Gnepie Nicolas Journal of Engineering Research and Application *w.ijera.com*
ISSN : 2248-9622 Vol. 9,Issue 7 (Series -V) July 2019, pp 50-56

RESEARCH ARTICLE OPEN ACCESS

Pratice of Drying Cocoa in Humid Tropical Zone: Case of Southern Cameroon

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ABSTRACT
An analysis of the practice of drying in the production areas of Southern Cameroon was made, this gave a way to observe that most producers are under educated and evolve individually.The drying devices that are mostly used in southern Cameroonare: traditional solar drying on tarpaulins and cemented areas, mainly in Bafia andNtui,and artificial drying with wood burning, inKumba.The bus or floor dryers have been abandoned, one for its low drying capacity and the other to avoid contamination of the cocoa beans by dust and other debris.The drying capacity varies between 50 and 300kg per cycle. In Bafia and Ntui after fermentation the beans were sorted and exposed directly to the sun with a drying time of 4 ± 1 days, while in Kumba after fermentation and sorting the beans were firstly exposed to the sun on tarps for 5 hours to 8 hours then they were put in a wood-burning dryer for about 2 days, resulting in a total drying time of 2.25± 0.08days. The towns of Bafia and Ntui are therefore characterized by the practice of insufficient drying and humid cocoa (11 and 12% correspondingly) but less acidic (pH=6.22 ± 0.40). The city of Kumba is characterized by a hybrid drying (traditional solar drying or artificial drying) an acceptable drying time, for a dry cocoa (X≤8%) but a high acidity (pH=5.38± 0.05). This study concludes that the traditional solar drying mode makes it possible to obtain well-seasoned beans. It makes it possible to recommend the use of the hybrid dryer in all localities while increasing the percentage of the traditional solar drying time, in order to obtain a better triplet drying time / water content/ acidity.
Keywords: Cocoa, post-harvest, drying process, drying time, merchant cocoa, quality.

Date Of Submission: 05-02-2019 Date Of Acceptance: 21-07-2019

I. INTRODUCTION

The coffee-cocoa sectoris a vital sector for the economies of tropical countries. They account for more than 46% of export earnings and employ more than 2/3 of the population (Kanmogne et al., 2012). In Cameroooncocoa production has grown significantly. Cameroon is the world fifth largest cocoa producer, producing 232000 Tons for the 2014/2015 season (ONCC, 2015). However, during these 10 years nearly 95% of this production is sold in grade II cocoaresulting in a significant loss for peasants of nearly 145billion Francs CFA. This poor quality of Cameroonian cocoa is due to post-harvest treatments whose primary objective is to transform harvested products intomarketable products into consumable products. To these end the simplest treatment option is: picking or harvesting, pod breaking, fermentation (Barel, 1998) and drying (Hii et al., 2009). All these operationsaffect the characteristics of the product and strongly depends on each other.They contribute to the quality of the final product(Cros et al., 1995). One can intervene on one or other of the links of this chain and adapt the set according to the product which one wishes to obtain. Studies have shown that drying is a veryimportant step because it has an influence on the quality of merchant cocoa beans (Kouakou et al., 2013). The purpose of the drying process is to reduce the water content of the beans from 55% to about 7% (Nogbouetal., 2015) and to reduce the acids produced during fermentation to an acceptable level (pH>5,5) (Guehi et al.,2010;Barel et al., 2013). The aims of thiswork is identify and characterise local cocoa drying practices in southern Cameroon. To achieve this goal, we assumed that drying practices and drying equipments were not suitable for drying in the context of use. As methodology we proceeded to characterize local drying practices in southern Cameroon through an investigation.

I. Survey tools and methods

I.1.Study sites

We started this study with a population of cocoa producers randomlychoosen in the cities of **Bafia** (4°45'00.0' North latitude and 11°14'00.0" east longitude), **Ntui (**4°20'0'' and 5°10' north latitudeand 11°10 and 11°80 east longitude) and**Kumba**(4°38'38.0"north latitude and 9°26'19.0"east longitude)

I.2.Sample

To choose the sample to be visited, we applied simple random sampling methods, whereby a sample was selected so that a possible sample of size 'n' had the same probability of being selected, individuals are randomly selected, all individuals had the same probability of being sampled they are all independent of each other. Thus, the choice of units to be visited was based on two main criteria:

- To be a cocoa producer;
- To be established in one of the following Cameroonianagro ecologicalzones: towns of Obala, Ntui or Kumba town.

On the basis of these criteria, 61 producers were selected, that is 36 at Bafia, 10 at Ntui and 15 atKumba.

I.3. Tools

We opted for a face-to-face interview. In our context of study, this method does not influence the information and does not distort the quality of the answers given by the different interlocutors.(Edoun, et al., 2010).

I.4. Investigation and information collection

This investigation was carried out between October and December 2017.

I.4.1. Collection of information and sample

The collection of information was done in several stages; a step of making contact in other to gain the trust of the producer. Followed by the step of collecting information (direct declaration of resource persons met on the sites).Finally, a step of monitoring post-harvest treatment of cocoa beansand of collecting samples of dried cocoa beans. Samples were taken at random from some producers, and were put in hermetic plastic bags, to avoid any rehumidification during transport to the laboratory for the analysis of water content.The analysis of the pH was done on the site.

I.5. Sample analysis

I.5.1. Water content of cocoa beans

The water content was determined using the**AOAC 14.004** (1990) method on a sample mass of2.000 ± 0.002 g. The analysis was made in triplicate and the water content of the samples was calculated according to formula 1:

$$X = \frac{M_1 - M_2}{M_2 - M_0} * 100 \qquad (1)$$

With:

X:Water content (% kg_{water}/k_{MS})

$M_{1:}$ Massof the fresh sample before steaming (g)

$M_{2:}$ Mass of the crucible containing thedry sample after steaming (g)

$M_{0:}$ Mass of empty crucible (g)

I.5.2. pH Determination

The pH was being measured using the method described by (AOAC, 1990). On a mass of 0.5 ± 0.005 g dry matter of cocoa powder.Theaqueous phase pH was measured using a pH-meter calibrated with buffer solutions, (acid buffer at pH=4, neutral buffer at pH=7 and alkaline buffer at pH=10).

II. Characteristics of drying units

II.1. Capacity

On the basis of the drying capacity, 45.9 % of producers, had a drying capacity of less than 200 kg/cycle of fresh beans, 29.5% had a drying capacity greater than300 kg/cycle, 19.7 % were in the range 200 à 300 kg/cycle and 3.3% had a capacity less than 100 kg/cycle (figure 1). A drying cycle taken here as the time between the end of fermentation and the time of the producer declares his cocoa dry.

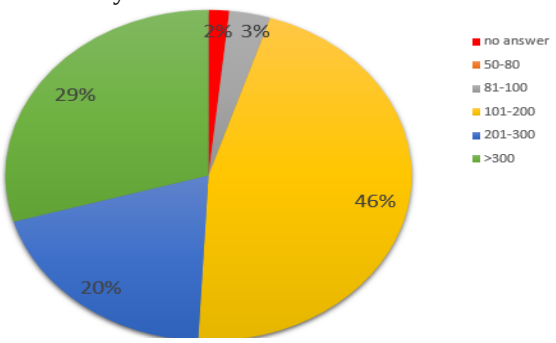

Figure 1: drying capacity per cycle

II.2.Dryers

The results of the survey revealed that the open sun dryer on tarpaulins, the open sun dryer on cemented area and the wood dryer are the 3 types of dryers used to dry cocoa in the main productive zones of Cameroon (figure 2). These 3 types were distributed per zones.

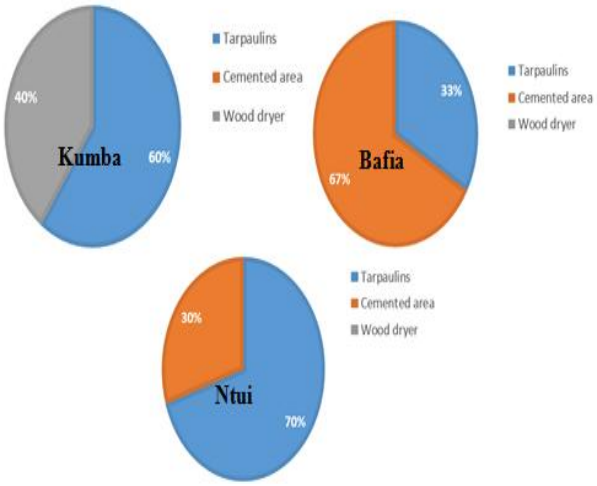

Figure 2: Type of dryer per zone of production

a) – open sun dryer on cemented area

open sun drying on cemented areas was done on a concrete platform, (figure 3a), having a thickness between 10 and 15 cm, length between 6 and 10 m and width between 4 and 5 m. the quantity of dried cocoa varied from300 to 500 kg of fresh beans per drying cycle. The cocoa beans were arranged in layers of 2 to 3 cm. the cemented areas are the drying devices mostly used in Ntui, about 67%, while drying on tarpaulin was only about 33% and there was no other types of drying.In showers, theywere covered with tarpaulin or were put in bags.Figure 3b shows the physical model of open sun drying on cemented surfaces.

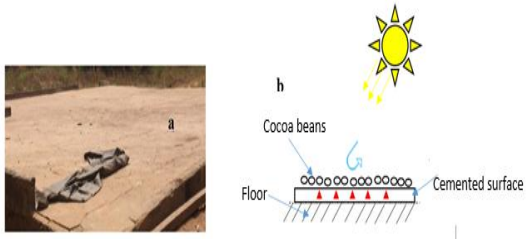

Figure 3: a) Cemented area, b) physical model of open sun drying on cemented area

Figure 4, shows the temperature profile of the city of Ntui for the day of 12 November 2017. For this study period the lowest temperature was 22°C and the highest was 28°C. that which fives us on average at 25°C. With a wind speed of 1.5 km/h or 0.4 m/s. Figure 4shows the pH evolution based on time. We observe on evolution of this pH which goes from 4.80 ± 0.50, at the end of fermentation at 6.20 ± 0.30, at the end of drying after 5 days. However, there is need her a permanent presence at on operator to monitor and brew exposed cocoa beans.

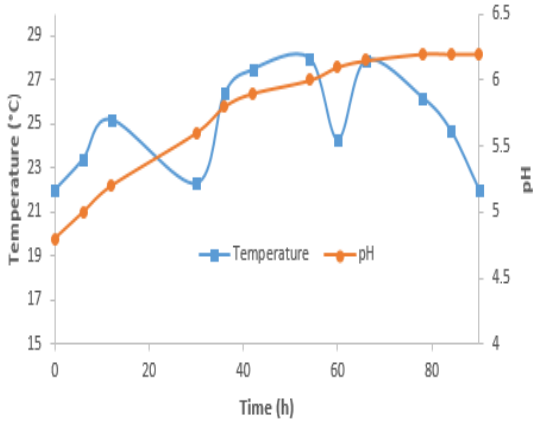

Figure 4: Temperature profile of the city of Ntui and pH Evolution based on time

b) – Open sun dryer on tarpaulins

the open sun dryer on tarps was done on an impermeable and opaque plastic canvas, (figure 5a), of thickness less than 3 mm, of lenght between 3 and 6 m of width between 3 and 4 m. the amount of dried cocoa varies from 100 to 200 kg of fresh beans per drying cycle.Cocoa beans were arranged in layers of 1 to 2 cm. At Bafia thats is the mostly used dryer, 70%, followed by the open sun dryer on cemented areas (30%).This dryer enables the protectionsof beans against foreign bodies but is dependent climatics change.Figure 5b shows physical model of open sun drying on tarpaulin.

Figure 5: a) Cocoa beans spread ontarps; b) Physical model of open sun drying on tarps

Figure 6, shows the temperature profile of the city of Bafia for the day of 18 october 2017. We observe a belt shape trend characterized by sunshine with an average temperature a 25.5°C and wind speed of 1.1 km/h or 0.3 m/s. We observe a pH evolution from 4.80 ± 0.50, at the end of fermentation at 6.22 ± 0.40, at the end of drying after 5 days. However, we observed the same disadvantages as in previous case.

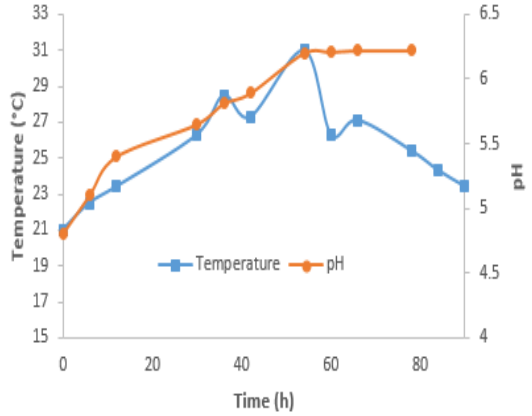

Figure 6: Temperature profile of Bafia town and evolution of pH based on time

c) – Wood dryer

Drying in wood burning kilns is mainly practiced in the south-west region of Cameroon, there are two types: The dryer of the type " SAMOA " and the dryer of the type " Cameroon " which is the most used.These two types of kilns were described by Kanmogne in 2012. In Kumba the trend is to use artificial wood fuel dryers (60%), and tarpaulins (40%).

Figure 7 present the temperature profile at Kumba for the day from 09 December 2017. The evolutionof temperature follows the same trend as in other cities.This time with an average temperature of 30 °C.With a wind speed of 7 km/h or 2m/s.The temperature in the dryers varies between 60 and 80 °C, so an average of 70 °C.There is a pH evolution, which goes from 5.01 at the end of fermentation, to 5.38 at the end of drying after 2 days and 6 hours of drying.

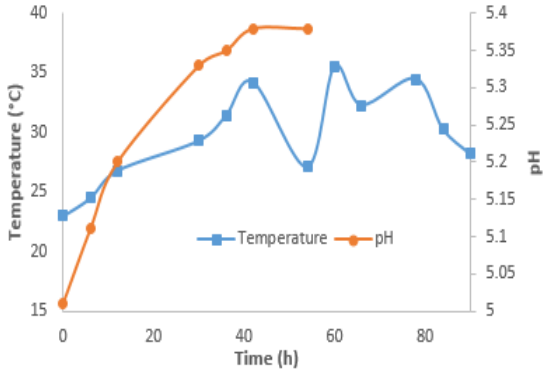

Figure 7: Average Temperature profile in Kumba and pH evolution of cocoa beans based on time

Very few producers still dry their product on the floor (Figure 9a), as this practice is punishable by an order of the Minister of Agriculture.Figure 9b shows the physical model of open sun drying on the floor.

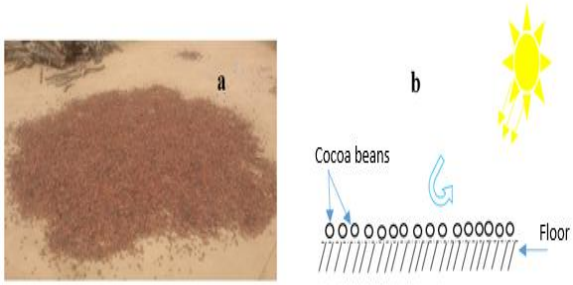

Figure 8: a) Cocoa beans spread on floor; b) Physical Model of open sun drying on floor

In the Bafia, there are bus dryers (Figure 9a).But these dryers have a very low capacity of capacity, 50 to 75 kg of fresh beans per drying cycle and a slow speed of drying.Figure 9b shows the physical model of solar bus drying.

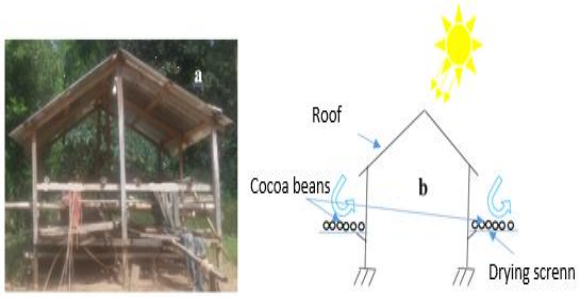

Figure 9: a) bus dryer; b) physical Model of autobus drying

III. POST-HARVEST TREATMENT OF COCOA BEANS

III.1.Pod breaking

This is an operation which consist of extracting the cocoa beans from the pods. It is done latest five (05) days after harvesting.

During harvesting, in the majority of cases cocoa pods are transported to the fermentation and drying site before been broken. In the investigated zones, 95% of producers were using gourdinto break cocoa pods, that which is advised because it prevents cocoa beans from being wounded. Against 5% who were using cutlasses. After pod breaking, the beans were scrapped off from mucilage before they were fermented.

III.2. Fermentation

Fermentationis a process which enables the rapid decrease of the germination of seeds and develop the precursors of aroma and chocolate taste. It was done in two parts. The first fermentation gives way to liquefy the pulp surrounding the bean.it is an anaerobic fermentation during which the glucose contained in the beans and the mucilage is transformed into ethanol. During the second fermentation, the alcoholic pulp is transformed into vinegar. It is an

aerobic fermentation during which ethanol is converted into acetic acid.

The fermentation devices encountered during our surveys were: banana leaves 87% and crates 13%.The beans were deposited on banana leaves, on the side of the thin white film (natural yeast), and covered with other leaves(figure 10a). The cluster of beans were kneaded every 2 days to standardize the fermentation. It was the same process for the fermentation of crates, (figure 10b). The duration of fermentation was from 6 to 7 days in the Mbam and Inoubou and in the Mbam and Kim, while it was 5 to 6 days in theMeme. At the end of fermentation,the beans have, a brown homogenous external color which is a sign of good fermentation (Koffi et al., 2013), water content of 55.0 ± 5.0% and pH of 4.80 ± 0.50. A fermentation cycle includes on average 250.0 ± 10.0 kg of beans.

Figure 10: Clusters of cocoa beans arranged for fermentation: a) on banana leaves, b) in a wooden box

III.3.Drying

In the production zones, after the fermentation, the cocoa beans will go through the following stages: Sorting, display, drying.the drying process in the differents zones is given by figures 11 and 12.

- **Sorting**:This step aims to separate the cocoa bean pod debris, banana leaves and beans in bad states (injured, poorly fermented).It is handmade;
- **Display:** After sorting the beans are exposed to the sun.They are spread in a layer of 1 to 2 cm on the tarpaulins, 2 to 3 cm on cemented areas and 3 cm in the artificial dryers.In the Kumba area the beans are first spread on tarpaulins to be exposed to the sun and then they are removed and spread on the racks of the artificial wood fuel dryers.The display is done manually, using rakes with wooden teeth.
- **Drying:** In the Ntui and Bafia areas, the beans are put in the sun from 6 am to 6 pm, and put back in the bags, in jute cloths, to be stored in the stores during the night.During drying, the beans are stirred every 2 hours, until the end of drying, which lasts 4.0 ± 1.0 days, for an average drying temperature of 25 °C.This is done manually using rakes.In the Kumba zone, the beans are sun-dried for a longer or shorter time depending on the producer, 8 ± 3 hours, and then it is completed by an artificial drying for 42 ± 6 hours, ie a drying time of 54 ± 2h per drying cycle, for an average drying temperature of 51 ° C.The beans are left in the artificial dryer for 5 hours then removed and left to rest for 5 hours to avoid damaging the hull of the bean, which would be due to too high temperatures (60 to 80 ° C), during artificial drying.

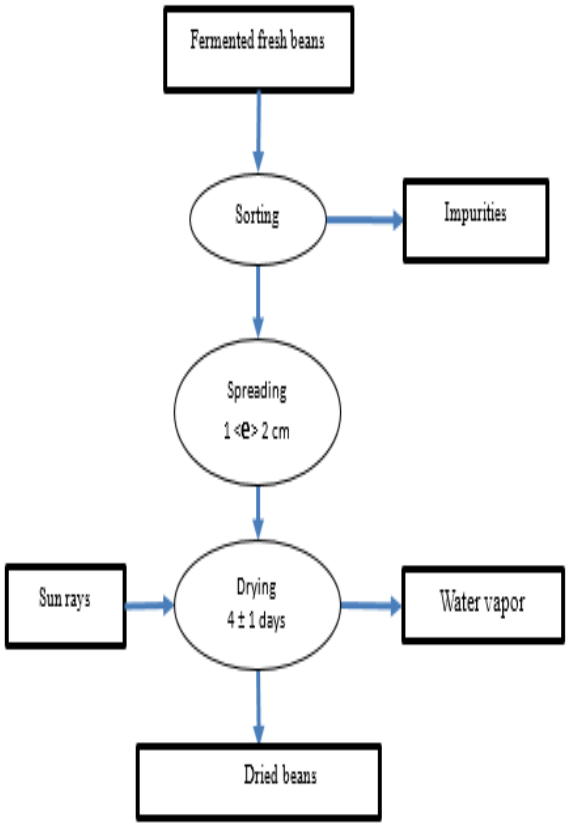

Figure 2: Flow chart of drying beans in Bafia and Ntui

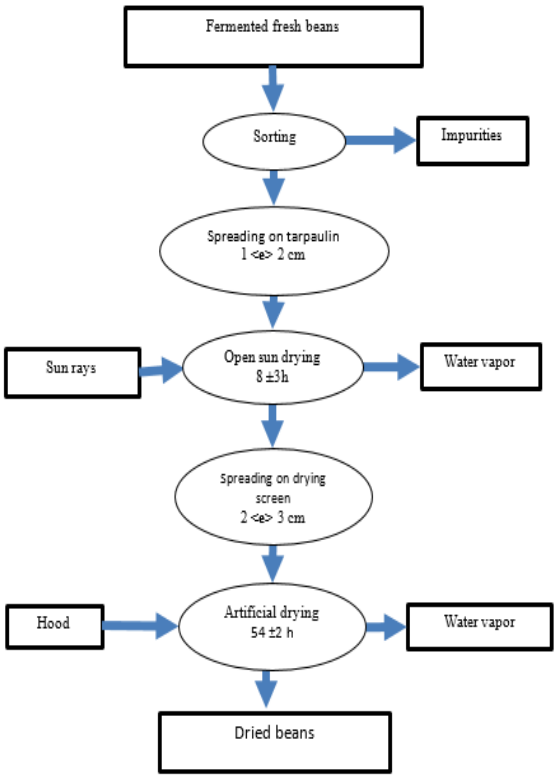

Figure 3: Flow chart of drying beans in Kumba

IV. ANALYSIS OF SAMPLE OF COLLECTED PRODUCTS

Table 1 gives the water content and the level of acidy of the beans, at the end of drying as well the duration of drying in principal zones of production in Cameroon.

Tableau1: Results of the analysis of driedbeansanddrying duration in principal zones of production in Cameroon

Zone	X (%)	X Standard	pH	pH Standard	Drying time (days)	Standard drying Time (days)
Ntui	11.0 ± 0.5	≤ 8%	6.20 ± 0.30	≥ 5.50	4 ±1	7 à 15
Kumba	8.0 ± 0.1		5.38 ± 0.05		2.25 ± 0.08	2 à 4
Bafia	12.0 ± 0.8		6.22 ± 0.40		4 ±1	7 à 15

These results show us that, the water content (X) of dried beans in the Bafia zones 12.0 ± 0.8% and Ntui 11.0 ± 0.5% is higher than the norm which stipulates that a cocoa Good quality merchant must have a water content less than or equal to 8%.This could be explained by the fact that producers do not respect the minimum number of days recommended for solar drying which is at least seven (07) days of exposure to the sun (Kouakou, 2013).While the water content of cocoa beans in the Kumba area is 8 ± 1%.This water content very close to the norm is achieved through the use of wood-burning drier, which is a dryer to achieve high temperatures (80 °C and above).

We also note that the pH of dried cocoa beans in the Bafia zones of 6.20 ± 0.30 and Ntui 6.22 ± 0.40, to the standard which states that the pH of dried beans must be greater than 5.5.This result could be achieved by drying at average temperatures below 40 ° C, resulting in gentle drying.While the pH of dried cocoa beans in the Kumba area 5.38 ± 0.05 is below the norm.This could be explained by the fact that the artificial drying by wood combustion does not allow the control of the temperature, one thus observes too high temperatures, about 80 °C, from where a more aggressive drying.

V. PROBLEMS AND NEEDS OF PRODUCERS

V.1.Problems of producers

The producers, 83.6 %, declare that their main problem is the duration of the drying too high which causes an interruption of the process and the appearance of mold on the beans, (figure 13), from where a bad quality of the beans at the time of sale which is the second problem reported by 95% of producers, because according to the exporters, the water content of the beans is higher than the norm (8%) in Bafia and Ntui, and a high acidity of the beans at the end drying, in Kumba.Hence a low selling price compared to other producing countries.The following problem is the difficulty of the drying and the need for constant human presence throughout the drying process.Other producers of Kumba 9.83% also pose the problem of contamination of beans by smoke.

Figure 3: Moulded cocoa beans

The problem of shortage of energy source does not arise because almost all producers use as energy source, the sun and / wood.The only method of regulating the drying temperature is by varying the flow of air and biomass in the case of those who have a wood-burning dryer which leads to the achievement of high temperatures.

Tableau 2: Main problemsof producers

Problems

	Ratio
Dryer control system (temperature and speed of drying air)	**60/61**
Too long time of drying process (longer than 5 days)	**51/61**
Permanent monitoring	**59/61**
Pension of operations	**61/61**
Quality of dried cocoa beans	**58/61**

V.2.Needs of Producers

It is clear that the need for production units is to be able to dry their products.This may involve the establishment of a new method of process during the drying of the beans and the definition of criteria that can allow the selection of a dryer respecting this process.For example:

- Large capacity dryer (>300 kg / cycle);
- Dryer to reduce human intervention;
- Dryer that uses available energy in the production area (sun, biomass, electricity);
- Dryer which allows a control of the drying parameters.

These results are elements for a generic functional specification that is essential for setting up a cocoa bean drying process adapted to the context of use.The analysis of the elements entering it shows that during the design activity, the degrees of freedom of the designers remain important insofar as there does not seem to be too much pressure on the economic cost.

VI. CONCLUSION

This survey shows that cocoa drying in the main production areas of Cameroon is of small-scale and is characterized by the exclusive use of two drying principles (open sun drying and wood-burning drying), with daily drying capacity between 100 and300 kg. Most of the workforce is made up of the Group of Common Initiatives (GIC) and individuals.The main problems of producers are related to post-harvest treatments, particularly drying. An analysis of the samples showed that the water content of the dried cocoa beans in the Ntui (11%) and Bafia (12%) zones is higher than the standard whereas those dried in the Kumba zone are acidic (pH <5.38).This poor quality of the beans is due to drying processes that are not adapted to the context of southern Cameroon. Hence a need to develop new drying processes that can overcome these various shortcomings.

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Gnepie Nicolas" Pratice of Drying Cocoa in Humid Tropical Zone: Case of Southern Cameroon" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.07, 2019, pp. 50-56