

Research Article

Characterisation of Ginger Drying Practices In Humid Tropical Regions and Proposal for Suitable Equipment

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Abstract

The main objective of this study was to propose suitable equipment for drying in humid tropical regions. Following the design and distribution of two online survey forms via Google Forms one for producers and the other for consumers a total of 547 completed forms were collected. The main findings showed that, in terms of growing areas, all ten regions of Cameroon are suitable for growing this plant, with the Littoral Region leading the way (15.70%), followed by the Central Region (14.40%), the West Region (13.10%), the North-West Region (11.50%) and the Adamaoua Region (10.20%). It also emerged that three main varieties are cultivated: white ginger (58.15%), black ginger (28.43%) and turmeric (11.82%). With regard to preservation methods, indirect solar drying was found to be the most widely used technique (67.40%) and the most recommended (96.50%), ahead of traditional drying. Furthermore, we have designed a PV/T solar dryer for fruit and vegetables. The design was carried out using the functional analysis method, which enabled us to identify the problem and define the functions to be fulfilled. The technological solutions were derived from the functional analysis of requirements and resulted in a hybrid PV/T solar dryer. The proposed dryer consists of two units: a drying chamber with a volume of 0.35 m³, in which air circulation is provided by two (02) continuous fans operating at 1.2 m/s, and a PV/T collector comprising a 150 Wp solar PV panel, coupled with climate data from Ngaoundéré.

Keywords : Drying, Ginger, Characterisation, Humid Tropical Zone, Adamaoua, PV/T dryer.

1. Introduction

Drying agricultural produce appears to be the most suitable, oldest and most widespread method used for preserving agricultural products with a high water content. It remains one of the least expensive options for farmers, alongside techniques such as cold storage. Traditional drying, for example, given the availability of solar energy, is the main method of preserving agricultural produce in the savannahs of Africa (Cameroon, Nigeria, etc.) (Rozis, 1995; Ekechukwu and Norton, 1999). Although it produces a finished product with a sufficiently low moisture content, this type of drying is currently limited by quality issues, partly due to adverse weather conditions (Nganhou et al., 2002). To address these issues, research has focused on artificial drying through the development of solar dryers, which enable the final product to be dried with minimal investment whilst taking advantage of this free energy source. As regards the use of solar energy, the average solar radiation in the humid tropical zone is 4.9 kWh/m²-day, whereas it is 5.8 kWh/m²-day in the dry tropical zone.

This irradiation is significantly lower during the rainy season, which coincides precisely with the peak processing period for agricultural products, making it difficult to effectively use solar drying for these products in general, and ginger in particular. Ginger, known by the scientific name 'Zingiber officinale', is a plant belonging to the monocotyledonous class (Ghasemzadeh and Rahmat 2010). It belongs to the Zingiberaceae family. This plant is cultivated in several countries, including India, China, Nigeria, Indonesia, Cameroon and many others. The aim of this study is to investigate the various growing regions and cultivated varieties, as well as the different drying techniques, and to propose suitable equipment to improve preservation.

2. Materials and Methods

2.1 Plant material

Commonly known as 'Djinja' in Cameroon, this plant is cultivated for its underground part, which consists of branched, globular tubers (rhizomes) that are pale beige in appearance and have a juicy, pale yellow flesh. It is shown in the following Photo 1.

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Photo 1 : Ginger rhizome FAO / OMS. 2017

Table 1: Botanical classification of ginger (Faivre et al., 2006; Gigon, 2012)

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Angiospermes
Class	Monocotyledones
Subclass	Zingiberidees
Order	Zingiberales
Family	Zingiberacees
Subfamily	Zingibéroïdees
Genus	Zingiber
Species	Zingiber officinale (Roscoe)

The cross-section is fibrous and grainy; it has an extremely aromatic smell and a warm, pungent flavour in which the nutrients are concentrated (Chan and Yong 2009). The upper surface of the rhizome bears short, flattened, obovate, oblique branches, which sometimes feature a sunken scar. The whole rhizome measures approximately 5 to 10 cm in length, 1.5 to 4 cm in width and 1 to 1.5 cm in thickness; it is sometimes split lengthwise (Srinivasan and Krishnapura 2017). It is used as a spice in a wide variety of dishes and is employed in the pharmaceutical industry and in traditional medicine (Gigon, 2012).

Les travaux de Faivre et al., (2006) et Gigon (2012) ont conduit à la classification botanique du gingembre (tableau 1).

2.2 Survey forms

Two survey forms, one designed for producers and the other for consumers, will provide a range of information, the most important of which are :

- Growing regions ;
- Varieties of ginger grown or consumed ;
- Growing and harvesting periods ;

- Drying methods ;
- Drying times ;
- Estimated post-harvest losses.

The forms were submitted online via a Google Form over a period of approximately three (03) weeks

2.3 Design of the PV/T hybrid solar dryer

The design was carried out using the functional analysis method. Functional analysis, or value analysis, provides the tools needed to identify the problem and define the functions to be fulfilled. A requirements analysis was conducted to clarify the fundamental requirement justifying the design of the hybrid PV/T solar dryer model. The requirement was validated by asking the following questions : Why is a hybrid PV/T solar dryer needed? What could change this requirement? What could render it unnecessary? This process involves developing an operational concept for the dryer, which is represented by the set of lower-order functions in a FAST diagram. Figure (1) presents the functional analysis technique for systems (FAST diagram), which shows how the technological solutions were arrived at. The hybrid PV/T dryer consists of a drying chamber and a coupled PV/T solar collector.

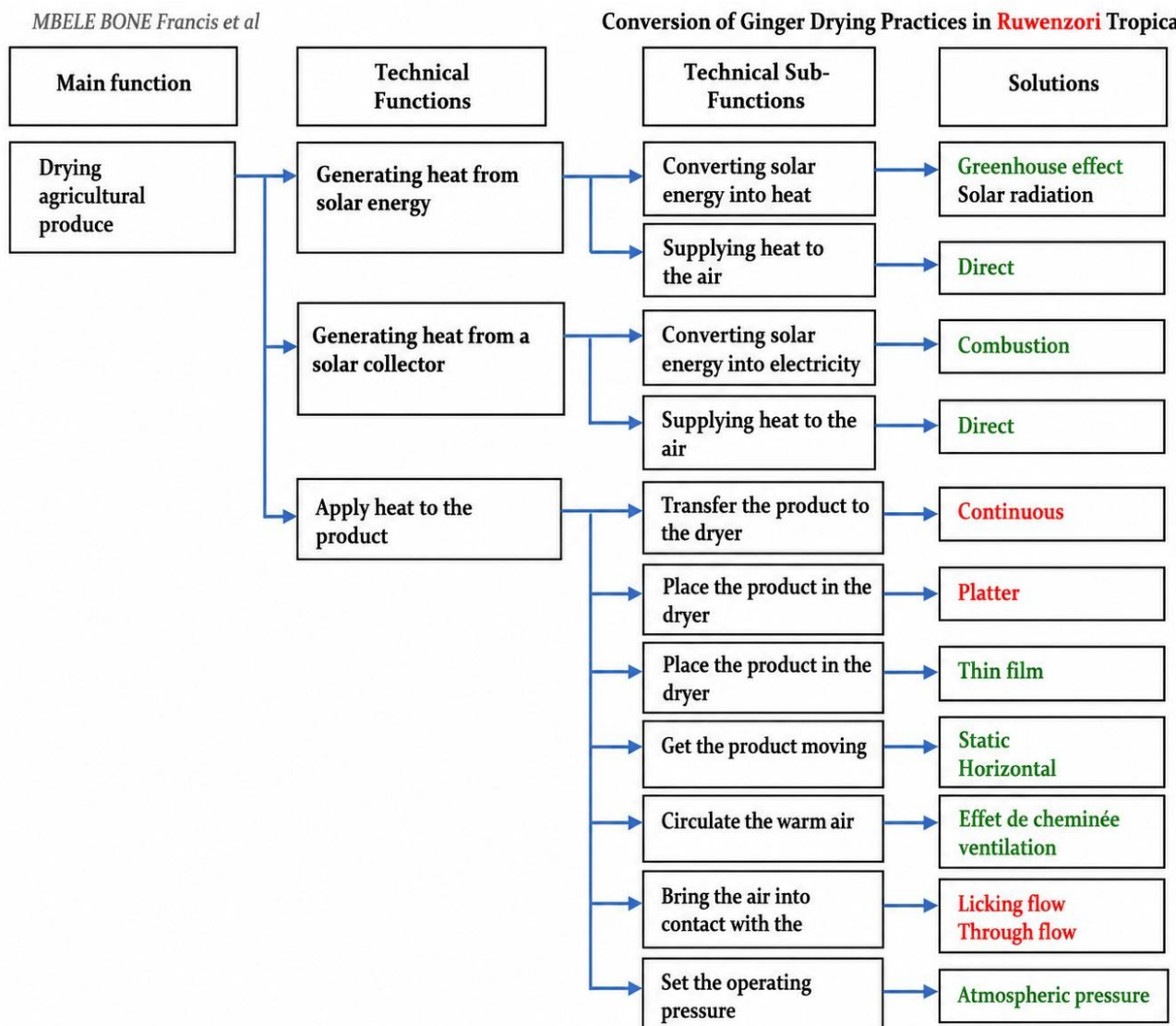


Figure 1 : FAST diagram of the solar dryer

2.4 Geometric modelling of the PV/T hybrid solar dryer

The aim was to propose a design for a hybrid PV/T solar dryer intended to improve ginger drying practices. The sizing was analysed based on the following parameters: the amount of moisture to be removed, the amount of heat required and the necessary air flow rate, in accordance with the following specifications:

Table 2 : Specifications for the design of the PV/T dryer

N°	Designation	Value
1	Average ambient temperature (°C)	Function of the day
2	Average relative humidity (%)	Function of the day
3	Initial moisture content of samples	75%
4	Final moisture content of samples	24%
5	Air velocity (m/s)	1.2 - 2.4
6	Maximum capacity of a rack	1 kg of fresh produce
7	Region of experimentation	Adamaoua
8	Geographical location	Latitude 7°19' North and longitude 13°14' East

In order to determine the optimal orientation and tilt angle of the solar panel, it was necessary to know:

- Total solar radiation at the test site;
- Amount of water to be extracted;
- Thermal energy required to remove the water;
- Required air flow rate;
- Heat required to heat the drying air.

3. Results and discussion

3.3 Characterisation of croplands in Cameroon

3.3.1 National distribution of ginger producers in Cameroon

The surveys were conducted online between 22 October and 13 November 2024. A total of 547 responses were received, comprising 313 for the questionnaire aimed at producers and 234 for the one aimed at consumers. The geographical distribution of producers' responses is shown in Figure 2 below.

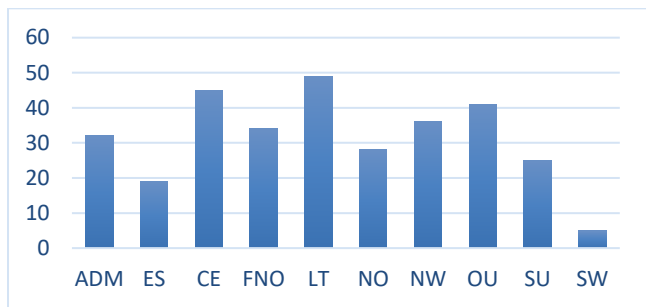


Figure 2 : National distribution of ginger producers in Cameroon

This figure shows that the Littoral Region leads the way with 49 producers, or 15.7%, followed by the Centre Region, with 45 producers, or 14.40%. These figures are consistent with the findings of Jyotsna et al. (2017), who demonstrated that the Littoral Region is the most favourable area for ginger cultivation. Furthermore, this result indicates that all regions of Cameroon are suitable for ginger cultivation, which may support Cameroon’s global ranking among the top 10 ginger-producing countries (Jyotsna et al., 2017).

3.3.2 Varieties grown in Cameroon

Field surveys indicate that three main varieties of ginger are grown in Cameroon (Figure 3).

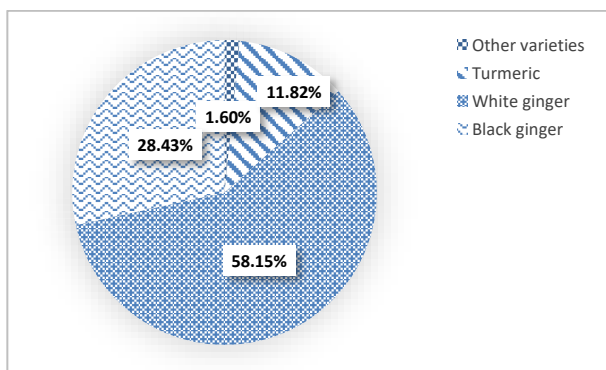


Figure 3 : Different varieties of ginger grown in Cameroon

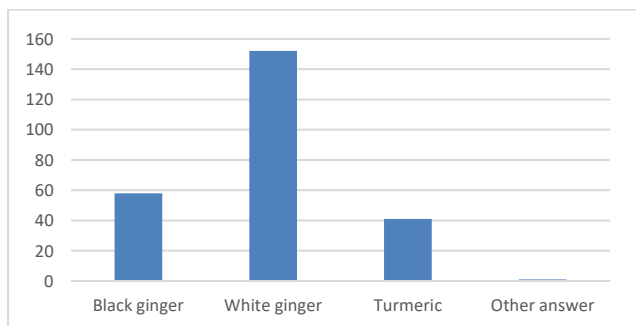


Figure 4 : Breakdown of ginger consumption

This figure shows that white ginger is widely cultivated (58.10%), followed by black ginger (28.40%). This

finding is explained by the specific properties of these two varieties, as outlined by Gigon (2012) and Faivre et al. (2006), and confirmed by Figure 4 above.

3.3.3 Growing and harvesting seasons for ginger in Cameroon

The results from the various responses collected show that the optimal period for growing ginger is between March and May each year, with a peak between April and May (Figure 5), and that it is harvested between September and November of the same year (Figure 6).

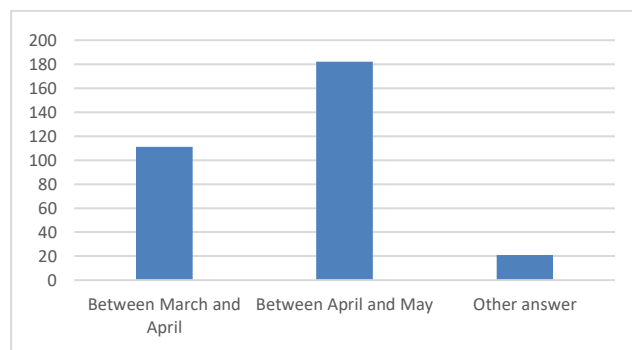


Figure 5 : Growing seasons for ginger in Cameroon

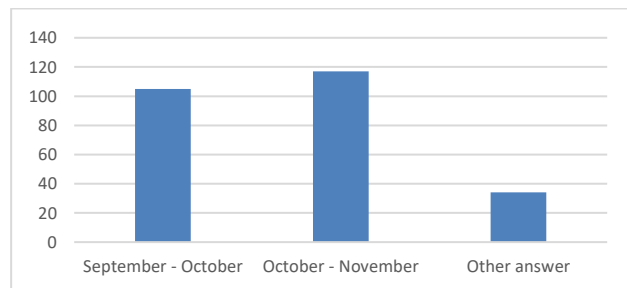


Figure 6 : Ginger harvest seasons in Cameroon

Figure 6 shows that the peak harvest period falls in October and November.

3.4 Ginger drying techniques in Cameroon

3.4.1 Drying methods used

Among the various methods currently used to dry agricultural produce, survey results show that solar drying is the most common method for preserving ginger, with a particular preference for direct solar drying (Figure 7).

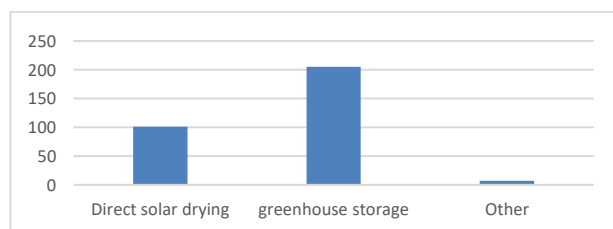


Figure 7 : Methods of drying ginger in Cameroon

This result can be explained by the fact that, as shown in Figure 8, the main harvest period falls between October and November, which coincides with the end of the rainy season in certain regions of Cameroon, particularly the Adamaoua region.

This finding is supported by the fact that 96.50% of survey respondents recommend sun-drying as a method of preserving ginger (Figure 8).

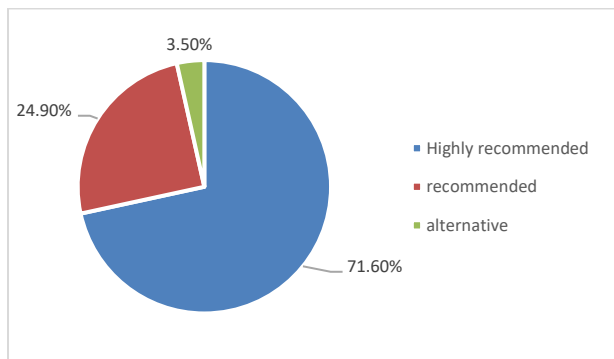


Figure 8 : Percentage of respondents recommending sun-drying as a method of preserving ginger

Despite the widespread use of sun-drying as a method of preserving ginger, the survey found that drying times vary from 3 days to over a week for an average quantity of 100 kg of fresh produce (Figure 9).

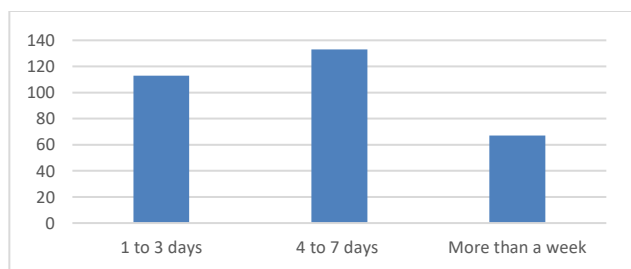


Figure 9 : Average drying time for 100 kg of fresh ginger

This very long drying time results in post-harvest losses ranging from 5% to over 10%, as shown in Figure 10. These findings are consistent with those of Kapseu et al. (2012), who highlight the high rate of post-harvest losses in sub-Saharan Africa.

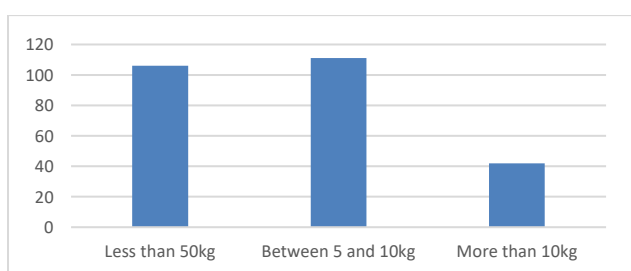


Figure 10 : Estimated post-harvest losses during the drying of 100 kg of fresh ginger

4. Proposed PV/T dryer model

Taking into account the various climatic conditions in the city of Ngaoundéré, the proposed pilot PV/T dryer will have the technical specifications set out in Table 3 below:

Table 3 : Features of the proposed PV/T solar dryer

Description	Value
Number of racks	03
Capacity per rack	1 kg
Ventilation type	Dual ventilation 3W - 12V
Solar panel	150 Wp - 8.3 A
PV surface area	1.05 m ²
Useful drying volume	0.35 m ³
Angle of inclination of the collector relative to the ground	31°

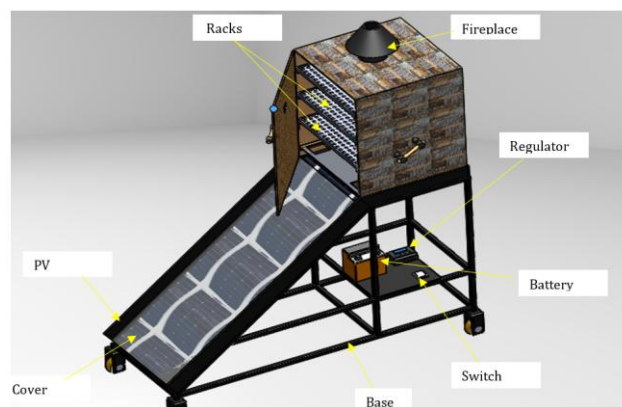


Figure 11 : Proposed pilot unit for the PV/T dryer

How it works

When sunlight hits the hybrid collector, the photovoltaic section generates electricity whilst the thermal section heats the air, creating a greenhouse effect beneath the panel between the two panes of glass. The electricity generated by the PV system powers the fans with direct current. This fan draws in outside air and forces it to pass beneath the collector to be heated, then blows it into the drying chamber. This hot, dry air passes through the racks where the produce is laid out to absorb moisture from the produce and exits through the chimney as cold, humid air.

Conclusion

The main objective of this study was to identify the different ginger-growing regions, the varieties and the most common drying method, as well as to reduce drying time compared to natural drying whilst maintaining the same quality of the final product through the use of a hybrid photovoltaic-thermal system. Following the distribution of two survey forms,

one for producers and the other for consumers, a total of 547 completed forms were collected. The main findings showed that all ten regions of Cameroon are suitable for growing this plant, with white ginger being the most widely grown and consumed variety. With regard to preservation methods, drying solaire se trouve le plus utilisé et le plus recommandé d'où l'importance de to set up a more suitable solar-powered facility for the town of Ngaoundéré in the Adamaoua Region.

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