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Solar drying techniques for okra in Ivory Coast

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Abstract

Okra is a very popular vegetable and fruit in Côte d'Ivoire. To preserve it, it is dried in the sun. However, this process is still carried out on an artisanal scale, and little work has been done to support producers. The aim of this study is to characterise okra drying in two regions of Côte d'Ivoire. The experimental method is based on a survey of producers of okra known as 'Baoule okra'. It emerged that drying is mainly carried out by women (98%). After harvesting, the fruit is dried whole (81%) or cut up (19%), on the same day (22.6%), the next day (75.5%) or days later (1.9%). However, they are laid out in various areas for drying, which lasts between 3 and 11 days in the dry season, but longer in the wet season. What's more, this process ends when the fruit can be easily broken with the fingers. Drying okra follows a process whose duration depends on the area, the spread and the season. To reduce post-harvest losses, female producers need to be supervised and trained.

Keywords: Okra, drying, drying area, characterization

Introduction

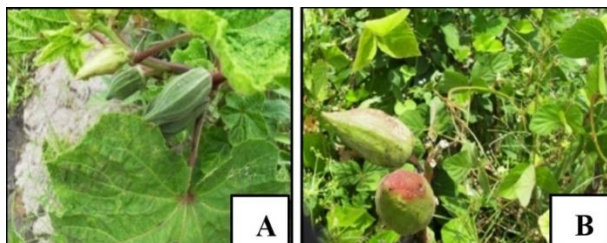
Since gaining independence, Ivory Coast's economic development has focused on agriculture. In order to benefit from this sector, the Ivorian state has seen fit to focus its development on the main activities, namely cash crops such as coffee, cocoa and rubber [1]. But food crops and market gardens, which are the staple diet of Ivorians, are often sidelined for lack of investment. In a bid to diversify crops, the Ivorian government has made efforts to support food crop producers [2]. One of these food crops is okra, which belongs to the Malvaceae family.

Okra is one of the most widely consumed vegetables in Ivory Coast, in both its fresh and dried forms [3]. It contains many nutrients (calcium, iron, proteins, vitamins A and C, phosphorus, potassium and magnesium) which are food supplements [4]. All parts of the okra plant (roots, stems, leaves, fruit and seeds) are used for food, medicinal, craft and even industrial purposes [5]. It has many virtues. It is of considerable economic importance, capable of satisfying many needs [6]. The price per kilogram varies from 700 to 1500 FCFA on local Ivorian markets [7]. With an annual production of around 193,000 tons in 2021, okra is grown all over Côte d'Ivoire on small areas of land, around huts or even low-lying areas [8, 9]. Cultivation is much more widespread in pre-forest and forest areas, which benefit from extensive drainage systems [10].

The highly seasonal nature of okra leads to periods of overproduction (May to November) followed by periods of shortage (December to April), often with a break in production in March and May [11]. In order to prolong its use, satisfy local demand and diversify their source of income, producers dry okra and preserve it as is or process it into powder. However, the market gardeners are organised on an individual basis, and lack any specific guidance or organisation. Yet drying is a particularly important operation, especially when it comes to preserving vegetables. Because of its direct impact on the quality of the final product, drying remains a key factor in obtaining satisfactory results. In Ivory Coast, this post-harvest process is still carried out on an artisanal scale, resulting in post-harvest losses. What's more, little work has been done to support producers. There is still little scientific knowledge of solar drying practices for okra in central of the country, hence the interest of this study. The aim of this study is therefore to characterize the solar drying of okra in the center of the country in order to enrich the database with a view to optimizing this process and reducing post-harvest losses.

2. Methodology

2.1. Material: Two varieties of okra are frequently grown in the center and center-west of the country. These are the Koto variety, known as 'Dioula okra', which produces ribbed fruit, and the Tomi variety, known as 'Baoulé okra', which produces non-ribbed (smooth) fruit (Figure 1). This study focused on the Tomi variety, which is used to produce 'djoumblé' (dried okra), highly prized in Ivory Coast.



A: Dioula okra (*Abelmoschus esculentus*)
B: Baoulé okra (*Abelmoschus caillei*)

Fig 1: Okra varieties commonly grown in Ivory Coast.

2.2. Methods

2.2.1. Study area and target population

The study was carried out through a survey in the Haut-Sassandra and Lacs regions, more specifically in the localities of Zoukougbeu, Boguedia, Bonoufla, Daloa, Gonaté belonging to the Haut-Sassandra region and those of Zatta, Lolobo, Yamoussoukro, Attiéougakro belonging to the Lacs region. It took place from June to September 2021. The choice of these regions was based on okra production criteria [12]. The survey involved all people with activities related to drying okra who were at least 18 years old.

2.2.2. Drawing up the questionnaire: The questionnaire was drawn up with the aim of characterizing okra drying by determining the characteristics of the players, identifying the drying areas and estimating the duration of the operation.

2.2.3. Survey technique: The snowball technique was used. Snowball sampling is a form of link-tracing sampling design in which individuals in the initial sample are asked to identify knowledge about okra drying [13]. These individuals are then asked to identify people connected with the activity, and so on for a fixed number of stages or cycles. This technique was chosen because it is a practical way of gathering information quickly and also proves to be an effective decision-making tool [14].

2.2.4. Data processing

Quantitative data were processed and analysed using Sphinx Plus.V5 software. Drying techniques were categorised by study area and then prioritised.

3. Results

3.1. Stakeholders involved in drying okra

People involved in drying okra were identified. A total of 290 people were surveyed and divided into four groups. Farmers and traders were the largest groups, representing 58% and 27% of respondents respectively. Next came housewives, an intermediate group with 13%. Finally, the smallest group was made up of students, who represented 2% of those interviewed (Figure 2).

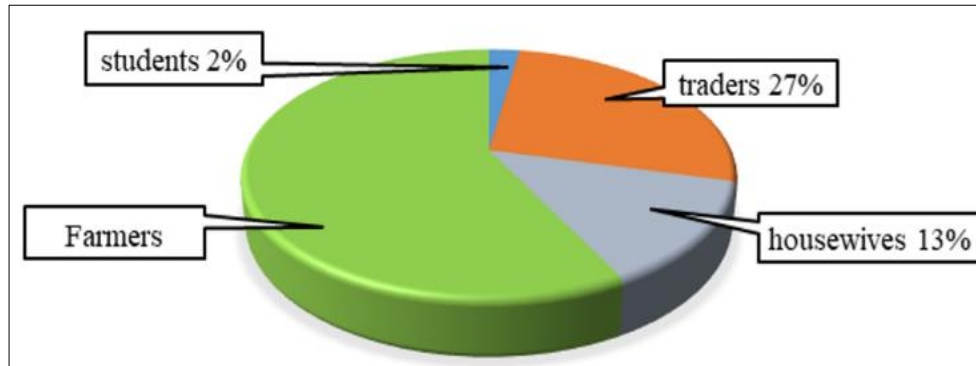


Fig 2: Stakeholders involved in drying okra

3.2. Sex, age and marital status

The sex, marital status and age of the respondents are shown in Table 1. The majority of people in the study sample who dried okra were women (98%). However, the majority were

married and single, with percentages of 71 and 21 respectively. The interviewees were divided into three categories according to age. Those aged over 40 were the most numerous with 49% (Table 1).

Table I: Sex, age and marital status of Stakeholders

Actors	Sex		Age			Marital status		
	Male (%)	Female (%)	18-30 (%)	31-40 (%)	40< (%)	Single (%)	Married (%)	Widowed (%)
Students	29	71	100	0	0	100	0	0
Traders	0	100	6	47	47	12	82	6
Housewives	0	100	10	38	51	26	64	10
Farmers	2	98	5	43	52	20	71	9
TOTAL	2	98	9	42	49	21	71	8

3.3. Level of education of stakeholders

Table II shows the educational level of the stakeholders involved in drying okra. The students interviewed all had secondary education (100%), unlike the other actors, whose

levels varied considerably. The majority of housewives and shopkeepers had primary education, with respective percentages of 56.4 and 50.6. However, people with no

schooling were not excluded from this activity. The majority of farmers (52.7%) belonged to this class (Table 2).

Table 2: Level of education of stakeholders

Actors	Level of education		
	Not in education (%)	Primary (%)	Secondary (%)
Traders	46,8	50,6	2,6
Students	0	0	100
Housewives	38,5	56,4	5,1
Farmers	52,7	44,9	2,4

3.4. Ethnic groups of stakeholders

The breakdown of stakeholders by ethnic group showed that okra drying is practised by several ethnic groups in Ivory Coast. In all the localities visited, the majority of farmers were Baoulé (41.9%) and the traders were mainly Malinké (48.1%). However, there was significant participation by non-natives in this activity (Table 3).

Table 3: Distribution of stakeholders by ethnic group

Actors	Ethnic group						
	Baoulé (%)	Bete (%)	Gnamboua (%)	Gouro (%)	Malinké (%)	Sénoufo (%)	Allogene (%)
Traders	23,4	5,2	1,3	2,6	48,1	5,2	14,3
Students	28,6	14,3	0	14,3	28,6	0	14,3
Housewives	33,3	12,8	10,3	12,8	15,4	5,1	10,3
Farmers	41,9	4,2	4,2	3	19,2	6,6	21
Total	35,5	5,9	4,1	4,5	26,6	5,9	17,6

3.5. Maturity stage, fruit shape and start of drying of Baoulé okra

The drying process for Baoulé okra depended on several parameters. The stage of maturity, fruit shape and start of drying are summarised in Table IV. Most people started drying the day after harvest (75.5%). They generally used young fruit (81%), which they dried as it was (Table IV).

Table 4: Maturity stage, fruit shape and start of okra drying

Maturity stage		Fruit shape		Start of drying		
Young fruit	Mature fruit	Cut	Whole	Same day	Next day	3-5 days later
81%	19%	19%	81%	22,6%	75,5%	1,9%

3.6. Okra drying areas

Drying okra in Ivory Coast is carried out in various areas (Figure 3). Table 5 summarises the frequency of use of okra drying areas. The drying area most frequently used by the population was black tarpaulins placed on cemented areas (43.4%) (Table 5).

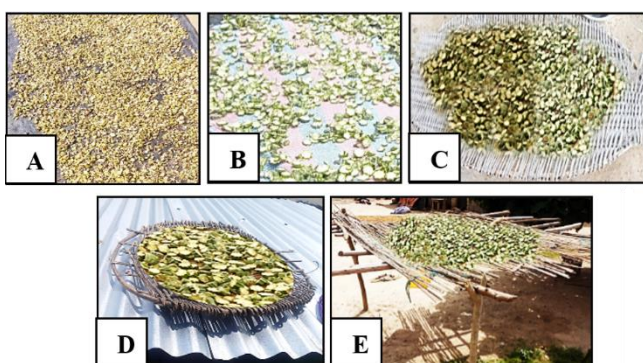


Fig 3: Okra drying areas used in Ivory Coast (A: Black tarpaulin; B: Bag; C: Rack on cemented area; D: Rack on roof; E: High rack).

Table 5: Frequency of use of okra drying areas

Drying areas				
Black tarpaulin	Bag	Clay on cemented area	Clay on roof	High clay
43,4%	20,7%	24,8%	9,7%	1,4%

3.7. Drying times

3.7.1. Drying times in the dry season

Table 6 shows the duration of fruit drying in the dry season (sunny period). This period, from December to April, is marked by high temperatures (29 – 35 °C). Of all the people who dried cut fruit, nearly 26.2% were unable to determine the drying time in the dry season. However, the majority (48.7%) stated that the drying time for cut fruit was approximately 6 to 7 days (Table 6).

On the other hand, those who used the fruit as is felt that it took a little longer. In fact, the majority of these people maintain that drying whole fruit lasts between 10 and 11 days in the dry season. However, some people (9.8%) were unable to estimate this duration (Table 6).

Table 6: Drying time for okra in the dry season

Cut fruit			Whole fruit		
Not determined	3 to 5 days	6 to 7 days	Not determined	7 to 9 days	10 to 11 days
26,2 (%)	25,1 (%)	48,7 (%)	9,8 (%)	22,6 (%)	67,7 (%)

3.7.2. Drying times in the wet season

Drying time for okra fruit was relatively long in the wet season (rain). Table VII shows the drying time of the fruits in the wet season. This season, from May to October, is marked by low temperatures (29°C - 35°C) and high relative humidity. Whether they use cut or whole fruit, the majority of people interviewed were unable to determine exactly how long okra dries in the wet season. However, most people (28.7%) thought that the operation could be carried out over 10 to 12 days for cut fruit. However, with whole fruits, the majority (47.3%) maintained that drying in the wet season reached 16 to 18 days (Table VII).

Table 7: Drying time for okra in the wet season

Cut fruit			Whole fruit		
Not determined	7 to 9 days	10 to 12 days	Not determined	13 to 15 days	16 to 18 days
64,4 (%)	6,9 (%)	28,7 (%)	45,9 (%)	6,8 (%)	47,3 (%)

3.8. End of drying

Figure 4 shows the signs by which producers determine the end of drying of Baoule okra fruits. It shows that all those interviewed (73%) considered that okra fruit was dry when it could be easily broken with their fingers. However, some producers (27%) relied on the characteristic noise that the dried fruits produced to determine the end of the operation (Figure 4).

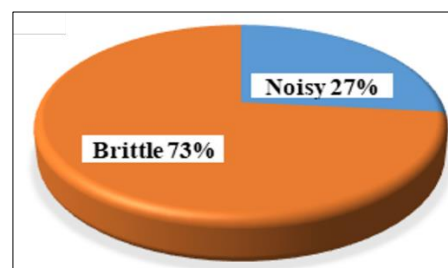


Fig 4: Signs marking the end of the drying process

4. Discussion

Among the post-harvest activities for okra, drying is a very important stage in the preservation of this fruiting vegetable. Farmers are the most numerous players (58%) among those surveyed, and are therefore at the root of okra production. These farmers are small-scale producers who play an essential role in the national production of vegetables, including okra, estimated at over 193,000 tonnes^[9, 15]. The people interviewed felt that once harvested, the produce had several uses: fresh sale, household consumption and drying (for preservation). Preserving okra would therefore not only prolong its use, but also add value to the product. In fact, according to an expert report, some producers and traders of okra felt that processing it into a dried product would be more advantageous than selling it fresh, as the value of dried products was higher than that of downgraded fresh products^[16].

The majority of people who dry okra are women. Whether they are single, married or widowed, they never miss out on this activity, which enables them both to satisfy their basic food needs and to contribute to family expenses. This could be linked to the fact that in rural areas, vegetable gardens are usually run by women, who grow the vegetables themselves. In the traditional system of vegetable production, the activities are devolved to the women and young people in the family^[17]. Researchers have also made this observation in a study of the economic importance of okra in Chad. They found that almost 75% of women have been growing okra since it was sown as a major source of income^[18].

Most of the localities visited were rural areas, which could account for the large number of people not attending school. This finding is in line with the results of Célestin, who notes that it is in rural areas that the proportion of people with no education is highest^[19]. The large proportion of uneducated people could have an impact on the quality of dry okra in terms of non-compliance with certain hygiene rules.

The large number of Baoulé among those interviewed may be linked to the local name given to this vegetable. According to Fondio's research, the Baoulé remain attached to their gumbo (Baoulé okra) and the Malinké, Senoufo, Tagbanan, etc. to theirs (Dioula okra). The preference for okra according to ethnic group seems to indicate that there is a cultural factor that guides consumers in their choice of food^[11]. Research carried out in the V-Baoulé region revealed that one of the most frequently consumed sauces was one made from fresh or dried okra. This would mean that drying okra is part of the customs of the Baoulé people, hence the proportion of Baoulé farmers among the actors^[20].

According to the ZEHLAB report, the rural areas of the Haut-Sassandra region account for more than 12% of migrants, most of whom are Burkina Faso nationals (75%). The majority of these migrants have no level of education (56%), work in several sectors of activity, mainly in the primary sector (agriculture) (39%) or in commerce (23%)^[21]. This finding could justify the significant presence of non-natives among the players involved in drying okra.

The frequency of use of tarpaulins and racks for drying okra is in line with the results of Kouakou *et al.*^[22]. In fact, black tarpaulins and racks are commonly used on the whole, even if some variations are observed in their frequency of use and therefore in their preference^[22]. The preference for black tarpaulins and sack tarpaulins among rice growers in Yamoussoukro has already been reported^[23]. However, the high use of black tarpaulins could be partly explained by their relatively low price, which makes them a drying area within

the reach of all growers^[23]. In addition, tarpaulins give off the most heat, which dries the fruit more quickly, hence the preference for black plastic^[24].

It is important to dry food products immediately after harvesting. This is not the case. In addition, failure to comply with drying times could contribute to a reduction in the nutritional quality of okra. In fact, drying is an important phase in post-harvest operations and influences the preservation of the product based on an essential parameter, i.e. moisture content^[24].

Difficulties in estimating drying time could be due to the low level of education of the people interviewed. As for the influence of the seasons on drying, this would be due to the climatic variations observed from one season to another. In the wet season, relative humidity is high, which slows down the drying process. This could explain the long drying times of up to 18 days, depending on the population.

4. Conclusion

This study has shown that the drying of okra of the Tomi variety (*Abelmoschus caillei*), commonly known as Baoulé okra, was carried out by various players. Their level of education was fairly low. This activity was mainly carried out by women, whether single, married or even widowed. Several ethnic groups were involved in drying okra, given its importance to the population's food and socio-economic well-being. However, the Baoulé were the main players. They mainly used the young fruit, which they dried as is in different areas, with varying frequency of use. However, black plastic sheeting was most commonly used for this purpose. In addition, the drying time depended on the season and the shape of the fruit. The process was generally completed when the fruit could be easily broken with the fingers.

References

1. Ivory Coast Ministry of Agriculture. State of plant genetic resources for food and agriculture. Second national report; 2009, Ivory Coast.
2. Diarra I, Dizoe DF, Sarka CGL, N'da L. Pro-planteurs: Study of market opportunities for food crops, final report, 2017, Ivory Coast, pp 120.
3. Fondio L, Kouame C, Djidi A, Traore D. Characterisation of cropping systems integrating okra in urban and peri-urban market gardening in Bouaké in central Ivory Coast. *International Journal of Biological and Chemical Sciences*. 2011;5(3):1178-1189.
4. Hamon S, Charrier A. Wide variation of okra collected in Benin and Togo. *FAO/IBPGR, Plant Genetic Resources-Newsletter*. 1985;56:52-58.
5. Maruis C, Gerad V, Antoine G. Okra, *Abelmoschus esculentus* (L.) Moench, a possible source of phospholipids. *Agronomy and Biotechnology, Oilseeds, Fats, Lipids*. 1997;4(5):389-392.
6. Nana R, Tamini Z, Sawadogo M. Effect of stress during the vegetative and flowering stages of okra. *International Journal of Biological and Chemical Sciences*. 2009;3(5):1161-1170.
7. National Council for the Fight against High Life. <http://cnlvc.ci/2017.cnlvc/2017/05/31/gombo>. 2017, Ivory Coast.
8. Fondio L, Aidara S, Djidji A, Zohouri G, Gnonhouiri G. Prophylactic diagnosis of the market gardening sector in the Abidjan region (ANADER South Regional Delegation): Limitations and tentative solutions. Study report, CNRA, 2001, Bouaké, Ivory Coast, pp 28.

9. FAOSTAT. <http://fao.org/faostat/fr/#data/QCL>; 2021.
10. Akassey PR. Guide to agriculture in Ivory Coast. Tome IV, Edition PRAT/EUROPA, 1992, pp 286.
11. Fondio L. Contributing to knowledge of the development of Tomi okra: *Abelmoschus caillei* (A. Chev.) Stevels (Malvaceae) in Central Ivory Coast: Influence of water and fertilizer supply according to sowing periods. Doctoral thesis, Felix Houphouët Boigny University, Ivory Coast, 2005.
12. Yao AB, Goula BTA, Kouadio ZA, Kouakou KE, Kanté A, Sambou S. Climate variability analysis and quantification of water resources in humid tropical zones: The case of the Lobo watershed in Central-Western Cote d'Ivoire. Ivoirian Journal of Science and Technology. 2012;19:136-157.
13. Goodman LA. Snowball sampling. Annals of Mathematical Statistics. 1961;20:572-579.
14. Keita G. Zootechnical performances of reproduction and growth of the frog *Hoplobatrachus occipitalis* in a semi-controlled environment in Daloa (Centre-West; Ivory Coast), PhD thesis, Jean Lorougnon Guédé University, Ivory Coast, 2023.
15. Hubert de Bon, Lassina F, Patrick D, Zana C, Yannick B. Study for the identification and analysis of constraints to market garden production according to the major agro-climatic zones of Ivory Coast. Expert report, 2019, Ivory Coast, pp 140.
16. Tano K, Bancal V. Study of methods for reducing post-harvest losses in vegetable crops in Ivory Coast. Support Project for the Development of the Cassava and Vegetable Crops Sectors in Ivory Coast (PRO2M), Expert Report, 2019, Ivory Coast, pp 91.
17. MINADER. National Agricultural Investment Plan (PNIA) 2014-2020. Ministry of Agriculture and Rural Development; 2013, Ivory Coast.
18. Alkhali S, Sena YG, Simon A. Economic importance and research work on okra. African Horticulture Development Network, FAO expert report, 2012, pp 10.
19. Langani Y, Célestin LS, Dembélé B, Ouédraogo M, Ouoba P, Kaboré I, Namalgué HG, Sinaré T, Ilboudo F, Ndiaye S, Barrère M, GMboup G, Ayad M. Burkina Faso Demographic and Health Survey 1998-1999. National Institute of Statistics and Demography, 2000, Burkina Faso, pp 326.
20. Felix MH. Biochemical and nutritional study of wild food plants in the south of V-Baoulé, Ivory Coast. PhD thesis, Swiss Federal Institute of Technology Zürich, Switzerland, 1992.
21. Mafou KC. The migrant in Ivory Coast: Profile, perceptions, preferences and degree of integration. Expert report, Friedrich-Ebert-Stiftung, ZECHLAB, Ivory Coast, 2021.
22. Kouakou BJ, Irié BZ, Dick E, Nemlin G, Bomisso LE. Characterisation of cocoa drying techniques and influence on marketed bean quality. Journal of Applied Biosciences. 2013;64:4813-4821.
23. Konan A. Modelling the kinetics of solar drying of paddy rice under natural convection. PhD thesis, Nangui Abrogoua University, Ivory Coast, 2014.
24. Cruz JF, Troude F, Griffon D, Herbert JP. Seed conservation in hot regions. 2nd edition, Tropical Agricultural Machinery Study and Experimentation Centre; c1988, p. 545.