



## Practices and damages encountered by wholesale traders during 'Kponan' yams (*Dioscorea cayenensis-rotundata*) storage in Abidjan, Côte d'Ivoire

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Received: 07-02-2022

Accepted: 04-08-2022

Published: 31-08-2022

### ABSTRACT

Yam wholesalers who practice speculative storage sometimes suffer significant losses the level of which has been little studied. Thus, this work was carried out to study the practices and deterioration factors of 'Kponan' yam during storage. To achieve this, 51 yam wholesalers in 4 communes of Abidjan (Abobo, Adjamé, Yopougon and Treichville) were interviewed using a survey form. The data showed that according to storage practices, yams are preferentially grouped by variety (100%) and old yams separately (88.2%). Wholesalers (94.1%) regulate the storage temperature either by fans (23.5%), by air openings in the wall (25.5%), or by fans and air openings in the wall (45.1%). Decay was the most common damage among all wholesalers (100%), followed by weight loss (52.9%), mold (35.3%), injury (29.4%), cracking (23.5%), and sprouting (17.6%). Heat was the main cause of yam damage, followed by moisture (82.3%), animals (31.4%), field storage conditions (17.6%), chemical use during cultivation (17.6%) and sprouting (17.6%). This study shows that the storage and temperature control techniques employed by wholesalers are far from mitigating the heat that is the main cause of damage to 'Kponan' yam (*Dioscorea Cayenensis-rotundata*) during storage.

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**Keywords:** *Kponan*, yam, wholesalers, practices, post-harvest losses, storage.

### INTRODUCTION

Among root crops with tubers, yams, belonging to the genus *Dioscorea* are grown throughout the planet (tropical, subtropical and temperate zones) and there are approximately 600 species on the surface of the globe, 90 of which are considered edible (Shekhar et al., 2015; Doussouh et al., 2016). Yam (*Dioscorea* spp.) is an important food

crop in many tropical countries of Asia, South America and West Africa (Demont et al., 2003). In West Africa, yam plays an important role in economic and nutritional terms, and in socio-cultural rituals (Demont et al., 2003; Ngue et al., 2007). Côte d'Ivoire ranked the 3rd yam producing country in the world after Nigeria and Ghana with 7.65 million in 2020 on an area of 1.200.405 ha (FAOSTAT,

2021). Côte d'Ivoire leads consumption in West Africa at 331 kcal per capita per day behind Benin (395 kcal) (Laly et al., 2019). In rural areas where yams are produced, people eat mainly yams during the harvest. In urban areas, yams are considered a high social class food (Kouakou et al., 2019). They are sources of income for producers and traders (Doukouré et al., 2000). The yam sector is important in terms of its contribution to the food security of the population. The supply of yams is insufficient in quantity and quality and is most often associated with seasonal fluctuations (Demont et al., 2003).

Post-harvest losses are caused by dehydration (65 to 85%) (Corneille et al., 2012), parasites (insects, nematodes, fungi, bacteria) and wounds during harvest, (Seka et al., 2009; Ayisah and Gumedzoe, 2012; Girardin and Nindjin ; 2015; Kouamé et al., 2017). These losses strongly reduce the yield of seed tubers and cause the disappearance of certain varieties (CNRA, 2009). 'Kponan' yam variety is an early variety of the *Dioscorea cayenensis-rotundata* complex. According to the previous work of Kouakou et al. (2019), 'Kponan' is most prized by consumers in Abidjan which population represents 38.52% of the country's urban population. In Côte d'Ivoire, 97% of the 'Kponan' is produced in the 'Zanzan' region and mainly 70% of this production is sold in Abidjan (Dolumbia et al., 2006). Face to the large and growing demand for 'Kponan' in Abidjan, it is necessary to guarantee market supply. This guarantee certainly depends on yams availability in production areas and the supply of urban markets but above all it requires the strengthening of wholesalers' capacities to invest in marketing (Mahyao et al., 2007).

According to Kouakou et al. (2019), 'Kponan' yam sold on wholesale markets in Abidjan comes from 6 geographic origins, the main ones being Bondoukou (60%), Bouna (33.3%) and Kouassi-Kouassikro (6.7%). The distance of 'Kponan' production areas from Abidjan shows the importance of conservation as a management system to reduce post-harvest losses. The consequence of the lack of

good conservation is a strong fluctuation in prices throughout the year, which jeopardizes adequate supply and stability of supply in the markets. Thus, improved storage techniques are needed to mitigate this high fluctuation in yams availability in relation to price (Demont et al., 2003).

In urban areas of Côte d'Ivoire, yam wholesalers' warehouses are generally built of brick and sometimes wood, with cemented interiors, and where storage conditions are unknown. Thus, yam suffers from enormous losses during marketing, during transport by truck and during storage by wholesalers. However, it is mainly losses during yam storage that constitute a serious loss of income for Ivorian agriculture (CNRA, 2009). Yam wholesalers who practice speculative storage suffer from losses that are sometimes significant. However, the level of these losses has been little studied until now (Mahyao, 2008). So, the present study was carried out to assess the impact of yams wholesale traders' storage practices on 'Kponan' (*Dioscorea cayenensis-rotundata*) deterioration.

## MATERIALS AND METHODS

### Yam variety

The biological material was 'Kponan' yam variety of *Dioscorea cayenensis-rotundata* specie commonly preferred by consumers in Abidjan.

### Study area

The study focused on Abidjan, which is the main marketing and consumption area for 'Kponan' yam. Precisely, the communes of Abobo, Adjamé, Treichville and Yopougon which are home to the main wholesale markets for 'Kponan' yams (Kouakou et al., 2019) were investigated.

### Target population and sampling

The target population consisted of all wholesale yam traders in Abidjan in the communes of Abobo, Adjamé, Treichville and Yopougon. With the exception of the commune of Adjamé, the list of wholesalers was provided by the town halls. For Adjamé,

the snowball technique was adopted to identify all of the yam wholesalers. Thus, an exhaustive sample of 51 wholesalers was surveyed, including 10 in Adjamé, 14 in Yopougon, 10 in Treichville and 17 in Abobo.

### Questionnaire survey

The survey was conducted to collect quantitative data on the 4 wholesale yam marketing sites in Abidjan. A questionnaire was drawn up using SPHINX Plus<sup>2</sup> (V5) software (Version 4.5.0.19) in order to understand the existing relationships between storage conditions and the types of damage during yam storage. This questionnaire had five sections, including basic questions about the respondent, questions about the respondent's socio-demographic characteristics, questions about the varieties of yams marketed, their supply chain and storage practices in the store.

### Data analysis

The collected data were entered using SPHINX Plus<sup>2</sup> (V5) software and transferred to Excel for database setup. All statistical analyses were performed using XLSTAT 2016 software. Comparisons between dependent variables were determined by the Chi-square test. Statistical significance was defined at the 5% level.

## RESULTS

### Socio-demographic characteristics of yam wholesalers in Abidjan

The socio-demographic characteristics of yam wholesalers in Abidjan are presented in Table 1. The 51 traders surveyed in the wholesale yam markets of Abidjan had a male/female sex ratio of 48/3. Women were very poorly represented in yam wholesaling, with 16 men for 1 woman wholesaler in Abobo and 8 men for 2 women wholesalers in Treichville. The age of the wholesalers is between 22 and 56 years with 31.4% of those of 22 to 35 age, 33.3% of those of 35 to 45 and 35.3% of those of 45 to 56 age. Wholesalers are globally educated (68.6%) with 27.5% of them having secondary

education level. The wholesalers have between 1 and 31 years of professional experience in yam sales with 39% of them who have between 1 and 10 years of activity. The most experienced traders have been in the yam business for 21 to 31 years (26%). The middle class has been in the business between 11 and 20 years for 35% of wholesalers.

### Yams marketed by wholesalers

Table 2 presents the main varieties of yams sold on the Abidjan wholesale market. The main yam varieties sold by all wholesalers (100%) are 'Kponan', 'Assawa', 'Krenglè' and 'Bètè-bètè'. The 'Florido' variety is only sold in all the communes, but by 72.5% of the wholesalers surveyed.

### Methods of storage of yams

The methods of storage of yams by wholesalers are presented in Figure 1. Abidjan wholesalers arrange yams by grouping them by variety and putting old yams on the side at respectively 100% and 88.2%. 94.1% of the wholesalers control storage temperature by using both fans and windows (45.1%) or only fans (23.5%) or windows (25.5%). Most of the wholesalers (96%) place yams on the floor but 4% of them use both floor and ground arrangements. Only 1.96% of wholesalers use insecticides (Table 3).

### Damages and deterioration factors of yams during storage

The types of damage observed during storage by wholesalers are presented in Figure 2 A. Rot was the most common damage (100%) observed by all wholesalers, followed by weight loss (52.9%), mold (35.3%), injuries (29.4), cracks (23.5) and sprouting (17.6%). The main factor in yam deterioration (Figure 2 B) is heat (100%), followed by relative humidity (82.3%). These are followed by animals (insects and rodents) (31.4%), field storage conditions (17.6%), chemical use (fertilizer and herbicide) (17.6%), soil quality (15.7%) and other factors (13.72%) such as overly sweet tubers and non-mature tubers.

**Yam deterioration**

Yam deterioration is observed in all of the communes. Therefore, damage is notified as high by 70% of the wholesalers of Treichville, followed by those of Yopougon (64.3%), Adjamé (50%) and Abobo (41.2%) (Figure 3 A). Among yams, 'Kponan' is the main yam variety prone to damage during storage (Figure 3 B). 'Kponan' deterioration was notified by 58.8% of the yam wholesalers of Abobo, 78.6%, 80% and 50% of those of Yopougon, Treichville and Adjamé respectively. Comparatively to 'Kponan', the other varieties subjected to damages are 'Assawa' (29.4% in Abobo, 30% in Adjamé, 14.3% in Yopougon and 20% in Treichville) and 'Bètè-bètè' (11.8% in Abobo, 20% in Adjamé and 7.1% in Yopougon) (Figure 3 B).

**Storage time of 'Kponan' yam in store**

Figure 4 shows the different storage times of 'Kponan' yam in stores by commune. In general, the storage time of 'Kponan' yam in the store not exceed 3 months. 40-42.86% of Adjamé, Treichville and Yopougon wholesalers can keep 'Kponan' up to a month where only 11.76% of those of Abobo store yams in the same time. The majority of wholesalers of yams keep 'Kponan' variety up to 2 months respectively for 52.94% of those of Abobo, 50% of those of Adjamé, 50% of those of Treichville and 35.71% of those of Yopougon. However, a small percentage of wholesale traders, namely 35% (Abobo), 21% (Yopougon), 10% (Adjamé) and 10% (Treichville) keep their yams between 2 and 3 months.

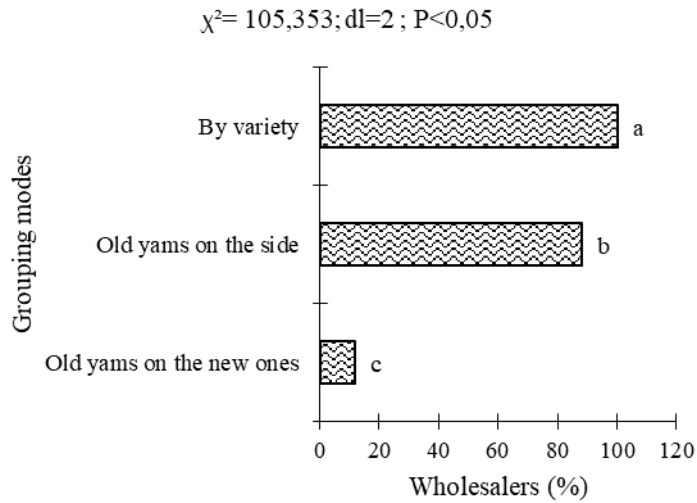
**Table 1:** Sociodemographic characteristics of yam wholesalers in Abidjan.

	Sex	Level of education (%)					Age class (%)			Experience years (%)		
	Ratio (M/F)	No instruction	Primary	Koranic	Secondary	Superior	[22-35]	[35-45]	[45-56]	[1-10]	[11-20]	[21-31]
Abobo	16/1	17.65	17.65	11.76	47.06	5.88	29.42	35.29	35.29	35.29	29.42	35.29
Adjamé	10/0	30.00	0.00	20.00	40.00	10.00	60	20	20.00	50	30.00	20.00
Yopougon	14/0	21.43	21.43	35.71	7.14	14.29	28.57	42.86	28.57	42.86	42.86	14.28
Treichville	08/2	70.00	0.00	10.00	10.00	10.00	10.00	30.00	60.00	30.00	40.00	30.00
<b>Abidjan</b>	<b>48/3</b>	<b>31.37</b>	<b>11.76</b>	<b>19.61</b>	<b>27.45</b>	<b>9.80</b>	<b>31.38</b>	<b>33.33</b>	<b>35.29</b>	<b>39.22</b>	<b>35.29</b>	<b>25.49</b>

**Table 2:** Main varieties of yams selling by wholesalers on Abidjan markets.

Yam varieties	Abobo	Adjamé	Yopougon	Treichville	Abidjan
<i>Kponan</i>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
<i>Assawa</i>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
<i>Krenglè</i>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
<i>Bètè-bètè</i>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
<i>Florida</i>	76.5 <sup>a</sup>	50 <sup>a,b</sup>	78.6 <sup>a</sup>	80 <sup>a</sup>	72.5 <sup>b</sup>
dl	4	4	4	4	4
χ <sup>2</sup>	16.79	22.222	12.533	8.33	59.253
P	< 0.01	< 0.001	< 0.05	0.080	< 0.001

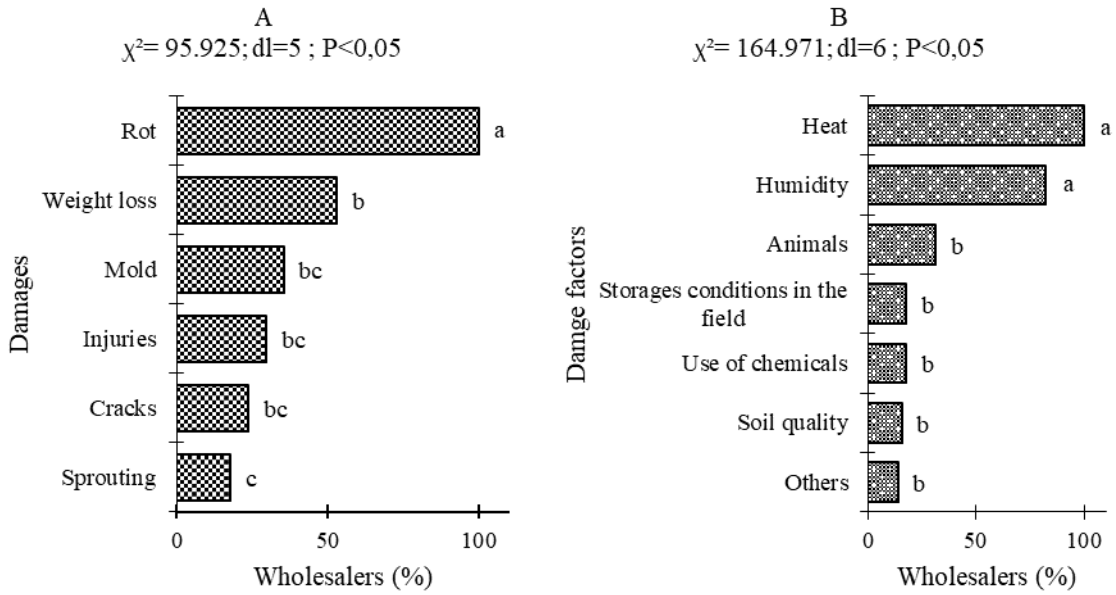
Statistical differences between values are indicated in the same column by the different superscript letters a, b and c. χ<sup>2</sup>: Chi-square, P: Probability value, dl: Degree of freedom.



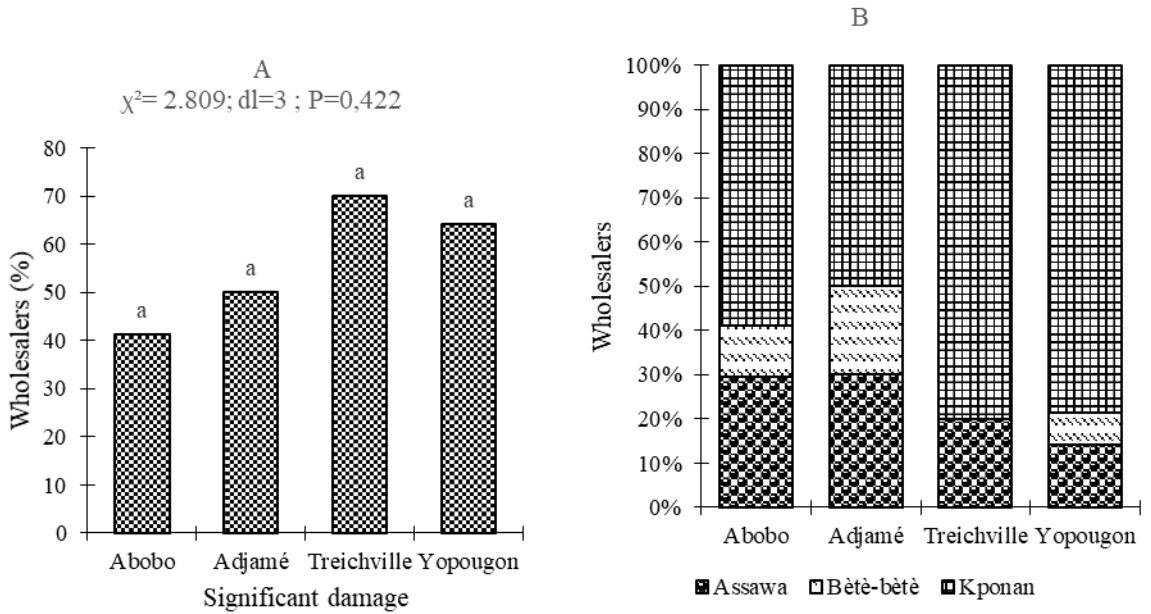
**Figure 1:** Storage methods of yams by wholesalers in markets.

**Table 3:** Storage practices for yams in stores.

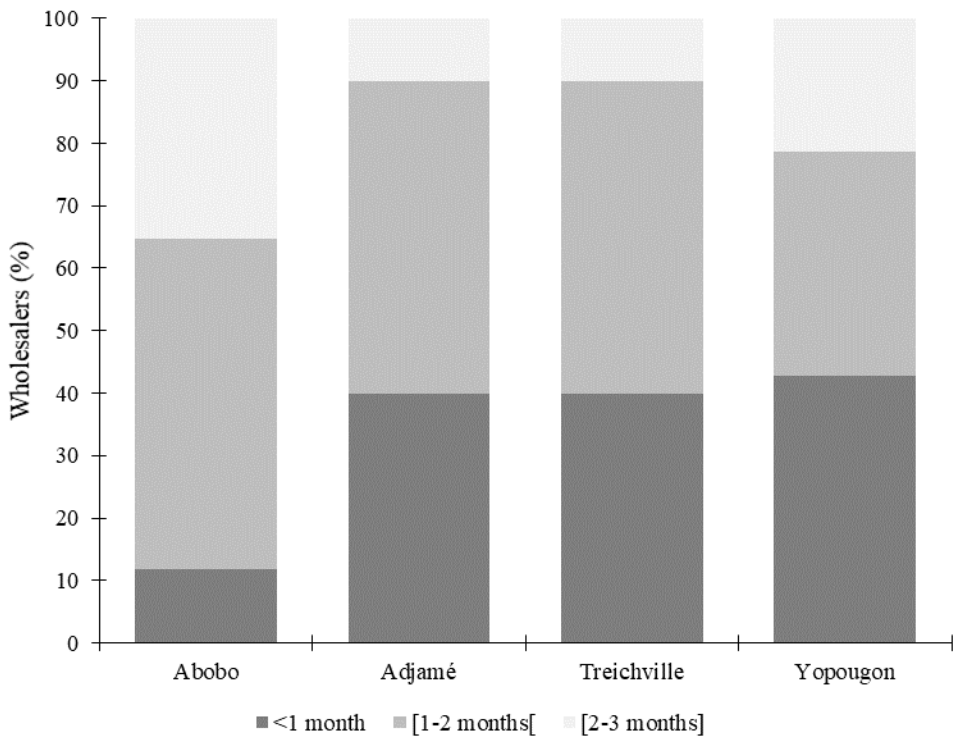
Storage parameters	(%)
Temperature control	94,1
<i>Control by Fans</i>	23,5
<i>Control by Windows</i>	25,5
<i>Control by Fans and Windows</i>	45,1
No temperature control	5,9
Arrangement of yams	100
<i>Arrangement yams on the ground</i>	96
<i>Arrangement on the ground and on the floor</i>	4
Protective measures against damages	1,96
<i>Use of insecticides</i>	1,96



**Figure 2:** Damages (A) and deterioration factors (B) during yam storage in wholesalers.



**Figure 3:** Damages rate according to communes (A) and yam varieties (B).



**Figure 4:** Storage times of 'Kponan' yam during storage.

## DISCUSSION

The purpose of this study was to relate storage practices to damages of 'Kponan' yam variety among wholesalers in Abidjan. During storage, yams are grouped by variety and by age and placed on the ground (96%) or placed on the ground and on the floor (4%). Aware of the harmful effect of the temperature on yams and the poor aeration on the quality of yam, wholesalers (94.1%) regulate the storage temperature either by fans (23.5%), by air openings in the wall (25.5%), or by fans and air openings in the wall (45.1%). However, it appears that these measures are insufficient to ensure good preservation of yams because of damages on yams are always observed in the storage structures. This deterioration could be due to the weak instruction level of wholesalers (37.3% with secondary and superior levels). This hypothesis is

highlighted by Kouakou et al. (2019) where data showed that the major difficulty encountered by uneducated wholesalers in carrying out their activity is the lack of knowledge of how to operate. The storage time for 'Kponan' yams varies between 1 and 3 months in store. This short time depend on consumer purchases frequency (the faster the yams are sold, the shorter the storage time in the store), yam maturity and storage environment (heat, relative humidity and oxygen). According to Kouakou and Anoh (2019), tuber maturity has an influence on storage time. Indeed, an immature tuber yields more easily to be the effects by heat which provokes deterioration. Thus, data reveals that the damage encountered during yams storage is mainly rotting (100%), followed by weight loss (52.9%), mold attack (35.3%) injuries (29.4), cracks (23.5) and sprouting (17.6%).

So, Heat and relative humidity are therefore the main factors of deterioration and contribute to the development of insects, molds and rodents. Kouakou and Anoh (2019) shown that the high nitrogen input significantly reduces the dry matter content of the yam and makes it more vulnerable to the effect of heat, which accelerates its decomposition. These results corroborate those of Mahyao (2008) in which losses in storage are caused by external agents such as insects, rodents, and molds. Other authors Corneille et al. (2012) have shown that dehydration of tubers during storage is responsible for losses that can amount 65 to 85% of the initial mass of the tuber. The storage time of yams is also influenced by several other factors, including effect of climate change (Loko et al., 2013), soil type, harvesting technique, storage temperature and pesticides (Kouakou and Anoh, 2019). According to Kouakou and Anoh (2019), when tubers are injured, they are no longer suitable for storage. A combination of many of these factors could explain the high damage reported by yam wholesalers in this study.

Furthermore, data show that '*Kponan*' which is the most prized yam by consumers is subjected to great damage with 50-80% of yams wholesalers. These results are in perfect agreement with those Girardin and Nindjin (2015) who emphasized that among yams, the varieties of the *Dioscorea cayenensis-rotundata* are more prone to rotting. The high susceptibility of '*Kponan*' to damage could be due to its harvest and post-harvest conditions. Indeed, July month is the beginning of the great abundance of '*Kponan*' yam (Mahyao et al., 2007). This makes July the month when the great abundance of *Kponan* yam begins (Mahyao et al., 2007). These peak harvest periods usually coincide with heavy rains, making it difficult for transporters to access '*Kponan*' yam production sites due to the impassability of roads during these periods. Producers sell their yams to wholesale

collectors in the village. They take their yams out of the fields using tricycles or motorcycles, which cause many injuries and scratches to the skin of the tubers. According to Kouakou (2019), when the roads linking the yam fields to the loading locations are in a very advanced state of degradation, a pre-collection is first made by tricycles or better adapted trucks. This situation provokes injuring which is no longer suitable for yam storage.

### Conclusion

It appears from this study that storage practices are identical in Abidjan. Temperature control in the stores by exposing the windows to the air current and by ventilation are far from mitigating the heat that is the main cause of damage. Decay and weight loss are still encountered during storage at the wholesale level. The contribution of "*Kponan*" yam to food security can only be fulfilled if its availability is ensured by proper storage for a long period.

### COMPETING INTERESTS

The authors declare that they have no competing interests.

### AUTHORS' CONTRIBUTIONS

YHK collected the data, analyze them and write the manuscript, KNK conceptualized, wrote the research protocol contributed to the improvement of the quality of the manuscript, KBK, contributed to the validation of the research protocol, questionnaire and survey guide, data analysis, DMCO contributed to the improvement of the quality of the manuscript with YDN and NGA

### ACKNOWLEDGEMENTS

The authors would like to thank the various officials of the town halls of Abobo, Adjamé and Yopougon for facilitating and putting us in contact with wholesalers. Many



thanks' to the wholesalers for their precious help in the process of collecting data.

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