2.0 **CHAPTER TWO**

## 2.1 Literature Review

Cocoa beans is mainly consumed as chocolates and widely used in beverages, cosmetics, pharmaceuticals and toiletry products. It is also associated with many health benefits (Porter.,2006; Taubert et al., 2007). The quality of cocoa beans is highly dependent on processing technologies and storage conditions for preventing the defective quality. Fermentation and drying are particularly important since they are largely responsible for the typical cocoa flavour precursors which develop later during the roasting of the beans and for the keeping quality of the raw beans (Niles.,1981). Primary processing of cocoa beans, from the farmer's point of view is time-consuming, hard work. Primary processing of cocoa includes harvesting, gathering the ripe fruits at a central location in the farm, fruit opening, removing of the beans, fermenting the beans and drying the beans. Cocoa processing consists of two major steps namely; fermentation and drying. Fresh cocoa beans are usually fermented using the heap, tray or box methods for 5 to 7 days depending on the condition of the beans (Opeke., 1987). During fermentation, the temperature of the beans will rise from ambient to about 50 to 55°C due to the exothermic oxidation reaction (Wood and Lass., 1985). Fermentation is the initial step needed in the development of various flavor precursors in the beans (Hii et al., 2009). Fermentation may be carried out in baskets, heaps or boxes and may last from 36 h to 6 days and drying may be done naturally in the sun and last from 7-8days to 10-12 days depending on the harvest periods or season (Legrand., 1999). In quality control applications, cut test based on the colour changes in cotyledons during fermentation has been considered as good test (Shamsuddin and Dimmick., 1986) when determining the degree of cocoa beans fermentation, along with the formation of brown color (Misnawi et al., 2003). One of the advantages of the primary processing of cocoa beans is that it is relatively inexpensive, and this gives good opportunities for small farm holders to use cocoa beans as a cash crop (Are & Gwynne-Jones., 1974). Added to this, small farm holders are aware of what characterizes good quality beans, and they know strategies for obtaining the good quality. Hence, the cocoa farmers produce high quality of cocoa beans which have given them premium prices in the market (Aneani and Takrama., 2004). Drying is an excellent way to preserve food and solar dryers are appropriate food preservation technology for sustainable development. Drying was probably the first ever food preserving method used by man, even before cooking. It involves the removal of moisture from

agricultural produce so as to provide a product that can be safely stored for longer period of time. To evaluate the drying characteristics of cocoa beans by

a) Tray dryer

b) Solar Cabinet dryer

c) Microwave oven

d) Open sun drying

## 2.1 **Nutritional values of Cocoa**

Cocoa contains a significant quantity of fat, ~40 -50% contained in cocoa butter. This is comprised of 33% oleic acid, 25% palmitic acid, and 33% stearic acid. The polyphenol content constitutes approximately 10% of a whole bean dry weight. The polyphenols that cocoa contains include catechins (37%), anthocyanidins (4%), and proanthocyanins (58%). The proanthocyanins are the most prevalent phytonutrient in cocoa. It is important to note that the bitterness of polyphenols is the reason that unprocessed cocoa beans are unpalatable; manufacturers have developed a processing technique to eliminate this bitterness. However, this process markedly decreases the polyphenol content. Polyphenol content can be lowered by up to tenfold. Katz DL, Doughty K, Ali A. (2011)

## 2.2 **Economic importance of Cocoa**

Cocoa is most commonly associated with chocolate and has a variety of nutritional benefits that can confirm positive health attributes. The cocoa bean is an accident source of dietary polyphenols, containing more finale antioxidants than most foods. It is well known that polyphenols are associated with beneficial health effects, therefore cocoa is rich in polyphenols, and dark chocolate, which contains a high percentage of cacao and high antioxidants compounds relative to other chocolate types, have assumed significant importance to health. Montagna MT, Diella G, Triggiano F, et al. (2019)

### 2.3.0 Method of drying Cocoa

The two methods of drying cocoa are discussed as follows:

#### 2.3.1 Traditional method of drying Cocoa

The traditional method of drying known as sun-drying or open air drying involved simply laying the product in the sun on mats, roofs or drying floors. Other on tree and include hanging the crop underneath a shelter on tree and on racks ion the field. Even though this type of drying is frequently the most commercially used and able technique to dry agricultural product in Africa its full utilization by farmers, sellers and processors different agricultural product is still needed. During sun-drying heat is transferred by correction from surrounding and end by absorption of direct and diffuse solar radiation on the surface of crop. The convert heat s partly conducted to the interior increasing the temperature of the crop and partly for affecting migration of the water and vapor from the interior to surface of the crops.

#### 2.3.2 Modern method of drying Cocoa

Recent efforts to improve on sun-drying have led to solar drying. Solar drying also used the sun as the heat source. A foil surface inside dehydrator helps to increase the temperature. Ventilation speeds up the drying time. Shorter time reduce the risks of food spoilage and mold growth.

Oven drying: everyone who has an oven has a dehydrator by combining the factors of heat, low humidity and air flow, an oven can be used as a dehydrator.

#### 2.3.3 Drying Experiment

For the drying experiment, the fresh cacao bean samples were gathered from the different mixture of verities. The first trial was conducted in January 2018 and the 2nd and 3rd trials in February 2018. Prior to the drying process, the fresh beans were fermented for 6 days using the basket method. The average of 40
kilograms of cacao beans fermented with the initial moisture content of 55% wet basis was loaded into the
rotating screen basket for each drying test to satisfy the estimated high loading rate. Moisture reduction was identified by weighing the representative sample. Drying continued until the mass

of the beans remain unchanged and also in accordance with Opeke ***[L.K. (1992). Tropical Tree Crops. Ibadan:***
***Spectrum Books Limited.]*** that drying should stop when the color of the beans turned brown and a pressed handful of beans together gives crack shells (testa) and a bean cut with the knife gives separated cotyledons

### 2.3.4 Drying

Drying is traditionally defined as that unit operation which converts a liquid, solid or semi-solid feed material into a solid product of significantly lower moisture content. In most cases, drying involves the application of thermal energy, which causes water to evaporate into the vapor phase. The requirements of thermal energy, phase change and a solid final product distinguish this operation from mechanical dewatering, evaporation, extractive distillation, adsorption and osmotic dewatering. Drying is one of the cheapest and easiest methods for preservation of high moisture foods or fruits. The major advantage of drying food products in the reduction of moisture content to a safe level that allows to extend the shelf life of dried products. Many methods of drying such as air drying, freeze drying, tray drying, solar drying, tunnel drying, spouted bed drying, foam mat drying, osmo-air drying etc. are in industrial practice in India to dry high moisture foods/fruits. Depending on suitability, economical value and quality of end product the method of drying is selected.

### 3.3.5 Tray drying

The samples of cocoa beans were dried in tray dryer and moisture content was calculated at different drying time intervals and data were analyzed. Shows that the variation in moisture content against drying time for samples. It was observed that the moisture content of samples decreases with increase in drying time. The drying was carried out at the temperature of 600C. The moisture content decreased from 49.35 to 7.5% in total drying period of 8 h respectively.

### 2.3.6. Microwave oven drying

The sample containing 0.5 kg of cocoa beans at 49.43% (w.b) moisture content was taken and drying is started from 1.00 PM and continued till 1.10 PM. During drying process, at every 5 min. interval, the moisture content of cocoa beans were determined and tabulated as shown in Table 3. The variation of moisture content with respect to drying time.

The moisture content of samples decreased from 49.43% (w.b) to 7.59% (w.b) in a total drying period of 10 min., it is clear that the moisture content of beans decreased with increase in 4.1.4 Open yard sun drying The sample containing about 0.5 Kg of cocoa beans (49.86%) was dried in open sun drying for total period of 30 h. In open sun drying, the sample was kept at 9:00 AM on the sunny day and continued up to 5:00 PM. The partly dried cocoa beans was wrapped in polyethylene cover and kept it room temperature. On the next day, the partly dried beans were again exposed to open sun and it is dried to a final moisture content of 7.14 % (w.b). During drying process at every two hour interval, the moisture content of sample was determined tabulated as shown in Table 4. Fig. 4 shows the variation of moisture content with respect to drying time and moisture content of samples decreased from 49.86 to7.14% in total drying period of 30 h. From the Fig. 4, it is clear that the decrease in moisture content slowly up to 12 h (34.49%) of drying periods and later it was found faster and it took 30 h time to loose moisture content from 49.86% to 7.14%. Though the different moisture levels, observed after a total drying period of 30h (7.14%), is very small, the drying experiment was continued for another one hour duration at which the dried cocoa beans could be easily made in to powder. As compared to open sun drying, the solar drying

### 2.3.7 Design Features of the Material

The developed cacao beans dryer and its general features are presented in Figure 1 which shows the isometric view of the cacao mechanical dryer. The dryer measures 126 cm long and 90 cm width. Its front and back walls measure 20 cm and 35 cm in height, respectively.

## 2.4 Previous work on the Study

***Mangesh Gavhale, Swapnil Kawale, e.l., (2015),*** In their project, they developed a limited scale town level solar dryer for tomato was created under Yola climate at scope 9°14′ N and longitude 12°26′ E utilizing locally accessible materials and the presentation was assessed. On the comparative methodology they fabricated seed dryer which is likewise more valuable for drying the seeds, crops for example maize, beans and so on. The pith of the dryer was to accomplish the powerful strategy for seed protection and wipe out the drudgery and item weakening related with customary techniques for open sun drying of seed. This is considering mitigating the climate impediment experienced by ranchers in crop drying particularly for tomatoes. The solar dryer comprises of plate, intelligent walls and glass rooftop, a preheating air safeguard plate, inward

boards for evacuation of dampness and chimney stack through which air stream passes across the dryer. Assessment of the dryer showed a raised temperature of around 47oC was attainable in the drying chamber. The dryer temperature and drying rate was viewed as higher than the regular open sun drying technique. The outcomes showed a significant benefit of solar dryer over the conventional open sun drying strategy in term of drying rate and lessen the chances for spoilage.[2]. Isaaac Ajunwa, Dangana M, Kulla ***Muhammed, Abdullahi D S Yawas, (2020),*** Their project was depended on the need of food conservation can't be over-underlined. Crops should be handled and safeguarded in the midst of their overflow to guarantee forever and specie maintainability in the midst of shortage. Flat plate collectors (FPCs) are in many cases made fixed and the places of reflectors utilized on them are not regularly determined; in this paper, a report of an exploratory trial of a roundabout sun powered dryer whose FPC is worked physically in a solitary hub to follow the sun is introduced. To abstain from causing additional expense on the current plan, the FPC was fairly made to be worked physically rather than the mechanization cycle. Utilizing the Designing Condition Solver (EES) and the TRNSYS 16 virtual products, the precise places of reflectors put east and west on the FPC were recreated for the main quarter a long time of the extended period of the investigation - this incorporated the long stretch of the test. This was to determine the best situations for the reflectors in other to accomplish most extreme insolation. For the period of the test, Walk, the precise places of the reflectors set east and west of the FPC were viewed as 40° and 80° separately comparative with the even plane. The exhibition of the solar dryer as far as the rate dampness misfortune, drying rate, authority productivity and drying proficiency was assessed when the FPC was fixed and when it was made to follow the sun and the outcomes got there from were looked at. In their examination, it was found that the dryer tried by physically following the sun expanded the complete rate dampness misfortune by 5.11%; the all-out drying rate by 2.10×10-5 kg/s; the typical authority proficiency by 3.92% and the generally drying productivity by 2.0% as contrast with when the FPC was fixed, for example not following the sun. The backhanded solar dryer was with the capacity to physically follow the sun in a solitary hub utilizing the meteorological states of Zaria, Nigeria was consequently found to have expanded the exhibition of the framework dryer as contrast with while following of the sun was not finished. ***Suraj Pathak, Shadab Shah, Mahipal Charan, e.l., (2020),*** Their paper proposed that the solar drier which is intended to overcome the limits of conventional sun drying techniques like direct daylight exposure, risk for sticking, interruption of birds and insects and absence of appropriate

monitoring. The sun-oriented dryer utilizes solar energy to warm up the air and dry the material stuffed into it. The framework comprises of an air radiator or sun based warmer and a sun powered drying chamber with plate rack. Warmed air in sun powered gatherer constrained by blower for example inner utilization of sunlight powered charger energy to stream in chambers where it is utilized for drying implies eliminating the dampness content from the stacked gatherer substances and interfacing chamber. Slant point is primary boundary for the computation of effectiveness of the dryer. Thus, right off the bat we have determined heavenly messenger of slant for the safeguard plate. The slant point ought to be not exactly latitude pointing toward the north side. So, we got the scope 19.01°N in Mumbai as needs be we got the slant point 15°C. By taking this slant points a reference we got the length of aggregate length of the solar dryer framework which is 116.41cm and Authority region around (80.4 x 40) cm^2.

### 2.5 Effect of drying method on product quality

#### 2.5.1 Surface mould assessment:

The dried cocoa beans were assessed qualitatively for external mould at levels such as none, light, moderately heavy, heavy and extremely heavy. The intensity at each level was based on the amount of mould covered on the dried bean surface, ranging from none (0%) to extremely heavy (100%) at 25% coverage interval. The data found were 92%, 1%, 1%, 0%, 0%; 97%, 2%, 1%, 0%, 0%; and 95%, 3%, 2%, 0%, 0%,92%,4%,3%,0%,0% tray dryer, solar dryer, micro wave oven, open yard sun drying

#### 2.5.2 Quality standards

Quality of cocoa is determined by a combination of factors that determine the acceptability of the cocoa to a buyer. These factors include proper fermentation, dried to the proper moisture level, free from abnormal odours and free from mould contamination. Cocoa is graded on the basis of the count of defective beans in the ‘cut test’. The cut test reveals the presence of certain defects which may cause off-flavors’ and indicates the degree of fermentation of the beans which has a bearing on the flavor and quality of the beans. The International standards organization cut test

procedure states that for a complete determination of bean quality, beans shall be opened or cut lengthwise through the middle, so as to expose the maximum cut surface of cotyledons.

### 2.5.3 Determination of quality by Cut test

The cut test scores of cocoa beans for different drying methods. The cut test score of tray dryer, solar cabinet dryer, Micro oven and Open yard sun drying was found to be 985, 970, 935 and 960 respectively. It is clear that the brown beans obtained in tray dryer were more in comparison to other drying methods.

### 2.5.4 Analysis of cocoa beans

The variations of pH, Titratable acidity, Acetic acid, free fatty acids of sample dried in four different methods are shown in Table. 8 The tray drier samples contain high amount of free fatty acids as compared to the solar dryer sample, Microwave oven, Open yard sun drying. Among the four methods i.e. solar cabinet, Microwave oven and Open yard sun drying methods the solar drier samples contain higher amount of acetic acid respectively. The micro wave oven has high content of titratable acidity as compared to tray drier, solar cabinet and open yard sun drying. The pH value was low in open yard sun drying as compared to tray drier, solar cabinet and microwave oven. From the results of drying experiment, analysis of the cocoa bean powder produced tray dryer followed by solar cabinet dryer and OYSD are considered as better quality product. If drying time is given weightage, then the cocoa bean powder produced in microwave oven may be chosen