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Research Article

Fruit Susceptibility of African Plum (*Dacryodes edulis* [G. Don] H. J. Lam) to Post-Harvest Fungi and Response of Some Pathogenic Fungi to Different Phytoextracts

Joseph Fovo Djeugap[1], Joachim Manfo Kuenbou[1], Arlette Meli Sonkoue[2], Alain Heu [3,4], Aime Magloire Tenkap Njopkou[1], Merveille Ebongo Assougouma[1] and Joliesse Koagne Nouteka[1]

[1]*Phytopathology and Agricultural Zoology Research Unit, Department of Crop Sciences, Faculty of Agronomy and Agricultural Sciences (P.O. Box 222 Dschang), University of Dschang, Cameroon*

[2]*Applied organic chemistry Research Unit, Department of Chemistry, Faculty of Science, University of Dschang, Box 67, Dschang, Cameroon*

[3]*Phytopathology and Plant Protection Research Unit, Department of Plant Biology, University of Yaoundé 1, Box 812, Yaoundé, Cameroon*

[4]*Department of Agriculture and Agropastoral, Higher technical Training College, University of Ebolowa*

Abstract

Edible fruits of African plum (called *safou*) are very perishable because of their susceptibility to unknown post-harvest fungi with the aim of contributing to the management of…., eight varieties of *safou* (base on the pulp color) were collected in the fields and markets and associated fungi were isolated and, identified using morphological approaches. Then, the bioactivity of aqueous and ethanolic extracts of three medicinal plants was evaluated against four pathogenic fungi selected after the pathogenicity test. The main post-harvest and aggressive fungi isolated on infected African plum fruits were: *Fusarium oxysporum* (occurrence=16.93%) *Colletotrichum gloeosporioides* (13.71%), *Pestalotiopsis microspora* (16.2%) and *Cercospora* sp. (15.32%). The fruits with whitish, yellowish and pinkish pulps were more susceptible to post-harvest pathogenic fungi while fruit pulps with green phenotype (light, dark and reddish green) were less susceptible. The bioactivity of aqueous extracts of *C. ambrosioides* and *C. longa* was similar to Mancozeb at 100 mg/mL against *Cercospora* sp. and they totally inhibited the growth of the pathogen. The effect of the ethanolic extract of *C. ambrosioides* at 100 mg/mL and *C. longa* at 25 mg/mL, 50 mg/mL and 100 mg/mL was fungicidal (killed the fungus) to all the four pathogenic fungi. This study highlights for the first time that aqueous and ethanolic extracts of *C. ambrosioides* and *C. longa* are potentials natural products that may be used to formulate a bio product for the management of post-harvest diseases of African plum.

Keywords: *Botanical fungicide, Curcuma longa, Dacryodes edulis L., Fruit susceptibility, Post-harvest fungi.*

Introduction

The increase in the global population is putting significant pressure on agriculture and this situation requires farmers to use healthy, high-yielding and sustainable planting materials (Anonymous, 2015). In Cameroon, post-harvest diseases are a main constraint for fruits and vegetables production (Kouame, *et al*., 2013). Post-harvest losses of fruits contribute significantly to food insecurity and consumption of infected products affect the nutritional status and health of populations due to the qualitative and quantitative reduction of nutrients and presence of bioactive phytochemical compounds like toxins (Atanda, *et al*., 2011; Ibrahim, *et al*., 2016). In

***Corresponding Author:**
Joseph Fovo Djeugap;

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fact, low consumption of fruits is associated with an increased risk of chronic health disorders, such as cardiovascular diseases, hypertension, hypercholesterolemia, osteoporosis, many cancers, chronic obstructive pulmonary diseases, and respiratory and mental health problems (De Olliveira, *et al*., 2018). The species *Dacryodes edulis* (G. Don) H.J. Lam) is tropical oleaginous forest species of the Burseraceae family; the fruit produced by the tree is an edible non-timber forest product (ENTPF) commonly called *safou* with a high trade value (Kengue, 2002). In Cameroon, the exploitation of non-timber forest products (NTFPs) generates 64.12 billion FCFA per year and contributes to an addition of 0.55% of the gross domestic product (CIFOR, 2015). The fruits are very fragile and perishable when fresh. *Safou* is a major economic activity that was estimated at 5 billion CFA francs in 1997 (Isseri, *et al*., 2002), and is used for both local and sub-regional and international markets. Based on the high economic value of the fruits and the growing demand in local and sub-regional markets, there is an increase in the number of plantations of *D. edulis* across the rainforest agroecological zones of the country. Despite the economic importance of *safou*, its production is handicapped by the highly perishable nature of the pulp, which reduces the conservation time, resulting in high post-harvest losses estimated at 50% of the production in Cameroon and Congo Brazzaville (Silou, 1991; Kengue, 2002). In the field and in the markets, the macroscopic observations of *safou* show that many unknown microorganisms infect the fruits after harvest. Based on these macroscopic observations, fungi seem to be the most popular. The development of these microbes may be favored by many factors such as the poor monitoring conditions of diseases in the field, unsuitable tools and techniques for harvesting and poor conditions during conservation of fruits.

In Cameroon, there is no chemical which is homologated to control diseases of *D. edulis* both in the field and during fruit conservation. The fruits are therefore produced and sold without chemicals (biological production), nor by using other control measures. This situation also favors disease sprayed in the field and during post-harvest. Moreover, pesticides application in Cameroon on the fruits after harvest could be harmful for consumer's health (Galani, *et al*., 2020; 2021). It is in this context that the use of natural products of plant origin was investigated in this study against post-harvest fungi in *safou* fruits with the aim of reducing post-harvest losses. Indeed, previous studies demonstrate the efficiency of *Chenopodium ambrosioides* and *Curcuma longa* extracts on plant diseases management of different crops (Jardin, *et al*., 2010; Chen, *et al*., 2018). In this study, susceptibility of eight different fruit varieties (based on the pulp color) to post-harvest pathogenic fungi and biological activity of some plant extracts against these pathogens was investigated. This disease control approach, if it proves effective, would allow farmers to safely protect their orchards and fruits against fungal diseases rather than used chemical which are sometimes known to be toxic to the environment and harmful to consumers (Moosavy, *et al*., 2008; Galani, *et al*., 2021).

Material and Methods

Collection of Samples, Isolation and Identification of Fungi

Infected fruits were collected in the markets and in the fields of some main production zones of *safou* in the country (Nkolmetou, Makenene and Melong) from July to August 2021.

Infected samples were washed with running tap water and disinfected with 1% sodium hypochlorite for 3 min and rinsed for 5, 10 and 15 min respectively with sterile distilled water to remove traces of disinfectant. The fragments (about 2 mm diameter) were collected from the infected tissues and deposited in the Petri dishes containing sterilized potato dextrose agar medium and incubated as recommended by Djeugap, *et al*. (2017). Then the fungi developed on the culture medium were isolated, purified and codified to ease the determination of the

occurrence of the fungi. The isolation frequency (IF) or occurrence of each fungus isolated was calculated according to Iqbal and Saeed (2012) formula. IF = (NS/TN) x 100, where: NS is the number of samples from which a specific fungus was isolated and TN is the total number of samples considered. After purification, the fungi were identified with identification books of fungi based on their morphological characteristics as observed under microscope (Barnett and Hunter, 1972; Dugan and Matthewes, 2006).

Assessment of the Varietal Susceptibility of D. edulis Fruits to Post-Harvest Diseases

The susceptibility of the fruits was evaluated under Lab conditions. The pathogenicity test was previously carried out by inoculating pure identified fungal species on healthy fruits collected in farmer's plantation followed Djeugap, *et al*. (2018) protocol. After the pathogenicity test, only the pathogenic fungi were inoculated separately on eight healthy fruits varieties after their disinfection (1% sodium hypochlorite solution for 5 min). These fruits were selected on the basis of their pulp color (whitish, dark-green, light-green, reddish-green, pinkish, yellowish, turquoise and purplish) (Fig. 1). These fruits were physiologically mature and do not having undergone any post-harvest treatment. Five replicates were considered per variety. A cylindrical orifice 5 mm in diameter and 0.5 cm deep was created in the middle of the fruit with a flamed cutter. Mycelia disks were obtained using a cookie cutter of 5 mm diameter and taken from the margin of 10 days-old fungal culture. Mycelia disks were deposited into each orifice and then covered with hygrophilic cotton soaked in sterile distilled water to maintain moisture. Each inoculated fruit was placed in a sterile transparent polyethylene bag and incubated at 21 ± 1°C for 5 days (Yaouba, *et al*., 2017; Djeugap, *et al*., 2018). The diameter of the lesion (DL) was measured with a flexible transparent and graduated ruler along the two perpendicular axes of the fruit (Shuman, 2001). DL (mm) = (Length of lesion + width of lesion) /2.

Preparation of Plant Extracts

The aerial organs of *Chenopodium ambrosioides* and *Panax ginseng*, the rhizomes of *Curcuma longa*, and the avocado pit (*Persea americana*) harvested in Bangangte locality were dried separately in the shade (rhizomes and avocado pit were previously cut into thin strips of about 5 mm diameter) for 14 days and then these organs were crushed separately and for each of them, 150 g of powder were introduced into a jar with a capacity of 2 liters containing 1 liter of solvent (95° ethanol or distilled water). After 48 hours of maceration, the mixture was filtered with Whatman No. 1 paper. The filtrates obtained were dried in the oven at a temperature of 40 °C during 5 days to obtained crude extracts (Keuete, *et al*., 2015).

Antifungal activity of the Plant Extracts against the Post-Harvest Pathogenic Fungi

The method used for the evaluation of the effect of plant extract concentrations on mycelial growth was the poisoned food technique (Fandohan, *et al*., 2004). In fact, the potato dextrose agar (PDA) medium was poured into 100 mL erlenmeyers, autoclaved at 121°C for 20 minutes and kept under sterilized hood to cool up to 50°C. Then the exact amounts of pure extracts were added to erlenmeyers and shacked gently to prepare a poisoned PDA milieu corresponding to the following concentrations: 25, 50, and 100 mg/mL. Two drops of Dimethyl Sulfoxide were added to the mixture to facilitate the dissolution of the extract. After homogenization, the medium was poured into 90 mm diameter Petri dishes. Sterile distilled water and Mancozeb were used as negative and positive controls, respectively. After solidification of the medium, a 5 mm plugs mycelia of a 7-day-old pure culture of each pathogenic fungus were kept aseptically in the center of plates (Umana, *et al*., 2016). Three plates were kept for each treatment. These dishes were then sealed with para-film and incubated at 25 ± 2 °C for 7 days. The toxicity was assessed by observing whether the total inhibition of the mycelial growth was followed by a fungicidal or fungistatic effect of the extract. So, the mycelial explants which growth was totally inhibited with plant

extract were removed and plated on a fresh PDA medium without extract. After 7 days of incubation (DAI), the activity of the extract was considered fungistatic if there was regrowth of the fungal species and fungicidal otherwise (Djeugap, *et al*., 2011).

Data Collection

Data collected were the mycelial growth, the inhibition percentage and the nature of the toxicity of the plant extract. The growth (G) of the pathogen was assessed by measuring the growth diameter every day from two orthogonal diameters drawn on the reverse side (bottom) of the Petri dishes and intersecting at the explant deposition point (Singh, *et al*., 2009). G = (d1+d2) /2 - d0, where d1 and d2 are the diameter of the mycelium measured in the two perpendicular directions, and d0 is the initial diameter of the mycelia plugs (5 mm). The inhibition percentage (IP) was deduced from the data obtained on the measurement of the mycelial growth. So, the following formula was used: IP= [(DC- DE) / DE] 100. DC is the growth diameter of the pathogen in the negative control Petri dish and DE is the growth diameter in the Petri dish supplemented with plant extract or Mancozeb.

Data Analysis

Data collected on the occurrence of fungi, the radial growth, the diameter of lesion and the inhibition percentage were subjected to analysis of variance (ANOVA) via the Agricolae package of R software version 3.5.1. As recommended, data in percentage were submitted to the arcsine squared root transformation prior to ANOVA. The Kruskal-Wallis multiple separation tests were used to separate means at the 5% probability level.

Results

Post-Harvest Fungi Associated with D. edulis Fruits, Pathogenicity and Varietal Susceptibility

Ten fungal species were identified on infected fruits of *D. edulis* among which there were many well-known plant pathogens like *Colletotrichum gloeosporioides, Alternaria alternata*, and *Fusarium verticilloides* (Fig. 2). The most frequent fungi were: *F. oxysporum* (16.93%), *P. microspora* (16.2%) and *Cercospora* sp. (15.32%) and *C. gloeosporioides* (13.71%) (Table 1).

All the isolated fungi caused infection on healthy fruits after manual inoculation. However, the level of aggressiveness vary from one variety to another. Indeed, *C. gloeosporioides* and *F. oxysporum* were the more aggressive species followed by *P. microspora* and *Cercospora* sp. (Table 1). All the eight *safou* varieties were susceptible to fungal inoculation. A dense mycelium bearing spores is visible on the most susceptible fruits after inoculation (Fig. 3).

The fruits with yellowish pulp were more susceptible (high diameter of lesion) to infection followed by whitish and pinkish pulp after inoculation with *F. oxysporum*, *Cercopora* sp, *C. gloeosporioides* and *P. microspora*. In fact, the diameter of lesions developed on yellowish, whitish and pinkish pulp were respectively 74.16 mm, 72.4 mm and 60.68 mm with *F. oxysporum*, 74.83 mm, 70.5 mm, 62.3 mm with *Cercospora* sp and 74.16 mm, 70.1 mm and 67.5 mm with *C. gloeosporioides*, 5 day after inoculation (DAI) (Table 2). The fruits with light green, dark green and reddish green pulps were less susceptible to post-harvest fungi. The diameter of lesions on light green, dark green and reddish green pulps were respectively 69.19 mm, 65.5 mm and 54.16 mm with *F. oxysporum,* 59.8 mm, 60.83 mm and 57.2 mm with *Cercospora* sp and 31.3 mm, 51.6 mm and 27.5 mm with *C. gloeosporioides,* 5 DAI. The aggressiveness of these three pathogens was significantly vary (p<0.05) from one fruit variety tested to another (Table 2).

Effect of Extracts of Panax ginseng, Chenopodium ambrosioides, Persea Americana and Curcuma longa on Post-Harvest fungi of safou

Globally, the ethanolic extracts were more effective than the aqueous extracts irrespective to the plant species. The growth inhibition of the fungi increase with the concentration of both the aqueous and ethanolic extracts. The growth inhibition of all

the plant extracts was significantly higher compared to the negative control (water). The positive control (Mancozeb) totally inhibited the growth of all the four post-harvest fungi at the recommended concentration. The effect of the aqueous extracts of *P. ginseng* and *P. americana* in all the concentration tested was not significantly comparable to the effect of Mancozeb (Table 3). However, at 100 mg/mL, the growth inhibition of the aqueous extract of *P. ginseng* was high against *C. gloeosporioides* (87.55%) and *P. microspora* (85.21%). The aqueous extract of *C. ambrosioides* totally inhibited the growth of *Cercospora* sp at 100 mg/mL. Also, the effect of the aqueous extract of *C. longa* was significantly (p<0.05) comparable to Mancozeb against *Cercospora* sp., *C. gloeosporioides* and *P. microspora* at 100 mg/mL.

Apart of the ethanolic extract of powder of the avocado pits which don't totally inhibited the growth of the fungi at the concentration tested, the remaining plant ethanolic extracts have totally inhibited (100%) the growth of some fungi at certain concentrations. In fact, the ethanolic extract of P. ginseng totally inhibited the growth of *Cercospora* sp. and *C. gloeosporioides* at 100 mg/mL while the ethanolic extract of *C. ambrosioides* totally inhibited the growth of *Cercospora* sp at 50 mg/mL and of all the four post-harvest fungi at 100 mg/mL (Table 4). The effect of the ethanolic extract of *C. longa* was significantly comparable (total inhibition) to Mancozeb against all the post-harvest fungi at all the concentrations tested (25, 50 and 100 mg/mL).

Toxicity of Plant Extracts against Post-Harvest Fungi of D. edulis Fruits

The aqueous extracts of *C. ambrosioides* and *C. longa* were fungistatic at 100 mg/mL against *Cercospora* sp. and *P. microspora* respectively. The aqueous extract of *C. longa* showed a fungicidal effect against *Cercospora* sp., *C. gloeosporioides* and *P. microspora* at 100 mg/mL. The ethanolic extract of *P. ginseng* was fungistatic against *C. gloeosporioides* and fungicidal against *Cercospora* sp. at 100 mg/mL. The ethanolic extracts of *C. ambrosioides* and *C. longa* were fungicidal for all the four pathogenic fungi at 100 mg/mL and from 25 to 100 mg/mL, respectively (Table 5). Obviously, Mancozeb was fungicidal against all the pathogens.

Table 1: Isolation frequency/occurrence (%) and aggressiveness of fungal species

Fungi	Number of observation	Occurrence (%)	Pathogenicity*
Colletotrichum gloeosporioides	17	13.71	+++
Alternaria alternata	5	4.03	+
Pestalotiopsis microspora	20	16.20	++
Aspergillus niger	8	6.45	+
Cercospora sp.	19	15.32	++
Penicillium digitatum	13	10.48	+
Geotrichum sp.	9	7.25	+
Fusarium verticilloides	5	4.03	+
Fusarium oxysporum	21	16.93	+++
Rhizopus nigricans	7	5.64	+

*Pathogenicity level: +++ = More aggressive, ++ = Aggressive, + = Less aggressive, - = Non-pathogenic.

Table 2: Diameter of the lesions (mm) of post-harvest fungi on different varieties of *D. edulis* fruits, 5 DAI

Pathogen	Whitish	Yellowish	Pinkish	Turquoise	Purplish	Light green	Dark green	Reddish green
A. alternata	23.1±1.3f	43.50±1.80c	30.12±0.7f	28.8±1.5d	49.8±1.6b	44.3±0.7def	21.6±2.2e	19.6±3.2e
A. niger	47.5±1.7d	49.16±3.61c	56.2±4.1de	25.5±0.4d	50.7±0.3b	46.50±2.4de	18.30±3.8e	12.16±2.2f
Cercospora sp	70.5±1.8a	74.83±0.57a	62.3±0.86b	62.7±0.2a	61.3±1.1a	59.8±1.52b	60.83±1.6ab	57.2±3.16a
C. gloeosporioides	70.1±2.5a	74.16±1.89a	67.5±0.82a	56.2±5.6ab	59.2±9.4a	31.3±10.7g	51.6±3.3abc	27.5±1.5d
Geotrichum sp	49.5±1.3d	58.33±1.75b	55.66±5.3e	33.83±8.83d	37.7±2.5c	55.83±1.4bc	49.33±7.25bc	33.6±2.78c
F. verticilloides	47.5±0.2d	55.66±6.82b	58.2±0.9bcde	33.51±0.76d	41.83±2.5c	42.3±2.29ef	32.8±1.32de	45.26±2.5b
F. oxysporum	72.4±0.11a	74.16±3.05a	60.66±0.76bc	50.83±5.1bc	61.3±2.51a	69.19±0.28a	65.50±3.46a	54.16±3.25a
P. digitatum	57.8±1.1c	56.83±3.17b	55.33±3.17e	28.50±1.4d	56.1±5.3ab	51.16±7.9cd	39.80±4.8d	22.83±1.52de
P. microspora	68.2±1.1b	75.8±0.50a	60.4±0.5bcd	43.3±2.7c	63.2±4.51a	38.5±1.5fg	23.1±1.7e	25.2±1.5de
R. nigricans	40.16±4.1e	56.83±6.25b	57.5±1.32cde	44.12±6.25c	57.1±2.8ab	55.16±2.3bc	57.66±2.02ab	45.16±5.25b

*Means followed by the same letter in the column are not significantly different according to Kruskall-Wallis test at 5%. DAI = days after inoculation.

Table 3: Effect of plant aqueous extract on growth inhibition (%) of the pathogens

Concentration (mg/mL)	*Cercospora* sp.	*C. gloeosporioides*	*F. oxysporum*	*P. microspora*
	Panax ginseng			
Control	0a	0a	0a	0a
25	34.81±0.32b	70.92±0.31b	49.63±0.64b	70.18±0.64b
50	51.11±2.43c	73.51±2.10c	54.62±3.25c	76.85±0.84c
100	60.55±0.55d	87.55±0.55d	72.96±0.31d	85.21±0.56d
Mancozeb	100e	100e	100e	100e
Chenopodium ambrosioides				
Control	0a	0a	0a	0a
25	67.22±0.31b	67.22±0.55b	49.44±0.55b	62.22±3.37b
50	84.63±0.64c	83.88±0.96c	64.07±2.73c	70.37±0.64c
100	100d	98.51±0.84d	82.59±1.78d	96.11±0.95d
Mancozeb	100d	100e	100e	100e
Persea americana				
Control	0a	0a	0a	0a
25	39.26±1.16b	58.33±0.58b	54.33±5.17b	45.74±0.13b
50	51.85±0.31c	63.67±2.08c	57.10±1.53c	57.96±0.84c
100	68.47±1.83d	70.00±1.73d	66.14±1.10d	72.22±0.78d
Mancozeb	100e	100e	100e	100e
Curcuma longa				
Control	0a	0a	0a	0a
25	95.56±1.47b	78.34±0.96b	81.67±2.01b	89.81±1.28b
50	97.33±2.25b	89.07±0.31c	88.14±0.84c	95.37±0.32c
100	100c	100d	95.93±0.64d	100d
Mancozeb	100c	100d	100e	100d

*Means followed by the same letter for each plant extract are not significantly different according to Kruskall-Wallis test at 5%.

Table 4: Effect of ethanolic extracts on growth inhibition (%) of the pathogens.

Concentration (mg/mL)	*Cercospora* sp.	*C. gloeosporioides*	*F. oxysporum*	*P. microspora*
Panax ginseng				
Control	0a	0a	0a	0a
25	95.37±1.28b	84.81±0.64b	77.03±3.61b	80.92±1.78b
50	97.21±2.1b	95.36±1.60c	87.96±2.31c	89.44±0.96c
100	100c	100d	98.70±0.64d	98.70±0.64d
Mancozeb	100c	100d	100e	100e
Chenopodium ambrosioides				
Control	0a	0a	0a	0a
25	97.44±0.6b	88.94±0.84b	90.63±0.64b	87.11±1.2b
50	100c	97.94±0.97c	95.63±0.66c	99.11±0.9b
100	100c	100d	100d	100b
Mancozeb	100c	100d	100d	100b
Persea americana				
Control	0a	0a	0a	0a
25	55.18±0.84b	70.33±1.15b	63.02±3.60b	64.18±0.84b
50	73.70±2.62c	74.05±2.00c	68.33±0.58c	75.55±0.55c
100	77.67±0.55d	76.33±3.51c	71.67±1.15d	86.11±1.47d
Mancozeb	100e	100d	100e	100e

Curcuma longa				
Control	0a	0a	0a	0a
25	100b	100b	100b	100b
50	100b	100b	100b	100b
100	100b	100b	100b	100b
Mancozeb	100b	100b	100b	100b

*Means followed by the same letter for each plant extract are not significantly different according to Kruskall-Wallis test at 5%.

Table 5 Toxicity (fungistatic or fungicidal effect) of the plant extracts

Plant extracts		*Cercospora* sp.	*Colletotrichum gloeosporioides*	*Fusarium oxysporum*	*Pestalotopsis microspora*
Panax ginseng	Aq	NA	NA	NA	NA
	Eth (100 mg/mL)	+	-	NA	NA
Chenopodium ambrosioides	Aq (100 mg/mL)	-	NA	NA	NA
	Eth (100 mg/mL)	+	+	+	+
Persea americana	Aq	NA	NA	NA	NA
	Eth	NA	NA	NA	NA
Curcuma longa	Aq (100 mg/mL)	+	+	NA	-
	Eth (50-100 mg/mL)	+	+	+	+
Mancozeb		+	+	+	+

Aq = aqueous extract, Eth = ethanoloic extract, (-) = Fungistatic effect and (+) = fungicidal effect. NA= not applicable because there was no total inhibition.

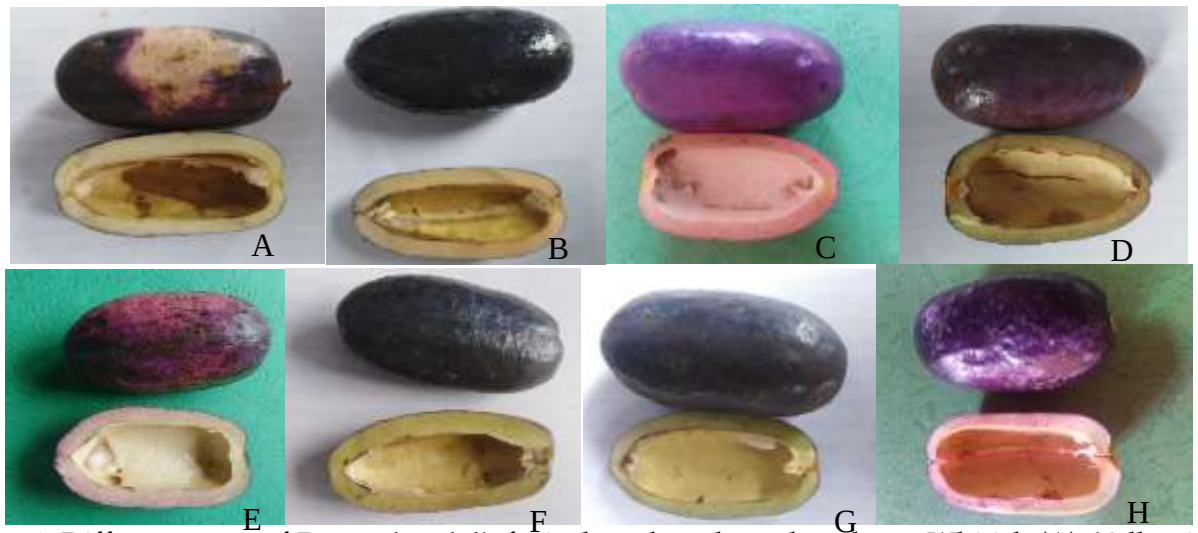


Fig. 1: Different types of *Dacryodes edulis* fruits based on the pulp colour : Whitish (A), Yellowish (B), Pinkish (C), Turquoise (D), Purplish (E), Light green (F), Dark green (G) and Reddish green (H).

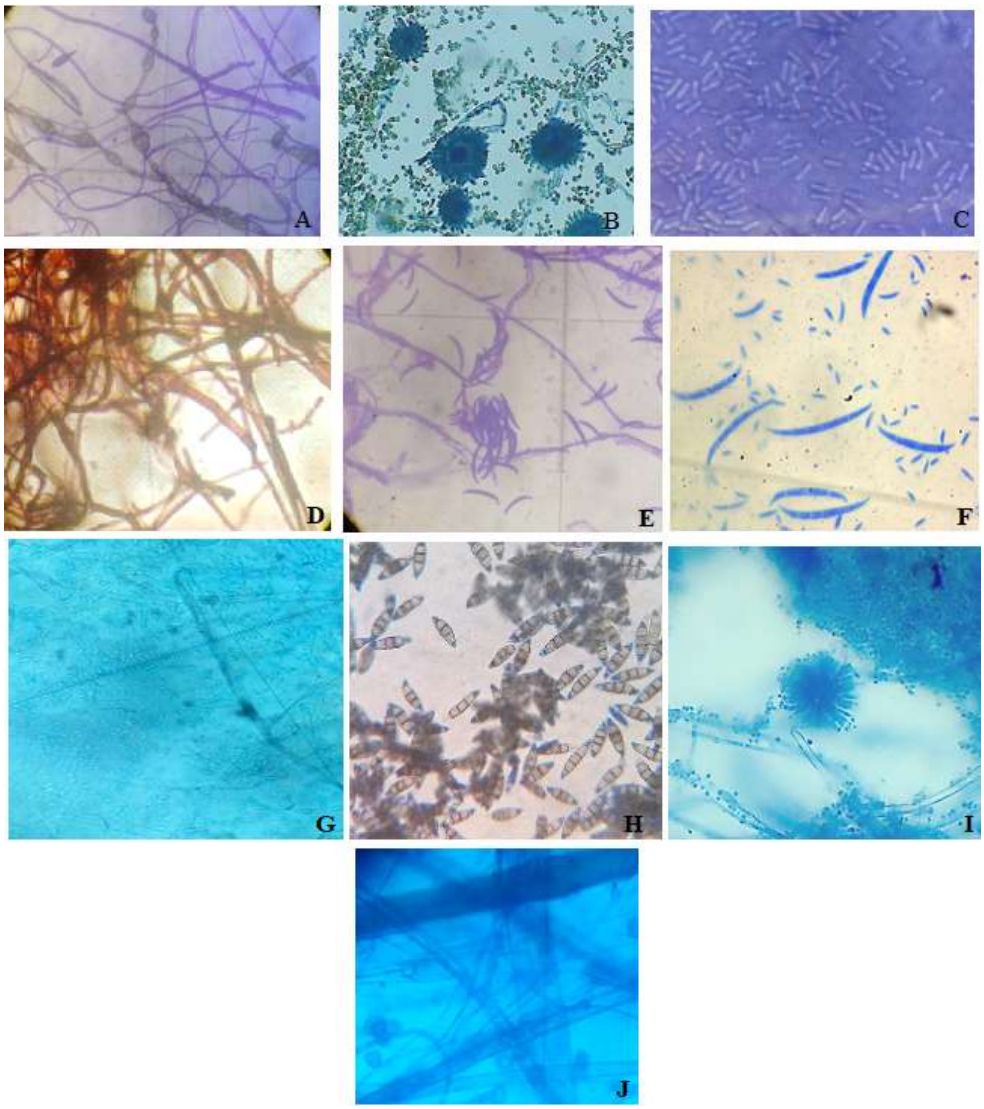
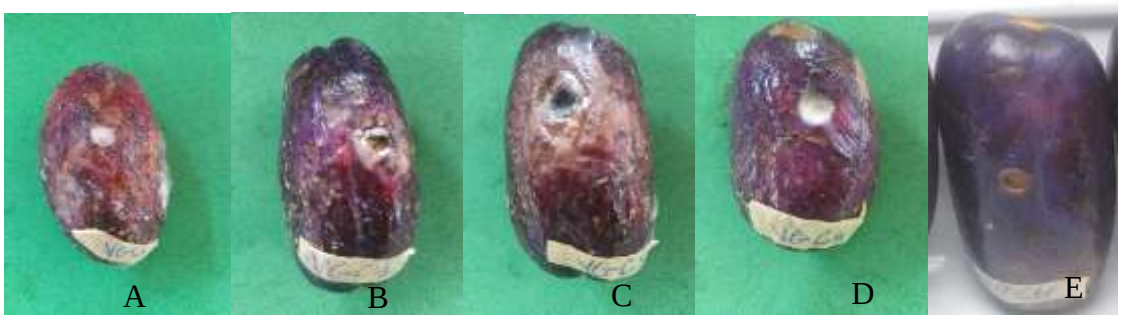


Fig. 2: Microscopic traits (conidiophores and conidia) of 10 - days old identified fungal species from fruits of African plum: *Alternaria alternata* (A), *Aspergillus niger* (B), *Colletotrichum gloeosporioides* (C), *Cercospora* sp.(D), *Fusarium oxysporum* (E), *Fusarium verticilloides* (F), *Geotrichum* sp.(G), *Pestalotiopsis microspora* (H), *Penicillium digitatum* (I) and *Rhizopus nigricans* (J), 400 X.

Fruits with whitish pulp

Fruits with yellowish pulp

Fruits with dark green pulp



Fruits with reddish-green pulp

Fig. 3: Susceptibility of varieties of African plum fruits inoculated with pathogenic fungi. A= *F. oxysporum* (soft rot), B= *C. gloeosporioides*, (anthracnose), C= *Cercospora* sp. (cercospora leaf spot) and D= *P. microspora* (soft rot), 5 days after inoculation. E = control. Mycelium and dense production of spores are visible on some fruits varieties.

Discussion

The frequently isolated post-harvest fungi associated with *D. edulis* fruits were: *F. oxysporum*, *P. microspora*, *C. gloeosporioides* and *Cercospora* sp. Several researchers have identified these genera as being responsible for damage to several forest products in post-harvest and reputed to be the cause of deterioration of many products such as fruits, seeds, vegetables and tubers both in the field and during storage (Serferbe, *et al*., 2015; Djeugap, *et al*., 2015; Dongmo, *et al*., 2017). This could be due to the fact that the agroecological zones (AEZ) where samples were collected belong to the same AEZ where our samples were collected. In fact, in the nature, pathogens are distributed on the basis of the climate, altitude, soil structure and composition, vegetation type and ecosystems (Parker, *et al*., 1985; Brooke, 2014). The high occurrence frequencies of *F. oxysporum*, *Cercospora* sp. and *C. gloeosporioides* obtained from *D. edulis* fruits could be also explained by the fact that these fungi are polyphagous and cosmopolitan (Agrios, 2008). The poor storage conditions of the fruits (their contact with water or humidity) could also favor their presence in the fruits. To the best of our knowledge, this is the first time these fungi are reported in *D. edulis* fruits. Most of the pathogenic fungi identified in post-harvest fruits of *D. edulis* were reported by previous works as also highly pathogenic to many plants and plant organs and seedlings both in

the Lab and field conditions (Mertely and Legard, 2004; Li and Zhang 2007; Soleha, *et al*., 2022; Yoganie, *et al*., 2022). Gaikwad, *et al*. (2014) showed that *F. oxysporum* was highly pathogenic on onion (*Allium cepa* L.) during storage.

This study showed the high susceptibility of *D. edulis* fruits to diverse post-harvest fungi. This could be due to the high water and oil content which favors the growth of the microorganisms and also to the perishable nature of the *safou* (Kengne 2002; Dagno, *et al*., 2012). This phenomenon was also reported by previous studies (Diéguez – Uribeondo 2004; Duduk, *et al*., 2021). Some aqueous (*C. longa*) and ethanolic extracts (*C. ambroisioides* and *C. longa*) of the plant tested showed a very high antifungal activity against the main pathogenic post-harvest fungi. This activity was comparable to the synthetic fungicide (Mancozeb) used as positive control. Similar results was obtained with the extract of *C. ambrosioides* against yeasts and *Candida krusei* (Sousa, *et al*., 2012), the extract of *C. longa* against *C. gloeosporioides* and other fungi like *Penicilium* spp., *Cladosporium oxysporum* and *Aspergillus flavus* (Chen, *et al*., 2018; Kwang, *et al*., 2005). The effectiveness of these plant extracts is due to the presence of secondary metabolites with high antifungal and antibacterial activity (Sousa, *et al*., 2012; Marchi, *et al*., 2019). However, ethanolic extracts were more effective than aqueous extracts. This difference in the efficacy between aqueous and organic extracts could be attributed to a difference in the capacity to extract active compounds. In fact, based on their high polarity, organic solvents extract more chemical compounds than poorly polarized or neutral solvent (Akhilesh, *et al*., 2010; Bougandoura and Bendimerad, 2012). Mancozeb which is a well-known and popular contact fungicide homologated in Cameroon for control many airborne and seed borne diseases was fungicidal to all the pathogens.

The aggressive post-harvest fungi associated with fruits of African plum were: *F. oxysporum*, *Cercospora* sp., *C. gloeosporioides* and *P. microspora.* The fruits with the green phenotype (light green, dark green and reddish green pulp) were less susceptible to post-harvest fungi, while fruits with whitish, yellowish and pinkish pulp were more susceptible. The aqueous extract of *C. longa* was fungicidal to *Cercospora* sp and *C. gloeosporioides* at 100 mg/mL. The ethanolic extract of *C. ambrosioides* and *C. longa* were fungicidal to all the aggressive fungi at 100 mg/mL and at 25 to 100 mg/mL respectively. The extracts of these two plant could be therefore used as an alternative to chemical in the management of post-harvest fungi of African plum after positive results in the field conditions.

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