr cycle after approximately 4320 minutes of continuous drying under the same climatic conditions. This shows how effective this technique in the loss of moisture content in the coco peat product.

Cabinet dryers mainly consist of solar collector panels which heat the air in the drying chamber, the chamber is equipped with a fan to assist in hot air circulation. The dryer also has well installed sensors for temperature and moisture and some are equipped with a Photo Voltaic panel to power on the fan. The solar cabinet dryers work effectively by trapping solar heat hence increasing the temperature within the drying chamber [3]. This is important in the drying process and assuring quality as the moisture content of the coco peat relatively depends on the temperature and humidity in the surrounding air. However, certain cost implications can prove challenging in the installation process of this dryers, also the available cabinet dryers do not dry large amounts of coco peat hence not convenient for drying coco peat in large scale.

Solar Tunnel Dryer.

A solar tunnel dryer is a tunnel-like framed structure covered with an Ultra Violet-stabilized polythene sheet, with a drying chamber. Various types of solar dryers have been developed and used to dry a wide range of coconut by-products. A drying chamber, a collector area, and a chimney are among the major components of the solar tunnel dryer. The tunnel dryer is used to dry the product [15] by use of the greenhouse effect, this effect is highly important in the drying process of coco peat since this method absorbs the excess moisture content that exists in the air hence improving the drying rate. Figure 5 shows a forced convention greenhouse dryer to depict how drying is achieved in a tunnel dryer, the solar panel is used to run the fan in locations that do not have electricity. Seveda (2015) [13] opine that at a temperature of 60^0c in a solar tunnel dryer can achieve a reduced rate of moisture content of up to 11.40% in 18 hours of exposure to solar heat.

Sevada (2015) [13] discusses the classification of solar tunnel dryers according to the mode of air flow, these are classified as natural convention dryers (passive solar dryers) and forced convention dryer (active solar dryers). Natural convention dryers do not need to pump air therefore they do not require fans, forced convection solar tunnel dryers require fans. It is however worth mentioning that the lower the ventilation in the tunnel, the higher the internal temperatures generated within the dryer [11]. This usually expedites the drying process; the moisture content of the air within the dryer rises, so does the humidity of the air that surrounds the product.

This will eventually slow down the drying process. A fan forces moist air out of the tunnel, and fresh air flows in through the tunnel's chamber as shown below.

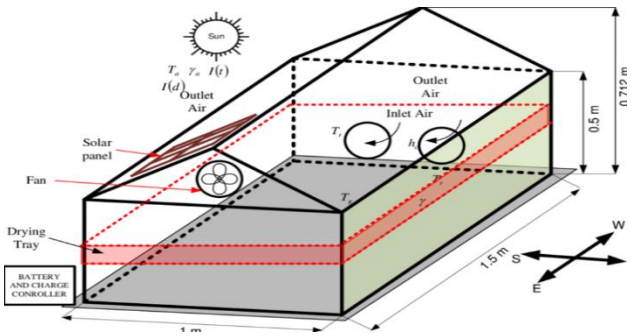

Fig. 3.Schematic view of a typical GHD under active mode.
Source; [11]

Solar Hybrid Dryers.

These are dryers that utilize solar energy and a supplementary source of heat such as the burning of biomass or electricity. During periods of low solar insolation or at night the stored energy is released through a heat exchanger system.

Some dryers utilize a concrete slab which has plenty of thermal mass. The concrete slab can therefore retain heat over a long period of time and release the heat when temperatures inside the dryer fall.

c. Industrial Coco Peat Drying Machines.

These are commercial machine dryers that have been specifically designed for drying coco peat. These machines are primarily designed for large-scale production and rely heavily on electricity to operate. In the case of the Rotary Drum dryer as shown in figure 6, the dryer is attached to machines that can open and sort coconut; the drum can separate coco peat, desalinate, dehydrate and dry in up to 40 minutes [5]. They are capable of ensuring coco peat quality is of the highest level, is cleaner and more environmentally friendly after treatment on high-temperature.

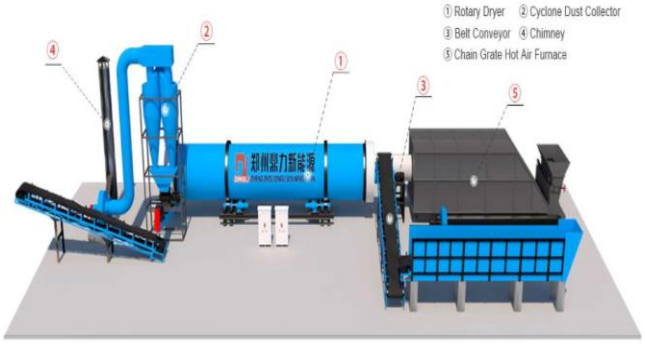

Fig. 6. Rotary Drum Dryer.
Source; [5]

In the Rotary drum dryer after dehydration and desalination, the 50-60% moisture coco peat is fed into the dryer in order to achieve flow drying. The coco peat is continuously raised and turned by shovelling plates inside of the dryer, this is spiralled forward through the drier inner, middle and the exterior layers of the drum. Heated air is used as a drying medium, the coco peat is entirely dried in the dryer to attain a moisture content of 14-18% (which can be adjustable). A conveyor belt then discharges the coco peat and a mechanism within the dryer keeps the coco peat from drying unevenly [5].

The coco peat drying machines are mostly electrical and need power to operate, these are industrial machines made largely for commercial purpose and large-scale production of coco peat. Atnaw *et al.,* (2017) [3] further opine that this reliance on electricity may significantly increase the cost of operation which may hinder the usage of dryers in areas that face electricity challenges such as rural areas. That not with-standing even in areas where electricity exists, the ability for potential users of such dryers to keep up with electricity costs is relatively low due to very low income. For this reason, such dryers are not readily applicable for use in developing countries on a wide scale or for large scale production of coco peat.

B. Other Convention Drying technique.

Aside from the techniques mentioned above, there are other traditional methods for drying coco peat that are universally applicable, such as firewood or fuel drying [3]. Firewood techniques have been used for centuries to dry coconut by-products and other agricultural products; however, this technique faces numerous challenges, such as changing weather patterns. Other fuel products that are not firewood can be used in the same way, such as biofuels and petroleum fuel products.

Biofuels are generally bio-waste by-products that are environmentally friendly and a good source of renewable energy; however, Atnaw *et al.,* (2017) [3] states that this technique has both advantages and disadvantages. It dries faster than open air drying, but it is important to note that the cost of building a dryer box and labour may be significantly higher, making it a significant disadvantage.

III. CONCLUSION

It goes without saying that there are numerous methods for drying coco peat using the techniques discussed above. However, the techniques can be classified in a variety of ways, depending on the drying method or the dryer design. Open air sun drying, on the other hand, is popular and has been widely used for decades as the primary method of drying coco peat, and has been widely adopted by farmers for their coconut by-products over the years. Conventional dryers, on the other hand, have been widely introduced as a replacement for solar drying in order to address the challenges posed by open-air drying, such as changes in weather patterns, animals, birds, pests, and disease during the drying period.

However, solar dryers are the most important of the available driers because they provide beneficial farming to the average modern farmer due to low input or investment costs and low maintenance costs in terms of labour and machine operation costs. It is important to note that the various drying methods, are all equally effective and provide a similar drying effect for the coco peat such as passive and active solar drying. For large-scale coco peat drying, industrial drying machines are available; however, unlike solar dryers, these machines have high operational costs in terms of electricity, labour, and maintenance. Farmers should therefore give solar tunnel dryers serious consideration as they can dry large amounts of peat in a short period of time. However, it is equally worth noting that during certain periods of the year such as winter low solar insolation is experienced, this is equally so for night period. Therefore, there is need for further consideration of hybrid solar based drying systems that can utilize solar energy directly and stored energy, so as to increase production even in unfavourable climatic conditions. This has seen significant increase over the year and is gaining popularity in recent years.

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