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Tagne Gabriel Fotso
Department of Biological Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon

Elias Nchiwan Nukenine
Department of Biological Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon

Rigobert Tchameni
Department of Earth Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon

Jean Wini Goudoungou
Department of Biological Sciences, Faculty of Science, University of Bamenda, P.O. Box 39, Bambili, Cameroon

Daniel Kosini
School of Health Sciences, Catholic University Institute of Saint-Jérôme, P.O. Box 5949, Douala, Cameroon

Vandi Tigamba
Department of Biological Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon

Cornel Adler
Julius Kühn-Institut, Institute for Ecological Chemistry, Plant Analysis and Stored Products Protection, Königin-Luise Str.19, D-14195 Berlin, Germany

Correspondence
Elias Nchiwan Nukenine
Department of Biological Sciences, University of Ngaoundere, P.O. Box 454, Ngaoundere, Cameroon

Use of Cameroonian *Hemizygia welwitschii* Rolfe-Ashby (Lamiaceae) leaf powder against *Callosobruchus maculatus* and *Sitophilus zeamais*

Tagne Gabriel Fotso, Elias Nchiwan Nukenine, Rigobert Tchameni, Jean Wini Goudoungou, Daniel Kosini, Vandi Tigamba and Cornel Adler

Abstract
Biological investigations were conducted at the laboratory of Applied Zoology, University of Ngaoundere, Adamawa Region between August 2016 to March 2017. The aim of this research was to evaluate the insecticidal and protectant efficacy of Cameroonian *Hemizygia welwitschii* leaf powder against *Callosobruchus maculatus* and *Sitophilus Zeamais* and germination ability of treated seeds. Cowpea or maize were admixed with the plant powder at the rates of 5, 10, 20 and 40 g/kg and commercial SilicoSec at 0.5, 1, 1.5 and 2 g/kg grains. At 40 g/kg, *H. welwitschii* caused to *C. maculatus* (82.50%) and *S. zeamais* (81.25%) adults similar mortality at 7 and 14 days after exposure respectively, while the mortality caused by SilicoSec at 2 g/kg was 100% for the both insects. Furthermore, significant reductions of insect growth and grain damage were recorded. Seed's ability to germinate was not affected by the product at the term of storage. Our findings revealed the insecticidal potential of *H. welwitschii* powder against *C. maculatus* and *S. zeamais.*

Keywords: *Callosobruchus maculatus*, *Sitophilus zeamais*, *Hemizygia welwitschii* leaf powder, insecticide

1. Introduction

The aim of agriculture is to provide food and nutrition security for the population. One of the most important constraints of having every day sufficient food is the post-harvest preservation of its quality and quantity [1]. Subsistence farmers comprise some of the poorest and marginalized people across Africa and also the most vulnerable to malnutrition. Their principal needs are simple: food security in terms of production and storage. In the Sahel, cereals and legumes are the staple food of the population [2]. World cowpea and maize production is increasing each year to meet the rising demand for food [3]. In sub-Saharan African countries where crop production is done only within the wet season [4], storage is a matter of survival. Unfortunately, during storage, pulses or cereals are heavily damaged by insect pests, especially the cowpea weevil, *Callosobruchus maculatus* F. (Coleoptera: Chrysomelidae, Bruchinae) and the maize weevil, *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) [5]. Various techniques and control methods have been developed and more are still being developed to reduce serious losses during storage. Among them, chemical insecticides were extremely used in controlling of cowpea and maize weevils. These chemical insecticides have negative impact on the environment, humans and non-target organisms. Due to these disadvantages of synthetic pesticides, small scale farmers are more inclined to use traditional approaches to protect their grains. This underscores the importance of search for alternative anti-weevil measures such as the use of plant derived to natural pesticides for grain storage since they would be readily available, affordable, relatively less toxic and detrimental to humans and the environment [6]. Plant materials are widely reported for their efficacy as insecticides, but with the dominance of essential oils, pure compounds or solvent extracts [7] which are not easily practicable for small farm families. In this context, several plant powders, also called insecticides of plant origin or botanical insecticides, have been tested and considered promising in the control of cowpea and maize beetles [5, 8]. Search for new insecticides derived from plants is ongoing. From available literature in the field, no scientific publication reporting *H. welwitschii* leaf powder as insecticide against stored grains pests was found. However, the volatile and repellent effect of *H. welwitschii* essential oil and its formulations were effective against mosquitoes [9]. This investigation aimed to study the efficacy of *H. welwitschii* leaf powder in the control of *C. maculatus* and *S. zeamais* respectively on cowpea and maize grains during storage.

2. Materials and methods

2.1 Commodities

Grains of cowpea and maize were collected from the Institute of Agricultural Research for Development (IRAD), Maroua and Ngaoundere stations (Cameroon) respectively in August 2016. The cowpea variety used was ''Lori'', a most susceptible variety to weevils, and used maize variety was ''Shaba'', the composite mostly cultivated by Adamawa farmers. Grains were thoroughly cleaned to remove kernels with visible damage symptom and disinfested by keeping the grains in a freezer at -18 °C for one month. The grains were kept in ambient conditions of laboratory for two weeks to allow its acclimatization before using for bioassays. The grains moisture contents were 9.88% and 11.65% for cowpea and maize, respectively.

2.2 Insect cultures

Adults of *C. maculatus* and *S. zeamais* were obtained from infested cowpea and maize bought from Ngaoundere market, Adamawa Region. Insects were thereafter mass reared on whole clean, undamaged and disinfested cowpea or maize in 5 L plastic jars. This was done by weighing 4 kg of the cowpea or maize grains into clean plastic jars. Samples were infested with 200 mixed sex adults of *C. maculatus* or *S. zeamais* and kept in the laboratory for mass culture. This culture was maintained and used as source of *C. maculatus* or *S. zeamais* for all bioassays. All insects of mixed sex needed for these experiments were not more than 2 days old for *C. maculatus* and 14 days old for *S. zeamais*. All the experiments were arranged in a completely randomized design with four replications.

2.3 Insecticidal materials

Collection and preparation of *Hemizygia welwitschii* powder

Fresh leaves of *H. welwitschii* were collected around the University of Ngaoundere in the Vina Division, Adamawa region of Cameroon between August and November 2016 and shed-dried at the room temperature for five days until they became crisp dry. The identification of the plant was confirmed at the Cameroon National Herbarium in Yaounde, where voucher specimen (Serial number: 6910/SRFK) was kept. The dried leaves were hands crushed into powder using pestle and moctar and sieved to obtain fine powders. The particle size of powder was ≤ 200 µm. Powder were stored in a deep-freezer at the temperature of -4°C until needed for bioassay.

Diatomaceous earth (SilicoSec)

The commercial insecticide, SilicoSec which is a diatomaceous earth formulation containing 92% SiO_2, 3% Al_2O_3, 1% Fe_2O_3 and 1% Na_2O and the average particle size between 8-12 µm [10]. It was obtained from Agrinosa Company-Biofa (Münsingen, Germany). The application rates used were 0.5, 1, 1.5 and 2 g/kg [11, 12].

2.4 Adult mortality and F_1 progeny production tests

Adult mortality and F_1 progeny production tests were carried out under the laboratory conditions (t ≈ 18.50 – 31.50°C; r.h. ≈ 21.00 – 66.50%). The quantities of 0.25, 0.5, 1 and 2 g of *H. welwitschii* powder and 0.025, 0.05, 0.075 and 0.1 g of SilicoSec (positive control) were separately introduced into 50 g of cowpea or maize in 500 mL glass jars corresponding to 5, 10, 20 and 40 g/kg for plant powder and 0.5, 1, 1.5 and 2 g/kg for SilicoSec [11, 12]. These doses of *H. welwitschii* powder were defined after a preliminary test. Negative control consisted of grains without insecticidal materials. All the jars, except the control were hand-shaken for about two minutes to ensure uniform distribution of the powders to the entire grain mass. A group of 20 *C. maculatus* or *S. zeamais* adults were added to each glass jar containing treated or untreated cowpea and maize, respectively. Each jar was then covered with cotton clothes and closed with a perforated metal lid for sufficient ventilation. Insects in each jar were sieved to count the number of live and dead after 1, 3, 5 and 7 days (*C. maculatus*) or 1, 3, 7 and 14 days (*S. zeamais*) of treatment. Insects were considered dead when no movement was observed after touching them with forceps four times within two or three minutes.

After 7 days (*C. maculatus*) or 14 days (*S. zeamais*) mortality recording, insects and powders were separated from the grains and discarded. Then, the treated and untreated grains were stored under the same experimental conditions until the F_1 progeny emergence. The emerged *C. maculatus* or *S. zeamais* adults in each glass jar were counted every week for 4 (*C. maculatus*) or 5 (*S. zeamais*) consecutive weeks. The inhibition rate (%IR) was calculated as follows:

$$\%IR = \frac{(Cn - Tn)}{Cn} \text{ x } 100$$

where, Cn is the number of newly emerged insects in the untreated jar and Tn is the number of insects in the treated jar.

2.5 Population increase and grain damage

Similar doses of *H. welwitschii* leaf powder and SilicoSec as for adult mortality described above were considered for 150 g grains of cowpea or maize to assess population increase and grain damage. A group of 30 adult insects were introduced into each glass jar containing treated or untreated grains. Each treatment was replicated four times. After three months of storage, the numbers of live and dead insects were determined for each jar. Seed damage assessment was performed by counting the damaged and undamaged grains. Percentage of seed damaged was calculated using the following formula:

$$\text{Seed damage} = \frac{\text{Number of seed damge x 100}}{\text{Total number of seeds}}$$

2.6 Seeds germination test

After separation of damaged and undamaged seeds, 20 seeds were taken randomly from the undamaged ones of each treatment (Section 2.5). The seeds were placed in moistened sand in perforated plastic plates. Each treatment was replicated four times. Germination was evaluated and recorded after 10 days [13, 14]. Data were recorded and computed for the percentage of seed germination according the following formula:

$$\%\text{ seed germination} = \frac{\text{number of germinated seed}}{\text{Total number of seed}} \text{ x } 100$$

2.7 Statistical analysis

Data on % cumulative mortality, % reduction of F_1 progeny, % damaged grains and % of germination was subjected to the ANOVA procedure using the Statistical Package for the Social Science (SPSS 16.0). Turkey's test (P = 0.05) was applied for mean separation. A logarithmic transformation [log10(x+1), where x = content in %] was performed before regression analysis. Abbott's formula (Abbott 1925) was used to correct mortality when mortality in the control are comprised between 3% and 10% before ANOVA procedure. The graphs were realized using the Sigmaplot 2000, version 11.0 software (Sigmaplot, 2008). Abbott's [15] formula was used to correct for control mortality before ANOVA.

3. Results

3.1 Adult *Callosobruchus maculatus* and *Sitophilus zeamais* mortality

The insecticidal activities of *H. welwitschii* powder and SilicoSec against *C. maculatus* and *S. zeamais* was represented in Fig. 1. Results showed that, plant powder and SilicoSec caused significant mortality which increased with increasing dosage and exposure period compared to the negative control. *H. welwitschii* achieved 8.75% of *C. maculatus* mortality within the first day of exposure at its highest dosage (40 g/kg) ($F_{(4, 15)}$ = 17.17; P < 0.001) while SilicoSec showed 45% mortality at its highest dosage (2 g/kg) ($F_{(4, 15)}$ = 458.25; P < 0.001) in the same exposure period. However, in maize treated with plant powder, adult's mortality of *S. zeamais* was 15% at its highest dosage of 40 g/kg ($F_{(4, 15)}$ = 35.25; P < 0.001), while SilicoSec (2 g/kg) caused 7.50% of *S. zeamais* adult's mortality ($F_{(4, 15)}$ = 14.57; P < 0.001). Maximum mortality (82.50%) was caused to *C. maculatus* by the highest content (40 g/kg) of *H. welwitschii* powder within 7 days after treatment while, complete mortality ($F_{(4, 15)}$ = 3124.25; P < 0.001) of *C. maculatus* was achieved by SilicoSec from 1g/kg, within 5 days after treatment. However the highest mortality (81.25%) of *S. zeamais* was induced by the plant powder at its highest content (40 g/kg) in 14 days of exposure ($F_{(4, 15)}$ = 641.20; P < 0.001), while the complete mortality was achieved by SilicoSec from 1g/kg within 7 days of exposure.

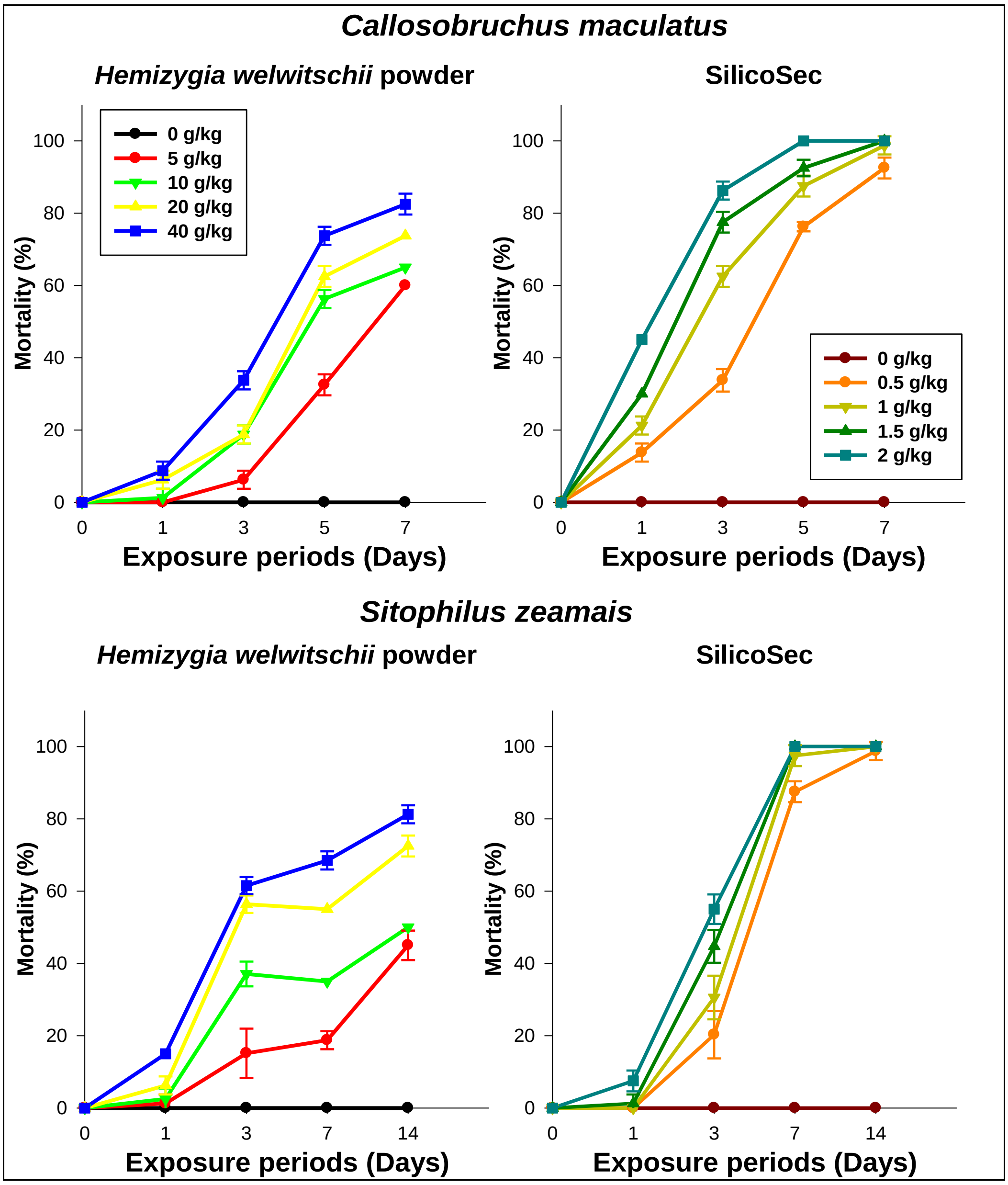

Fig 1: Corrected cumulative mortality of *Callosobruchus maculatus* and *Sitophilus zeamais* exposure to *Hemizygia welwitschii* leaf powder.

3.2 F_1 progeny production

H. welwitschii powder and SilicoSec generally caused for the both insect species significant reduction in progeny production at all doses relative to the negative control (Table 1). Adult emergence decreased when the product doses increased. At the lowest doses, the mean number of adult's *C. maculatus* observed in cowpea grains treated with *H. welwitschii* leaf powder (5 g/kg) was 13.25, while with SilicoSec (0.5 g/kg), the mean number of F_1 emerged was 9.00 adults. At the highest dosage (40 g/kg) of *H. welwitschii*, the number of emerged adults was 2.25, whereas no F_1 progeny was recorded in grain treated with highest content (2 g/kg) of SilicoSec. *H. welwitschii* at its highest dosage (40 g/kg) inhibited 96.47% *C. maculatus* adult emergence, while SilicoSec almost suppressed completely the F_1 progeny emergence even at the lower dosages compared to 67 *C. maculatus* emerged in negative control. However, at its lowest dosage (5 g/kg), the number of *S. zeamais* F_1 emergence in maize grains treated with *H. welwitschii* powder was 4 insects while SilicoSec at the lowest dosage of 0.5 g/kg completely suppressed the emergence of *S. zeamais* recorded as compared to 41.75 F_1 adult's *S. zeamais* emerged in the negative control. Complete inhibition of *S zeamais* progeny was recorded in the maize treated with plant powder (at its highest content of 40 g/kg) and SilicoSec at all its dosages.

Table 1: Progeny production of *Callosobruchus maculatus* and *Sitophilus zeamais* in grains treated with *Hemizygyia welwitschii* leaf powder and SilicoSec in the ambient laboratory conditions.

Products Contents (g/kg)	Insects	
	Mean Number of F_1 adult progeny	**% reduction in adult emergence relative to control**
H. welwitschii	***Callosobruchus maculatus***	
0	67.00 ± 6.22^{c}	0.00 ± 0.00^{a}
5	13.25 ± 2.99^{b}	80.06 ± 5.06^{b}
10	8.50 ± 1.73^{ab}	87.11 ± 3.55^{bc}
20	6.5 ± 1.73^{ab}	90.17 ± 3.18^{cd}
40	2.25 ± 1.70^{a}	96.47 ± 2.70^{d}
$F_{(4, 15)}$ value	255.12***	575.59***
SilicoSec		
0	67.00 ± 6.22^{c}	0.00 ± 0.00^{a}
0.5	9.00 ± 3.36^{b}	86.68 ± 4.72^{b}
1	3.25 ± 0.96^{ab}	95.16 ± 1.35^{c}
1.5	2.25 ± 2.22^{ab}	96.68 ± 3.41^{c}
2	0.25 ± 0.50^{a}	99.67 ± 0.66^{c}
$F_{(4, 15)}$ value	289.67***	1002.34***
H. welwitschii	***Sitophilus zeamais***	
0	41.75 ± 1.50^{b}	0.00 ± 0.00^{a}
5	4.00 ± 3.37^{a}	90.51 ± 7.74^{b}
10	2.25 ± 1.16^{a}	94.67 ± 2.85^{bc}
20	1.25 ± 1.26^{a}	97.06 ± 2.92^{bc}
40	0.25 ± 0.50^{a}	99.42 ± 1.16^{c}
$F_{(4, 15)}$ value	375.21***	470.44***
SilicoSec		
0	41.75 ± 1.50^{b}	0.00 ± 0.00^{a}
0.5	1.00 ± 1.41^{a}	97.52 ± 3.54^{b}
1	0.50 ± 1.00^{a}	98.75 ± 2.50^{b}
1.5	0.00 ± 0.00^{a}	100.00 ± 0.00^{b}
2	0.00 ± 0.00^{a}	100.00 ± 0.00^{b}
$F_{(4, 15)}$ value	1304.20***	2094.71***

Means within the column followed by the same small letter do not differ significantly at the 5% level according to Tukey's test. *** $P < 0.001$

3.3 Population increase and damage reduction

3.3.1 Population increase

The results presented in fig. 2 shows that *Hemizygia welwitschii* leaf powder and SilicoSec were effective in reducing the population increase of *C. maculatus* and *S. zeamais* compared to the negative control and the level of insects varied with the dosages applied. In the cowpea seeds treated with *H. welwitschii* leaf powder at its highest content (40 g/kg), a total of 130.25 insects was recorded (105.25 dead and 25 live) while, SilicoSec at its highest dosage (2 g/kg) recorded a total of 47.75 *C. maculatus* insects (36.25 dead and 9.5 live) compared to untreated samples where the total number of *C. maculatus* recorded was 1085.50 (770.50 dead and 315 live). However, the highest suppression of *S. zeamais* population in grains treated with the plant powder was observed at its highest dosage (40 g/kg) with mean number of 43.25 insects (23.25 dead and 20.00 live), while in the maize seeds treated with SilicoSec, all insects found died and following the contents, their number ranged between 31.00 to 35.25. In the untreated maize, the mean total number of population from S. zeamais recorded was 109.75 insects (9 dead and 100.75 live).

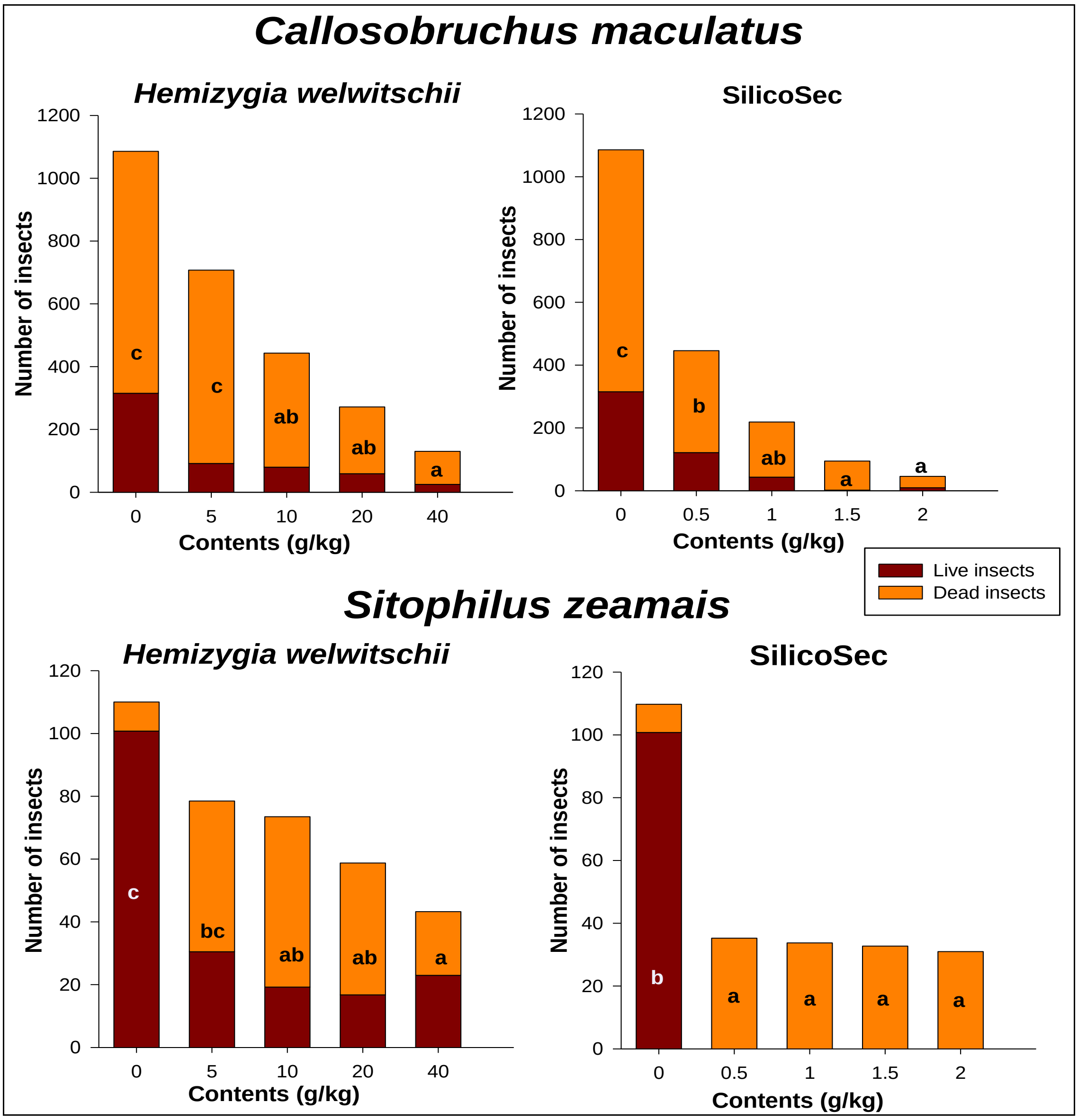

Fig 2: Number of live and dead *Callosobruchus maculatus* and *Sitophilus zeamais* in cowpea and maize, respectively stored for three months.

3.3.2 Damage reduction

There were significant differences ($P < 0.01$) among the tested contents of *H. welwitschii* leaf powder and SilicoSec in reducing damage caused by *C. maculatus* and *S. zeamais*. The damage rate in seeds decreased with the increasing of the contents level (Figure 3). The percentage damage in cowpea seeds among different dosages of the *Hemizygia welwitschii* leaf powder ranged from 13.16 to 47.51%. At the highest dosage (40 g/kg), *H. welwitschii* recorded 13.16% of cowpea seeds damaged while SilicoSec recorded only 2.11% damage after three months of storage compared to the negative control which recorded 73.12% grain damage. However, the maize seeds damaged treated with SilicoSec ranged between 1.61-0.31% which have better protection than those of *H. welwitschii* leaf powder where the seeds damaged ranging from 15.35-4.22%. *H. welwitschii* leaf powder applied at its highest content (40 g/kg) recorded a minimal seeds damaged (4.22%), while SilicoSec at 2 g/kg (0.31%) in stored maize. However, better protection of maize grains was achieved by SilicoSec at all its contents. The highest maize seeds damage (19.47%) was recorded from untreated samples.

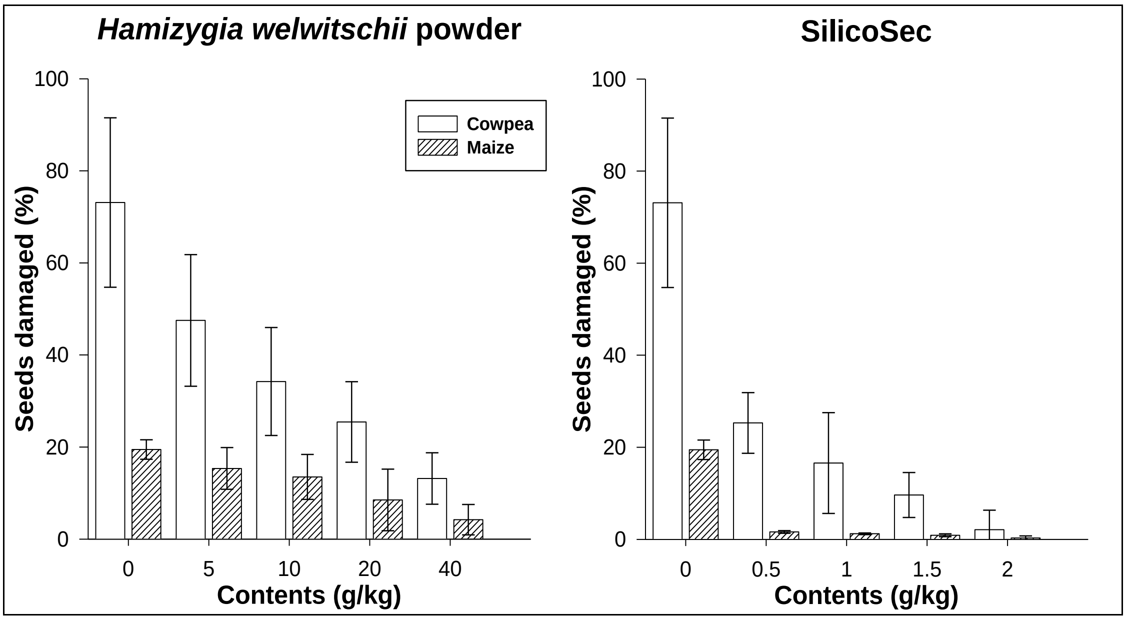

Fig 3: Percentage of seeds damaged caused by *Callosobruchus maculatus* and *Sitophilus zeamais* in cowpea and maize treated with four contents of *Hemizygia welwitschii* leaf powder and SilicoSec stored for three months under ambient laboratory conditions.

3.4 Percentage of germination

The results indicated a considerable positive effect of *H. welwitschii* powder on the germination rate of cowpea and maize seeds after three months of storage (Figure 4). Significant difference ($P < 0.001$) was observed between negative controls and the different contents. With cowpea, *H. welwitschii* leaf powder at his highest content (40 g/kg) recorded 72.50% of germination while, the highest mean percentage of germination recorded in the maize seeds treated with *H. welwitschii* leaf powder was 75% at this same content. However, SilicoSec recorded the highest germination rate of cowpea seeds (87.50%) at the dosage of 1.5 g/kg, while this percentage was 75% for the maize seeds. The maize seeds treated with the lowest contents of the two powders (5 g/kg for plant leaf powder and 0.5 g/kg for Silico Sec) and negative control (0 g/kg) recorded the same germination rate.

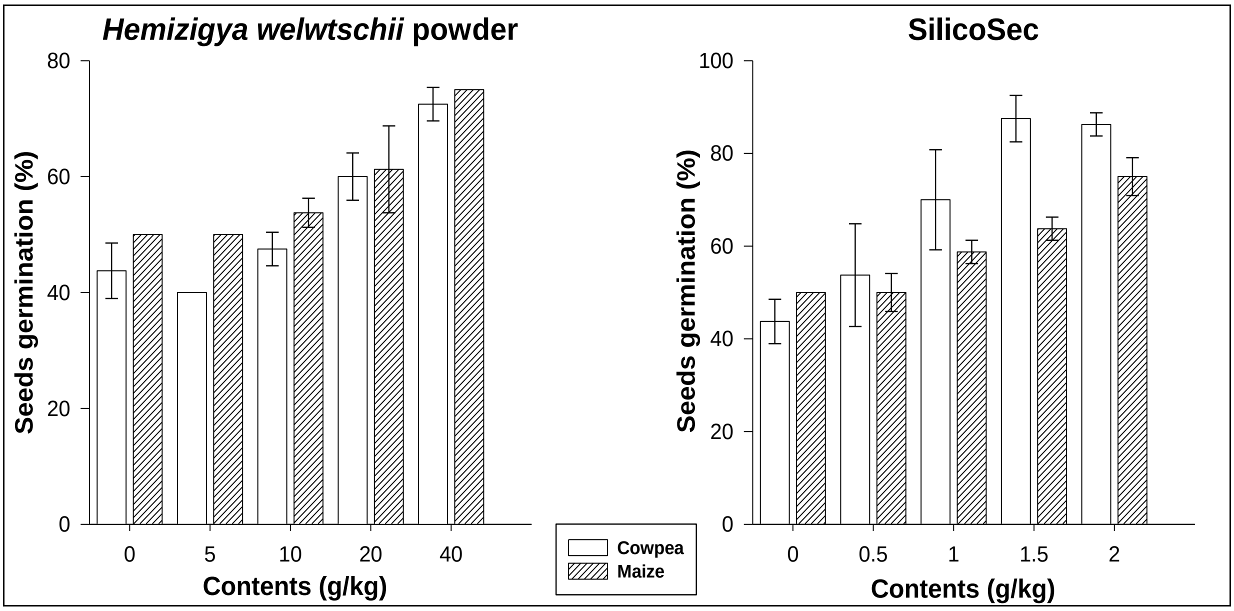

Fig 4: Percentage of seeds germination of cowpea and maize treated with *Hemizygia welwitschii* leaf powder and SilicoSec after three months of storage.

4. Discussion

Plants are considered as a rich source of bioactive chemicals and may be an alternative source of insect control agents so as to ensure food security in developing countries such as Cameroon. Indeed, the potential of plants for stored food preservation in Cameroon against insects have been the subject of several studies [8, 16, 17]. *Hemizygia welwitschii* leaf powder therefore might have properties required in chemicals for controlling insect feeding on stored grains which include: toxicity to adults, reduction of F_1 progeny, population increase and seeds damage. The findings obtained in this study agreed with the earlier reports that powdered plant parts could adequately protect stored grains against storage insects [18]. The results obtained in this study shown that *H. welwitschii* leaf powder is effective as grains protectant against *C. maculatus* and *S. zeamais*. This agreed with previous report of Katamssadan *et al*. [8], who shown the efficacy of *Plectranthus glandulosus* leaf powder on the mortality and F_1 progeny production of the same insects. Our result on the insecticidal efficacy of *H. welwitschii* against *S. zeamais* is different from that of Nukenine *et al*. [19]. These authors reported that, at the dosage of 40 g/kg, and exposure time of 14 days, *P. glandulosus* powder caused complete mortality of *S. zeamais*, while in our study *H. welwitschii* caused 81.25% mortality of *S. zeamais* and 82.50% mortality of *C. maculatus* within 14 days and 7 days of exposure respectively at the same dosage of 40 g/kg. This suggest that, the efficacy of plant powders against insect pests could varied with the plant used and insects. Also, the mortality recorded by *H. welwitschii* against *C. maculatus* suggested that, this powdered plant could also protected cowpea seeds from attack of its major pest. Similarly, Chouka *et al*. [20] and the present study recorded, respectively 83 and 81.25% mortality of *S. zeamais* caused respectively by *P. glandulosus* and *W. welwitschii* powders harvested in Ngaoundere, Cameroon. The results of these authors were different from that obtained in our study for *S. zeamais*, but corroborate with our findings in the case of the effect of *H. welwitschii* against *C. maculatus* (82.5% of mortality within 7 days of exposure) which is not different from 83% of mortality caused by *P. glandulosus* on *S. zeamais* at 40 g/kg within 14 days of exposure.

The mode of action of *H. welwitschii* on the mortality of *C. maculatus* and *S. zeamais* was not yet clearly demonstrated. Adults mortality recorded with *H. welwitschii* leaf powder might be attributed to contact toxicity or to the induction of some unknown physiological changes. Effective adhesion of dust particles to spiracles of pest and their death due to suffocation might be one of the many possible reasons of adult mortality. The efficacy of a botanical is not only measured by its capacity to kill the adult insects but by its ability to inhibit progeny emergence in treated grains [21]. Results of inhibition of progeny production showed that *H. welwitschii* leaf powder significantly reduced and completely inhibited progeny emergence of *C. maculatus* and *S. zeamais*, showing its enormous ability to control both insects. Reduction in progeny development may be due to early mortality of parents recorded in the mortality test. Udo [22] reported that there is a correlation between F_1 progeny emergence and parent

mortality as well as the possible presence of oviposition deterrent. So, effective control of protectants is qualified as mortality of adult and/or immature, confirmed by lack of progeny generation as reported by Katamssadan *et al*., [8]. Our findings agree that of Nukenine *et al*., [23] which recorded complete inhibition of the two *S. zeamais* strains in the maize grains treated with *P. glandulosus* from 4 g/100 g, while in our study the inhibition rates of *S. zeamais* were also completed (99.42% of inhibition) in the maize treated with 40 g/kg. But in the case of the effect of *W. welwitschii* powder against the F_1 progeny of *C. maculatus*, the results obtained in our study were different from that of these authors. This also shows that *H. welwitschii* could inhibited the F_1 cowpea progeny.

Like SilicoSec, most of the treatments of *H. welwitschii* showed significant reduction of cowpea or maize seeds damage, caused respectively by *C. maculatus* and *S. zeamais* after three months of storage as compared with the untreated grains which suffer greater damage. Reduction in progeny development may be due to early mortality and partial or complete retardation of embryonic development [24]. Plant product has been reported to inhibit locomotion [25]; hence, the beetles were unable to move freely thereby affecting mating activities [26].

The reduction in seed damage could be as a result of the reductive effect recorded in population growth after three months of storage. As the progenies emerged, more dead adult of both insects were observed than live ones which could be due to the possible biochemical constituents present in *H. welwitschii leaf powder* which invariably caused mortality. The cowpea and maize seeds treated with *H. welwitschii* powder significantly conserved their viability and among the concentration, there was noticed difference between the germination rate in treated cowpea or maize seeds. This agree with earlier studies conducted by Onu and Aliyu [27] and Keita *et al*., [28] who reported that seeds treated with powders and extracts did not loose their viability. There was marked difference between the percentage germination in treated cowpea seeds compared to treated maize and the lowest content of *H. welwitschii* powder recorded the lowest percentage of seeds damage for the two commodities. In fact, the seeds used for germination were non-perforated but they could contain the immature stages of weevil that could destroy the parts of seed embryo. Goudoungou *et al*. [12] affirmed that this level of germination rates was related to the development of weevils, which emerged at these level contents. Previous studies also reported that seeds treated with plant powders did not lose their viability [28]. The highest germination rates were recorded at the higher concentrations (40 g/kg) of the plant powder (72.50% of germination for cowpea and 75.00% for maize). This shows that *H. welwitschii* leaf powder has no adverse effect on germination. According to Couturon [29], when environmental conditions are not well controlled, germination rate decreases quickly. That could partly explain the loss of viability.

5. Conclusion

The results of the present investigation revealed the great potential of *H. welwitschii* leaf powder as cowpea and maize seeds protectants against *C. maculatus* and *S. zeamais* respectively. Within 7 days after treatment, the mortality (82.50%) recorded with *H. welwitschii* at its highest dosage (40 g/kg) on cowpea against *C. maculatus* in 7 days after treatment was similar to that recorded on maize against *S. zeamais* (81.25%) in 14 days after exposure. While, complete mortality was achieved with SilicoSec against the two insects

At this content level, the plant powder slightly completely inhibited progeny production and suppressed grain damage. Farmers could utilize this locally available plant powder in keeping their cowpea and maize seeds from *C. maculatus* and *S. zeamais* respectively free attack in the storage. The percentage of germination for cowpea and maize seeds was not affected by the plant powder and SilicoSec. The findings of the present investigation based on laboratory experiments, can therefore recommended the potential exploitation of leaves of *W. welwitschii* as admixtures in pest management strategies, especially by small scale farmers who store small amounts of pulses and maize for consumption and planting. However, further research work is required to study the active ingredients of this plant leaf, effective formulations, application method, mode of action, effects on other stored insect pests non-target organisms and consumer safety, before promoting their use in stored product protection especially by small farmers who store pulses and cereals for consumption and planting.

6. Acknowledgment
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