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Evaluation Of The Insecticidal Effects Of Extracts And Extracts Fractions Of *Nicotiana tabaccum* (Solanaceae) And *Carica papaya* (Caricaceae) On Termites Of The Genus *Nasutitermes*, Main Pests Of Cocoa Trees In Côte D'ivoire.

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ABSTRACT

With a view finding alternative to chemical control, respectful of the environment and effective against harmful termites, the insecticidal properties of extracts and extracts fractions from the powder of tobacco leaves and seeds of papaya were tested on termite workers of the genus *Nasutitermes*. The extracts were obtained by maceration and liquid-liquid extraction. In the laboratory, termite workers, collected at National Center of floristic, were exposed to the extracts in order to assess their effectiveness on the mortality of the latter. Each test was performed with 50 individual termites and repeated four times. The tests were compared to the blank control. Biological tests were carried out on termites with extracts concentrated for 100 and 200 mg/l. All extracts obtained from tobacco leaves were proved to be very effective against termites with maximum mortality in less than 8 hours for aqueous extract. The LC50 obtained with the other tobacco leaf extracts were very low (1,2 to 3,4 mg/l) add depending of solvent used. As for the extracts obtained from papaya seeds, except hexane extract which gave satisfactory results at concentration of 100 mg/l, other extracts did not show any efficacy on termite mortality. Nevertheless, the aqueous and DCM extracts of this powder show efficacy at a high concentration. The LC50 of hexane extract is between 8,8 and 9,6 mg/l taking into account the studied concentrations. Chemical compounds such as alkaloids, sterols and terpenes, saponins and tannins which are in these extracts would be responsible for insecticidal activity of these extracts.
Keywords: insecticidal plants, allelochemicals, pest termites, laboratory test.

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INTRODUCTION

Insects form richest class in terms of species [1]. They have colonized all environments and have provided great ecosystem services (pollination, protein source, fertilization and soil aeration). However, some insects are sources of several diseases affecting humans [2], animals [3] and even plants [4]. Other insects such as termites can be real pests in agriculture and agroforestry [5] and damaging in both plantations and stocks [6,7]. Although some termites play an important role in maintaining ecosystems and improving soils [8], others have acquired the status of pests by seriously and regularly attacking cultivated plants [9–11]. In the United States of America, their damage had even been estimated to 1.7 billion dollars [12]. To date, several means of control have been developed against termite pests of crops. Among all the means of controlling these insects, chemical control remains the most effective and the most widely used [13,14]. However, its chemical insecticides resulting from the synthesis of several molecules today represent a danger both for humans and for their environment [15]. The persistence of chemical insecticides makes them a public health problem [16]. Increasingly, new concepts such as "one health" have emerged [17,18]. This concept proposes to seek new methods that respect the environment and human health to maintain the density of pests at the tolerance threshold in plantations. In recent years, scientific research has increasingly focused on the field of insecticidal plants [19,20]. Insecticidal plants are indeed a godsend for the search for new effective molecules, respectful of the environment and capable of reducing the pest action of insects in general and termites in particular in plantations. Sociological and anthropological studies have shown, for example, that tobacco leaves [21] and papaya seeds [22] have been used empirically by farmers to counter insect infestations in plantations. However, current scientific studies on the real impact of these plants on termites remain few. The general objective of this work is therefore to study the effect of extracts of these plants on termites in a controlled environment. The termites chosen for the study are those of the genus *Nasutitermes*. Indeed, termites of those genus have been recognized as real pests of cocoa trees in Côte d'Ivoire [11]. Ultimately, the study will make it possible to propose control methods to cocoa producers in Côte d'Ivoire.

MATERIAL AND METHODS

Material

This work was carried out under laboratory conditions (T°: 27 ± 2°C; HR: 80%) in Petri dishes. The termites used for this study are workers of the *Nasutitermes* genus. They collected at the National Center of Floristic located at the Félix Houphouët Boigny University. Two plants are studied in this work: papaya seeds and tobacco leaves. They were collected and then dried out in the shade of a room temperature for two and three weeks respectively. The various powders obtained from the dried organs were used for the extractions. Two types of extractions were done in this work. These are extraction by maceration and liquid-liquid extraction.

Extraction By Maceration

For each plant powder studied, a mixture of ethanol and distilled water in an "8:2" proportion was used as solvent. The amount of solvent used depended on its absorption by the powder studied. After 24 hours, the extract was first filtered on Wathman paper and then on cotton. The hydroalcoholic extracts obtained were dried in an oven at 40° for 5 days. The marc, resulting from this first maceration, was dried in the laboratory at temperature room temperature for 2 days. Once dry, the marc was taken up in hexane. The beaker was shaken vigorously and left to stand for 24 hours then filtered. The extract obtained was passed through a rotary evaporator in order to recover the crude hexane extract.

Liquid-Liquid Extraction

From the crude hydro-ethanolic extracts, several fractionations were carried out. The principle is to take the raw hydro-ethanolic extract obtained in solvents of increasing polarity. A liquid-liquid extraction is carried out with successively dichloromethane (DCM), ethyl acetate and distilled water in a separatory funnel. For a used solvent, the operation is repeated two to three times until exhaustion. The various fractions obtained were concentrated using a rotary evaporator, then dried in an oven.

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Phytochemical Screening

The extracts obtained from the different methods used underwent several tests in order to know the different families of molecules contained in each extract (Table 1). The main phytochemical groups that have been sought from the tests are alkaloids, flavonoids, tannins, saponins, quinones, steroids and terpenoids.

Table 1: Characterization of the different chemical compounds contained in the extracts obtained

Chemical group	Tests	Presence
Alkaloids	Dragendorff reagent	Orange-red staining (Razafindrambao, 1973; Sangare et al., 2012)
Saponosides	Foam test	Height of persistent foam, greater than 1 cm (Wagner, 1983)
Sterols and terpenes	Liebermann reaction	Purple staining that turns blue and then green (Koffi et al., 2015).
Tannins	Concentrated HCl	Formation of a precipitate (Bekro et al., 2007).
Polyphenols	Ferric chloride (FeCl3)	Appearance of a more or less dark blue-blackish or green color (Bekro et al., 2007).
Quinones	20% hydrochloric acid Concentrated ammonia.	Appearance of a color that turns yellow, red or purple in the aqueous phase (Bekro et al., 2007; Koffi et al., 2015)
Anthraquinones	Diluted NH4OH chloroform extract	More or less red coloration (Bruneton, 1993)

Biological Tests

Device

The various extracts obtained were tested on termites in order to study their insecticidal effect. They were concentrated at 100 and 200 mg/l depending on their effectiveness. The protocol of Tahiri et al. [23] was used in this study. Four dosages were tested; these are doses of 10, 20, 50 and 100 µl (corresponding to 1; 2; 5 and 10 mg/l for concentrated extracts at 100 mg/l and 2; 4; 10 and 20 mg/l for those concentrated at 200 mg/l). In each petri dish, 1 ml of distilled water was put. According to the inscription marked on the petri dish, the corresponding extract dosage is added using a micropipette. To this mixture was added 3.5 g of termite mound soil, all homogenized. After this manipulation, the box was left in the open air for 20 to 30 min. Then, 50 termite workers were put into each closed petri dish and stacked by assay. For each test, 4 controls were carried out. The boxes were then stored in a cupboard in total darkness.

Follow-Up Of The Various Tests

The tests were followed for 24 hours in order to verify the effectiveness of the tested extract by observing the behavior of the termites in the petri dishes. Dead termites in each Petri dish were counted and removed from the dishes at each observation. However, if after 24 hours, all the termites tested with one extract are dead, the test is repeated and monitored at regular intervals of 2 hours. The experiment stopped with the death of all the termites which were placed in the presence of the extracts or the control termites.

Statistical Tests

The means were subjected to a one-way analysis of variance (ANOVA) at the threshold of $P < 0.05$. The means were then compared using the Newman-Keuls test. The Probit test made it possible to calculate the LC50s of each extract. The average mortality rates were calculated and corrected using Abbott's [24] formula.

RESULTS AND DISCUSSION

Four extracts were obtained with each plant studied. They are the hexanic extract, aqueous extract fractions, ethyl acetate and DCM for tobacco. With *Carica papaya*, seed powder, hydroethanol extraction yielded a crude extract with two distinct phases: one fat-soluble and the other water-soluble. After separation of the two phases, the water-soluble phase was fractionated. No chemical substances were extracted after the execution of the liquid-liquid extraction using ethyl acetate as the extracting solvent. Extracts obtained are the fatty part of the hydroethanolic extract, the hexanolic extract and the fractions of aqueous and DCM extracts

Extracts And Fractions Of Extracts From Tobacco Leaves

Nasutitermes sp workers exposed to extracts and fractions of extracts from the powder of dried tobacco leaves showed significant sensitivity to concentration of 100 mg/l. This results in the death of the termites tested at the different concentrations used. The tests carried out with tobacco powder were all satisfactory. However, the aqueous fraction and the hexane extract gave the best results at high concentrations in 2 hours. As for the DCM extract fraction and the ethyl acetate fraction, the tests were conclusive at high concentrations after 24 hours. With regard to the tests carried out with the fraction of aquatic extract, the mortality of the termites exposed to the concentration of 10 mg/l recorded in 2 hours was 14 ± 6.9. Nevertheless, the mortality recorded with the different concentrations of this extract tested was statistically identical to that of the controls. After 4 hours, mortality was maximum for termites placed in the presence of concentrations of 10 mg/l. As for the other concentrations tested, mortality was maximum after 8 hours for the concentration of 5 mg/l and 10 hours for the concentrations of 1 and 2 mg/l. mortality at the control level was 0.75 ± 1.5 after 10 hours (Figure 1).

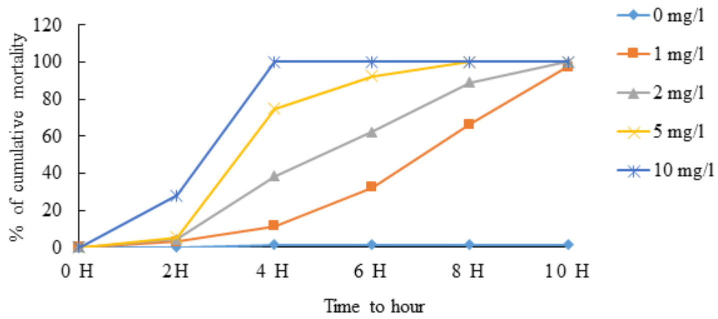
The mortality of the workers in the presence of the hexane extract obtained from the marc of the hydroalcoholic maceration in comparison with the control tests showed the great effectiveness of this extract (Table 2). Indeed, 2 hours after the launch of the tests, more than half of the termites tested per batch died for the concentrations of 5 and 10 mg/l with respectively 38.75 ± 8.54 and 47.5 ± 5 dead termites on the 50 termites tested by petri dishes. The readings show maximum mortality for the termites tested at a concentration of 5 mg/l after 24 hours. Maximum mortality is reached for concentrations of 1 and 2 mg/l after 48 hours.

Table 2: Mean mortality rate of *Nasutitermes sp* workers according to tobacco leaf extracts as a function of concentrations and time

Time	**Extract studied and Concentration**					
	Hexane extract					
	0 mg/l	1 mg/l	2 mg/l	5 mg/l	10 mg/l	P
2 H	0 ± 0 a	6,75 ± 4,11 ab	18,25 ± 10,91 b	38,75 ± 8,53 c	47,5± 5 c	0,0001
6 H	0 ± 0 a	6,75 ± 4,11 ab	18,25 ± 10,91 b	41,25 ± 10,31 c	50 ± 0 c	0,0001
24 H	0,25 ± 0,5 a	20,75 ± 19,72 ab	40,25 ± 11,44 bc	50 ± 0 c	50 ± 0 c	0,0001
36 H	6 ± 7,43 a	31,25 ± 12,84 b	44,75 ± 6,07 bc	50 ± 0 c	50 ± 0 c	0,0001
48 H	14,75 ± 23,5 a	49,25 ± 1,5 b	50 ± 0 b	50 ± 0 b	50 ± 0 b	0,0001
	Ethyl acetate extract fraction					
	0 mg/l	1 mg/l	2 mg/l	5 mg/l	10 mg/l	P
24 H	0 ± 0 a	20,33 ± 2,52 b	32 ± 4 c	47,33 ± 4,61 d	50 ± 0 d	0,0001
48 H	0,33 ± 0,58 a	30,66 ± 7,37 b	48,66 ± 2,31 c	50 ± 0 c	50 ± 0 c	0,0001
72 H	0,33 ± 0,58 a	41,66 ± 2,1 b	50 ± 0 c	50 ± 0 c	50 ± 0 c	0,0001
	Dichloromethane (DCM) extract fraction					
	0 mg/l	1 mg/l	2 mg/l	5 mg/l	10 mg/l	P
24 H	0 ± 0 a	13 ± 17,64 ab	22,5 ± 12,26 abc	32 ± 16,26 bc	44,50 ± 6,81 c	0,002
48 H	1,25 ± 1,1 a	14,75 ± 17,89 b	26 ± 14,35 c	39,25 ± 12,47 c	50 ± 0 c	0,0001
72 H	0,33 ± 0,58 a	50 ± 0 b	50 ± 0 c	50 ± 0 c	50 ± 0 c	0,0001

ANOVA test at the 95% threshold; Newman-Keuls Pairwise Multiple Comparison Test Lowercase letters show differences in a row

Figure 1: Cumulative mortality as a function of time of *Nasutitermes* workers treated with aqueous fraction extract of tobacco at different concentrations



The results obtained with the fractions of acetate and DCM extracts (Table 2) follow the same trend. The maximum termite mortality was obtained for these two extracts in 72 hours, i.e. 3 days after the launch of the tests. However, the average number of dead termites at 24-hour intervals is greater with the acetate fraction than the DCM fraction.

LC50 Obtained With Extracts And Fractions Extracts Of Tobacco Leaf

The CL50, which allows to know the concentration of extract capable of reducing the workers tested by half in 24 hours, was calculated from the results of the tests carried out. The lowest concentration was recorded for the aqueous extract (0.475 mg/l). It is followed by the LC50 of the hexane extract (0.12 mg/l). As for the DCM extract, its LC50 was 3.4 mg/l (Table 3).

Table 3: Lethal concentrations (LC) to obtain 50 and 99% mortality of *Nasutitermes sp* workers and their 95% confidence limits for extracts of tobacco leaf powder

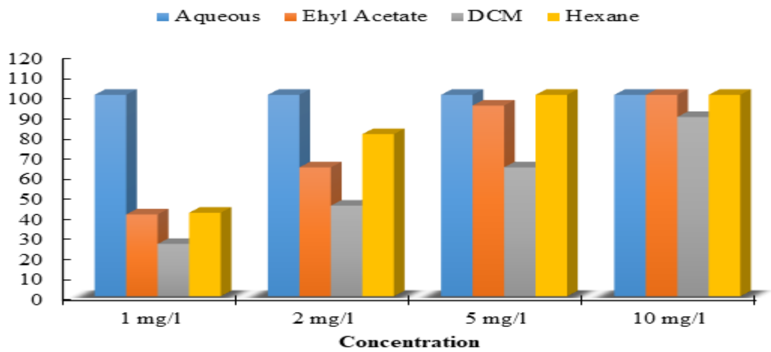
Extract	LC50 (mg/l)	LC50 Terminals at 95 %	LC99 (mg/l)	LC99 terminals at 95%.
Aqueous	0,47	0,01 – 0,75	3,35	2,82 – 4,40
Hexane	0,12	1,04 -1,32	3,36	2,97 – 4,00
Etlyl acetate	1,39	1,03 – 1,68	6,43	5,61 – 7,66
DCM	3, 4	2,89 – 3,88	15,30	13,62 – 17,47

Probit model of lethal concentration calculation

Comparison Of The Efficiency Of The Different Extracts

The comparison of the different extracts obtained from tobacco leaves after 24 hours of treatment shows that the aqueous extract is the most effective against termites. Also, the effectiveness of all extracts increases with increasing concentration. Thus, for the concentration of 1 mg/l, the mortality of termites varies from 26 to 100% depending on the extracts, while at the concentration of 5 mg/l, the mortality of termites varies from 64 to 100%. The DCM extract fraction gave the lowest mortality rates (Figure 2).

Figure 2: Comparative effect of the different tobacco extracts according to the concentration after 24 hours of treatment



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Extracts And Fractions Of Extracts From Papaya Seeds

Apart from the hexane extract at a concentration of 10 mg/l, the various crude extracts and fractions of extracts obtained from papaya seeds tested on termites at a concentration of 100 mg/l showed no significant difference with the controls regardless of the concentration tested.

The hexane extract of papaya seeds showed good efficacy at a concentration of 200 mg/l. In 24 hours, termite mortality was average with the concentration of 20 mg/l (27 ± 2.65 ind deaths). This mortality was statistically different from that of the control for the concentrations of 4 and 10 mg/l which recorded respectively 13 ± 7 and 19 ± 7.55 ind deaths. Termite mortality increases with the time of exposure of termites to the extract (Table 4). With regard to the fatty part of the crude hydroethanolic extract and the DCM fraction of this extract, the test results are statistically different from the control at a concentration of 20 mg/l after 24 hours of exposure to the product. However, the mortality obtained with the other concentrations tested showed no significant difference with that recorded with the control tests regardless of the exposure time (Table 4). The aqueous fraction of the hydroethanolic extract at a concentration of 200 mg/l at different concentrations showed no significant difference with the control.

Table 4: Mean mortality rate of *Nasutitermes sp* workers according to papaya seeds extracts as a function of concentrations and time.

Time	Extract studied and Concentrations					
	Fraction of hexane extract at 100 mg/l					
	0 mg/l	1 mg/l	2 mg/l	5 mg/l	10 mg/l	P
24 H	0,00 ± 0 a	1 ± 1,16 a	3 ±2,16 a	4,25 ± 1,71 a	28 ± 21,18 b	0,004
48 H	1 ± 0,82 a	3,5 ± 1,29 a	4,75 ± 3,86 a	8,75 ± 2,99 a	37 ± 14,49 b	0
72 H	2 ± 1,16 a	8,25 ± 2,63 a	8,75 ± 4,35 a	11 ± 1,41 a	40,75 ± 11,1 b	0
	Fraction of hexane extract at 200 mg/l					
	0 mg/l	2 mg/l	4 mg/l	10 mg/l	20 mg/l	P
24 H	1,33 ± 1,53	15,66 ± 4,04	13 ± 6,93	19 ± 7,55	27 ± 2,65	0,002
48 H	16,66 ± 7,09	22,33 ± 3,06	17 ± 3,61	22,33 ± 7,02	34,33 ± 2,52	0,01
72 H	38,33 ± 3,06	37,33 ± 4,04	33 ± 14,57	42,33 ± 7,51	45,33 ± 4,51	0,44
	Hydroethanolic fatty extract at 200 mg/l					
	0 mg/l	2 mg/l	4 mg/l	10 mg/l	20 mg/l	P
24 H	0,33 ± 0,58 a	1 ± 1 a	0 ± 0 a	0 ± 0 a	4,67 ± 0,57 b	0
48 H	4,33 ± 1,53	5 ± 2,65	4,67 ± 3,51	7,33 ± 3,51	8,67 ± 4,04	0,418
72 H	38 ± 4	33,33 ± 6,51	36,67 ± 2,52	39 ± 3	36,33 ± 4,16	0,574
	Fraction of extract with Dichloromethane at 200 mg/l					
	0 mg/l	2 mg/l	4 mg/l	10 mg/l	20 mg/l	P
24 H	2 ± 1 a	1 ± 1 a	0,33 ± 0,58 a	4,33 ± 2,52 ab	9,33 ± 6,81 b	0,045
48 H	3,33 ± 0,58	12,67 ± 9,87	19 ± 26,89	37,66 ± 13,65	40,66 ± 16,17	0,069
72 H	22,66 ± 8,62	17,66 ± 7,02	34 ± 16,52	39,67 ± 10,5	45 ± 8,66	0,054
	Aqueous extract fraction at 200 mg/l					
	0 mg/l	2 mg/l	4 mg/l	10 mg/l	20 mg/l	P
24 H	0,33 ± 0,58	0 ± 0	0 ± 0	6,67 ± 11,55	5,33 ± 9,24	0,592
48 H	0,33 ± 0,58	0 ± 0	0 ± 0	6,67 ± 11,55	5,67 ± 9,82	0,594
72 H	38 ± 5,57	37,66 ± 7,02	26,66 ± 23,29	38,33 ± 2,52	43 ± 4,58	0,53

ANOVA test at the 95% threshold; Newman-Keuls Pairwise Multiple Comparison Test Lowercase letters show differences in a row

LC50 Obtained With Extracts And Fraction Extracts Of Papaya Seeds

The different LC50s obtained vary from one extract to another (Table 5). The lowest LC50s were recorded on the hexane extracts at concentrations of 100 and 200 mg/l (respectively 9.60 and 8.89 mg/l). The highest LC50 was obtained on the hydroethanolic fatty extract (20.4 mg/l).

Table 5: Lethal Concentrations (LCs) for obtaining 50 and 99% mortality of *Nasutitermes sp* workers and their 95% confidence bounds of papaya seed powder extracts

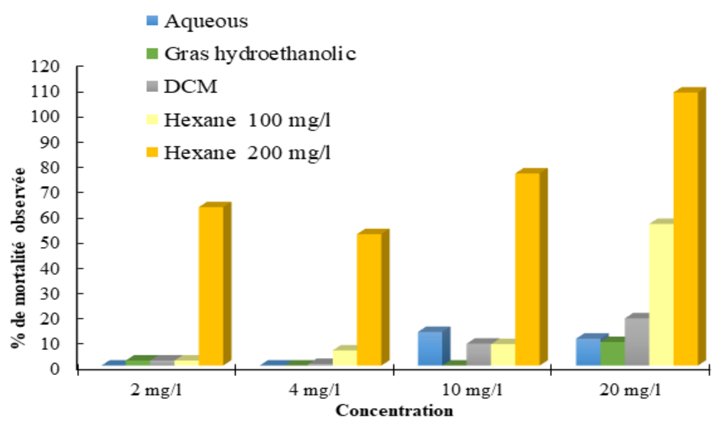
Extract	CL50 (mg/l)	Terminal CL50 à 95%	CL99 (mg/l)	s CL99 à 95%
Hexane 100 mg/l	9,60	8,99 - 10,34	19,33	17,66 - 21,55
Hexane 200 mg/l	8,90	7,21 - 12,07	39,62	29,79 - 61,79
Aqueous 200 mg/l	19,20	15,20 - 28,72	39,46	29,58 - 63,67
Fatty 200 mg/l	20,50	16,00 - 32,84	37,98	27,95 - 66,31
DCM 200 mg/l	16,04	13,53 - 20,76	32,59	26,16 - 45,12

Probit model of lethal concentration calculation

Comparison Of The Efficiency Of The Different Extracts

The comparison between the different extracts of papaya seed powder revealed the effectiveness of the hexane extract. The aqueous extract, at high concentrations, causes mortality in termites. At concentrations of 1 and 2 mg/l, the aqueous, fatty and DCM extracts concentrated at 200 mg/l and the hexane extract concentrated at 100 mg/l have no impact on termites (Figure 3).

Figure 3: Comparative effect of the different papaya seed extracts according to the concentration after 24 hours of treatment



Hexane extract of solution concentrated to 100 mg/l is tested at the following concentrations 1; 2; 5 and 10 mg/l respectively.

Phytochemicals In Extracts

The phytochemical screening carried out showed that alkaloids and saponosides are the most important in the extracts obtained from the powder of tobacco leaves. Tests for sterols and terpenes, quinones and polyphenols were all positive. In the crude hexane extract of tobacco leaf powder, the presence of sterols and terpenes and polyphenols was revealed. Compared to the other extracts tested, the aqueous extract contain more compounds. Phytochemical screening reveals that the crude hydroethanolic extract of papaya seeds contains large quantities of alkaloids and saponins. Sterols and terpenes and polyphenols, although present, are not abundant. Sterols are very abundant in the crude hexane extract and a little less in the fatty part of the crude hydroethanolic extract. Saponosides are very abundant in the fatty part of the hydroethanolic extract and absent in the DCM and hexane extract (Table 6).

Table 6: Chemical compounds identified in extracts obtained from tobacco leaves and papaya seeds

Chemical comps	Tobacco E. Raw	Tobacco DCM	Tobacco acetate	Tobacco aqueous	Tobacco hexanique	Papaya E. Raw	Papaya aqueous	Papaya DCM	Papaya Fatty	Papaya hexane
Alkaloids	+++	-	++	+++	-	+++	++	-	-	-
Saponosides	+++	-	++	+++	-	+++	++	-	+++	-
Sterols and terpenes	++	++	-	-	++	++	-	+	++	+++
Tannins	++	++	-	-	-	-	-	-	-	-
Quinones	++	-	-	++	-	-	-	-	-	-
Anthraquinones	+	-	-	+	-	-	-	-	-	-
Polyphenols	++	-	++	++	++	++	++	-	-	-

DISCUSSION

All tobacco leaf extracts were effective against termites in the laboratory. After ethnobotanical surveys, several authors [22,25,26] have revealed that farmers use plants alone or in combination with other substances to control insects in a empirical both in stocks and in plantations. The short duration of the tests with the aqueous extracts of tobacco leaves could be explained by the molecules contained in these extracts. Indeed, the phytochemical screening revealed that the aqueous tobacco extract contained more compounds. The other extracts obtained from the tobacco leaves made it possible to obtain the maximum mortality for all the concentrations after 72 hours. All extracts and fractions of extracts obtained from tobacco maceration are rich in alkaloids. The best-known alkaloid to date in tobacco leaves is nicotine [27]. An analysis of the crude extract of tobacco leaves reveals 9 to 36 mg of nicotine per gram of dry leaves [28]. In addition, the results of work by Boulogne [29] revealed that the decoction of tobacco leaves contains alkaloids (110 mg/g), phenolic compounds (88 mg/g) and terpenoids (552 mg/g). Our results are partly in agreement with those of Shiberu et al. [30]. The tests carried out by these authors on termites of the genus *Macrotermes* with the aqueous extract of tobacco leaves proved effective in 24 hours, but it was after 72 hours that maximum mortality was reached. These observed differences could be explained by the method of obtaining the extracts and the concentrations used. Indeed, in this work, the aqueous extract was obtained by fractionation from the crude hydroethanolic extract. This method allows a coarse separation of substances thanks to the polarity of the chemical compounds. Tiwari et al., [31] as well as Boulogne, [29] showed the insecticidal effect of tobacco leaves on many insects. Whatever the extraction method used, the extracts obtained from tobacco leaves show very good efficiency. In addition to its effectiveness, its toxicity and even its insecticidal effect against insects, the molecules contained in tobacco leaves like nicotine are also very toxic to mammals. Mimetic of acetylcholine, it binds to post-synaptic receptors and causes stimulation followed by depression of the vegetative system, motor nerve endings of muscles and the centra nervous system [32].

With regard to the extracts obtained from papaya seeds, apart from the hexane extract (60% mortality at a concentration of 10 mg/l, the extracts concentrated at 100 mg/l had no effect on termites tested at 200 mg/l concentration, the mortality rate of termites exposed to the recorded hexane extract was higher than the average and increasing with the concentrations.This could be explained by the chemical composition of this extract. The apolar compounds contained in the hexane extract, essentially made up of sterols and terpenes, are therefore insecticides at high concentrations. These chemical compounds are involved in the defenses of plants against insects [33]. For [34], these compounds have contact toxicity, so at the superficial level, the oil forms an impermeable film on the insect's cuticle and deprives it of air, causing it to asphyxiate fats can occur because of their amphiphilic character. The other extracts tested showed an efficacy of around 10% at the maximum concentration tested. These results agree with those of Tahiri et al. [23] who showed that the hexane extract of the seeds of the fruits is toxic for termites. However, these authors also highlighted the average efficacy of the aqueous extract of papaya seeds in their study. This difference between their results on the efficacy of the aqueous extract of papaya seeds and those of the current study could be attributed to the level of maturity of the seeds used. Indeed, Tahiri et al. [23] worked on the seeds of the green fruit whereas in this study the seeds used come from ripe papayas. This difference in the results would be due to the compounds contained in the seeds at the stage studied. Indeed, the chemical profile of allelochemicals varies with the phenological stage of the organ. The insecticidal properties of the plants studied would come from their secondary metabolism. These compounds are associated with a plant defense system against insects and other organisms according to [35]. For [33], these compounds are not common to all plants. They are differentiated according to the families and species of plants considered. Called by some authors allelochemicals because of their defensive nature, for Whittaker [36], they play an antinutritional role affecting the growth, survival, behavior or biology of living organisms that feed on plants or are associated with them. These compounds vary from one plant to another, from one organ to another, from one region to another, from one season to another depending on the pressures [37].

CONCLUSION

This study has shown that tobacco leaves and papaya seeds are effective against termites. The application of different extracts from these different plants has shown their effectiveness. All extracts from tobacco leaf powder have been shown to be effective against termites at a concentration of 100 mg/l. Nevertheless, the aqueous and hexane extracts of tobacco leaf powder have obtained the best mortality rates as a function of time (within 24 hours). With regard to the powder of tobacco seeds, although the fatty part of the hydroethanolic extract and the aqueous extract gave conclusive results at high concentrations at the concentration of 200 mg/l, the hexane extract gave the best results. These laboratory tests have shown that the chemical substances emitted by plants to protect themselves against their aggressors differ from one plant to another. While alkaloids appear to be the molecules responsible for the insecticidal activity of tobacco leaves, lipid compounds are responsible for the insecticidal activity of papaya seeds.

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