IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 15, Issue 8 Ser. I (August 2021), PP 25-36
www.iosrjournals.org

Integrated management of *Callosobrochusmacullatus* (Coleoptera: Bruchidae) during storage andnutritional and organoleptic qualityassessment of the treated *Vigna unguiculata*[L.] Walp

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Abstract

***Background**: In developing countries, farmers generally use synthetic insecticides to protect their stored foodstuffs from numerous predators such as Callosobruchus maculatus. However, although effective, they cause many adverse effects on the environment and on the health of consumers. The present study aims to evaluate the insecticidal effect of Cassia mimosoides extracts against C. maculatus attack during the conservation of Vigna unguiculata.*

***Methodology**: For this purpose, resistance tests of 6 different varieties of Vigna unguiculata against the attack of C. maculatus were first carried out. Toxicity tests of extracts (5, 10, 15 and 20 g/kg) with hexane, acetone and methanol on C. maculatusfor 6 days and their effect on the F1 progeny as well as the loss of seed mass during three months of storage were evaluated. The obtained stokes seeds were processed and submitted to physicochemical and sensory analysis.*

***Results**: The results of the analysis showed that the variety Lorie, which is not very susceptible to C. maculatus attack, considerably inhibited oviposition and significantly reduced the rate of emergence of C. maculatus compared to the varieties Bocolo, Mogonou, Tobourou, KI and Pavidji. The hexane extract was more active and at 10g/Kg resulted in 65% mortality, complete reduction of F1 progeny and complete protection of the seeds for 3 months of storage. Physicochemical analyses indicated that the extracts did not alter the proximal composition of different seeds except for the antinutrients which increased. Storage with these extracts altered the organoleptic properties and affected the taste, tenderness and crispness of the derived products.*

***Keywords**: Resistant varieties; Insecticidal activity; Cassia mimosoides extract; cowpea; Callosobruchus maculatus; sensory and nutritional characteristics*

Date of Submission: 06-08-2021 Date of Acceptance: 19-08-2021

I. Introduction

Cowpea (*Vigna unguiculata* [L.] Walp) is one of the most widely consumed legumes in developing countries, particularly in Africa, where it is a staple food[1]. Cowpea seeds are twice as rich in protein as cereal seeds (20 to 25% of their dry weight) and contain most of the amino acids necessary for human nutrition[2]. This richness in protein improves the nutritional quality in cereal-legume mixtures. It is also an excellent source of soluble and insoluble fibre, vitamins (B9) and minerals, especially potassium, phosphorus, calcium, magnesium, copper, iron and zinc[3;4]. In recent decades, cowpea has evolved from a subsistence crop to an important cash crop in various African countries, boosting their economies[5]. If annual production were high, cowpeas would be given greater consideration in strategies to promote food security in sub-Saharan Africa, where more than 239 million people are chronically malnourished[6; 7]. One of the main reasons for the low availability of cowpea for consumption is the importance of post-harvest losses observed during storage by pests such as *Callosobruchus maculatus*[8].

Callosobruchus maculatus (F.) (Coleoptera: Bruchidae) is currently a major problem for legume seeds in storage. It is responsible for about 56 to 69% mass loss per year or about 45.6 – 66.3% protein loss[9]. The importance of the damage caused force farmers to resort to several protective measures including the use of synthetic insecticides which is actually the most used technique in the post-harvest period[10]. This method, although effective, has many disadvantages on the environment, on the health of the consumer but also the relatively high price that progressively limits its use [11]. The search for alternative solutions is pushing towards new biological molecules, namely essential oils and plant powders[12; 13; 14]. Despite their effectiveness, essential oils and plant powders have some shortcomings: essential oils are known to be highly volatile compounds and less persistent in protecting seeds; plant powders, on the other hand, do not allow for a good distribution of the active ingredients of the powders on the seeds and also require large masses for effective protection. The search for other formulations taking into consideration other criteria such as persistence, good distribution of the active ingredient on the seeds and the use of low mass of products for a good protection of foodstuffs are important. In addition, the concept of varietal resistance has always been the concern of researchers who try to obtain agronomic varieties resistant to pests[15]. The preservation of seeds based on metabolites extracted from plants could modify the nutritional and organoleptic quality of derived products. This is the case of the work of Collilaw[16] reporting that secondary metabolites such as total phenolic compounds, tannins, alkaloids would interact with some nutrients leading to their polymerization and consequently their non-assimilation by the body. The objective of this study is to evaluate the level of natural resistance of different varieties of *Vigna unguiculata* to the attack of *C. maculatus*, the insecticidal activity of *Cassia mimosoides* extracts against this pest and their impacts on the physicochemical and organoleptic quality of the derived products.

II. Materials And Methods

Insect rearing

The strain of *Callosobruchus maculatus* used was obtained from infested seeds of *Vigna unguiculata* purchased from traders at the local market in Ngaoundéré. These seeds were sieved and the resulting *C. maculatus* adults were reintroduced into 900 mL glass jars containing about 500 g of previously sterilized cowpea seeds. These jars were stored under ambient laboratory conditions (T: 25.1±3.0°C; RH: 66.4±10.1) for seven days. Thereafter, the insects were removed and the infested seeds were left to incubate until adult emergence. At emergence, sieves were performed and bruchids used for testing were up to 24 hours old.

Plant material

Cowpea morphotypes: sampling and conditioning

The plant material (Table 1) consisted of six local morphotypes of cowpeas, including one improved variety (Lorie) from IRAD and five local morphotypes purchased from farmers at the local markets in Maroua (Far North, Cameroon) and Garoua (North, Cameroon). The difference between morphotypes was established using morphological (color, shape, weight, hilum appearance) and ecological (area of origin) descriptors. Seeds were stored in a freezer at -20°C for 20 days to remove any life forms and then left at laboratory room temperature for two weeks to acclimatize to laboratory conditions before use (Nukenine*et al.*, 2011).

Table 1: Some descriptive characters of the different varieties of *V. unguiculata*

Code	Source	Loca name	Caractéristiques de la graine
Lo/EN/D/01	IRADMaroua/FN	Parfar	White with black eye, rough
KI/EN/M02	Maroua/FN	danedjoum	White with black eye, smooth
Bo/EN/K04	Lara/FN	Bocolodjé	White with black eye, rough
Mo/EN/MOZ05	Mawa/FN	Mogounou	Red without eye, rough tegument
TOB/N/T06	Tobourou/North	/	White with pink eye, smooth
Pav/EN/MO08	Kuyapé/FN	Pavidji	White with black eye, smooth

FN: Far North; /: Absent

Biopesticides

The mature young leaves of *C. mimosoides* were harvested in September 2020 at Koza locality located in the Far North region of Cameroon. Once harvested, the leaves were dried in the shade for three weeks, then crushed and sieved (Ø =1 mm). The obtained powders were used for the further experimentation.

Extraction of the active principles and phytochemical analysis of the extracts.

The extraction was carried out by the method of maceration at 1/5 (*m/v*, kg. L^{-1}) in the extraction solvents including hexane, methanol and acetone. The same procedure was repeated three times to give the different concentrated extracts which were kept in the refrigerator at 4°C until the beginning of the tests. For phytochemical screening, the groups evaluated were alkaloids according to the method of Bidie*et al.*[17] total polyphenols according to N'Guessan*et al.*[18] ; flavonoids according to the method of Debray*et al.*[19]; saponosides according to the method of Dohou*et al.*[20] ; steroids, anthocyanins, tannins, coumarin, sterols and terpenes according to the method of Fankam*et al.*[21]

Susceptibility index of different varieties of cowpea to attack by *C. maculatus*

Ten pairs of *C. maculatus* up to 1-day old were introduced into 900 mL glass jars each containing 50 g of seeds of each variety. These jars were sealed with lids previously perforated to allow aeration of the chamber. Seven days after infestation, all insects were removed by sieving and the infested seeds were reintroduced into the jars. Each trial was repeated four times and observations were made daily until emergence. At emergence, insects were sieved out, counted, and their numbers recorded. The first day of emergence from each jar was recorded, and the criterion for the end of emergence was based on the absence of emergence on at least three consecutive days[22]. The susceptibility index, which is the susceptibility of different varieties to *C. maculatus* attack, was determined by the formula of Dobie[22].

$$\mathrm{SI} = \frac{\mathrm{Logarithm\ F}}{\mathrm{MDT}} * 100$$

Where: SI: Susceptibility Index; MDT (Median Developmental Time): time (in days) from infestation to 50% of F1 emergence. F: total number of emerged F1 progeny.

Seeds with an index between 0 – 3.9 were considered resistant, between 4 – 7.9 moderately resistant, between 8 – 10.9 susceptible and those with a susceptibility index greater than or equal to 11 very susceptible[23].

Evaluation of the effect of different extracts on *C. maculatus* mortality

Four solutions of extracts (0.25; 0.5; 0.75 and 1g/mL) were prepared by dissolving the different extracts in the different extraction solvents; then 1ml of each of these solutions was introduced into the glass jars containing 50 g of the different varieties. The resulting mixture was shaken for five minutes and then left at room temperature for one hour. A batch of 20 bruchid aged up to 24 hours was introduced into each jar. Product-free batches consisting of 50 g of each variety then 1 ml of solvent was used as a negative control and 50 g of each variety plus 1 ml of Delvaps(Commercial insecticide) as a positive control. Each treatment was repeated four times. Life and dead bruchids were counted at 1-, 3- and 6-day post infestation.

Effects of the different extracts on F1 progeny.

Six days after infestation, the contents of each jar were cleared of bruchids and left for observation. Each week, observations were made until emergence. At emergence, the number of emerging bruchids was recorded and the criterion for the end of emergence was based on the absence of emergence on at least five consecutive days in the same jar.

Evaluation of the effect of extracts on population growth and damage caused by *C. maculatus* during three months of storage.

The procedure as described above was used and at the end of three months of storage, the number of dead and live insects were counted, the non-perforated seeds and the perforated seeds were counted. The weight of the perforated seeds and the weight of the non-perforated seeds were weighed. The evaluation of weight losses was assessed and the percentage of damaged seeds (P) was calculated according to the FAO (1985) method using the following formula[24]:

$$\mathrm{P}(\%)= \frac{\text{Number of damaged seeds}}{\text{Total number of seedss}} \times 100$$

Evaluation of physicochemical and organoleptic properties of healthy and treated seeds

Physicochemical characterization of seeds

The physicochemical characteristics were evaluated before and after treatment of the seeds are dry matter according to the method of AFNOR[25], total ash was quantified according to the method described in AFNOR[26], protein content according to the method of Kjedhal[27], lipid content according to the method of Russe[28], total sugars were extracted and measured according to the method described by Fischer and Stein[29]. The method of López-Mejía and co-workers in 2014[30] was used to assay total phenolic compounds in extracts and treated seeds. Total tannins were assayed according to the method of Makkar*et al.*[31]. Aluminium chloride colorimetric technique was used for flavonoid content[32].

Sensory analysis of seeds

The variety chosen for the analysis was the variety Lorie. It was chosen because it is the most appreciated and consumed variety by the populations in the different study areas and the seeds that underwent the sensory analysis were the undamaged ones treated at the lowest effective concentration after three months of storage. Given the culinary habits of the populations with respect to cowpea consumption, the seeds were boiled. The sensory analysis studied was aimed at analysing and interpreting the organoleptic characteristics of the products as perceived by the sense organs[33], i.e., the color, odor, texture and taste of cowpea products. The products thus obtained were subjected to a hedonic test carried out in the sensory analysis laboratory according to the principle of a classification test which consists, for a given characteristic, in ranking in order of increasing intensity the samples presented simultaneously to 20 tasters of different sexes, ages and backgrounds who are used to consuming these products. At the end of this test, the numerical ratings from 1 to 7 where 1 corresponds to "extremely bad" and 7 to "extremely good" are presented in the form of tables and analysed by means of the test of. Friedman test.

Statistical Analyses

The data on percent mortality and percent reduction of F1 offspring were transformed into arcsin√(x/100). These transformed data were subjected to the analysis of variance (ANOVA) procedure using the statistical analysis system[34]. For the separation of means, Tukey's test was used. Probit analysis was conducted to determine the lethal doses causing 50% (LD50) mortality of C maculatus. Abbott's formula[35] was used to correct for mortality relative to the control prior to the application of ANOVA and Probit analysis. For sensory analysis, results were statistically analyzed using Friedman's test. The Fischer coefficient was calculated by the Ki-square test (x2). The comparison of the different samples was done by calculating the Fc coefficient and comparing it to the "S" value of the x2 table with k-1 degree of freedom at the 5% level[36]. SPSS software was used for the analysis of biochemical compounds of the seeds.

III. Results

Phytochemical evaluation of different plant extracts

Phytochemical screening was carried out on the crude hexane, acetone and methanol extracts of *C. mimosoides* and the data are shown in the Table 2. This screening revealed the presence of several secondary metabolites among which, alkaloids, triterpenes, sterols, flavonoids, phenolic compounds, sterols and coumarin. We observed that the extracts of *C. mimosoides* contain a wide range of bioactive compounds as mentioned in the literature. Also, it was observed a remarkable presence of triterpenes, steroids and saponins in the hexane extracts compared to the acetone and methanol extracts. Total phenolic compounds, flavonoids were abundant in the polar solvent extracts (acetone and methanol) and absent in the apolar solvent (hexane). The acetone and methanol extracts contained seven types of compounds (total phenolics, flavonoids, tannins, alkaloids, coumarin and saponins) whereas the hexane extract contained only three types of compounds (triterpenes, sterols and saponins).

Table 2: Phytochemical screening of extracts

Metabolites	Hexane	Acetone	Methanol
Total phenols	-	++	++
Flavonoids	-	++	++
Tannins	-	+	+
Coumarins	-	+	+
Alkaloids	-	-	++
Triterpenes	++	+	+
Steroides	++	+	-
Saponins	++	+	+

+++ = More abundant; ++ = Abundant; + = Positive; - = Negativ

Susceptibility of cowpea varieties and impact on the development of *C. maculatus*

The development andmedian development time of *C. maculatus* and susceptibility index of different cowpea varieties was evaluated and the data are summarized in Table 3. It was found that the resistance of cowpeasbeans to *C. maculatus* attack (P <0.001) varied with the variety used and for all parameters studied. The duration of the cycle of *C. maculatus* varied from 31.5 to 35.5 days with the smallest value in the development cycle recorded in the morphotype Bocolo (31 days) and the variety Lorie was the variety that recorded the greatest value. Similar observations were recorded in the median time of development which varied from 35 to 43 days with a low median time of development within the variety Pavidji and a high value within the variety Lorie.

Table 3: Development time and susceptibility index of six varieties of *V. unguiculata*

Varietiess	Cycle time	Average development time	Susceptibility index
Lorie	35.50 ± 0.57^{a}	43.00 ± 0.81^{a}	7.90 ± 0.06^{e}
KI	32.25 ± 0.50^{c}	39.75 ± 1.25^{b}	13.42 ± 0.46^{d}
Bocolo	33.00 ± 0.81^{bc}	36.75 ± 0.95^{bc}	14.45 ± 0.36^{bc}
Mogounou	34.50 ± 1.29^{b}	40.00 ± 0.81^{ab}	13.24 ± 0.41^{c}
TOB	31.75 ± 1.00^{c}	35.75 ± 0.50^{c}	14.79 ± 0.21^{b}
Pavidji	31.50 ± 0.50^{c}	35.50 ± 0.57^{c}	16.07 ± 0.31^{a}
F(9,50)	14.85***	19.57***	111.62***

*** p<0,0001. FL: Fiduciary Limit. For the same column, means with the same letter do not differ significantly according to Tukey's test at the 5% level.

Insecticidal efficacy of the different extracts on *C. maculatus*

The insecticidal effect of the extracts of *C. mimosoides* at different concentrations is illustrated in the Table 4. Exposure to the different extracts caused mortality of *C. maculatus* on the different varieties of *V. unguiculata* depending on the time and dose of administration (Table 4). At 1-day of exposure at the dose of 5 g/kg, maximum mortality rates of 100, 24, 3 % were recorded for the hexane, acetone and methanol extracts respectively. This illustrates that the hexane extract was more effective than the methanol and acetone extracts on all varieties tested. On the other hand, at the minimal dose of 5g/kg of hexane extract at 3 days of exposure, 100% mortality of *C. maculatus* was observed only on the variety Lorie while this rate was reached only after 6 days of exposure and at the same dose for the other varieties. Similarly, the variety PAV also obtained low mortality rates of *C. maculatus* compared to the varieties TOB, KI for the same products and at the same dose. This shows that there is a relationship between the insecticidal effect of *C. mimosoides* and the cowpea variety used. These results could be explained by the presence in the extracts of secondary plant metabolites responsible for various activities among which insecticidal properties[50].

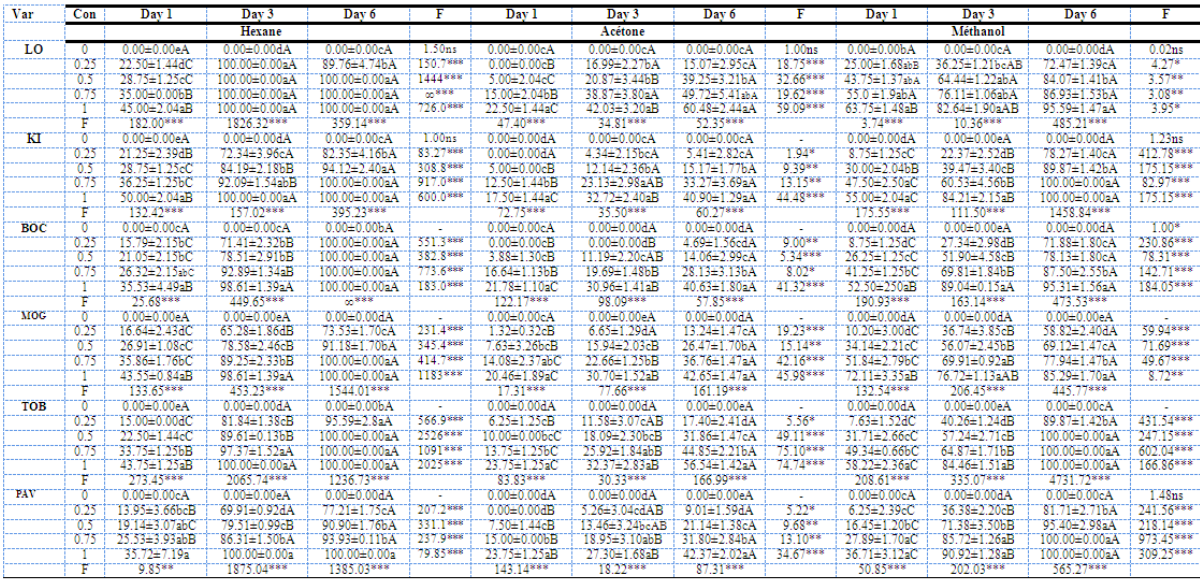
Effect of extracts on inhibition of F1 progeny of *C. maculatus*and mass losses of cowpeas during storage.

All extracts of *C. mimosoides* inhibited the production of F1 progeny of *C. maculatus*. This inhibition varied with the extract and the dose used(Table 5). The hexane extract was more effective in reducing the progeny of *C. maculatus*. Indeed, for these extracts, a complete reduction of the following progeny of *C. maculatus* was recorded at the minimum dose of 5 g/kg on all *V. unguiculata* varieties. However, the acetone extract was the least effective. Regarding mass loss of cowpeas, the results illustrated in Table 6 showed that the extracts significantly reduced the percentage of seed mass loss after three months of storage.

Physicochemical characteristics of seeds treated with extracts

The physicochemical characteristics of previously treated cowpea seeds are presented in Table7. We observed that there is no significant difference (P> 0.05) between the treated seeds and the control seeds for all the evaluated parameters. The ash, protein, total sugar and lipid contents vary respectively between 4.03 (TOB, Control) to 5.01 (Lorie, Acetone); 22.54 (Lorie, Control) to 25.75 (Bocolo, Control); 1.59 (Lori, Acetone) to 3.59 (Mogonou, Control) and 58.13 (Bocolo, Control) to 63.06 (TOB, Hexane). We can thus say that the treatment of the seeds with the extracts does not modify the physicochemical characteristics of cowpeas. However, we observed an increase in the content of anti-nutritional factors regardless of the variety studied.

Table 4: Cumulative mortality of *C. maculatus* on different varieties of cowpea after treatment by *C. mimosoides* extracts



Var	Con	Day 1	Day 3	Day 6	F	Day 1	Day 3	Day 6	F	Day 1	Day 3	Day 6	F
			Hexane				Acétone				Méthanol		
LO	0	0.00±0.00eA	0.00±0.00dA	0.00±0.00cA	1.50ns	0.00±0.00cA	0.00±0.00cA	0.00±0.00cA	1.00ns	0.00±0.00bA	0.00±0.00cA	0.00±0.00dA	0.02ns
	0.25	22.50±1.44dC	100.00±0.00aA	89.76±4.74bA	150.7***	0.00±0.00cB	16.99±2.27bA	15.07±2.95cA	18.75***	25.00±1.68abB	36.25±1.21bcAB	72.47±1.39cA	4.27*
	0.5	28.75±1.25cC	100.00±0.00aA	100.00±0.00aA	1444***	5.00±2.04cC	20.87±3.44bB	39.25±3.21bA	32.66***	43.75±1.37abA	64.44±1.22abA	84.07±1.41bA	3.57**
	0.75	35.00±0.00bB	100.00±0.00aA	100.00±0.00aA	∞***	15.00±2.04bB	38.87±3.80aA	49.72±5.41abA	19.62***	55.0 ±1.9abA	76.11±1.06abA	86.93±1.53bA	3.08**
	1	45.00±2.04aB	100.00±0.00aA	100.00±0.00aA	726.0***	22.50±1.44aC	42.03±3.20aB	60.48±2.44aA	59.09***	63.75±1.48aB	82.64±1.90aAB	95.59±1.47aA	3.95*
	F	182.00***	1826.32***	359.14***		47.40***	34.81***	52.35***		3.74***	10.36***	485.21***	
KI	0	0.00±0.00eA	0.00±0.00dA	0.00±0.00cA	1.00ns	0.00±0.00dA	0.00±0.00cA	0.00±0.00cA	-	0.00±0.00dA	0.00±0.00eA	0.00±0.00dA	1.23ns
	0.25	21.25±2.39dB	72.34±3.96cA	82.35±4.16bA	83.27***	0.00±0.00dA	4.34±2.15bcA	5.41±2.82cA	1.94*	8.75±1.25cC	22.37±2.52dB	78.27±1.40cA	412.78***
	0.5	28.75±1.25cC	84.19±2.18bB	94.12±2.40aA	308.8***	5.00±0.00cB	12.14±2.36bA	15.17±1.77bA	9.39**	30.00±2.04bB	39.47±3.40cB	89.87±1.42bA	175.15***
	0.75	36.25±1.25bC	92.09±1.54abB	100.00±0.00aA	917.0***	12.50±1.44bB	23.13±2.98aAB	33.27±3.69aA	13.15**	47.50±2.50aC	60.53±4.56bB	100.00±0.00aA	82.97***
	1	50.00±2.04aB	100.00±0.00aA	100.00±0.00aA	600.0***	17.50±1.44aC	32.72±2.40aB	40.90±1.29aA	44.48***	55.00±2.04aC	84.21±2.15aB	100.00±0.00aA	175.15***
	F	132.42***	157.02***	395.23***		72.75***	35.50***	60.27***		175.55***	111.50***	1458.84***	
BOC	0	0.00±0.00cA	0.00±0.00cA	0.00±0.00bA	-	0.00±0.00cA	0.00±0.00dA	0.00±0.00dA	-	0.00±0.00dA	0.00±0.00eA	0.00±0.00dA	1.00*
	0.25	15.79±2.15bC	71.41±2.32bB	100.00±0.00aA	551.3***	0.00±0.00cB	0.00±0.00dB	4.69±1.56cdA	9.00**	8.75±1.25dC	27.34±2.98dB	71.88±1.80cA	230.86***
	0.5	21.05±2.15bC	78.51±2.91bB	100.00±0.00aA	382.8***	3.88±1.30cB	11.19±2.20cAB	14.06±2.99cA	5.34***	26.25±1.25cC	51.90±4.58cB	78.13±1.80cA	78.31***
	0.75	26.32±2.15abC	92.89±1.34aB	100.00±0.00aA	773.6***	16.64±1.13bB	19.69±1.48bB	28.13±3.13bA	8.02*	41.25±1.25bC	69.81±1.84bB	87.50±2.55bA	142.71***
	1	35.53±4.49aB	98.61±1.39aA	100.00±0.00aA	183.0***	21.78±1.10aC	30.96±1.41aB	40.63±1.80aA	41.32***	52.50±250aB	89.04±0.15aA	95.31±1.56aA	184.05***
	F	25.68***	449.65***	∞***		122.17***	98.09***	57.85***		190.93***	163.14***	473.53***	
MOG	0	0.00±0.00eA	0.00±0.00eA	0.00±0.00dA	-	0.00±0.00cA	0.00±0.00eA	0.00±0.00dA	-	0.00±0.00dA	0.00±0.00dA	0.00±0.00eA	-
	0.25	16.64±2.43dC	65.28±1.86dB	73.53±1.70cA	231.4***	1.32±0.32cB	6.65±1.29dA	13.24±1.47cA	19.23***	10.20±3.00dC	36.74±3.85cB	58.82±2.40dA	59.94***
	0.5	26.91±1.08cC	78.58±2.46cB	91.18±1.70bA	345.4***	7.63±3.26bcB	15.94±2.03cB	26.47±1.70bA	15.14**	34.14±2.21cC	56.07±2.45bB	69.12±1.47cA	71.69***
	0.75	35.86±1.76bC	89.25±2.33bB	100.00±0.00aA	414.7***	14.08±2.37abC	22.66±1.25bB	36.76±1.47aA	42.16***	51.84±2.79bC	69.91±0.92aB	77.94±1.47bA	49.67***
	1	43.55±0.84aB	98.61±1.39aA	100.00±0.00aA	1183***	20.46±1.89aC	30.70±1.52aB	42.65±1.47aA	45.98***	72.11±3.35aB	76.72±1.13aAB	85.29±1.70aA	8.72**
	F	133.65***	453.23***	1544.01***		17.31***	77.66***	161.19***		132.54***	206.45***	445.77***	
TOB	0	0.00±0.00eA	0.00±0.00dA	0.00±0.00bA	-	0.00±0.00dA	0.00±0.00dA	0.00±0.00eA	-	0.00±0.00dA	0.00±0.00eA	0.00±0.00cA	-
	0.25	15.00±0.00dC	81.84±1.38cB	95.59±2.8aA	566.9***	6.25±1.25cB	11.58±3.07cAB	17.40±2.41dA	5.56*	7.63±1.52dC	40.26±1.24dB	89.87±1.42bA	431.54***
	0.5	22.50±1.44cC	89.61±0.13bB	100.00±0.00aA	2526***	10.00±0.00bcC	18.09±2.30bcB	31.86±1.47cA	49.11***	31.71±2.66cC	57.24±2.71cB	100.00±0.00aA	247.15***
	0.75	33.75±1.25bB	97.37±1.52aA	100.00±0.00aA	1091***	13.75±1.25bC	25.92±1.84abB	44.85±2.21bA	75.10***	49.34±0.66bC	64.87±1.71bB	100.00±0.00aA	602.04***
	1	43.75±1.25aB	100.00±0.00aA	100.00±0.00aA	2025***	23.75±1.25aC	32.37±2.83aB	56.54±1.42aA	74.74***	58.22±2.36aC	84.46±1.51aB	100.00±0.00aA	166.86***
	F	273.45***	2065.74***	1236.73***		83.83***	30.33***	166.99***		208.61***	335.07***	4731.72***	
PAV	0	0.00±0.00cA	0.00±0.00eA	0.00±0.00dA	-	0.00±0.00dA	0.00±0.00dA	0.00±0.00eA	-	0.00±0.00cA	0.00±0.00dA	0.00±0.00cA	1.48ns
	0.25	13.95±3.66bcB	69.91±0.92dA	77.21±1.75cA	207.2***	0.00±0.00dB	5.26±3.04cdAB	9.01±1.59dA	5.22*	6.25±2.39cC	36.38±2.20cB	81.71±2.71bA	241.56***
	0.5	19.14±3.07abC	79.51±0.99cB	90.90±1.76bA	331.1***	7.50±1.44cB	13.46±3.24bcAB	21.14±1.38cA	9.68**	16.45±1.20bC	71.38±3.50bB	95.40±2.98aA	218.14***
	0.75	25.53±3.93abB	86.31±1.50bA	93.93±0.11bA	237.9***	15.00±0.00bB	18.95±3.10abB	31.80±2.84bA	13.10**	27.89±1.70aC	85.72±1.26aB	100.00±0.00aA	973.45***
	1	35.72±7.19a	100.00±0.00a	100.00±0.00a	79.85***	23.75±1.25aB	27.30±1.68aB	42.37±2.02aA	34.67***	36.71±3.12aC	90.92±1.28aB	100.00±0.00aA	309.25***
	F	9.85**	1875.04***	1385.03***		143.14***	18.22***	87.31***		50.85***	202.03***	565.27***	

ns p>0,05 ;** p<0,05 ;** p<0,001 ; *** p<0,0001; F: Fiduciary Limit. For the same column, means with the same letter do not differ significantly according to Tukey's test at the 5% level; Con: concentration

Table 5: Effect of different extracts on the production of the F1 progeny of C. maculatus on different varieties of cowpeas

Varieties	Concetration	Inhibition percentage		
		Hexaneextract	Acetoneextract	Methanolextract
LO	0	0.00±0.00^{b}	0.00±0.00^{a}	0.00±0.00^{a}
	0.25	100.00±0.00^{a}	29.29±4.77^{ab}	48.99±5.69^{b}
	0.5	100.00±0.00^{a}	77.23±4.67^{ab}	52.38±5.02^{b}
	0.75	100.00±0.00^{a}	87.23±4.67^{ab}	63.44±7.41^{b}
	1	100.00±0.00^{a}	93.52±5.88^{b}	100.00±0.00^{c}
	F	241.57***	4.21***	57.17***
KII	0	0.00±0.00^{b}	0.00±0.00^{a}	0.00±0.00^{a}
	0.25	100.00±0.00^{a}	11.43±8.48^{ab}	37.51±5.08^{b}
	0.5	100.00±0.00^{a}	22.49±8.95^{ab}	48.52±4.40^{bc}
	0.75	100.00±0.00^{a}	28.18±8.59^{ab}	55.91±4.71^{c}

	1	100.00 ± 0.00^{a}	35.13 ± 7.44^{b}	78.62 ± 3.55^{d}
	F	641.57***	3.44***	52.16***
BOC	0	0.00 ± 0.00^{b}	0.00 ± 0.00	0.00 ± 0.00^{a}
	0.25	100.00 ± 0.00^{a}	24.68 ± 10.41^{a}	46.27 ± 2.90^{b}
	0.5	100.00 ± 0.00^{a}	30.37 ± 12.01^{ab}	55.08 ± 3.42^{c}
	0.75	100.00 ± 0.00^{a}	42.34 ± 7.63^{ab}	71.74 ± 3.37^{c}
	1	100.00 ± 0.00^{a}	49.55 ± 11.62^{b}	83.97 ± 0.31^{d}
	F	541.57***	4.10***	164.28***
MOG	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.25	100.00 ± 0.00^{a}	16.37 ± 2.76^{b}	50.79 ± 2.84^{ab}
	0.5	100.00 ± 0.00^{a}	13.95 ± 2.15^{bc}	68.37 ± 3.36^{b}
	0.75	100.00 ± 0.00^{a}	20.93 ± 2.06^{cd}	75.85 ± 3.66^{c}
	1	100.00 ± 0.00^{a}	38.65 ± 2.98^{d}	83.96 ± 1.24^{d}
	F	841.57***	43.87***	163.56***
TOB	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.25	100.00 ± 0.00^{a}	24.81 ± 7.93^{ab}	42.76 ± 10.23^{a}
	0.5	100.00 ± 0.00^{a}	67.22 ± 3.71^{b}	64.800 ± 5.08^{bc}
	0.75	100.00 ± 0.00^{a}	76.53 ± 3.21^{c}	74.20 ± 4.07^{b}
	1	100.00 ± 0.00^{a}	86.85 ± 1.54^{d}	85.69 ± 1.82^{c}
	F	471.57***	70.50***	38.00***
PAV	0	0.00 ± 0.00^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.25	100.00 ± 0.00^{a}	18.88 ± 5.27^{a}	55.84 ± 3.70^{ab}
	0.5	100.00 ± 0.00^{a}	31.95 ± 4.35^{ab}	65.55 ± 4.35^{bc}
	0.75	100.00 ± 0.00^{a}	37.89 ± 4.13^{b}	74.48 ± 3.23^{c}
	1	100.00 ± 0.00^{a}	43.32 ± 3.28^{c}	79.58 ± 2.13^{d}
	F	413.57***	20.19***	108.21***

** p<0,05 ;** p<0,001 ; *** p<0,0001; F: Fiduciary Limit. For the same column, means with the same letter do not differ significantly according to Tukey's test at the 5% level; Con: concentration

Table 6: Percentage of mass loss of different varieties of cowpea after three months of storage treated with *C. mimosoides* extracts

Varieties	Concentration	Mass losses percentage		
		Hexane	Acetone	Methanol
LOR	0	44.64 ± 1.95^{a}	$57.56\pm1.50_{a}$	57.56 ± 1.50^{a}
	0.25	0.00 ± 0.00^{b}	$51.53\pm2.52_{a}$	21.33 ± 2.23^{b}
	0.5	0.00 ± 0.00^{b}	31.54 ± 3.49^{b}	12.38 ± 1.20^{c}
	0.75	0.00 ± 0.00^{b}	23.80 ± 1.47^{bc}	5.79 ± 1.94^{cd}
	1	0.00 ± 0.00^{b}	18.52 ± 1.52^{c}	0.00 ± 0.00^{d}
	F	526.67***	57.95***	208.13***
KII	0	59.24 ± 0.99^{a}	59.24 ± 0.99^{a}	59.24 ± 0.99^{a}
	0.25	0.00 ± 0.00^{b}	53.10 ± 3.18^{ab}	19.77 ± 3.18^{b}
	0.5	0.00 ± 0.00^{b}	45.47 ± 3.30^{bc}	12.97 ± 2.96^{bc}
	0.75	0.00 ± 0.00^{b}	36.24 ± 3.05^{cd}	2.76 ± 2.76^{cd}
	1	0.00 ± 0.00^{b}	28.62 ± 3.41^{d}	0.00 ± 0.00^{d}
	F	3567.26***	17.84***	103.79***
BOC	0	66.71 ± 1.08^{a}	85.94 ± 0.26^{a}	70.36 ± 2.22^{a}
	0.25	0.00 ± 0.00^{b}	83.87 ± 0.24^{a}	50.54 ± 0.23^{a}
	0.5	0.00 ± 0.00^{b}	76.52 ± 1.94^{b}	43.94 ± 1.94^{ab}
	0.75	0.00 ± 0.00^{b}	69.75 ± 2.79^{bc}	11.42 ± 0.17^{b}
	1	0.00 ± 0.00^{b}	62.64 ± 1.40^{c}	16.51 ± 16.51^{b}
	F	3815.13***	34.70***	10.65***
MOG	0	58.61 ± 1.61^{a}	62.02 ± 0.90^{a}	62.02 ± 0.90^{a}
	0.25	0.00 ± 0.00^{b}	57.45 ± 0.48^{a}	24.11 ± 0.48^{b}
	0.5	0.00 ± 0.00^{b}	51.27 ± 1.37^{b}	$17.93\pm1.\ 37^{c}$
	0.75	0.00 ± 0.00^{b}	46.49 ± 1.74^{b}	11.49 ± 1.74^{d}
	1	0.00 ± 0.00^{b}	40.20 ± 1.77^{c}	0.00 ± 0.00^{e}
	F	1319.77***	41.29***	466.89***
PAV	0	71.06 ± 1.91^{a}	81.84 ± 0.84^{a}	71.06 ± 1.91^{a}
	0.25	0.00 ± 0.00^{b}	74.78 ± 1.69^{b}	44.77 ± 2.24^{b}
	0.5	0.00 ± 0.00^{b}	68.43 ± 1.79^{bc}	34.26 ± 2.17^{c}
	0.75	0.00 ± 0.00^{b}	63.95 ± 1.57^{cd}	10.27 ± 0.73^{d}
	1	0.00 ± 0.00^{b}	$59.\ 33\pm1.29^{d}$	0.00 ± 0.00^{e}
	F	1376.91***	36.25***	286.40***
TOB	0	62.31 ± 2.24^{a}	78.21 ± 1.13^{a}	65.65 ± 2.20^{a}
	0.25	0.00 ± 0.00^{b}	75.80 ± 1.05^{ab}	42.46 ± 1.06^{b}
	0.5	0.00 ± 0.00^{b}	71.50 ± 1.55^{b}	27.34 ± 3.95^{c}
	0.75	0.00 ± 0.00^{b}	6.20 ± 0.81^{c}	0.00 ± 0.00^{d}
	1	0.00 ± 0.00^{b}	59.30 ± 1.15^{d}	0.00 ± 0.00^{d}
	F	772.87***	42.90***	185.22***

** p<0,05 ;** p<0,001 ; *** p<0,0001; F: Fiduciary Limit. For the same column, means with the same letter do not differ significantly according to Tukey's test at the 5% level; Con: concentration

Variety	Extracts	Content (Unit/100 g of dry matter)					
		Ash (g)	Proteins (g)	Lipids (g)	Sugar (g)	TPC (mg)	Tannins (g)
Lorie	Control	4.33±0.18	22.54±0.15	2.68±0.32	60.00±0.10	212.51±1.24	2.23±0.24
	Hexane	4.38±0.78	25.44±1.53	2.39±0.22	60.40±1.33	-	-
	Acetone	5.01±0.01	25.54±0.27	1.59±0.28	61.09±0.10	454.25±1.21	46.78±1.74
	Methanol	4.65±0.24	25.49±0.09	2.30±0.12	60.44±0.027	466.75±1.14	49.45±2.23
	F(3,12)	1.00ns	0.013ns	10.17ns	1.36ns		
Mogonou	Control	4.05±0.20	24.37±0.48	3.59±0.42	60.57±0.70	144.5±2.14	3.12±0.24
	Hexane	4.12±0.23	24.16±0.24	3.11±0.10	61.26±0.67	-	-
	Acetone	4.25±0.25	24.16±0.09	2.96±0.51	61.41±0.99	354.45±1.75	50.12±1.23
	Methanol	4.98±0.45	23.04±1.72	2.96±0.51	62.53±1.30	365.14±1.23	50.43±2.21
	F(3,12)	0.01ns	1.33ns	1.522ns	2.182ns		
Bocolo	Control	4.85±0.45	25.75±0.57	2.32±0.19	61.47±0.58	134,5±1.42	4.12±1.74
	Hexane	4.98±0.25	24.19±0.62	3.14±0.61	61.21±0.91	-	-
	Acetone	5.01±0.54	24.91±0.47	2.23±0.34	61.40±0.39	375.14±1.24	50.45±2.45
	Methanol	4.89±0.12	24.43±0.31	2.98±0.20	58.13±0.32	332.12±2.21	52.51±5.12
	F(3,12)	0.00ns	1.182ns	63.811	21.88ns		
TOB	Control	4.03±0.11	23.26±0.64	2.59±0.88	62.70±1.14	18.21±2.12	4.13±1.21
	Hexane	4.98±0.21	23.04±0.66	2.44±0.77	63.06±0.61	-	-
	Acetone	4.78±0.36	22.99±0.69	2.82±0.40	62.73±0.44	245.45±2.14	48.78±1.23
	Methanol	4.98±038	23.72±0.09	2.63±0.58	61.86±0.48	265.41±1.85	49.25±3.15
	F(3,12)	1.185ns	0.993ns	0.163ns	1.471ns		

Table 7: Physicochemical characteristics of treated and untreated cowpea seeds

TPC: Total phenolic compounds; n.s.: not significant (P >0,05); -: Absent

Organoleptic properties of the derived products

The sensory analysis data on the cooked form show that the incorporation of extracts on the cowpeas have an impact on the sensory characteristics of the derived products compared to the control (Figure 1). The test of Friedman shows us in general a significant difference (F > 9.49 at 5%) between the treated forms and the control product with a better general acceptability for the control product resulting from the seeds not treated by the extracts(Table 8).

Table 8: Friedman constants of different sensory characteristics of the cooked form of cowpeas

Sensorycharacteristics	Cook	F	Observation
Sweet and salty sensation	253.66	9.49	Differents
Salty sensation	149.66	9.49	Differents
Bitter sensation	122.66	9.49	Differents
Fragrant smell	71.66	9.49	Differents
Yellow color	194.66	9.49	Differents
Softness in the mouth	99.66	9.49	Differents
Preference	23.66	9.49	Differents

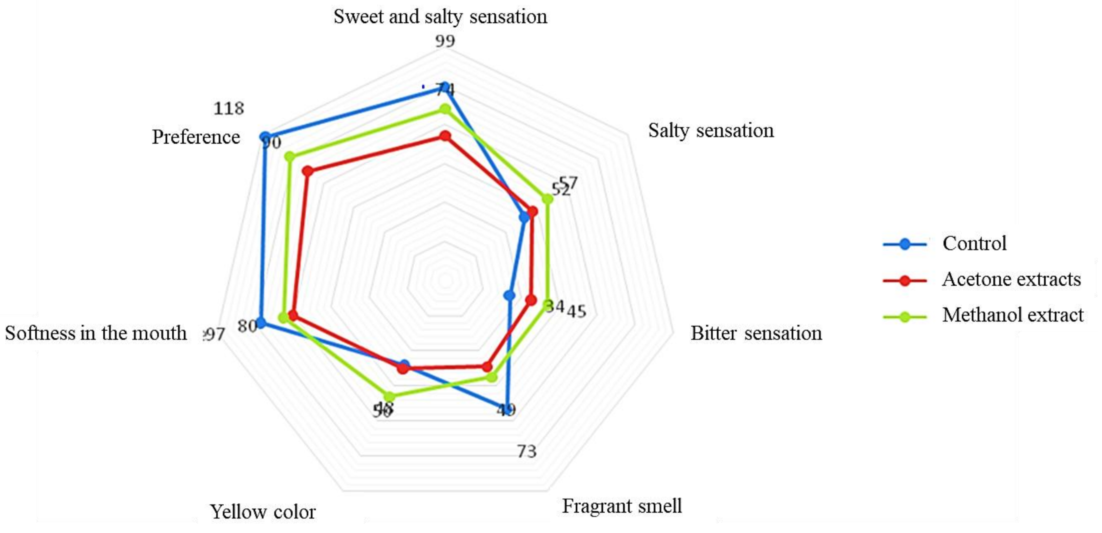


Figure 1: Sensory profile of cooked cowpea treated with *C. mimosoides* extracts and untreated

IV. Discussion

Phytochemical screening was carried out that acetone and methanol extracts contained seven compounds such as total phenolics, flavonoids, tannins, alkaloids, coumarin and saponins whereas the hexane extract contained only three types of compounds including triterpenes, sterols and saponins. The presence of these compounds in these extracts could be explained by the fact that plants synthesize during their growth aromatic compounds or secondary metabolites that are involved in many physiological processes such as cell growth, rhizogenesis, seed germination, fruit ripening, defense against external aggression[37]. The absence of some compounds in the hexane extract could be explained by the fact that hexane is an apolar solvent and therefore could not bind some polar compounds. Similarly, the presence of triterpenes in the methanol extracts can be explained by the fact that some polar compounds are associated in their structures with apolar compounds such as triterpenes.

The susceptibility index of these varieties to *C. maculatus* attack varied from 7.9 (Lorie) to 16.1 (Pavidji). These results allow us to distinguish two groups according to the susceptibility profile: a group with a susceptibility indexes 8–10.9 which significantly inhibited oviposition and reduced the rate of emergence of *C. maculatus* including the variety Lorie and another group with a very low susceptibility to *C. maculatus* attack with an index higher than 11 which weakly inhibited the reproductive activity of *C. maculatus* and the varieties involved included Bocolo, Mogonou, Tobourou, KI and Pavidji. These observations could be due to either the physical nature of the seeds such as texture, hardness, geometric surface, sphericity of the seeds. Regarding hardness, it is attributed to the water content of the seeds and the higher it is, the more the average development time and cycle length are delayed[38].

Thus, the high-water content obtained in some varieties could explain these higher resistance results in Lorie than in other varieties of *V. unguiculata*. Kouninki*et al.*[39] on the other hand mention that these resistance factors are much more related to the biochemical nature and physicochemical characteristics of the variety. These authors illustrate a high content of antitrypsin factors (> 0.8%) within resistant varieties compared to that present in susceptible varieties (< 0.5%). This resistance results in inhibition of larval development without affecting either egg production or larval penetration into seeds. The values obtained compared to those in the literature could also be due to the strain used. Indeed, Jackai and Asante[46] reported that parameters such as fecundity, adult emergence, duration and an average time of development and susceptibility index are probably the factors that give a strain its infestation power.

Our results are similar to those obtained by Kossini*et al.* [47]Kouninki*et al.* [39] who respectively showed that the nature of a variety influences the development of bruchids. Similarly, the work of Moumouni*et al.*,[4 8] which showed a difference in susceptibility in terms of variety to the development of bruchidae. These results differ from those obtained by Attachi*et al.*,[49] who showed by comparing the biological parameters of this insect from different combinations of factors related to three thermo-hygrometric conditions (32 °C and 60% R.H., 27 °C and 70% R.H. and 23 °C and 80% R.H.), four food substrates (cowpeas (*Vigna unguiculata* (L.) Walp.) and *Cassia occidentalis* grains and pods) and two strains of *C. maculatus*, showed that only the cowpea grain substrate resulted in a significant increase in net reproductive rate and intrinsic population growth rate.

The insecticidal effect of the extracts of *C. mimosoides*revealed that there is a relationship between the insecticidal effect of *C. mimosoides* and the cowpea variety used. These results could be explained by the presence in the extracts of secondary plant metabolites responsible for various activities among which insecticidal properties[50].The difference in mortality observed between the different extracts could be explained by the nature of the compounds and chemical groups present in each extract, the nature depending on the solubility of the molecules which is related to the polarity of the solvent used Mahmoudi*et al.*[48]. The high mortality rates observed for the hexane extracts could be explained by the nature of the bioactive compounds present in these extracts, on the one hand, but also to the level of sensitivity of the insects to these compounds[40]. Our results are similar to those obtained by Tapondjou*et al.* [14]Kossini*et al.* [47] who respectively showed a high mortality of *C. maculatus* exposed to *Eucalyptus saligna* oils, a high mortality of *Sitophilus zeamais* facing *Eucalyptus saligna*essential oils and a high mortality of *C. maculatus* which increased with increasing dose and exposure period with the hexane extract of *G. kaussiana* compared to the acetone and methanol extracts.

Indeed, the phytochemical tests evaluated reveal that the hexane extracts of *C. mimosoides* leaves contain more terpene compounds than the other extracts and could therefore justify the high mortality observed in these hexane extracts. In the same way, the works carried out by Ojimelukwe[51], Tapondjou*et al.* [14] revealed a strong mortality towards *Triboliumconfusum, T. castaneum, Sitophilus zeamais, Prostephanustruncatus, Rhyzopertadominica* and *Callosobruchus* due to the terpene compounds of the essential oils. On the contrary, Adeniyi *et al.*[52] obtained a high mortality of *Acanthoscelidesobtectus* in ethanolic extracts.

On the other hand, alkaloids, saponins, steroids, phenolic compounds and tannins predominantly present in acetone and methanol extracts act much more as antinutrients preventing nutrient assimilation[41], while terpene compounds contained in large quantities in hexane extracts exert toxicity at the level of the nervous system, disrupting the exchange of sodium and potassium ions leading to the direct death of the insect [42; 43]. In this study, we observe an increase in the mortality rate with time and dose of administration, which would be related to the increase in contact time as well as the quantity of the active ingredients. Regarding the variety, the differences in mortality recorded could be explained by the physical characteristics of the seeds. It has been shown by several authors that insecticide products are more effective on large and smooth seeds than on small and rough seeds which do not allow a good distribution of the products on the seeds. This explains the high mortality recorded in the Lorie variety compared to the other varieties. The values of the lethal dose 50 (LD_{50}) vary with the extracts and decrease with the increase of the exposure period. At one day of exposure, the LD_{50} values ranged from 1.20 (KI) to 2.40 (PAV), 1.58 (KI) to 3.99 (PAV), and 0.64 (KI) to 0.148 (PAV) for Cassia extracted with hexane, acetone and methanol respectively while, after 6 days of exposure the maximum values recorded were 0.17 (Hexane), 1.19 (Acetone), 0.18 (Methanol). The variability of LD_{50} would be related to the variety of cowpea and the insecticidal potential of the extracts. For example, the variety KI keeps the low values of LD_{50} while, the variety PAV exhibited the highest values.

All extracts of *C. mimosoides* inhibited the production of F1 progeny of *C. maculatus*. Regnault*et al.*, [44] obtained similar results and explained that this could be related to the chemical composition, especially the presence of terpene compounds which would have ovicidal and larvicidal activity at the neonatal stage. Similar results were obtained by Thiaw*et al.*[53] who observed a reduction in the progeny of *Caryedon serratus* on *V.subterranea*treated with *C. occidentalis* and *Calotropis procera* powders. Similarly, the work of Kossini*et al*.[47] revealed a significant reduction in the progeny of *C. maculatus* on seeds treated with *Ocimumcanum* and *Gnidiakaussiana* extracts. The work of Keita[54] and Tapondjou*et al*.[14] also showed a complete reduction of immature stages of *C. maculatus* exposed to *T. occidentalis*essential oils. In contrast, Agnes *et al*.[55] also showed that acetone extract of *Callistemon rigidus* was less effective in controlling the progeny of *Acanthoscelidesobtectus*.

On the other hand, the reduction of the progeny induced by acetone and methanol extracts would be due to the presence in the extracts and in the seeds of anti-nutritional substances such as tannins, phytates, phenolic compounds that complex the availability of nutrients necessary for the feeding of immature stages of *C. maculatus*. On the other hand, authors have mentioned that legumes possess anti-nutritional factors that confer to these seeds a certain natural resistance to pest attack[56]

These results are also in agreement with those of Rajasekaran and Kumaraswami[45]who reported that seeds treated with plant extracts significantly reduced the subsequent progeny of *Sitophilus oryzae*. Regarding mass loss of cowpeas, the results show that the extracts significantly reduced the percentage of seed mass loss after three months of storage. Similar results were obtained by Nukenine*et al.* [12] who obtained significant reduction in the rates of damaged seeds and mass losses of maize seeds treated with *Azadirachta indica* and *Plectranthusglandulosus* powders against *S.zeamais*.

The hexane extracts were more effective and reduced to 100% seed mass loss at the minimum dose of 5 g/kg followed by methanol extract with 100% mass loss reduction at the dose of 15 g/kg on *V. unguiculata*. On the other hand, the acetone extracts recorded a seed protection of 22.49 to 59.46% at the maximum dose of 20 g/kg whatever the variety used. These results could be explained by the feeding behavior of the pest which consumes the food directly. In general, the reduction of damaged seeds and the losses in mass are explained by the presence of metabolites responsible for the insecticidal activity.

Concerning the physicochemical characteristics of the cowpea variety, the ash contents are in agreement with those reported by Mazahid*et al.* [57] who obtained average contents of 3.25% with voandzou seeds from Sudan. The same is true for Amartiefio*et al*.[58] and Abiodum*et al*.[59] who reported contents between 3.57 g/100 g and 4.85 g/100 g of dry matter for seeds originating from Namibia, Swaziland and Nigeria. But these contents are different from those obtained by Diallo Koffi*et al.* [60] who obtained low values ranging from 2.5 to 2.9. According to Amarteifio*et al.* [61] this difference in ash contents could be explained by soil texture and composition which would affect plant mineral uptake and varietal differences. The lipid content results obtained are similar to the values obtained by Boateng, *et al*.[62]. These authors showed that legume seeds, with the exception of soya beans and peanuts, generally contain little lipids. However, the contents obtained are higher than those reported by Abiodun and Adepeju[63]. The total carbohydrate content is in agreement with that reported by Boateng *et al*.[62] and Mazahib[57] obtaining the values range from 54 to 65% DM. These observed differences between the results can be attributed to varietal properties, and environmental conditions of their cultivation[61; 64]. The protein content values are different from those reported by Amartiefio*et al*.[58] This difference would be due to genotypes and environmental growing conditions[64]. The content of total phenolic compounds and tannins increased from 212.51 mg/100 g of dry matter (DM) to 466.75mg/100g and from 2.23 mg/100 g of DM to 49.45mg/100 g of DM for the variety Lorie. This increase would be due to the presence in the extracts of these secondary metabolites (Table 2). However, these contents are low compared to the values that can alter the bioavailability of nutrients in these seeds which are 2700mg/100g for phenolic compounds and 2000mg/kg for tannins[65]. Collinaw[16] showed that some treatments like soaking, cooking significantly reduce the content of these anti-nutritional factors.

The sensorial profile analyses revealed that extraction using organic solvant modify the odor, the color, increase the bitterness, on the one hand, on the other hand, decreases the salty taste and the tenderness of the formulated derived products compared to the control product. Similar observations were reported by Rose de Lina *et al.*[66] ho indicated that the use of essential oils significantly influenced the smell and taste of preserved cowpea samples. However, there was a conservation of the sweet-salty flavor in both products which could be related to the presence of some aromatic compounds in the extracts. In general, the modification of the organoleptic characteristics in this study would be related to the chemical composition of the extracts previously incorporated characterized by the presence of metabolites such as tannins, saponins which would increase the bitterness of the treated products compared to the control product.

V. Conclusion

Cassia mimosoides extracts have proven insecticidal properties to control *C. maculatus* during cowpea storage. These extracts contain a wide range of compounds that are responsible for insecticidal activities. The interaction variety of insecticidal properties would be interesting. These extracts do not significantly affect the nutritional quality of the derived products and improve the sensory characteristics, especially the aroma of the treated products. They could therefore constitute an efficient alternative in cowpea preservation, replacing chemical insecticides, which are not without consequences on consumer health.

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