Investigation on the Drying of Dioscorea Schimperiana in the West Region of Cameroon

Fabien Akana Tsopmo, Jules Marcel Keutchanga Foncha, Jean Claude Damfeu, Bernard Gaga Dadi, Abraham Kanmogne, and Jean Nganhou

***Abstract* — The drying method and types of agricultural dryers used by farmers in rural West Cameroon were surveyed. These are direct solar drying (predominant). Different types of dryers are associated with each of these drying methods. These are the open-air bamboo mat dryer and the collar dryer. An analysis of the actual drying needs in rural areas and an evaluation of the means available to meet them are conducted based on a survey of farmers in rural areas. The conservation of Dioscorea Schimperiana is very difficult because of the unfavorable climatic conditions during production. The local unit of measure is the basket, which weighs between 5 and 25 kilograms. The purchase price of Dioscorea Schimperiana from the producer is higher in the rainy season. The drying time varies between 1 to 2 weeks for the bamboo dryer and 3 to 4 weeks for the necklace dryer. Laboratory determination of the dry-base moisture content of the post-drying Dioscorea Schimperiana samples collected during the surveys shows that it varies from 12.1 to 19.04 % instead of 11 % which is the recommended moisture content. The range of moisture content found shows insufficient drying.**

***Keywords* — Cameroon, Dioscorea Schimperiana, Dryer, Drying, Moisture Content.**

I. Introduction

Yam is a monocotyledonous food crop of the Dioscoreaceae family that produces widely consumed tubers or rhizomes [1]. Worldwide, there are approximately 600 to 800 species of yam plants that represent an immensely important natural resource, largely undeveloped [2]. This tuber is an age-old food in both Africa and Oceania where its cultivation and use are the subjects of ancestral and often ritual know-how. Its use as a staple food in Africa dates back more than five centuries. This was before the introduction of cassava and maize in the 16th and 17th centuries, and the more recent imports of rice and wheat [1]. More than nine species of yam are cultivated in Cameroon, including Dioscorea Schimperiana [3].

Dioscorea Schimperiana is a species of yam of variable length and characterized by long hairs on the skin. This yam is an integral crop for food security in the western regions where it is grown. It is the only yam with a traditional and well-defined drying technology. Therefore, it became a concern when it was considered an endangered yam species [4]. It exists in three varieties: yellow, red, and yellow spotted with red depending on the color of the pulp. This pigmentation would be due to the carotenoids, and provitamins A contained in this species. In Cameroon, disorders due to vitamin A deficiency remain a public health problem. The yam Dioscorea Schimperiana by its color would reduce these deficiencies in vitamin A. The first objective of post-harvest treatments is to transform harvested products into marketable or directly consumable products. To this end, the simplest sequence of treatments is harvesting, preparation of the product, and drying. All these operations affect the characteristics of the product and are strongly interdependent. They constitute a chain that determines the quality of the final product. One can intervene on one or the other of the links of this chain and adapt the whole according to the product that one wishes to obtain. Drying, the last link in the chain, is essential for a good number of agricultural products and is more decisive for the desired quality of the product. It is by acting on the drying conditions that the most important improvement in quality is obtained [5], [6]. Therefore, to valorize and adjust new technologies to the problems of drying Dioscorea Schimperiana in West Cameroon, the Energy Laboratory of the National Advanced School of Engineering of Yaounde has assigned itself a research mission, of making an inventory of the problems related to the drying of Dioscorea Schimperiana. This inventory is based on:

- Analysis of the real needs and current solutions for drying Dioscorea Schimperiana, which is highlighted by answering the questions why, where, when, and how Dioscorea Schimperiana is dried in West Cameroon;
- The identification of unsatisfied needs by answering the following question: what the unresolved problems are related to the current drying methods;
- The evaluation of the means available to satisfy them, which are the financial resources of producers, the energy, material, and human resources of the applicants.

The objective of this approach is to propose improvements in drying methods that meet the needs and possibilities of Cameroonian rural producers by recommending a type of

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F. A. Tsopmo, Energy, Water and Environmental Laboratory, National Advanced School of Engineering, Yaoundé, Cameroon.
(e-mail: akanafabien@yahoo.fr)
J. M. K. Foncha, Civil and Mechanical Engineering Laboratory, National Advanced School of Engineering, Yaoundé, Cameroon.
J. C. Damfeu, Energy, Water and Environmental Laboratory, National Advanced School of Engineering, Yaoundé, Cameroon.
B. G. Dadi, Civil and Mechanical Engineering Laboratory, National Advanced School of Engineering, Yaoundé, Cameroon.
A. Kanmogne, Energy, Water and Environmental Laboratory; Civil and Mechanical Engineering Laboratory & National Advanced School of Engineering, Yaoundé, Cameroon.
J. Nganhou, Energy, Water and Environmental Laboratory; Civil and Mechanical Engineering Laboratory & National Advanced School of Engineering, Yaoundé, Cameroon.

Dioscorea Schimperiana dryer. The expected effect is to improve the quality of the dried product. To achieve this objective, we hypothesized that the drying method and the type of dryer influence the quality of the dried product. To this end, a series of surveys were conducted among Dioscorea Schimperiana growers and consumers in rural areas of West Cameroon, which enjoys a climate conducive to the cultivation of Dioscorea Schimperiana. In this part of the country, three production areas were identified for the surveys: the Bandjoun, Bayangam, and Batoufam area in the KOUNG-KHI, the Baham and Bameka area in the Highlands, and the Batcham area in the Bamboutos.

II. Materials and Methods

A. Study Site

The study was conducted in the highland region of West Cameroon (4°54' to 6°36'N latitude and 9°18' to 11°24'E longitude) (Fig. 1). The climate of the study area is of the "Cameroonian highland" type. The temperature varies from 16 to 27 °C and relative humidity ranges from 45.26 % during the driest months (January-February) to 85.64 % during the wettest months (July-August). The rainfall, 2000 mm per year on average, is spread over a single season from March to November.

Fig. 1. Map of Cameroon showing the study area (Western Region of Cameroon).

B. Survey

In the vast majority of cases, Dioscorea Schimperiana is produced by smallholders, mostly living in rural areas, and whose age varies between 50 and 70 years or more. The synthesis of the results of the surveys conducted by Tchiègang and Ndomdjo [2], in the NDE department and by Diene [7] in FOTOUNI, in the HAUT-NKAM department, West Cameroon region, allowed us to highlight other production areas of DIOSCOREA SCHIMPERIANA in the West region. The production zones that constitute our main survey areas are:

- KOUNG-KHI (Bandjoun, Bayangam, Batoufam);
- The Hauts Plateau (Baham, Bameka);
- Bamboutos (Batcham, BADZA'A village).

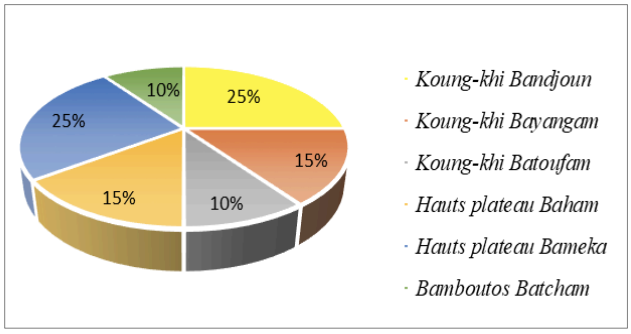

Fig. 2. Sample size and distribution for the surveys.
Size is the total number of farmers surveyed, i.e. 200.

We conducted our surveys with hundreds of people in the different target areas. The respondents were chosen from rural areas with a high concentration of farmers, and which were either large Dioscorea Schimperiana-producing localities or not. Fig. 2 presents the sample used in each village.

C. Vegetal Material

The plant material used is dried Dioscorea Schimperiana. After interviewing the planters and filling out the survey forms, we take a sample of the Dioscorea Schimperiana that the planters declare dry to determine its water content in the laboratory.

D. Experimental Device

The determination of the water content of the samples taken was possible thanks to the experimental devices described below:

1) Ventilated oven

This is a 900 W drying chamber that can operate in a temperature range of 30 °C to 250 °C. It is equipped with a regulation system with a mechanical set point and a mercury thermometer to read the internal temperature. The setpoint temperature, fixed using a potentiometer, is 103 ± 2°C. The system works in natural convection. The oven is equipped with stainless steel shelves on which the samples of the product to be tested are placed. This oven allows us to obtain an anhydrous product.

2) Electronic balance

It is a Sartorius brand, with a maximum range of 3000g, a reading accuracy of ± 10- 4 g, and a stabilization time of about 02 seconds.

E. Methods

The collection of information in the field is done by the direct declaration of the farmers. The farmer or his spouse is interviewed to obtain information on the production harvested, the period of production and harvesting, the method of drying, the quantity dried, the type of dryer used, post-harvest losses of fresh produce, post-drying losses, the purchase price from the producer, the size of the farm, unresolved problems related to drying, desired improvement, and available resources. The farmer declares the quantities harvested according to the local unit of harvest (usually the basket). The interviewer converts this into kilograms using a weight calibration procedure. The quantities sold are obtained by the same procedure. As for the area, if the farmer cannot declare it at first, we gradually lead him to estimate it himself. This exercise requires not only the availability of the farmer but also a good memory. These constraints often led to reluctance or reserve on the part of the interviewees. In the laboratory, the samples of dry Dioscorea Schimperiana are weighed using the electronic balance, then placed in the oven at 103 ± 2 °C. After 48 hours, they are removed from the oven, then reweighed to determine the anhydrous mass of the product which allows for the determination of the water content of the samples [8], thanks to (1).

$$X_{eq} = \frac{m_h - m_s}{m_s} \times 100 \quad (1)$$

III. Results

A. Production and Exploitation

In Cameroon, the cultivation of Dioscorea Schimperiana is favorable in the Mediterranean zone which is generally characterized by a long rainy season (8 months) and a short dry season (4 months). It is a savanna and dry forest zone and the conservation of Dioscorea Schimperiana in this zone is difficult due to the particularly unfavorable climatic conditions. The production of Dioscorea Schimperana is done in an artisanal way and is much more intended for local consumption.

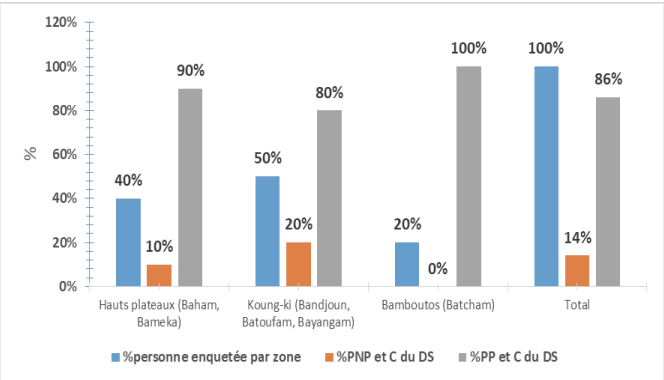

Fig. 3. Size and distribution of surveys showing: the number of people surveyed per zone, non-producers but consumers (NP and C) of the ND, Producer, and consumers (PP and C) of the ND.

The results of the survey showed that all the people in the target population were familiar with this yam. The cultivation period (planting) is between March and April and its maturation period is one year. Harvesting takes place when the soil is prepared for planting, i.e. between January and February.

B. The Local Unit of Measurement, Quantity, and Quality of the Undried Product

In all areas surveyed, the local unit of measure is the basket. Four types of baskets are used in these areas: 5, 10, 15, and 20 liters. The quantity produced in these different zones is very small, with two to three 20-liter baskets per harvest. But 2 to 3 people interviewed in the villages of Bandjoun and Bayangam told us that they can produce more than 200 kg of yams per season.

C. Conservation Methods for Raw Dioscorea Schimperianna

The conservation of raw D. Schimpériana is done in several ways by the populations of the villages surveyed. Conservation by burying consists of placing the tubers in a hole dug in the ground near the huts. The bottom of the hole is previously lined with dried banana leaves. After the burial, the tubers are covered with a few dead banana leaves and the hole is closed with soil. The tubers can also be stored on the ground for staggered harvesting. For above-ground storage, fresh D. Schimperana tubers can be stored on racks attached to the outside of the hut walls or in a room free of moisture. Make sure that the injured parts are covered with ash.

D. Drying of Dioscorea Schimperiana

The drying of Dioscorea Schimpériana follows a very well-defined protocol: Harvesting of tubers in the field or the home gardens, washing with water by children or women, steaming of yams in the field, peeling, cutting into cubes for drying.

The drying method used in the different areas surveyed is the natural or traditional type, which consists of exposing yam cossettes directly to solar radiation on a hard, generally horizontal surface for several days. The farmer spreads the food at the beginning of the day. He mixes them two or three times a day. He protects them from rain, rodents, and insects. Then he stores them under a shelter in the evening to avoid their rehydrating in contact with the dew. He uses tactile cues to judge whether his products have reached a good level of dehydration and finally stores the food in different types of containers and attics. Natural sun-drying thus uses a combination of variable exposure to sunlight and warm, relatively dry air (50%), as well as physical effort to spread, mix, protect, and bag the commodities. This drying method has many advantages:

- It is very cheap since the sun's energy is free;
- It does not require expensive tools or equipment;
- The ancestral techniques are well mastered and are part of the culture of the users;
- They are products whose taste is known and accepted by the population and for which there are good local outlets.

But it also has many disadvantages:

- Possibility of residual moisture causing mold;
- Frequent presence of dust and foreign elements;

- Infestation by insects;
- Samples were taken by rodents;
- Microbiological quality is often questionable;
- Short shelf life leading to a rapid alteration of the appearance and taste of the product appearance and taste of the product;
- Very "time-consuming" process for the producers.

For all these reasons, natural drying, while remaining within the framework of tradition, must know simple and cheap improvements, which have been the subject of numerous research and experiments [5], [9]-[12]. Indeed the majority of local populations do not have the financial means to purchase complicated and expensive equipment, but small changes could remedy many of the drawbacks described above and improve yield.

E. Different Types of Dryers Used

Several types of dryers were identified during our surveys. We can mention among others:

- On bamboo mats or plastic sheeting etc.
- In the form of collars.

Fig. 4. Drying of Dioscorea Schimperiana on a bamboo mat in Bameka, a village in West Cameroon, in the Highlands Department (5°38'N, 10°33'E).

(a)

(b)

Fig. 5. a) drying of a small quantity of Dioscorea Schimperiana in the basket; b) and on plastic in Batcham, a village in West Cameroon, in the Bamboutos department (5°32'N, 10°14' E).

Fig. 6. Drying of Dioscorea Schimperiana on sacks in Batoufam, a village in West Cameroon, in the KOUNG-KHI department (5°21'N, 10°24'E).

Both types of drying are practiced in the surveyed areas.

1) Advantages:

- Very low cost of the dryer;
- Mastery of ancestral techniques;
- Accessible manufacturing materials;
- No need for labor.

2) Disadvantages

- Loss of products;
- Sometimes exposed to residual moisture, causing mold;
- Presence of foreign elements and dust;
- Relatively slow drying;
- Poor product quality;
- Insect infestation.

The drying time varies depending on the nature of the dryer, the season, and consequently the production area [13]. Generally speaking, it varies from 1 to 2 weeks when drying on bamboo mats or plastic sheeting and from 3 to 4 weeks in the form of a collar, this is in all areas surveyed.

F. Conservation of the Product after Drying

The dried product is stored in stainless steel pots, or the attic as shown in Fig. 7.

(a) (b)

Fig. 7. a) Preservation of the product in a stainless-steel pot; b) after packaging in plastic.

G. Post-Harvest Losses

These losses can be assessed at several levels, from tuber rot to drying to sale. Tuber rot is an important loss due to the humid climate of the West Cameroon region and these losses are not evaluated. There are also losses due to mold caused by poor preservation of the product. A product that is poorly preserved after drying is no longer edible and must be thrown away or transformed into pet food.

H. Criteria for Assessing the Quality of the Dried Product

The assessment of the quality of the dried product depends on its color, its flexibility, and the duration of drying. It is said that a dried product should not be "aggressive" or brittle but should be flexible. During our investigations, the product was

considered dry if its color became dark gray, not "aggressive", nor brittle, and for a period of one to two weeks, depending on the climate.

Fig. 8. Dry product found at the Bandjoun market in the Koung-Khi department (5°22' 31" N, 10°24' 44" E).

The determination of the moisture content in the laboratory of the samples taken by zone is represented in Fig. 9. The analysis of the results obtained shows that drying is insufficient in many production zones, as the water content of the samples is higher than the recommended limit of 7% on a dry basis [14].

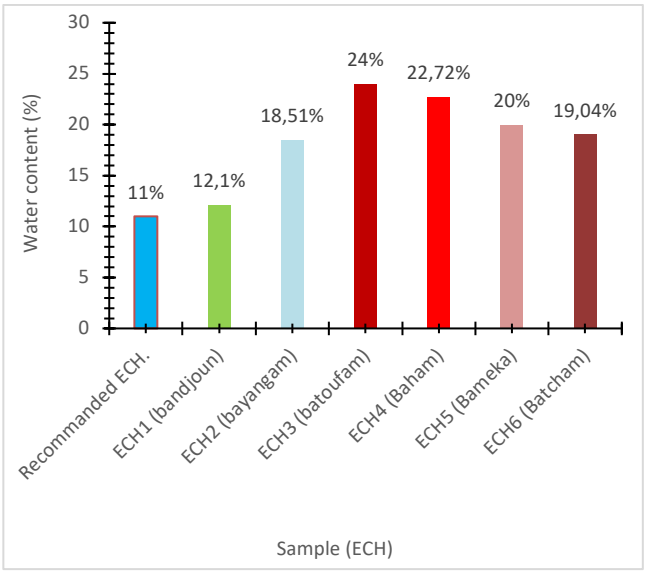

Fig. 9. Comparative study between the calculated and recommended water content.

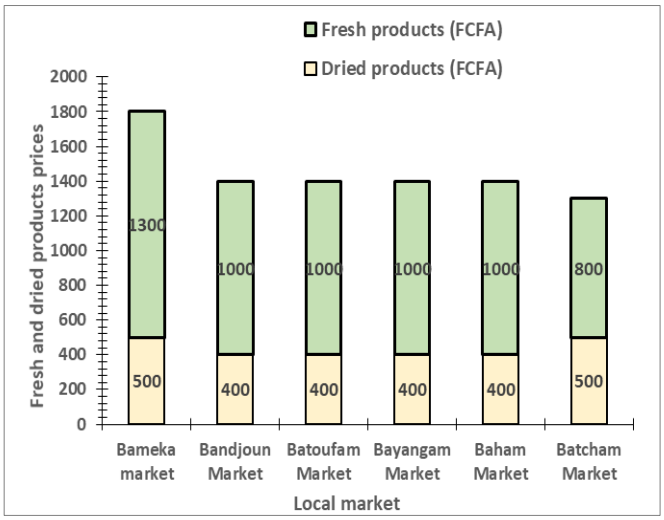

Fig. 10. The purchase price of products on local markets.

I. Purchase Price of Products on Local Markets

The purchase price of tubers and dried products on local markets varies according to the season, the production area, and the quality of the products offered. These prices can range from simple to triple depending on whether the product is fresh or dried, from the period of maximum production to the period of shortage. In West Cameroon, for example, the prices for the agricultural product studied are shown in Fig. 10.

J. Dryer Costs and Farmers' Resources

The resources of the farmers here are based on the financial and energy resources available in the production areas.

1) Availability of the different energy sources

- Electricity: It is distributed only by ENEO. Electricity is available in urban areas and some households in rural areas. The inhabitants consider electricity to be expensive and use it only for lighting purposes.
- Petroleum: Petroleum is a well-known energy source in rural areas and is used in many villages with kerosene lamps as the primary means of lighting.
- Gas: Gas distribution does not reach rural areas. It is mainly found in urban areas.
- Solar energy: West Cameroon enjoys average sunshine, although this decreases during the rainy season. The annual global radiation on a horizontal plane is on average 6.0 kWh/m2/day.
- Wood: In savannah and dry forest areas, wood is a less expensive source of energy than oil.

2) Financial resources

The cost of the dryers used in the areas surveyed is negligible. They are made from local materials. Of the 200 farmers interviewed, 160 wanted a hybrid solar/wood dryer at an acceptable cost, and 30 proposed a contribution in kind (wood, bamboo) and assistance in building a dryer. The rest want to have a dryer without any personal financing.

K. Needs about the Drying of Dioscorea Schimperiana

In general, the natural drying method is the most widely used in the production areas surveyed. This drying method poses several problems related to its use. These include;

- Rain: since drying is done in the open air, the yam pods at the end of the drying process (Dioscorea Schimpériana) receive rainfall, which increases the drying time and contributes to the destruction of the products by molds,
- The maintenance of the dryers is not at all easy. Manufacture in local materials (bamboo, plastic, mat, bag),
- Very long drying time: the major disadvantage of solar drying is the very long drying time of two to three weeks in the dry season, which sometimes results in poor product quality and a deposit of mold on the products after drying.

IV. Conclusion

The field survey highlights the cultural and ethnic-nutritional importance of Dioscorea Schimperiana for the populations of the villages of West Cameroon. This variety

of tuber is part of the dietary habits of these populations with various cooking methods, including the pounding made from dried Dioscorea Schimperiana pods, which is particular to the Bamileke people of West Cameroon.

Several methods of conservation are used: conservation by burial, above ground, and in the form of cossettes. The last case of conservation consists in using a natural drying system where the product is directly exposed to the sun on a bamboo mat or a polyethylene film. This current drying system of Dioscorea Schimperiana leads to post-harvest loss, due to the humid climate of the West Cameroon region, but also to the presence of foreign bodies such as dust, stones, and insects in the Dioscorea Schimperiana.

This drying system used in West Cameroon is not satisfactory for producers who wish to have a dryer capable of performing the following functions:

- Ensure drying in all seasons;
- Cost less in construction;
- Preferably use solar energy when it is sufficiently available because it allows obtaining a quality product;
- To avoid the taste of mold in the product;
- To introduce and stir the product easily in the dryer;
- Protect the product from rain and insects;
- Better heat retention in the dryer.

The dryer desired by the producers is intended for the drying of Dioscorea Schimperiana, which can be used in both the dry and rainy seasons. A hybrid solar/wood dryer, which we recommend, would be better suited, as wood is chosen because of its availability and cost in the production zone, which is generally a savannah and dry forest zone.

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CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

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