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Artificial Ripening of Mango (*Manguiféra indica. L*) with Calcium Carbide (CaC2) and Ethephon: Problem of Fruit Safety in the Markets of Abidjan, Côte D'ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Fruit ripening is a natural process that can also be stimulated by various artificial means. In recent years, artificial ripening has become increasingly popular in developing countries. This practice has become questionable due to various health problems associated with the use of its chemicals.

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Aims: The aim of this study was therefore to list the products and techniques used for the artificial ripening of mangoes in Côte d'Ivoire. A cross-sectional survey was carried out in 5 communes of Abidjan on the ripening and marketing of mangoes for local markets in Côte d'Ivoire.
Study Design: Descriptive and analytical cross-sectional study with a single questionnaire passage.
Place and Duration of Study: This study was conducted at the Department of Food Science and Technology, Laboratory of Nutrition and Food Safety, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.
Methodology: This study was carried out to evaluate the different mango trade in Abidjan. The investigation period extended over two months, from April 1 to May 31, 2022, and involved 225 traders, or 45 per municipality. The markets were selected based on the main mango unloading points, with the aim of having two wholesale markets for each municipality. The selection of traders was based on the size of their activity.
Results: The study showed that a large number of mango traders used ripening products. The products used in all markets were calcium carbide "caba" and ethephon "cabadji", of which caba was used by the majority (80%) of traders. For caba, 95% of traders used the incubation technique, while for cabadji, 100% of traders used the sprinkling technique. These practices are carried out with less protection and disinfection. Most of these applicators felt some kind of effect (headache, prolonged cold, dizziness, etc.) after using these products. Consumption of mangoes sold on the national market depends essentially on knowledge of these ripening practices.
Conclusion: The aim of this study was to list the products and techniques used for the ripening in Côte d'Ivoire. The study revealed a variety of products used for mango ripening, the main being calcium carbide (caba) and almephon (cabadji). Caba is used for incubation and Cabadji for spraying.

Keywords: Mangoes; growth accelerator; processing; Côte d'Ivoire.

1. INTRODUCTION

Fruit ripening is a natural process in which fruit undergoes various physiological, biochemical and molecular transformations from the mature green stage to commercial maturity [1]. With the advancement of science and technology, various artificial methods of fruit ripening have been observed, mainly to meet consumer demand and other economic factors [2]. During this process, traders use various chemical agents to accelerate the ripening and ripening of the fruit. However, the use of these chemicals on fruit (mango) remains problematic due to possible toxic effects on consumer health. In Côte d'Ivoire, mango production exceeds 180,000 tons per year [3]. Mango is mainly grown in the north of the country and is the third most important cash crop in the country after cotton and cashew nuts [4]. Once shipped to markets in the south of the country, the fruit is less processed and consumed directly as a dessert. In fact, consumers like them when they are ripe and use the color of the skin to make their choice. In order to satisfy these consumer demands, some retailers use ripened products, even though these products are banned. This maturing practice is increasingly common in developing countries such as Côte d'Ivoire [5]. However, the products and methods used in this practice are not well known to consumers and pose a serious health risk. Furthermore, these growth accelerators have been the subject of several studies and their ability to cause probable effects (carcinogenic, genotoxic, hepatotoxic) on the health of consumers and traders has been demonstrated worldwide [6,7,8]. In view of this situation, it is essential to shed full light on the use of these products and the various methods used to accelerate the ripening of mangoes sold on the Abidjan markets. This work aimed at listing the products and techniques used to accelerate mango ripening in Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1 Area to Study

This study was carried out in 5 communities (ABOBO, ADJAME, YOPOUGON, PLATEAU, COCODY) in the city of Abidjan (Côte d'Ivoire). These different areas are shown on the map below (Fig. 1).

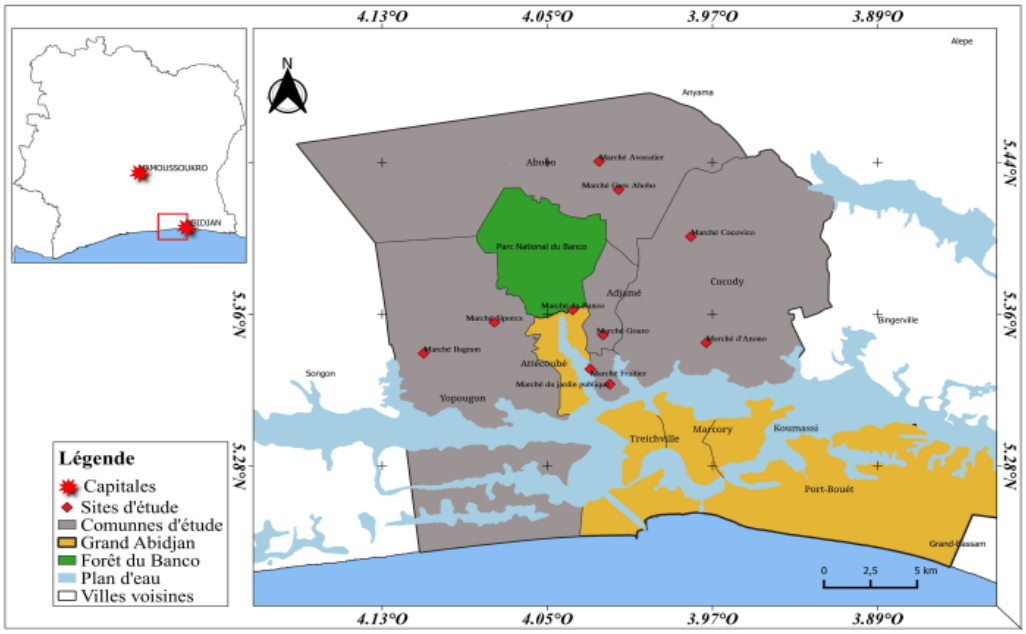

Fig.1. Presenting the different markets surveyed according to municipality type and size of the study

2.2 Study type and Size

This study was a cross-sectional descriptive and analytical survey with a single questionnaire that lasted two months: from 1 April to 31 May 2022. The survey involved 225 traders, 45 from each municipality.

2.3 Criteria for Selecting the Study Population

The markets were selected based on the main mango unloading areas (Marketplace) in the city of Abidjan. In each commune, two (2) wholesale markets were targeted according to the importance of mango trading activities in these areas. Traders were selected based on the size of their business (as wholesalers).

2.4 Data Collection Tool

The data collection tool was a questionnaire addressed to local mango sellers in the 5 different target municipalities of Abidjan. The questionnaire covered a number of key points such as: socio-demographic profile, product identification, ripening technique used, health aspects related to the use of ripening products and some environmental aspects related to the use of growth accelerators. Tables should be explanatory enough to be understandable without any text reference. Double spacing should be maintained throughout the table, including table headings and footnotes. Table headings should be placed above the table. Footnotes should be placed below the table with superscript lowercase letters.

Table 1. Number of respondents per walk, by municipality

Municipality	Different Markets	Number Surveyed
Abobo	Main Station Abobo	23
	New Abobo station	22
Adjamé	Gouro Marketplace	24
	Banco Marketplace	21
Yopougon	Siporex Marketplace	20
	Gesco Marketplace	25
Plateau	Fruit Marketplace	26
	Public garden	19
Cocody	Cocovico Marketplace	23
	Anono Marketplace	25
Total workforce	10 Marketplace	225

2.5 Statistical Analysis of Data

The data was analyzed using descriptive statistics. The average number of terms per market and per municipality was determined and their frequencies were calculated to assess the extent of their distribution. The Pearson Chi-square test was used to assess variability.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Sociodemographic profile and sales experience of the people surveyed

able 2 shows the sociodemographic characteristics of the traders interviewed in the different marketplace. The majority (97.6%) of the traders interviewed were women, many of them (53.9%) were in the age group between 31 and 50 years old. Furthermore, a high proportion (71.9%) of women traders in all markets surveyed were illiterate.

3.1.2 Use of growth-enhancing products for the ripening process

Fig. 2. shows the use of ripening agents in the Abobo, Adjamé, Yopougon, Cocody and Plateaux markets. The results showed that in all the markets surveyed, the majority of traders used fruit ripening accelerators to ripen mangoes.

Table 2: Socio-demographic profile of market traders surveyed

Characteristics of those surveyed	Abobo (%)	Adjamé (%)	Yopougon (%)	Cocody (%)	Plateau (%)	Total (%)
Gender						
Masculine	00	12	00	00	00	2.4
Feminin	100	88	100	100	100	97.6
Age range						
18-30 Answers	37	16.00	33.3	16.7	36.4	27.86
31- 50 Answers	51.8	64	40	50	63.6	53.9
51- 65 Answers	11.2	20	26.7	33.3	00	18.24
66- Additional	00	00	00	00	00	00
Level of teaching						
Non-scholarly	74.1	80	67	66	72.7	71.96
Primary	3.7	16	20	9	9.1	11.56
Secondary	18.5	4	13	25.0	18.2	15.74
University	3,7	00	00	00	00	0.74

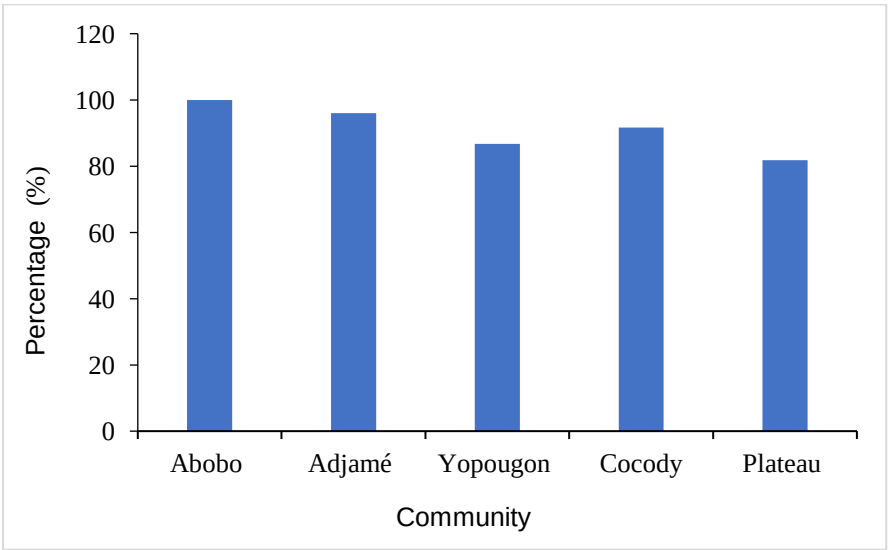

Fig. 2. Percentage use of ripening products

3.1.3 Identification of growth accelerators for ripening

Fig.3. shows the products used to accelerate fruit ripening in the surveyed Marketplace. The results showed that the products used were different in all markets (*P*= .05). Most traders (70%) used calcium carbide (Fig. 3), commonly known as "caba" (Fig. 4). The remaining minority (30%) used the ethephon (Fig. 5), commonly known as "cabadji".

3.1.4 Identification of growth accelerators for ripening

Table 3 provides a broad evaluation of the ripening outcomes. The data indicates that most growers (72.2%) opt for these products due to their efficacy, and 74.38% of users are content with the fruit's ripening results (color, flavor, ripening duration). In terms of cost to buy and usage chemical products patterns, it is worth mentioning that Cocody represented 27% of the respondents, and 11% of product users based on their routines hailed from the Abobo district.

3.1.5 Ripening techniques for mangoes in the Marketplace under reviewμ

The ripening techniques used and the quantities of products used are shown in Fig.6. and 7. The majority of the respondents used two techniques (wrapping or brooding and spraying). The wrapping or brooding method was used with calcium carbide, while ethephon was used by spraying. In Adjamé, Yopougon, and Cocody, the majority (80%) of people used ½ kg of calcium carbide to ripen 2 cartons, except in Abobo and Plateau where the majority (73%) used 1 kg to ripen 3 cartons of mangoes. In terms of liquid products, traders in Adjamé and Yopougon used 250 ml of dilute ethephon solution to ripen 2 cartons, while traders in Abobo, Plateau and Cocody used 100 ml of dilute solution to ripen 2 cartons.

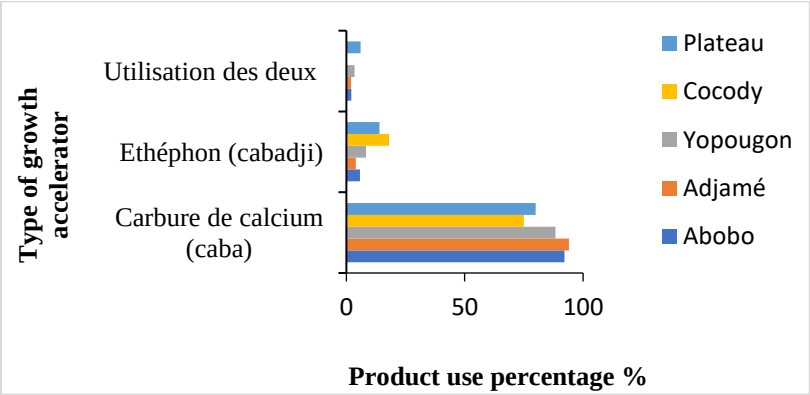

Fig.3. Type of product used for ripening Merchants' assessment of ripening results

Fig. 4. Calcium carbide

Fig. 5. Ethephon-based products

Table 3. Identification and selection characteristics of ripening products used

Product characteristics	Abobo (%)	Adjamé (%)	Yopougon (%)	Cocody (%)	Plateau (%)	Total	Chi-square	*P*
Product selection								
Efficiency	70.4	72	80	75	63.7	72.2		
Prize	18.5	24.00	20	16.7	27.3	21.3		
Habitus	11.1	4	00	8.3	9.1	6.5	9.802	**.63**
Effectiveness of the product								
Satisfaction	81.5	76	66.7	75	72.7	74.38		
Not very satisfied	18.5	16	26.7	8.3	9.1	15.72		
Dissatisfaction	00	8	6.7	16.7	18.2	9.90	7.011	**.53**
Curing time								
1 Day	6.7	6	7	6.6	19.6	9.18		
2 Day	60.0	78	59.7	76.7	62.2	67.32	13.65	**.32**
3 Day	33.3	16	33.3	16.7	18.2	23.5		

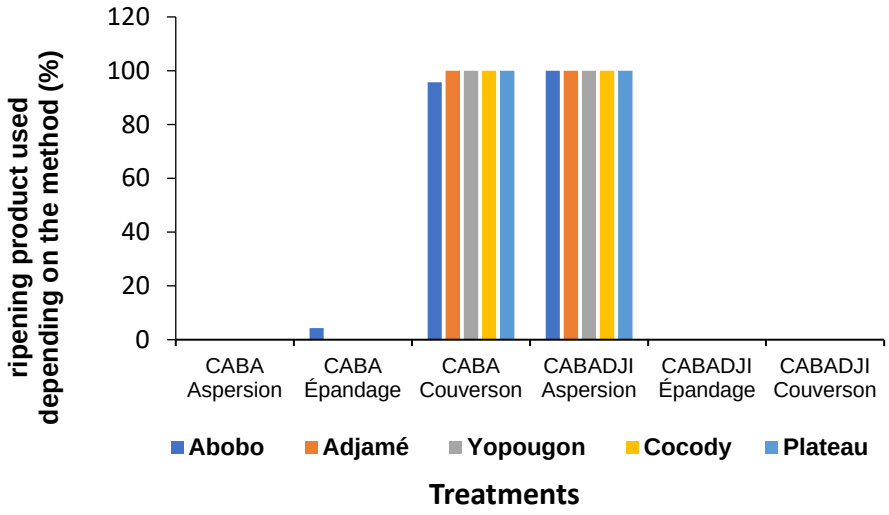

Fig.6. Techniques used to process mangoes

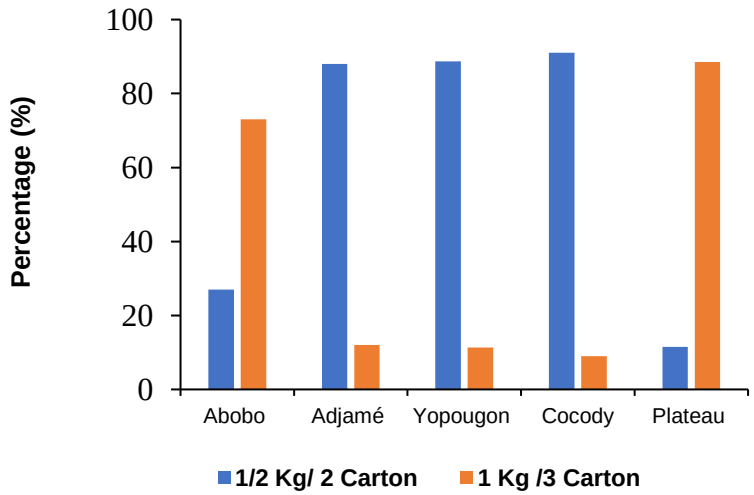

Fig.7. Quantity of products per proportion of mango

3.1.6 Mango ripening conditions at Abidjan markets

The results of the ripening conditions are depicted in Table 4. The majority (87.7%) of operators applied the products themselves. Moreover, most of them didn't consider the time of day or the weather when applying the products. All participants in this study (100%) applied the products outdoors and did not consider any disinfection measures prior to sale.

3.1.7 Risk of exposure of retailers to residues of ripening products

In the Fig. (8, 9, 11), we see the dangers faced by traders while ripening mangoes. Most traders (74.38%) do not guard themselves against the risk, while even for those who do, merely using a glove is not enough. More worrying is that personal hygiene remains a neglected concern even when up to 65.98% of traders handle harmful chemicals. An overwhelming 71.34% of product users report having experienced an impact, be it feeling dizzy or experiencing skin rashes. The main visible trends are breathing difficulties (42.76%), headaches (24.66%), and skin irritation (10.16%).

3.1.8 Risk of consumer exposure to artificially ripened mangoes

In Fig. 11, data reveal that accelerating mango ripening increases the risk of consumer exposure. Chi-square testing confirmed that the identical risks apply to all communes.

Table 4. Conditions for ripening process

Technique used	Abobo (%)	Adjamé (%)	Yopougon (%)	Cocody (%)	Plateau (%)	Total (%)	Chi-square	*P*
How to apply								
Professional	00	00	00	00	00	00		
Yourself	96.3	88	80	83.4	90.9	87.7	16.27	.25
Colleagues	3.7	12	20	16.7	9.1	12.3		
Period to apply								
Morning	7.4	8.00	26.7	25	9.1	15.24		
Middle	7.4	20	20.0	8.3	18.2	14.78		
Evening	7.4	4	00	00	00	2.28	18.03	.32
Any time of day	77.8	68	53.3	66.7	72.7	67.7		
Area of treatment								
In the open air	100	100	100	100	100	100		
Aging room	00	00	00	00	00	00	4.704	.42
Sanitation Fruit								
Disinfecting to sell	00	00	00	00	00	00		
No sanitation	100	100	100	100	100	100	8.155	.42

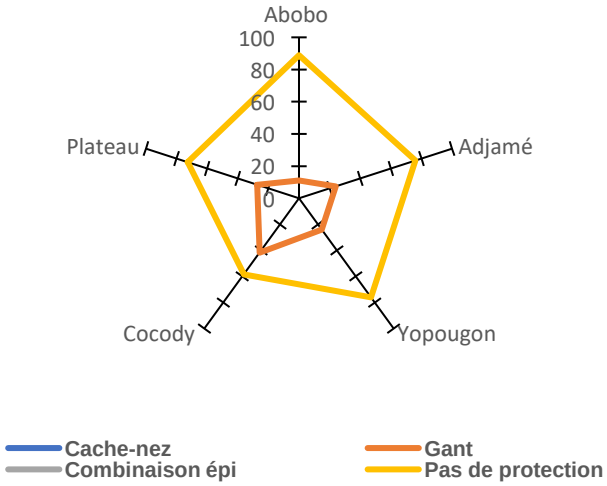

Fig. 8. Protection tools (%)

Every trader surveyed, 100% in total, failed to take any precautions to sanitize fruits prior to sale. Furthermore, all traders (100%) neglected to implement a safety waiting period after treatment before fruit can be sold.

3.1.9 Environmental exposure and degradation associated with accelerated mango ripening

In Table 5, we can see the details about how the environment affects the ripening of mangoes. The survey results indicate that 81.08% of people surveyed had no clear plan for handling chemical treatment residues. A significant 71.6% of traders disposed of these residues directly on market premises without attempting to safeguard the area from environmental

3.2 Discussion

The research conducted in various markets identified two ripening agents utilized to hasten the ripening of mangoes. Traders commonly employ calcium carbide and ethephon, known as caba and cabadji. Calcium carbide, with the chemical formula CaC2, is a byproduct of metallurgy that generates acetylene, an analogue of ethylene, upon contact with water. Conversely, ethephon is a chemical widely employed in agriculture as a plant growth regulator, breaking down into ethylene, the active compound regulating plant growth. Ethephon, with the chemical formula C2H6ClO3P, exists as a solid at room temperature, possessing a molar mass of 144.494 g/mol. In aqueous solutions with a pH above 4, it decomposes into ethylene, phosphate, and chloride ions. In Ivory Coast, it is utilized in liquid form, primarily to expedite growth and enhance the coloring of numerous fruits and vegetables, such as imparting a yellow or orange hue to pineapples during processing.

Calcium carbide (cac2) is used to artificially ripen fruit, although this practice is controversial due to potential risks to human health such as toxicity and arsenic contamination. it reacts with water to produce acetylene, which speeds up the ripening process, but is banned in some countries due to health concerns associated with its use in food [9, 10]. When used in food, it breaks down into ethylene, a plant growth hormone. However, its use must adhere to strict rules, as it is not authorized for all types of fruit. There have been suspicions of fraudulent use of this substance on plantains in some countries [11, 12]. The use of these products in fruit ripening is not limited to Côte d'Ivoire, even though they are not registered. Other similar studies have reported the use of these products in Burkina Faso, Ghana, Cameroon, Nigeria, India, Bangladesh and Pakistan [13-17].

Their use is thought to be related to their low cost on the market compared to registered products. Traders use two (2) main methods: the wrapping or brooding technique and spraying. The technique used depended on the nature of the product. Caba is solid and cabadji liquid. Caba is used for incubation and cabadji is used for spraying. The weighed calcium carbide is wrapped in paper and packed in a container with the fruit. The calcium carbide at the bottom of the container comes into contact with the moisture in the ambient air and decomposes, producing acetylene, a gas similar to ethylene, which triggers the fruit ripening process [13,18,19].

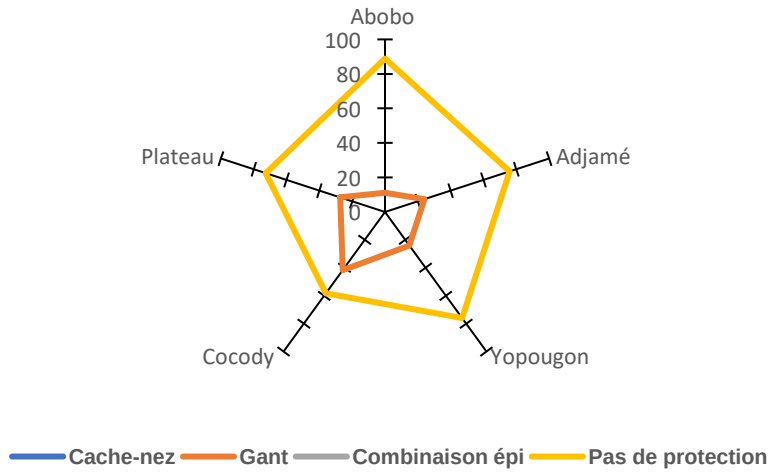

Fig. 9. Personal cleanliness following product usage (%)

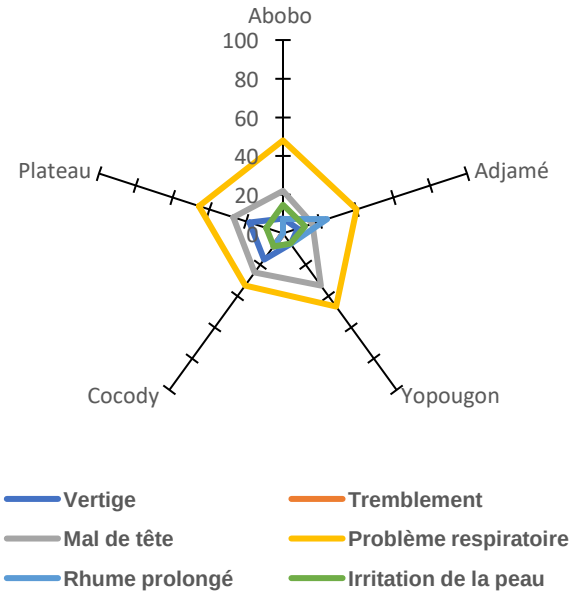

Fig. 10. Effects felt after treatment (%)

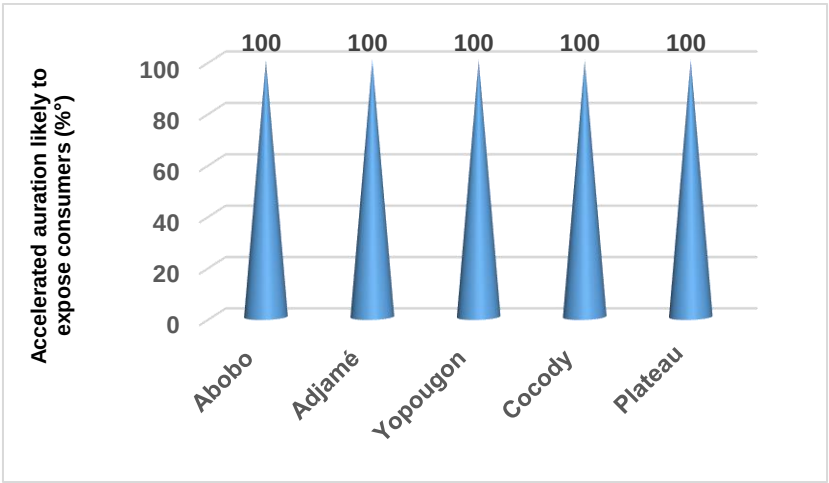

Fig. 11. Health risk of consumer exposure

Table 5 Risk of environmental degradation linked to the use of mango ripening products

Technique used	Abobo (%)	Adjamé (%)	Yopougon (%)	Cocody (%)	Plateau (%)	Total	Chi-square	*P*
Residue handling								
Yes	17	12	19.7	24.3	21.6	18.92		
No	83	88	80.3	75.7	78.4	81.08	3.030	**.553**
Getting started								
Packing	17.2	11.9	20	24.7	22	19.16		
No dragging	82.8	88.1	80	75.3	78	80.84	3.908	**.42**
Waste disposal								
Inside the market	74.7	78	70.7	66	68.6	71.6		
In a waste bin	00	0.0	9.6	18.3	15	8.58		
Getting closer to the market	25.3	22.0	19.7	15.7	16.4	19.82	10.135	**.60**

Fig. 12. Carbide (CaC2) crushing sites in the banco Marketplace

Fig. 13. Pouring of calcium carbide on the ground in contact with water at the Abobo Marketplace

Fig. 14. Open-air market rubbish bin at the Anono Marketplace

Fig. 15. Carbide (CaC2) paid into the Siporex Marketplace

They can cause cancer, metabolic disorders, stomach ulcers, and certain mental disorders. Most shopkeepers are illiterate and unaware of the health risks. They apply their products in the open without any protective measures. These products can expose not only the applicator but also consumers and local residents. Some of the compounds in these products are nonvolatile and are likely to end up in [20,24,25,26,27]. This is the case for arsenic and ethephon residues, which have been reported on both the peel and pulp of treated bananas.

In addition to the above, the marketing of artificially ripened mangoes is causing a real environmental problem. The results showed that 82% of respondents did not have a residue management plan in place following the use of these growth accelerators. These products could therefore end up in the air and water, exposing the population even more and seriously damaging all the components of the environment. Studies carried out in Mali (Koutiala) and Côte d'Ivoire (Grand-Lahou, Yamoussoukro, Abidjan) have revealed the pollution of well water by pesticides (malathion, deltamethrin) in agricultural areas [28].

4. CONCLUSION

The aim of this study was to list the products and techniques used for the ripening in Côte d'Ivoire. The study revealed a variety of products used for mango ripening, the main being calcium carbide (caba) and almephon (cabadji). Caba is used for incubation and Cabadji for spraying.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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