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Research Paper

Characterization of edible yam (*Dioscorea* spp) in Walungu, South Kivu –DRC

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ABSTRACT: *In this paper, the characterization of edible yam (Dioscorea spp) conducted in Walungu, South Kivu –DRC. The aim of this study is to characterize different varieties of yam cultivated in these study area .The survey and nutritional analysis at the laboratory of the Congolese Control Office (OCC) in Bukavu was carried out. 40 respondents in each two areas were used as the minimum acceptable sample size for each yam stakeholder group. Two varieties were present in those areas namely the Nabongwe variety (Dioscorea cayenensis) and the Naboya variety (Discorea rontundata). 87.50% observe the presence of pests in their fields. Yam varieties with yellow flesh and white flesh dominate (55.41%). It is good in quality (96.25%) with purplish brown and black tubers (55.43%) and yellowish and whitish flesh (56.24%). The yam produced in this area has more humidity .The humidity for D. rotundata is (78.43%) against 78.26% for D. cayenensis in the Karhongo area and with respectively DM rate of 28.67% and 29.76%. The samples with high calcium content were obtained from tubers harvested from the D. cayenensis variety in the Karhongo area with an average rate of 41.78%. D. cayenensis varieties were rich same level in ash, protein and iron compared to D. rotundata. Cultivation of yam is intended to respond to food and financial demands of the population.*

KEYWORDS: *Yam, Varieties, Nutritional characterization, Morphological characterization*

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I. INTRODUCTION

Yam cultivation contributes to the food security of more than 300 million people around the world [1], [2] and [3]. Yam (*Dioscorea* spp) of the Dioscoreaceae family is a tuber plant of great importance as a food, economic and socio-cultural source for populations in the tropical world of Asia, the Caribbean, the Pacific, America and Europe, Sub-Saharan Africa, especially in West Africa [4].

The main producers are located in West Africa and provide 91% of world production and these tubers constitute a staple food for more than 60 million people in the world, Nigeria being the largest producer with more than 38 million tons [1]. There are more than 600 species in total, but only about 100 of them are edible. Among the plants cultivated in the tropics, it is the second plant with roots and tubers after cassava [5].

However, the cultivation of yams is confronted with many biotic and abiotic constraints leading to production declines and problems of conservation of genetic resources [6]. Its dietary importance is due to the taste quality and nutritional value of the tubers, to the fact that the yam can be grown in dry or humid areas, and above all to the possibility of covering the human diet for 9 to 11 months [3],[7].

Despite this importance, yam remains one of the few crops whose cultivation techniques have seen very little improvement. Vegetative propagation remains the main mode of reproduction of this plant and therefore promotes an increase in the rate of contamination and the gradual disappearance of certain genotypes. This vegetative propagation technique has the disadvantage that a significant part of the harvest is saved as seed [8]. This reduces the share of production available for food. It is estimated between 25 to 50% on average, the

proportion of the yam harvest reconverted into seed [9]. Farmers still use a wide variety of landraces that are important in agriculture and food [10]. Studies have revealed that there is a wide range of yam management practices, due to the fact that the techniques and practices used vary greatly with the cultural and ecological diversity of the environment of the socio-linguistic groups [11] and [12].

In DR. Congo, yam consumption is generally limited to production areas due to transport problems and the lack of processing technology. Exports to other underprivileged regions of the country and to neighboring countries remain low. However, it could constitute one of the means of food self-sufficiency in these countries [13]. The performance of yam in the DR. Congo with regard to bioactivity and nutritional values, the species show good antioxidant and anti-hyperglycemic properties as well as high nutritional value. Thus, could be promoted as functional foods in the DR. Congo. Yam is widely cultivated in the country and is among the major root and tuber crops grown by subsistence farmers in the forest zone regions of the country [14]. In addition, despite its importance, research on yam is not done [15].

In South Kivu, yam receives very little research attention on pests (diseases and pests), morphological characterization and nutritional qualities, etc. Although the role of farmers is recognized, understanding of the processes involved and of the social, economic and ecological factors that determine the maintenance and evolutionary dynamics of the diversity of cultivated yams is still fragmentary and unevenly known depending on the agro-ecological conditions in the South Kivu province.

The inventory, the morphological characterization and the nutritional qualities of the varieties cultivated in different traditional agro ecosystems would allow the safeguarding of this genetic heritage as well as its use in breeding programs. It is to fill the gaps related to the lack of scientific data on cultivated yams that this study was initiated. The aim of this paper is to characterize different varieties of yam cultivated in Walungu territory, South Kivu province.

II. MATERIALS AND METHODS

The territory of Walungu is located in the province of South Kivu in the east of the DR Congo at 2°38' south latitude and 28°40' east longitude (Figure 1) and is subdivided into two chiefdoms, including that of Ngweshe in the North and South-East and that of Kaziba in the South.

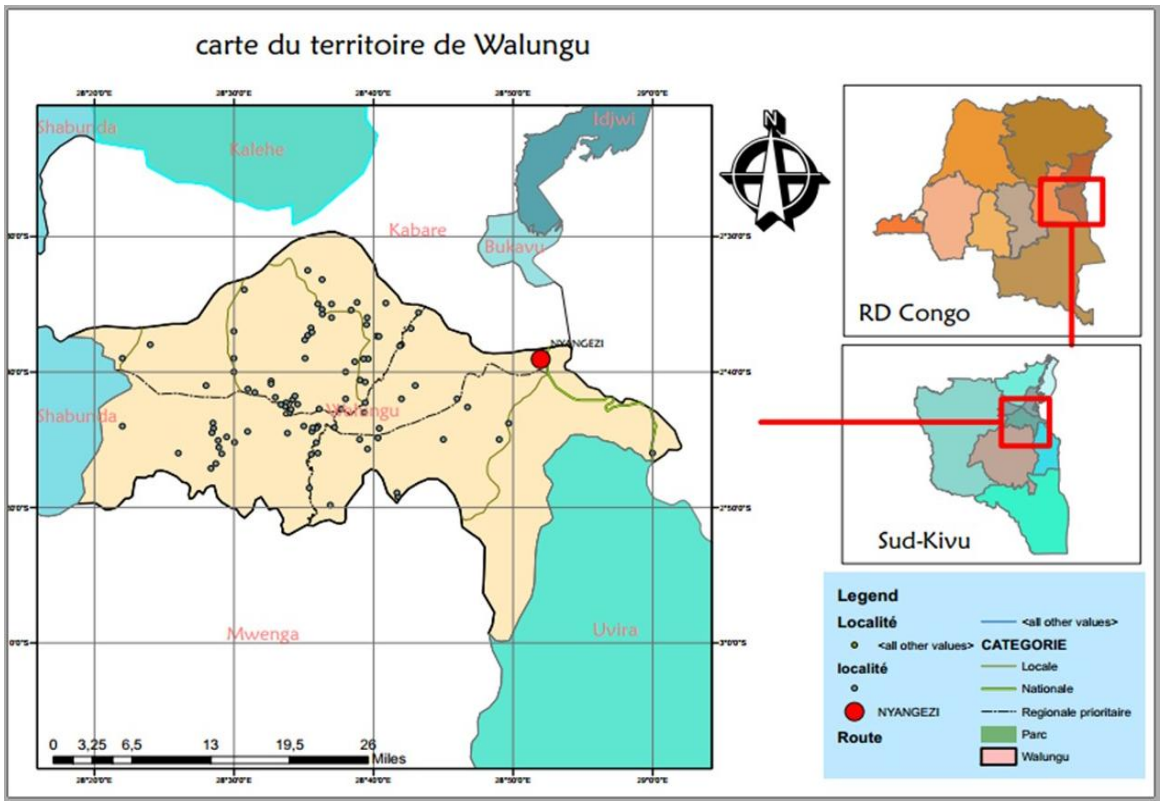


Figure1: Walungu territory, the study area

With an altitude varying between 1000 m in the East at Kamanyola) and 2000 m at Mulume munene, the territory of Walungu has a cold tropical climate of low altitude. There are two seasons, namely the dry season (May – September) and the rainy season (September – May) with varying temperatures between 17°C (in

July) and 20°C (in October), and rainfall oscillating between 900 and 1500 mm per year with an annual average of 1300 mm. Being a part of the Bushi which extends between the equator in the North and the Tropic of Capricorn in the South, the territory of Walungu is housed in the massifs of Mitumba on the western slope of the Rift Valley. This positioning in the mountains gives it a mild and dry climate, i.e. an altitude climate. The soil is clayey-loamy-sandy in nature and the marshes are rich in humus. The subsoil contains gold, quartz, amethyst, which sometimes undergo occasional artisanal mining. These soils are of different natures depending on whether the place is marshy or mountainous. In the swamps, they are a humus layer; the soil is clayey or loamy while in the mountains it becomes sandy clay. The vegetation of the Walungu territory is made up of grassy savannahs, a few Mugaba and Mushwere forest reserves and wooded areas scattered throughout the territory, mostly created by the settlers, the Mission Antiérosive (MAE) and the National Committee of Kivu (CNKI -) (CAID, 2021). The territory of Walungu is mainly watered by rivers, the most important of which are Luvinvi, Ulindi and Kadubo. Most of these flow into the Ruzizi River. There are other small rivers Nsesha, Mugaba, Luzinzi, Mayi-Mingi and Gombo. The territory of Walungu has within it a small lake named Mudekera above the high mountains in the chiefdom of Kaziba, its location gives it the status of a tourist site [16].

The criterion retained for the choice of producers is that of the representativeness of the sampling of actors surveyed. We were particularly interested in household heads producing yams. In view of the low density of inhabitants in the study villages, the availability of producers and the concern to have reliable data for the analyses, by reasoned sampling, 80 yam producers distributed in two different areas of study including 40 yam producers in the Karhongo area and 40 yam producers in the Walungu center area. The sample size was obtained by the following formula: $n = \frac{Z^2 x\ P(1-P)}{d^2} = \frac{1.96^2 x\ 0.5(1-0.5)}{0.11^2} = 79.37$ n is the sample size, Z is the level of confidence according to the reduced central normal distribution (for a level of confidence of 95%, z = 1.96), P is the estimated proportion which presents the characteristic (when this proportion is unknown P = 1/2), and d being the tolerated margin of error. Considering a margin of error of 11% [17].

The survey was carried out in 6 villages of the two groups (Walungu center and Karhongo) selected in the territory of Walungu in South Kivu. It only concerned yam producers, i.e. any individual integrating yam into his cropping system. Besides the mere presence of the yam in the field, it is more the responsibility of the individual who exercises decision-making power over the allocation of productive resources and the product [18]. The survey method consisted in questioning each farmer individually. The data collected is of two types: qualitative data (the different varieties cultivated, the problems encountered in production and marketing, the most appreciated variety, the factors which determine their appreciation and the reason for yam consumption) and the quantitative data (marketing price and farm income).

The samples of yam fragments were randomly harvested from the fields, transported in bags and kept at room temperature for two weeks then sent to the laboratory of the Congolese Control Office (OCC) in Bukavu for nutritional analysis. The fragments of the different varieties of yam are washed in tap water, peeled, cut into small pieces using a knife and dried in the shade. The fragments obtained are ground using a manual grinder. The powder obtained is used for the various nutritional analyses: humidity, dry matter, proteins, ash, calcium and Iron [19] and [20].

The data collected were encoded and the means of the various parameters were presented in the form of graphs using Microsoft Excel 2013. The descriptive analyzes were carried out by the R software under its R Studio extension (version 3.5.2). An analysis of the variance was carried out under the "Agricolae" package of the R 3.6.2 software following a linear model to detect the differences in the nutritional parameters according to the two varieties of yams and according to the environment. The Chi-square test was performed for qualitative variables to reveal differences at the 5% significance level. A logistic regression was performed to identify the factors influencing the choice of a yam variety and its appreciation.

III. RESULTS AND DISCUSSION

3.1 Yam varieties

Table 1: List of yam varieties in the study area

No	Common name	Scientific name	Flesh color
1	Nabongwe	*Dioscorea cayenensis*	Yelow
2	Naboya	*Dioscorea rotundata*	White

Two varieties were identified in the study area, namely Nabongwe (*Dioscorea cayenensis*) and Naboya (*Dioscorea rotundata*). Our results agree with those of [21] who also found those yam varieties. The yams of the *D. cayenensis* and *D.rotundata* complex are the most important and represent more than 95% of the total production in West Africa [21], with significant varietal and genetic diversity [22] and [23]. It should be noted

that the morphological types found during this study are very low compared to those found in other African countries such as Benin where several morphological types (more than eight) have been identified [24]. It is also very low compared to that described by [25] on *D. rotundata*, a species cultivated in Benin. Table 1 presents the list of yam varieties encountered in the study area.

Morphological characterization

Table 2 presents the results on the morphological characterization and the mode of management of yam cultivation in the two groups of the Walungu territory.

Table 2: Morphological characterization and management of yam cultivation

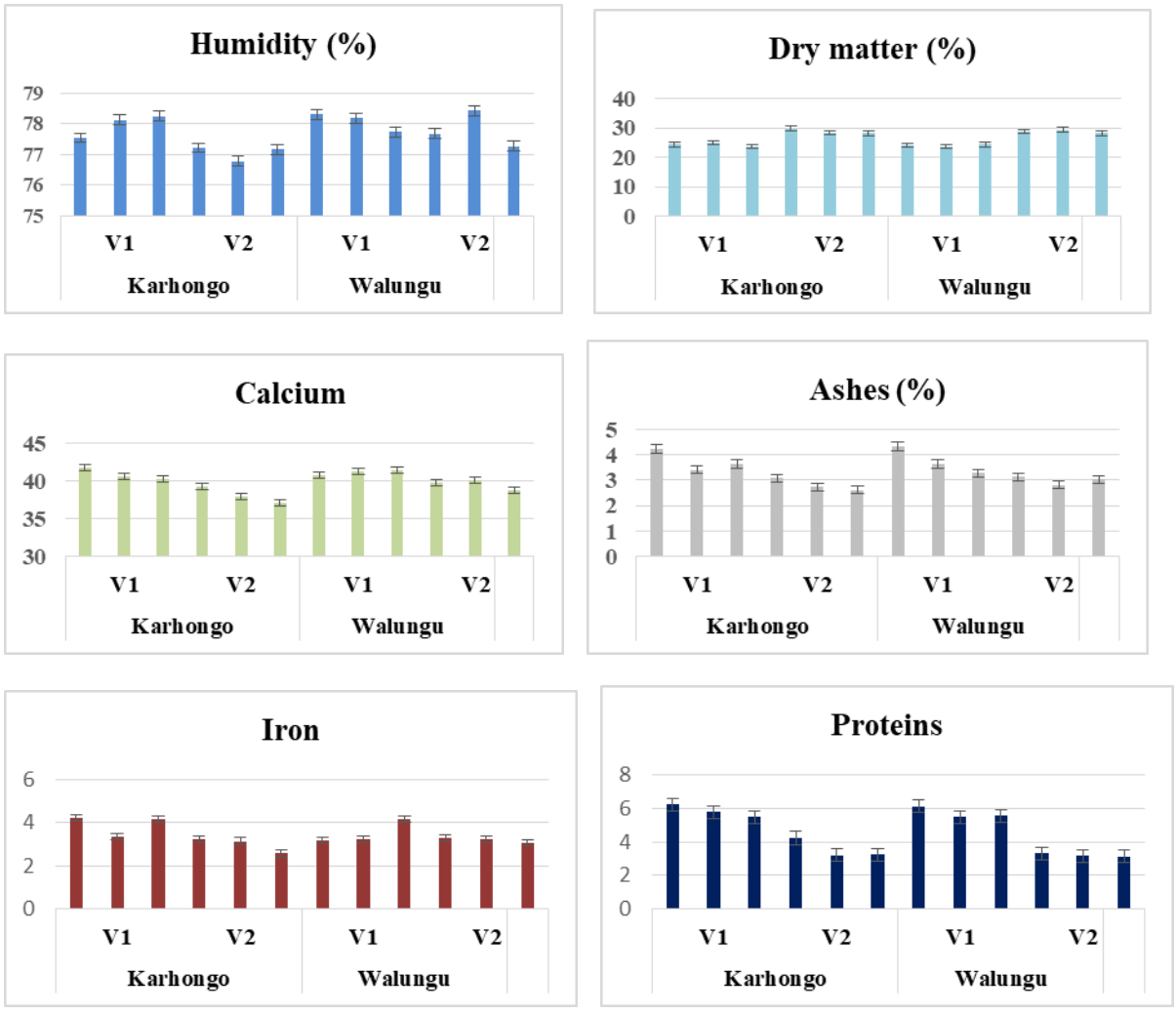
Factor	Variables	Karhongo	Walungu	Total	Khi2	p-value
Field area(Hectare)	<0,5	16.66	3.34	20.00		
	>1	4.18	12.09	16.27		
	0,5 à 1	29.16	34.57	63.73		
Cultural method	Association	50.00	50.00	100.00		
Type of association	Banana, bean	11.96	10.63	22.59		
	Bean, Corn	3.22	0.62	3.84		
	Bean, Cassava	0.00	4.36	4.36		
	Bean, Taro	3.22	0.00	3.22		
	Cassava, maize	16.97	14.38	31.35		
	Cassava, Sweet Potato	0.00	0.62	0.62		
	Cassava, Taro	1.96	1.88	3.84		
	Sweet Potato	4.46	3.13	7.59		
	Taro, Bean	8.21	14.38	22.59		
Pest presence	Yes	41.25	46.25	87.50	1.4629	0.2265
	No	8.75	3.75	12.50		
Varieties	Yellow-fleshed yam	19.16	18.75	37.91		
	Yellow and white-fleshed yam	24.16	31.25	55.41		
	White-fleshed yam	6.68	0.00	6.68		
Quality varieties	Good	46.25	50.00	96.25		
	Good, bed	3.75	0.00	3.75		
Tuber colors	Purplish brown	19.15	18.75	37.90		
	Purplish brown, black	24.18	31.25	55.43		
	Black	6.67	0.00	6.67		
Flesh Colors	Whitish	6.25	0.00	6.25		
	Yellowish	18.76	18.75	37.51		
	Yellowish, Whitish	24.99	31.25	56.24		

63.73% of the farmers in these study groups have areas of between 0.5 and 1 hectare on average and combine commonly associated crops such as cassava and maize (31.35%), followed by 22 .59% respectively of the association banana tree and bean and that of bean and taro. 87.50% observe the presence of pests in their fields and yam varieties with yellow flesh and white flesh dominate at 55.41% with good quality (96.25%) in the colors of purplish brown and black tubers (55.43%) with 56.24% yellowish and whitish flesh. Factors such as tuber size, color and cooking time influence the ability of producers to adopt their yam production in the study area. These results are similar to those obtained by [26] in Ethiopia but consistent with those reported by [27] in Nigeria. Other researchers talk about the impact of the producer's experience on the maintenance and sustainability of yam cultivation [28] and can be explained by the fact that farmers acquire and develop more skills over time.

Nutritional characterization

The evaluation of the nutritional qualities of yam varieties found in the two groups is presented in Figure 2. These analyzes focused on the moisture content, dry matter content, calcium, ash content, iron as well as protein content. The evaluation of the content of certain elements of the yam samples produced in the Walungu territory show that these varied not only according to the varieties but also according to the environment. Indeed histograms (Figure 2) show yam produced in the Walungu area has more humidity (78.43 %) for *D. rotundata*, against 78.26% obtained in *D. cayenensis* in the Karhongo area and with an associated SM rate of 28.67% and 29.76% respectively for the two. On the other hand, samples with high calcium content were obtained from tubers harvested from the *D. cayenensis* variety in the Karhongo group with an average rate of 41.78 %. *Dioscorea cayenensis* or V1 was rich in ash (4.34 %), protein (6.12%) and iron (4.19 %) compared to

D. rotundata or V2. There is no difference between the average levels of these properties compared to the two groups of yam. According the nutritional characteristics, the two varieties showed slight differences, and this could be explained by the richness of the soils of the production areas and genetics. These claims have been made by [29] and [30]. Yam is more or less cultivated in Africa and constitutes an important source of calories and nutrients for the population [30] and [31]. It plays a role in strengthening food security through its lower sensitivity to climatic risks and pest attacks than cereals and legumes in the same areas [32]. The tubers are mainly made up of carbohydrates which represent 90% of the dry matter, the main element of which is starch. In addition to carbohydrates, they also contain proteins, lipids, vitamins and mineral salts in small but significant quantities [31],[32]. The tubers are mainly made up of carbohydrates which represent 90% of the dry matter, the main element of which is starch. In addition to carbohydrates, they also contain proteins, lipids, vitamins and mineral salts in small but significant quantities [33]. It plays a major role as subsistence, commercial and socio-cultural crop [34]. Because of its richness in carbohydrates, proteins, vitamins and mineral salts, yam is the main source of carbohydrates for millions of populations [30], [35] and [36].



Legend :V1: Variety Nabongwe (*Dioscorea cayenensis*), V2 :Variety Naboya (*Dioscorea rotundata*)

Figure 2: Nutritional qualities of edible yam varieties

IV. CONCLUSION

Two yam varieties namely the Nabongwe variety (*D. cayenensis*) and the Naboya or Bihama variety (*D. rotundata*) were present in Walungu territory, South Kivu province, eastern DR Congo. 87.50% observe the presence of pests in their fields. Yam varieties with yellow flesh and white flesh dominate (55.41%). It is good in quality (96.25%) with purplish brown and black tubers (55.43%) and yellowish and whitish flesh (56.24%). The yam produced in this area has more humidity .The humidity for *D. rotundata* is (78.43%) against 78.26% for *D. cayenensis* in the Karhongo area and with respectively DM rate of 28.67% and 29.76%. The samples with

high calcium content were obtained from tubers harvested from the *D. cayenensis* variety in the Karhongo area with an average rate of 41.78%. *D. cayenensis* varieties were rich same level in ash, protein and iron compared to *D. rotundata*.

Such a limited number of morphotypes is that there have been very few yam accessions introduced into our study environment. Unlike other regions, where a higher number of morphotypes is probably due to several waves of cytogenetic introduction. Our only suggestion would be addressed to the actors responsible for monitoring production in order to promote good agricultural practices for the contribution to food security who must now increase their efforts to inform and train yam producers without forgetting the awareness component of producers on their interest in massively producing yams. These factors are therefore very important in the use and production of yam in the study environment and their consideration will ensure the improvement of the yield of yam cultivation in Walungu territory.

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