

# Sweetpotato cultivation: characteristics, constraints and preferred traits of producers and consumers in Côte d'Ivoire

Jean Hugues Martial Kouassi,<sup>a,b\*</sup> Konan Evrard Brice Dibi,<sup>b</sup>  
Mambé Auguste-Dénise Boye,<sup>a</sup> Brice Sidoine Essis,<sup>b</sup>  
Amani Michel Kouakou,<sup>b</sup> Boni N'zué<sup>b</sup> and Dominique Dufour<sup>c,d\*</sup>

## Abstract

**Background:** In an environment where the adoption of improved varieties resulting from plant breeding programs is limited, it is essential to identify end-user preferences beforehand. A participatory survey was conducted in eight localities in Korhogo and Bouaké regions (central and northern Côte d'Ivoire respectively) to identify producers' preferences and increase the adoption of improved varieties. The study involved 160 producers and consumers through focus group discussions and individual interviews.

**Results:** Sweetpotato is mostly grown on small plots (<1 ha) of land (89.2%), with women (66%) as the main producers. In the Bouaké region, sweetpotatoes are grown on mounds (100%), whereas in Korhogo they are grown on ridges (86.2%). The main food products or forms of preparation from roots are fries (34.7%), boiled (34.3%), mashed (12.4%), and sweetpotato stew (9.1%). Major constraints, including low price of roots (26.3%), low productivity (16.2%), and post-harvest storage issues (14.5%), were identified as affecting sweetpotato production.

**Conclusions:** The selection of new varieties should be oriented towards high-yielding varieties with high dry matter content, deployed stems, and roots of round, oblong, or elliptical shape with good culinary characteristics (dry matter, sweet taste, dry texture, absence of fiber). Plants must be drought resistant, be tolerant to poor soil, diseases, and pests, and have a good yield. The color of skin and flesh of the sweetpotato, although constituting criteria of choice, are not essential for the acceptance or the rejection of a variety by users.

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**Keywords:** end-user preferences; participatory varietal selection; farming system; efficient breeding; food security

## INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L) Lam) is increasingly important for food and nutrition security in sub-Saharan Africa.<sup>1</sup> It is a climate-resilient plant that is easily propagated and can grow with few external inputs on poor soils under different rainfall regimes.<sup>2</sup> It is one of the root and tuber crops consumed by over 2 billion people worldwide.<sup>3</sup>

Sweetpotato is produced annually in all regions of Côte d'Ivoire, but it is mainly grown in the northern and central regions.<sup>4</sup> Annual production is about 52 232 t<sup>5</sup> and consists mainly of white- and yellow-fleshed varieties. It is usually consumed fried or boiled.<sup>6</sup> According to Peters,<sup>7</sup> 30–80% of total sweetpotato production is consumed in fried form in some regions in Côte d'Ivoire, as well as in Nigeria, Ghana, and Burkina Faso.

Local and introduced (from Mozambique, Burkina Faso, and Peru) varieties are grown in Côte d'Ivoire.<sup>8</sup> Introduced varieties are mostly the result of research carried out by breeders over

the last two decades. The focus has been on high-yielding, orange-fleshed varieties, rich in provitamin A and with high nutritional values.<sup>9</sup> Much effort has been invested in assessing the

\* Correspondence to: Jean Hugues Martial Kouassi, Laboratoire d'Amélioration de la Production Agricole (APA), UFR Agroforesterie, Université Jean Lorougnon Guédé (UJLoG), BP 150 Daloa, Côte d'Ivoire, E-mail: [jhmkouassi@gmail.com](mailto:jhmkouassi@gmail.com); or Dominique Dufour, CIRAD, UMR Qualisud, Montpellier, France, [dominique.dufour@cirad.fr](mailto:dominique.dufour@cirad.fr)

a Laboratoire d'Amélioration de la Production Agricole (APA), UFR Agroforesterie, Université Jean Lorougnon Guédé (UJLoG), Daloa, Côte d'Ivoire

b Centre National de Recherche Agronomique (CNRA), Bouaké, Côte d'Ivoire

c CIRAD, UMR Qualisud, Montpellier, France

d Qualisud, Université de Montpellier, CIRAD, Montpellier SupAgro, Université d'Avignon, Université de la Réunion, Montpellier, France

adaptability of the introduced germplasm and has focused on yield under biotic and abiotic stress as the main traits.<sup>10</sup> However, the released varieties have recorded a low adoption rate by end-users.

The lack of inclusion of participatory approaches in many breeding programs in developing countries negatively affects the level of adoption of newly developed varieties.<sup>11,12</sup> Farmers have always selected and grown the varieties they prefer. Most of the traits considered important by farmers, however, may not be well known to breeders or, if known, breeders lack the techniques to assess them.<sup>13</sup> Jenkins *et al.*<sup>14</sup> indicated that understanding consumer preferences can enhance the adoption of a new released variety. According to Dibi *et al.*,<sup>6</sup> apart from the yield, other determining factors in choice of a variety are sweetness and dry texture of the boiled root. However, food preferences can vary among individuals, age groups, gender, and sometimes cultures, as well as geographical locations.<sup>15</sup>

In some countries, such as Côte d'Ivoire, farmers are conservative,<sup>16</sup> and understanding information on factors affecting the adoption of new genotypes is critical for improving their adoption. Participatory rural appraisal is an action research tool that involves community members or end-users with the aim of harnessing their knowledge to solve local problems.<sup>17</sup> This assessment uses many approaches, such as individual surveys and focus group discussions (FGDs). The method has been designed to allow local people to be involved, not only as sources of information, but also as partners in the collection and analysis of information.<sup>17,18</sup> Thus, involving farmers in the evaluation of varieties according to their preferences and understanding the factors that hinder adoption could increase the effectiveness of breeding programs, and hence increase yield and adoption of sweetpotato. The objective of this study was to identify the preferences of sweetpotato end-users in Côte d'Ivoire.

## MATERIAL AND METHODS

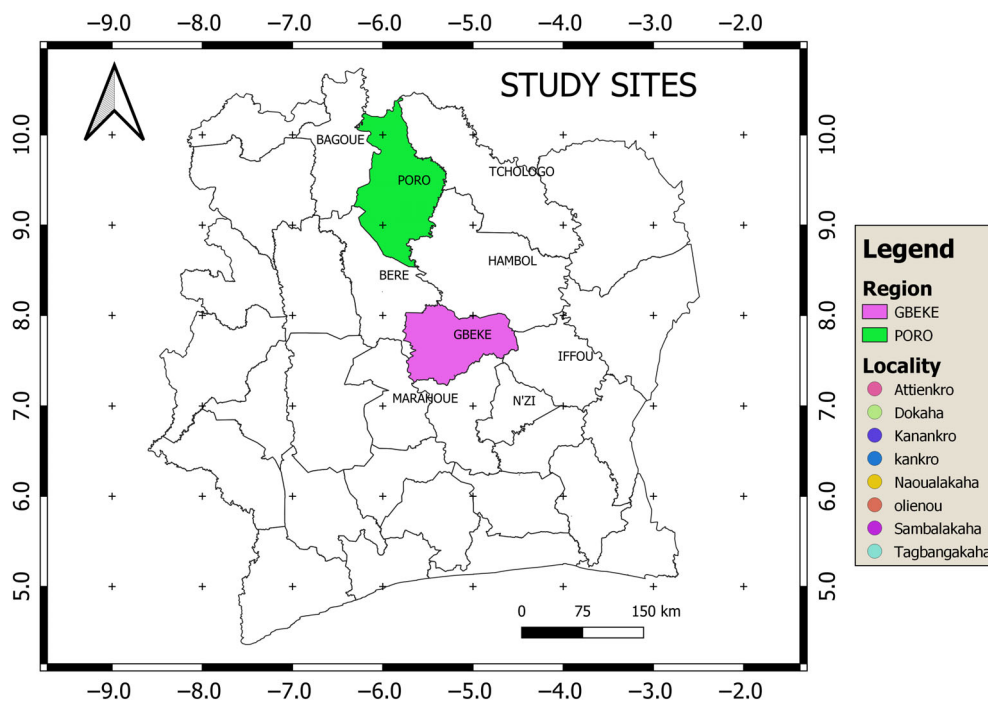
### Study sites

This study took place in eight villages of Côte d'Ivoire. Four of them were in the Korhogo region in the north: Tagbangakaha (9°20' N, 5°38' W), Naoualakaha (9°19' N, 5°38' W), Sambalakaha (9°23' N, 5°35' W), and Dokaha (9°24' N, 5°38' W). The remaining four villages were in the district of Bouaké in the center of the country: Kanankro (7°44' N, 4°59' W), Kanhankro (7°44' N, 4°57' W), Attienkro (7°43' N, 5°00' W) and Oliénoú (7°42' N, 4°59' W). These are two of the major sweetpotato growing regions in Côte d'Ivoire (Fig. 1). The district of Korhogo has a dry tropical regime of the Sudanese–Sahelian type, characterized by a dry season from November to April and a rainy season from May to October,<sup>19</sup> whereas the district of Bouaké has a Sudanese type of climate where long-term data show two dry seasons and two rainy seasons, but seasonality can vary year to year.<sup>20</sup>

### Data collection

Data to assess the preferred traits, the cropping system, and the constraints to sweetpotato production were collected through FGDs and individual interviews with farmers and consumers. To facilitate data collection, the languages used were French and three local languages (Baoulé, Sénoufo, and Dioula) with the help of a translator. Four FGDs were conducted in each of the two regions. Each FGD was composed of at least ten participants; namely, a breeder, two technicians, a rural development and extension officer, community opinion leaders, farmers, and consumers. All the discussions were conducted with women being two-thirds of the group, because they are much more involved in sweetpotato activities than men are.

Semi-structured questionnaires were developed to be administered to sweetpotato farmers and consumers. Sampling was carried out within households at the district level, where a total of



**Figure 1.** Map of Côte d'Ivoire showing the study areas.

**Table 1.** Rank of sweetpotato and other main crops in two districts of Côte d'Ivoire

Rank	Bouaké villages				Korhogo villages			
	Attienkro	Kahankro	Kanankro	Oliénoú	Dokaha	Naoulakaha	Sambalakaha	Tagbangakaha
1	Sweetpotato	Yam	Peanut	Sweetpotato	Sweetpotato	Sweetpotato	Rice	Peanuts
2	Cassava	Cassava	Cassava	Cassava	Peanuts	Rice	Maize	Maize
3	Vegetables	Sweetpotato	Yam	Rice	Vegetables	Peanut	Sweetpotato	Rice
4	Rice	Vegetables	Sweetpotato	Vegetables	Maize	Vegetables	Cotton	Vegetables
5	Yam	Cashew nuts	Vegetables	Maize	Rice	Maize	Peanut	Sweetpotato
6	Maize	Maize		Yam	Bean		Vegetables	Cotton
7							Yam	Cashew nuts

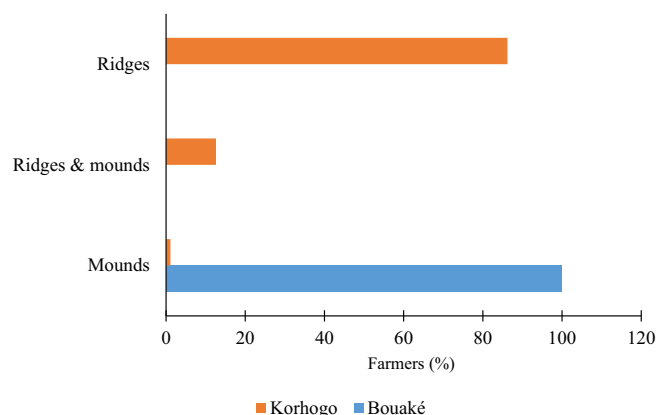
80 sweetpotato growers and consumers from each district were selected with a balanced proportion between growers and consumers. Sampling was carried out within villages, where four villages were selected in each district. Another random sampling was carried out at the village level, where 20 households were selected in each village to participate in the interviews. This makes a total sample size of 80 participants per district and 160 participants for the two districts. Information such as production constraints and preference traits were considered by each group. At the individual level, data were collected on socio-demographic aspects, food prepared, seed system, sources of supply, techniques for storing cuttings, and user preferences.

### Data analysis

The data from the individual surveys were analyzed descriptively. The Pearson chi-square test was used to assess variability of criteria between regions. The Statistical Package for Social Sciences (SPSS) was used to perform the analyses.

**Table 2.** Sweetpotato planting and harvesting system

District	Planting system		Harvesting method	
	Monoculture (%)	Intercropping (%)	Total (%)	Split (%)
Bouaké	62.9	37.1	33.9	66.1
Korhogo	73.6	26.4	100	0
Mean	68.2	31.7	66.9	33.0



**Figure 2.** Seedbed type.

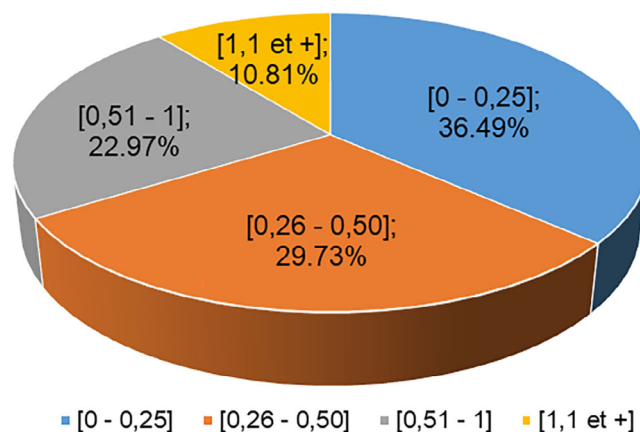
## RESULTS

### Demographics

The populations surveyed in the study area were 66% female and 34% male, aged between 18 and 67 years, and mostly illiterate (85.75%). Of the respondents, 49% were between 36 and 53 years old, 30% between 18 and 35 years old, and 21% over 54 years old.

### Role of sweetpotato in farming and food systems

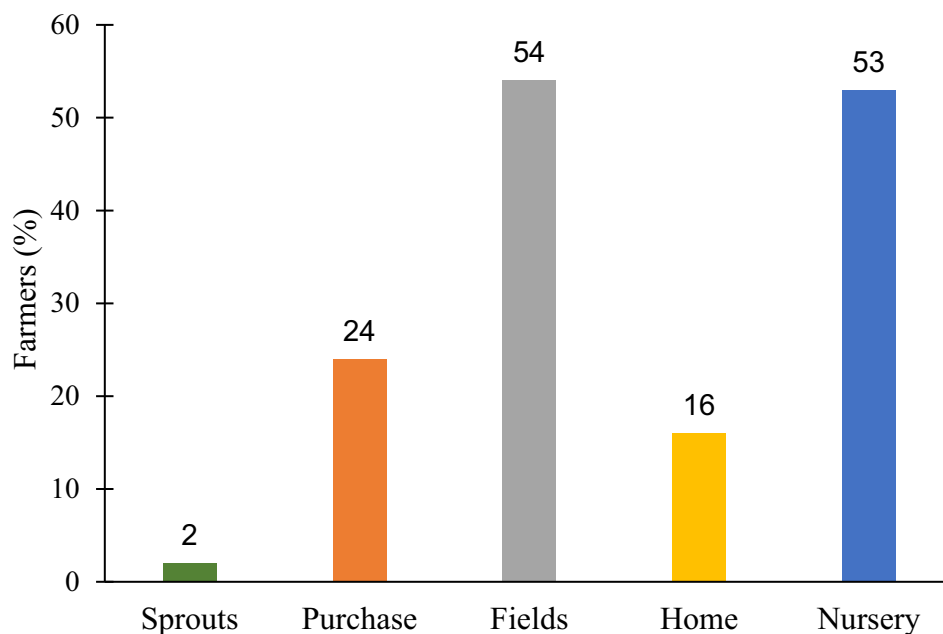
According to the producers, cassava, sweetpotato, yam, groundnut, rice, and maize were the main crops grown in the study areas. In the villages of Dokaha, Oliénoú, Naoulakaha, and Attienkro, sweetpotato was ranked first by 28.6%, 25.8%, 22.3%, and 34.8% of the participants respectively (Table 1). In Kanhankro villages, sweetpotato ranks third after yam and cassava, and in Sambalakaha after rice and maize. In the villages of Kanankro and



**Figure 3.** Farm size (hectares).

**Table 3.** Use of labor

Districts	Use of labor		
	Family labor family (%)	Family and hired labor and salaried workers (%)	Salaried workers (%)
Bouaké	25.8	56.5	17.7
Korhogo	25.3	43.7	31.0
Mean	25.5	50.1	24.3



**Figure 4.** Conservation techniques for sweetpotato cuttings.

Tagbangakaha, sweetpotato ranked fourth and fifth. In Kanankro, sweetpotato was ranked after groundnut, cassava, and yam, whereas in Tagbangakaha it was ranked after groundnut, maize, rice, and vegetables. The main reasons cited for sweetpotato production are to market in local and regional markets (82.85%) and for self-consumption (17.15%).

#### Sweetpotato planting and harvesting system

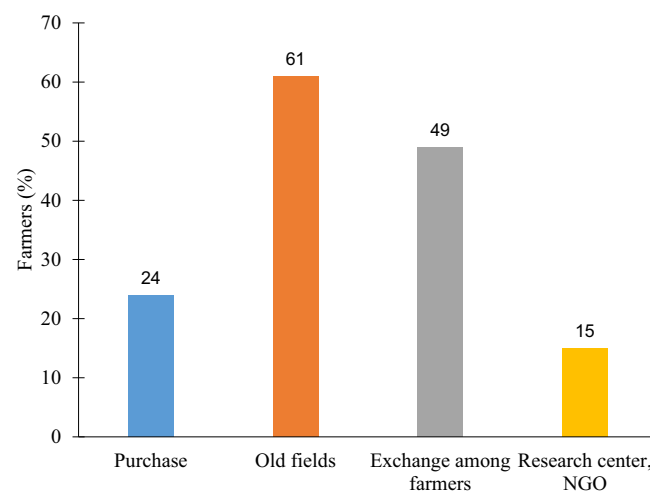
Monoculture of sweetpotato is practiced by 68.2% of the farmers, compared with 31.7% for intercropping (Table 2). All farmers surveyed in Bouaké district grew sweetpotato on ridges, while in Korhogo 86.2% of the crop was grown on ridges and 12.6% on ridges or mounds (Fig. 2). The area cultivated with sweetpotato varied from 0.12 to 4.0 ha. However, the majority (89.2%) of farmers had sweetpotato on small areas ranging in size from 0.12 to 1.0 ha, with 36.5% of farmers having areas smaller than 0.25 ha. They were followed by those with plots between 0.25 and 0.50 ha (29.7%), and between 0.50 and 1.0 ha (23.0%). Only 10.8% of farmers had an area larger than 1.0 ha (Fig. 3). All farmers in the Korhogo region confirmed that total harvesting was the system most used in the region, whereas 66.1% of farmers used split harvesting, against 33.9% for total harvesting, in Bouaké (Table 2). Most farmers responded that they use labor rather than mechanization for the preparation of plots, the building of ridges, and weeding. Thus, 50.1% of farmers used family and hired labor, against 25.5% for family labor and 24.3% for hired labor (Table 3).

#### Source and storage of sweetpotato cuttings for next crop

Across the study area, several techniques are used by farmers to obtain cuttings for production (Fig. 4). To establish a new plantation, producers mainly obtain cuttings from their own old plots left after harvest. This technique is used by 40.9% of the producers surveyed. Farmers may also set aside plots for stem production. The most common of these techniques is to grow sweetpotato cultivars in the field in lowlands (36.2%) or in fenced gardens (35.6%) from cuttings taken the previous season. In cases where the fields are far from the houses, some producers (10.07%)

reported that the stems are taken to the house to ensure permanent surveillance to avoid theft and drying out. Similarly, during the rainy season, regrowth of stems from tuberous root fragments left in the soil after harvesting is observed (1.3%).

In the event of a shortage of stems or when a new cultivar is discovered by another producer, farmers exchange stems. Cuttings are then given or exchanged (32.9%). Other producers purchase cuttings from traders (16.1%). Some farmers claim to have imported sweetpotato cultivars from other regions (Bagoué, Mountains, Tchologo) or from neighboring countries (Mali, Burkina Faso). The purchase of cuttings is not well developed by producers but is indicated by 16.1% of them as a source (Fig. 5). A few people in the surveyed groups have received improved varieties, such as "Irene", "TIB-440060", "Bela" (IIAM-CIP BD004), and "Vita" (NASPOT 9 O) from research institutions and non-governmental organizations.



**Figure 5.** Sources of sweetpotato cuttings. NGO, nongovernmental organization.

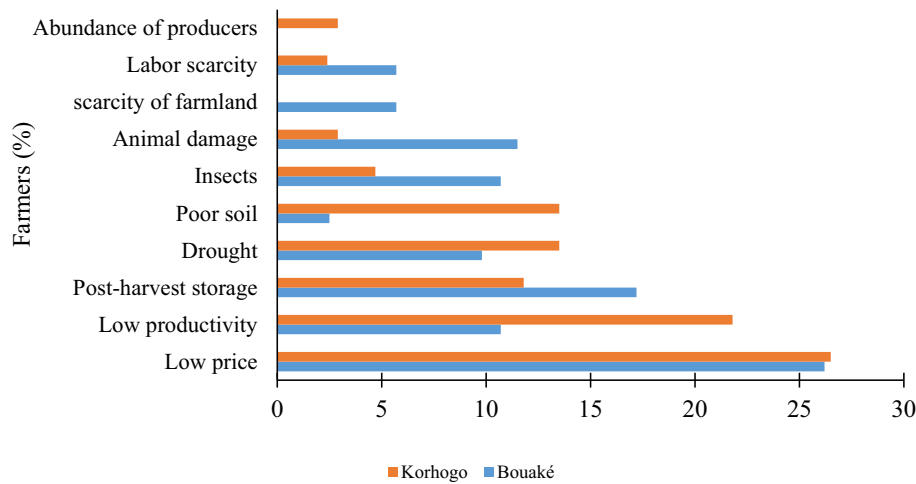


Figure 6. Production constraints of sweetpotato.

### Production and marketing problems

Ten constraints related to sweetpotato production and marketing were identified in central and northern Côte d'Ivoire (Fig. 6). Of these, seven were identified as major constraints, with predominance for the low price of tuberous roots (26.3%). This is followed by low productivity (16.2%), difficulties related to post-harvest conservation (14.5%), scarcity of rainfall (11.6%), poor soil (8.0%), pest pressure (7.7%), and scarcity of labor (4.0%). These constraints depend very significantly on the districts where the crop is

produced and marketed ( $\chi^2 = 190.03$  and  $P = 0$ ). The constraints concerning the lack of sales of products, the scarcity of labor, and the difficulties linked to conservation are common to both regions. However, some specificity was also observed. In Bouaké, animal damage and scarcity of farmland are a hindrance to sweetpotato production. On the other hand, in Korhogo, the scarcity of rainfall and poor soils are limiting factors for sweetpotato production.

### Use of sweetpotato tuberous roots

Fried, mashed, braised, boiled, and pounded sweetpotato (foutou) are the main food products consumed in the study areas. In

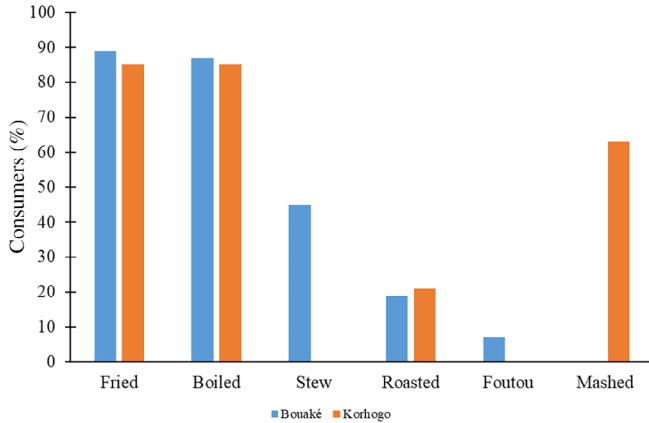


Figure 7. Sweetpotato food products.

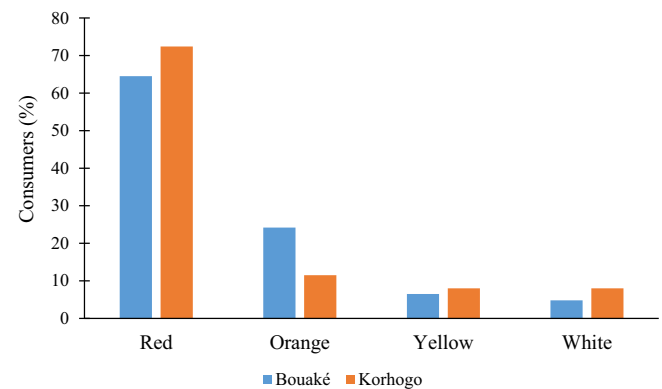


Figure 9. Preferred root skin color.

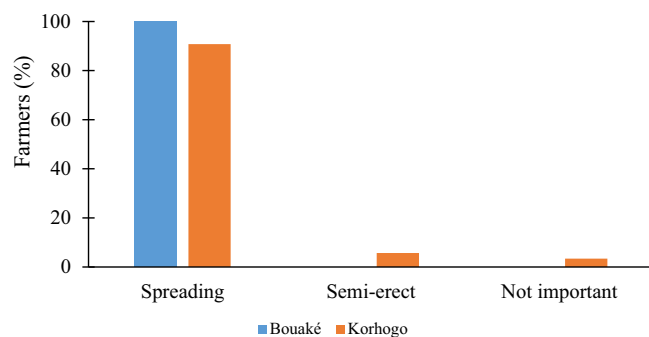


Figure 8. Preferred plant type.

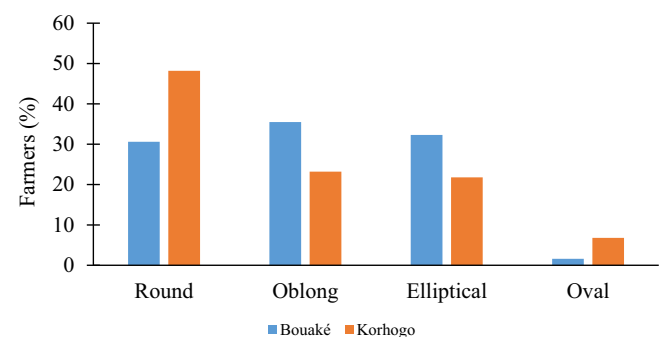


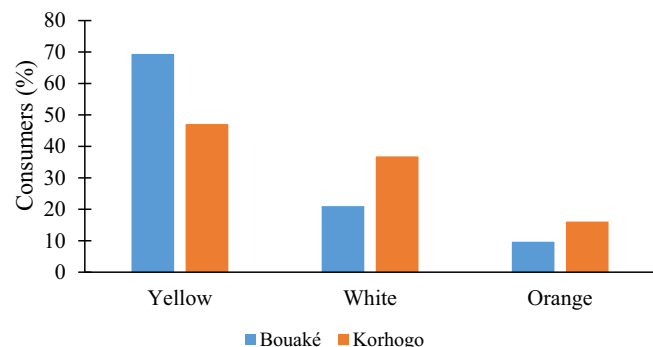
Figure 10. Preferred root shape.



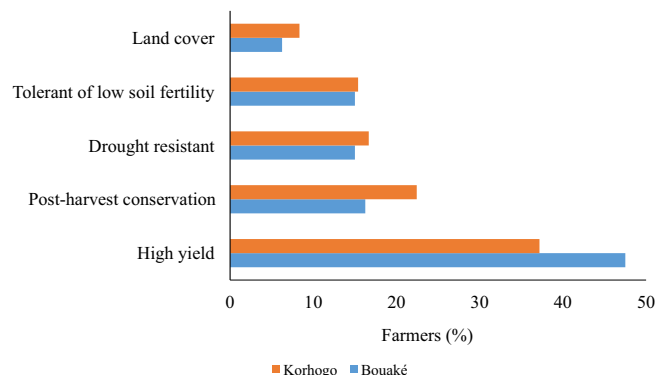
Korhogo, roots are processed into fried (33.5%), boiled (33.5%), porridge (24.8%), or braised (8.3%). In the Bouaké district, chips (36.0%) and porridge (35.2%) are also the most consumed. However, two other products, ragout and pounded sweetpotato, are added to their consumption (Fig. 7).

### Preferred characteristics of sweetpotato

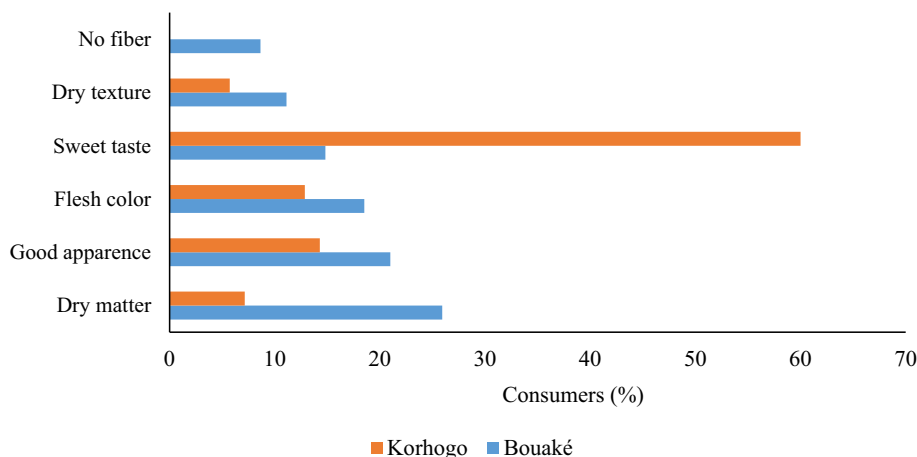
The characteristics preferred by growers are presented in Figs. 8, 9, 10, and 11. For plant type (Fig. 8), 95.4% of the participants preferred the spreading canopy because they covered the soil well



**Figure 11.** Root flesh color.



**Figure 12.** Farmers' preferred sweetpotato traits (percentage of farmers indicating the trait as important).



**Figure 13.** Consumers' preferred sweetpotato traits (percentage of consumers indicating the trait as important).

and reduced the amount of weeding. For skin color (Fig. 9), the majority (68.4%) of respondents preferred purple color, compared with 17.8% who had no preference. In terms of shape (Fig. 10), round was the most preferred (39.4%), followed by oblong (29.3%) and elliptical (27.0%). The oval shape was the least preferred (4.2%). In terms of flesh color (Fig. 11), 58.2% of the farmers grew mainly yellow and white flesh varieties (28.9%) compared with those growing varieties with orange flesh (12.9%).

### Criteria of end-users for preferred roots

Twelve preferred traits were identified. There was variation in the importance of the traits from one region to another. In Korhogo, end-users have a preference for varieties that are high yielding, drought resistant, tolerant of low soil fertility, have good post-harvest storage, and sweet (Fig. 12). Dry matter, flesh color, appearance, dry texture, and absence of fiber are of particular interest to the populations of Bouaké (Fig. 13). The most important preference criteria in Bouaké and Korhogo were high yield, sweetness, long post-harvest shelf life, and tolerance to low soil fertility.

## DISCUSSION

From the north to the center of the country, women are the main producers of sweetpotatoes. Indeed, in most African societies, women are the main decision-makers and guarantors of family food security.<sup>21,22</sup> The potential of sweetpotato as a food security and income-generating crop was confirmed in the current study by the combination of participants (farmers, traders, and consumers) identified as being associated with the crop. In the study, the ranking of sweetpotato relative to other crops also demonstrates its importance in food security and its potential as an income generator alongside other roots and tubers, such as cassava<sup>23</sup> and yam,<sup>6</sup> which are also major crops in Côte d'Ivoire. According to Kays and Horvat,<sup>24</sup> the preference for sweetpotato varies according to ethnic origin and geographical location. For example, in the central district of Bouaké, producers prefer to grow sweetpotatoes on mounds (100%), and harvesting is sometimes done in a fractional way. Split harvesting consists of digging up the large roots as and when needed, while also allowing the small roots to continue to develop. In the north, in the district of Korhogo, sweetpotato is grown on ridges and harvesting is done on a piecemeal or total basis depending on the size of the farms. The populations of this area (the Baoule) have always grown root

and tuber crops such as yam and cassava on mounds, whereas in the north (Korhogo) the Senoufo populations mainly grow sweetpotatoes on ridges, like their cotton and vegetable crops. Our results are at odds with those of Djinet *et al.*,<sup>22</sup> who showed that sweetpotato farmers mainly use ridges to the detriment of ridges in different localities of Chad.

Two systems practices were identified for sweetpotato production. The preferred cropping practice of producers is monoculture (68.2%), followed by intercropping (31.7%). This finding is corroborated by the work of Koussoube *et al.*<sup>25</sup> in a study in Burkina Faso, where monoculture seemed to be the dominant practice.

Sweetpotato production faces enormous difficulties. Among them are the scarcity of rainfall, scarcity of labor, poor soils, and pest pressure. But ultimately these difficulties translate into the fundamental problem of lower yields, low price, and the difficult challenge of post-harvest storage. The scarcity of rainfall has been reported as a major constraint in sweetpotato production in Benin<sup>26</sup> and Chad.<sup>22</sup> According to the farmers, the lack of sales and the problem of root conservation could lead them to abandon sweetpotato cultivation in favor of other more profitable and easily conserved crops.

The results of the survey revealed that sweetpotato is an integral part of the dietary habits of local people who consume the roots.<sup>27</sup> Sweetpotato is consumed as porridge, stew, fried, pounded, braised, and mashed. According to Kays and Horvat,<sup>24</sup> the preference for sweetpotato varies according to location. Thus, in the north and in the center of Côte d'Ivoire, sweetpotato is consumed as porridge, fried, and braised. Pounded sweetpotato and stew are mainly consumed in the center, whereas mashed potatoes are widely consumed in the north. These differences in consumption could be linked to the meager incomes of producers. In Côte d'Ivoire, rural populations consume more sweetpotatoes in boiled form because frying them takes a lot of time and the oil needed to prepare them is expensive. Moreover, the consumption of mashed sweetpotato by the populations of the center is explained by the dietary habits of these populations, which are mainly made up of pounded yam, cassava, and banana.

End-users use morphological traits to select sweetpotato varieties. Length of the stems, color of the skin and the pulp, and shape of the roots are used by producers to select varieties for cultivation.<sup>27</sup> Producers, therefore, have preferences on morphological criteria that deserve to be capitalized on for better adoption of new varieties. The preference for the purple or red color of the skin is associated with their resistance during post-harvest handling and transport. According to Hayma<sup>28</sup> and Kouassi *et al.*,<sup>27</sup> red-skinned varieties seem to keep better than white-skinned varieties. They can be kept in the field until they are used because they are more resistant to weevil attacks and drought.<sup>29</sup>

High yield (above 7 t/ha), good market value, sweetness, post-harvest preservation, and tolerance to low soil fertility were the most preferred traits of producers. These results are similar to those of Doussoh *et al.*<sup>30</sup> (who cited good market value, tolerance to low soil fertility, and post-harvest conservation) and Dibi *et al.*<sup>6</sup> (who noted the importance of sweetness and high yield) in their work on sweetpotato in Benin and Côte d'Ivoire respectively. The introduction or creation of new white, yellow, or orange fleshy varieties with long stems, red or orange roots' skin color with round, oblong, or elliptical shapes, having good agronomic performance and meeting the culinary characteristics of end-users should promote the sweetpotato sector and improve the livelihoods of producers in Côte d'Ivoire. The results of the current study will provide a tool for breeders to ultimately improve the adoption of new varieties. Participatory plant

breeding involving farmers at certain critical stages of the selection process allows continual refining of selection.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest in this work.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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