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INSECTICIDAL ACTIVITY OF *MONOON LONGIFOLIUM*, *HELIANTHUS ANNUUS*, AND *CROTON HIRTUS* AGAINST *CALLOSOBRUCHUS MACULATUS*

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ABSTRACT
Acetone (ACT) and hexane (HXN) extracts of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders (Fabaceae) leaf, aerial parts of *Helianthus annuus* L. (Asteraceae), and *Croton hirtus* L'Her (Euphorbiaceae) were tested at concentrations of 16.66 – 200 mg/ml for mortality against cowpea weevil, *Callosobruchus maculatus*, in stored cowpea. Seeds were dressed with each extract, air-dried, and incubated with weevils in closed Petri dishes for 336 h at ambient laboratory conditions. Mean mortality data were generated for different time intervals per concentration. Mortality increased with incubation time for ACT and HXN extracts; all plants reached a peak of 100% at the maximum time, 336 h. High insecticidal activities were recorded for ACT extract (LT_{50}, 17 h. at 200 mg/ml) and HXN extract (LT_{50}, 140 h at 16.66 mg/ml) of *H. annuus,* as well as *C. hirtus* ACT extract (LT_{50}, 133 h at 200 mg/ml). With reference to LC_{50}, the order of insecticidal activity was: *H. annuus* ACT (11 mg/ml) > *C. hirtus* HXN (25 mg/ml), which suggested *H. annuus* as the most potent biopesticide against *Callosobruchus maculatus*. *C. hirtus* is recommended for long-term preservation of stored cowpeas using either ACT extract at 33.33 mg/ml, or HXN extract at 200 mg/ml for 240 h and 168 h., respectively. Furthermore, *H. annuus* ACT extract (200 mg/ml) and HXN extract (66.66 mg/ml) of *M. longifolium* also provided long-term preservation after 168 h and 240 h., respectively.

Keywords: *Croton hirtus* aerial parts*, Monoon longifolium* leaf*, Helianthus annuus* aerial parts*,* extracts, *Callosobruchus maculatus,* insecticidal activity.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp. (Fabaceae) It is an important legume species and an excellent source of protein, vitamins, and antioxidants consumed as food and as animal feed worldwide, especially in semi-arid tropical and desert regions (Horn *et al*., 2022; Abebe & Alemayehu, 2022). It is used as a source of flour because its seeds contain a high protein content (23–32%) compared to many other legume species (Abebe & Alemayehu, 2022). It is grown throughout the world, with particular emphasis on the tropics, and Nigeria, Niger, and Burkina Faso accounted for 74.3% of all African cowpea production (Horn *et al*., 2022). The crop is grown mainly for food, fodder, green manure, vegetables, and for weaning in many African countries. Cowpea consumption is known to have multiple beneficial physiological effects in regulating and avoiding a variety of metabolic illnesses in animal models.

Callosobruchus maculatus, commonly known as the cowpea weevil, is a common pest of stored legumes, including cowpeas, causing extensive damage that culminates in significant economic loss. Chemical intervention, as a tool for curbing seed damage during storage, is replete with attendant drawbacks; hence, the use of biopesticides is becoming popular. The use of natural products in cowpea preservation is a new, globally accepted tool for improving farmers' economic gains. Shunmugadevi & Radhika (2020) and Kalpna *et al* (2022) have published reviews of plant products that give protection against weevil infestation. In addition, specific reports by Fotso *et al.* (2019), Ehimemen & Salisu (2020), Adesina *et al.* (2022), and Akbar *et al.* (2022) on appropriate plants are also available. Recently, the insecticidal effect of *Monoon longifolium* (Sonn.) B. Xue & R.M.K. Saunders (Fabaceae) leaf hexane (HXN) and acetone (ACT) extracts (Gbolade *et al*., 2024a), and *M. longifolium* powder (Gbolade & Ehiarinmwian, 2024b) were published. Similarly, Gbolade & Olowojoba (2024c) and Gbolade *et al*. (2025) have also reported the effectiveness of *Croton hirtus* L'Her (Euphorbiaceae) extract and powder in protecting stored cowpeas from weevil attack.

Apart from the mosquito larvicidal (Luu-dam *et al.,* 2023) and insecticidal activities of *C. hirtus* (Namadou *et al*., 2023), as well as larvicidal and adulticidal effects of seed essential oil of *Helianthus annuus* L. (Asteraceae) on *Aedes aegypti* (Omoniwa *et al*., 2024) and larvicidal effect of aqueous pericarp extracts of *M. longifolium* on *Aedes aegypti* (Junaid *et al*., 2024), the literature is scanty on insecticidal activities of these three plants. However, the only previous insecticidal reports on oviposition deterrence and emergence inhibition of *Callosobruchus maculatus* by *M. longifolium* (Gbolade *et al*., 2024a; Gbolade & Ehiarinmwian, 2024b) and *C. hirtus* (Gbolade & Olowojoba, 2024c; Gbolade *et al*., 2024d) were recently documented.

Despite the previous reports of *H. annuus, M. longifolium*, and *C. hirtus* in inhibiting oviposition and emergence of *Callosobruchus maculatus* during cowpea storage, there are no known mortality studies on the weevils documented. Consequently, and in view of the growing concern to develop natural product-based pesticides, we investigated the mortality potential of hexane and acetone extracts of the aerial parts of *H. annuus* and *C. hirtus*, and of *M. longifolium* leaves, for the control of cowpea weevils during storage.

MATERIALS AND METHODS

Plant collection and extraction

Aerial parts of *C. hirtus* and *H. annuus* were collected from the Crown Estate, Igbinedion University, Okada (IUO). At the same time, *M. longifolium* leaves were obtained within the College of

Pharmacy, IUO, in November 2023. Authentication was done at the Department of Pharmacognosy herbarium, IUO (*C. hirtus* IUO/19/290; *H. annuus* 1UO/24/407; *M. longifolium* IUO/16/102). Different plant parts were air-dried separately on a concrete floor for 7 days and then ground into a coarse powder using a mechanical grinder. Powdered plants were stored separately in plastic containers until needed.

Each dried plant material (800 g) of *C. hirtus, H. annuus,* and *M. longifolium* was sequentially macerated with n-hexane. Then, acetone was placed in a large glass jar (3 L) with a lid for 7 days, stirred occasionally with a glass rod. It was then filtered, evaporated to dryness on a hot water bath at 40°C. Yields were determined [(*C. hirtus*: hexane 1.3%, acetone 2.4%), (*H. annuus*: hexane 0.85%, acetone 2.4%), and (M. longifolium: hexane 0.70%, acetone 18.52%)], and the crude extracts were refrigerated until required.

Insect culture and bioassay

Infested cowpeas (brown variety) were purchased from Okada market in Okada community, Edo State, Nigeria. Insect culture was maintained according to Olayemi *et al* (2022). As such, adult weevils (*Callosobruchus maculatus*) were obtained from the infested seeds and introduced into a 500 ml transparent plastic jar containing a sufficient number of wholesome uninfested cowpea seeds. The jar was covered with a clean muslin cloth to allow aeration for respiratory purposes and was kept in the laboratory at ambient conditions (30±2 °C, 65±5% relative humidity). The parent stocks of weevils were removed after 15 days when adequate oviposition was evident and discarded. Further incubation continued for up to 50 days until sufficient F_1 progeny were obtained and used for the experiment.

Clean, uninfested cowpea seeds (10.0–15.1 g) were used. Different amounts (0.05, 0.1, 0.2, 0.4, and 0.6 g) of acetone or n-hexane extract of each plant were separately dissolved in the extracting solvent (3 ml) to give 16.66, 33.33, 66.66, 133.33, and 200 mg/ml for coating 50 clean cowpea seeds in a glass petri-dish by swirling. Cowpea seeds were similarly coated with the positive control, Rambo® insecticide powder (Gongoni Company Limited, Nigeria; MFD. 04/2021, EXP. 03/2024, containing 0.60% permethrin), as well as the negative control (hexane or acetone, 3 ml). The standard insecticide was initially dissolved in the extracting solvent. All treatments were subsequently transferred to plastic Petri dishes and left to evaporate for 2 h. Ten F_1-generation weevils were then introduced into each Petri dish, covered, and incubated in wooden lockers at ambient conditions (30±2 °C, 65±5% relative humidity) for up to 14 days. Each test agent and the controls were assayed in triplicate. Percentage mortality at two-day intervals up to 14 days was determined, and mean±SEM recorded.

Statistical analysis

Results of assays were expressed as a mean ± standard error of the mean. The differences between the positive control and the tested agents were determined using one-way analysis of variance (ANOVA). Differences in means were considered significant* at $p<0.05$.

RESULTS

Effect of extracts on LT_{50}

In this investigation, the mean percentage mortality of weevils increased with incubation time for extracts from the three plants, peaking at 100% at 336 h. For the hexane (HXN) extract of *H. annuus*, the best LT_{50} was 140 h at 16.66 mg/ml, and was comparable to the positive control, permethrin at 3.33 mg/ml (Table 1). With acetone (ACT) extract, however, LT_{50} decreased with concentration (142 h at 16.66 mg/ml) to 17 h at 200 mg/ml, and was more effective than the positive control. ACT extract of *H. annuus* (LT_{50} 17 h.) was more effective than HXN extract (LT_{50} 143 h) at the highest concentration, 0.6 g. In the case of *M. longifolium,* ACT extract exhibited concentration-dependent LT_{50} values (258.2–168 h) at higher concentrations (66.66–200 mg/ml) (Table 1). For this plant, the best LT_{50} (10.5 h) was also observed at the lowest concentration of *M. longifolium* HXN extract and was more active than the *H. annuus* ACT extract. However, it does not appear to be a good parameter for measuring the insecticidal activity of the ACT extract. From Table 1, LT_{50} was consistent with the expected decrease (168 – 133 h) when *C. hirtus* ACT extract was tested at 16.66 - 200 mg/ml. ACT extract at 200 mg/ml was comparable to the positive control in terms of LT_{50} (133 h). This parameter is therefore more valuable in evaluating the effectiveness of ACT extracts of *H. annuus* and *C. hirtus* on *Callosobruchus maculatus*, but *H. annuus* was more potent. Whereas LT_{50} was only relevant in measuring insecticidal potency of *H. annuus* among the three HXN extracts, it proved to be more valuable in the case of their respective ACT extracts, resulting in the order of effectiveness of *H. annuus* > *C. hirtus* > *M. longifolium..*

Table 1: Lethal Time $_{50}$ (hours) after treatment of weevil-infested cowpeas with plant extracts

Treatment	***Helianthus annuus* aerial part**		***Monoon longifolium* leaf**		***Croton hirtus* aerial part**	
	Hexane extract	**Acetone extract**	**Hexane extract**	**Acetone extract**	**Hexane extract**	**Acetone extract**
Permethrin (3.33 mg/ml)	145.00	133 .00	145.00	133.00	145.00	133.00
16.66 mg/ml extract	140.00	142.00	10.50	168.00	n.d	168.00
33.33 mg/ml extract	172 .00	118 .00	11.10	222.24	n.d	146.00
66.66 mg/ml extract	258.00	108.00	15.96	258.24	19.00	n.d
133.33 mg/ml extract	175.00	24.00	15.96	240.00	24.00	142.00
200 mg/ml extract	143.00	17.00	16.80	168.00	n.d	133.00

n.d = not determined

Effect of extracts on weevil mortality

For every concentration of the three plants tested (except *C. hirtus* HXN extract), a progressive increase in mortality at different time intervals, which attained a maximum of 100% at 336 h, was observed (Tables 2 - 4). At each time interval, *H. annuus* HXN extract did not elicit a concentration-dependent increase in mortality. However, the ACT extract gave a concentration-dependent increase in mortality at all time intervals (Table 2). At

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240 h, HXN and ACT extracts (73.3%) of *H. annuus* at the least concentration of 16.66 mg/ml were comparable with the standard insecticide, permethrin (80%) in eliciting weevil mortality. However, both extracts were equipotent to permethrin (50-53% mortality) at 168 h. During 4–240 h of exposure, a concentration-dependent decrease in mortality was evident at 16.66–66.66 mg/ml for HXN extract, whereas a concentration-dependent increase was observed for ACT extract. This indicates that the ACT extract was more effective in weevil control than the HXN extract. In this investigation, the ACT extract at a maximum concentration of 200 mg/ml showed a reasonable insecticidal effect (>90% mortality) on weevils at 168 h and 240 h. Based on the concentration index, *H. annuus* ACT extract showed higher mortality (LC_{50}: 11 mg/ml) against weevils at 168 h. This further corroborates its higher efficacy compared with the HXN extract

Table 2: Mean mortality (%) of *Helianthus annuus* on *Callosobruchus maculatus*

Concentration	1 hour	2 hours	4 hours	6 hours	10 hours	12 hours	24 hours	168 h	240 h	336 h
Aerial parts hexane extract										
PMT (3.33 mg/ml)	0	0.00	0.00	6.70±0.67	16.70±0.88	26.70±0.66	26.70±0.66	50.00±0.58	80.00±1.15	100.00
16.66 mg/ml extract	3.30±0.33	3.30±0.33	6.70±0.33	10.00±0.58	20.00±0.58	30.00±0.99	36.70±0.88	50.00± 0.58	73.30±0.66	100.00
33.33 mg/ml extract	0	3.30±0.33	3.30±0.33	6.70±0.33	10.00±0.58	16.70±0.33	23.30±0.88	40.00±1.53	53.30±0.88	100.00
66.66 mg/ml extract	0	0.00	3.30±0.33	3.30±0.33*	6.70±0.33*	13.30±0.33	13.30±0.33	16.70±0.33*	43.30±0.88*	100.00
133.33 mg/ml extract	6.70±0.33	6.70±0.33	6.70±0.33	6.70±0.33	6.70±0.33*	13.30±0.33	20.00±0.58	40.00±0.99	50.00±0.58	100.00
200 mg/ml extract	0	0.00	10.00±0.58	16.70±0.66	16.70±0.66	26.70±0.33	46.70±0.33	50.00±0.58	56.70±0.33	100.00
Aerial parts acetone extract										
PMT (3.33 mg/ml)	0.00±0.00	13.30±0.33	13.30±0.33	13.30±0.33	16.70±0.33	20.00.00±0.58	37.00±0.33	53.30±0.71	83.30±0.88	100.00
16.66 mg/ml extract	0.00±0.00	0.00±0.00	10.00±0.00	16.70±0.67	23.00±0.67	23.00±0.67	33.30±0.88	50.00±0.00	73.30±0.67	100.00
33.33 mg/ml extract	0.00±0.00	3.30±0.33*	13.30±0.33	16.70±0.89	26.70±0.33	37.00±0.33	40.00±1.00	66.70±0.33	83.30±0.33	100.00
66.66 mg/ml extract	0.00±0.00	3.30±0.33*	13.30±0.67	20.00±0.58	30.00±0.00*	37.00±0.33	46.70±0.33	76.70±0.33	86.70±0.33	100.00
133.33 mg/ml extract	0.00±0.00	16.70±0.33	16.70±0.33	23.30±0.33	30.00±0.00*	40.00±0.00	50.00±0.58	80.00±0.00	86.70±0.67	100.00
200 mg/ml extract	3.30±0.33	16.70±0.33	20.00±0.00	30.00±0.00*	30.00±0.00*	43.30±0.33*	53.30±0.33	93.30±0.33	96.70±0.33	100.00

Values above are the mean of three replicates. n=6 (±SEM). Values with superscripts* indicate significant difference at *P<0.05 when compared to the positive control, using ordinary One –way analysis (ANOVA). PMT = permethrin (positive control)

With *M. longifolium,* there was comparable insecticidal activity of HXN extract (86.7% mortality at 16.66 mg/ml) with permethrin (80%) at 240 h, but at 168 h, the extract was more effective (73.3%vs50%). Furthermore, there was an increase in mortality (73.3-80%) from 16.66-66.66 mg/ml at 168 h and 86.7-93.3% at 240 h, followed by a slight decline (Table 3). This implies that a minimum HXN extract concentration of 66.66 mg/ml will be required to achieve a reasonable insecticidal effect against weevils (> 90% mortality) after 240 h. HXN extract is therefore more effective than ACT extract. ACT extract at a minimum concentration of 16.66 mg/ml (50% mortality) was comparable to the standard insecticide (53.3%) in insecticidal potency after 168 h. Application of HXN extract at 66.66 mg/ml for 240 h is recommended for achieving adequate preservation of stored cowpea.

Table 3. Mean mortality (%) of *Monoon longifolium* on *Callosobruchus maculatus*

Concentration	1 hour	2 hours	4 hours	6 hours	10 hours	12 hours	24 hours	168 h	240 h	336 h
Leaf hexane extract										
PMT (3.33 mg/ml)	0	0.00	0.00	6.70±0.67	16.70±0.88	26.70±0.66	26.70±0.66	50.00±0.58	80.00±1.15	100.00
16.66 mg/ml extract	6.7±0.57	13.3±0.33	23.3±0.33	33.3±0.66 *	46.7±0.66*	60±1.00	63.3±0.66	73.3±1.27	86.7±0.88	100
33.33 mg/ml extract	6.7±0.33	6.7±0.33	13.3±0.97	26.7±0.97 *	36.7±0.97	60±0.57	70±1.00*	73.3±0.97	86.7±0.33	100
66.66 mg/ml extract	0	3.3±0.33	13.3±0.33	20.0±0.57	26.7±0.77	46.7±1.27	56.7±0.77	80±0	93.3±0.33	100
133.33 mg/ml extract	6.7±0.33	13.3±0.33	33.3±0.33	36.7±0.77 *	40 ± 0.57*	46.7±0.97	56.7±0.97	70±0.57	83.3±0.33	100
200 mg/ml extract	6.7±0.33	10±0.57	16.7±0.33	30.0±0.57 *	40±0*	43.3±0.33	60±0.57	73.3±0.33	93.3±0.77	100
Leaf acetone extract										
PMT (3.33 mg/ml)	0.00±0.00	13.30±0.33	13.30±0.33	13.30±0.3 3	16.70±0.33	20.00.00±0. 58	37.00±0.33	53.30±0.71	83.30±0.88	100.00
16.66 mg/ml extract	3.3±0.33	3.3±0.33*	6.7±0.33	10±0.58	20.0±0.58	30.0±0.99	36.7±0.68	50.0±0.58	73.3±0.66	100
33.33 mg/ml extract	0	3.3±0.33*	3.3±0.33*	6.7±0.33	10±0.58	16.7±0.33	23.3±0.88	40.0±1.53	53.3±0.66	100
66.66 mg/ml extract	0	0	3.3±0.33*	3.3±0.33*	6.7±0.33*	13.3±0.33	13.3±0.33*	16.7±0.33*	43.3±0.58*	100
133.33 mg/ml extract	6.7±0.33	6.7±0.33	6.7±0.33	6.7±0.33	6.7±0.33*	13.3±0.33	20.0±0.58	40.0±0.99	50.0±0.58	100
200 mg/ml extract	0	0	10.0±0.58	16.7± 0.33	16.7± 0.33	26.7±0.33	46.7±0.33	50.0±0.58	56.7±0.33	100

Values above are the mean of three replicates (±SEM). Values with superscripts* indicate significant difference at *P<0.05 when compared to the positive control, using ordinary One –way analysis (ANOVA). PMT = permethrin (positive control)

From Table 4, only the ACT extract of *C. hirtus* elicited concentration-dependent increases in mortality at 168h (49 – 78%) and 240h (70 – 95.33%). In this case, higher concentrations of extract (33.33- 200 mg/ml) were more effective (90-95.33% mortality) than permethrin (83.33%) at 240h. Therefore, a minimum of 33.33 mg/ml of ACT extract will provide reasonable insecticidal activity (>90%) after 240 h. Using HXN extract, concentration-dependent increases in mortality were also recorded up to 168 h. At the peak exposure time of 168 h, the highest extract concentration, 200 mg/ml, gave a reasonable insecticidal effect (> 90% mortality) and is therefore recommended for long-term preservation of stored cowpea. However, based on an LC_{50} of 25 mg/ml at 168 h, the HXN extract of *C. hirtus* was more effective than the ACT extract. Based on LC_{50} at 168 h, the order of insecticidal potency of the three plant extracts can be ranked as: *H. annuus* ACT (11 mg/ml) > *C. hirtus* HXN (25 mg/ml).

Table 4: Mean mortality (%) of *Croton hirtus* on *Callosobruchus maculatus*

Concentration	1 hour	2 hours	4 hours	6 hours	10 hours	12 hours	24 hours	168 h	240 h	336 h
Aerial part acetone extract										
PMT (3.33 mg/ml)	0.00±0.00	13.30±0.33	13.30±0.33	13.30±0.33	16.70±0.33	20.00.00±0.58	37.00±0.33	53.30±0.71	83.30±0.88	100.00
16.66 mg/ml extract	2.00±0.33	2.00±0.33*	3.00±0.33*	4.00±0.58*	4.00±0.58*	4.00±0.99*	7.00±0.88	49.00±0.58	70.00± 0.66	100
33.33 mg/ml extract	1.0±0.33	3.00±0.33*	3.00±0.33*	4.00±0.33*	5.00±0.58*	5.00±0.33*	9.00±0.88*	63.00±1.53	90.00± 0.66	100
66.66 mg/ml extract	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
133.33 mg/ml extract	1.00±0.33	1.00±0.33*	2.00±0.33*	4.00±0.33*	4.00±0.33*	4.00±0.33*	10.00±0.58*	70.00±0.58	93.33 ±0.58	100
200 mg/ml extract	3.00±0.58	3.00±0.33*	4.00±0.33*	5.00±0.33*	8.00±0.38	9.00±0.33*	14.00±0.33*	78.00±0.58	95.33± 0.33	100

Aerial parts hexane extract										
PMT (3.33 mg/ml)	0	0.00	0.00	6.70±0.67	16.70±0.88	26.70±0.66	26.70±0.66	50.00±0.58	80.00±1.15	100.00
16.66 mg/ml extract	0.00±0	3.33±0.33	6.67±0.33	6.67±0.33	10.00±0.58	13.33±0.33	20.00±0.58	43.33±0.88	n.d	n.d
33.33 mg/ml extract	3.33±0.33	3.33±0.33	6.67±0.33	10.00±0.58	13.33±0.33	16.67±0.67	23.33±0.58	50.00±0.58	n.d	n.d
66.66 mg/ml extract	3.33±0.33	10.00±0.58	13.33±0.33	16.67±0.67	16.67±0.67	23.33±0.88	26.67±0.33	56.67±0.33	n.d	n.d
133.33 mg/ml extract	10.00±0.58	13.33±0.33	16.67±0.67	20.00±0.58*	36.67±0.80	40.00±1.33	56.67±0.33	80.00±1.15	n.d	n.d
200 mg/ml extract	20.00±0.58	20.00±0.58	33.33±0.23	36.67±0.33*	43.33±0.33*	46.67±0.33	50.00±0.58	93.33±1.33	n.d	n.d

Values above are the mean of three replicates (±SEM). Values with superscripts* indicate significant difference at *P<0.05 when compared to the positive control, using ordinary One –way analysis (ANOVA). n. d, not determined. PMT = permethrin (positive control)

DISCUSSION

The results obtained in this study suggest great potential for the extracts of *M. longifolium* leaf, *C. hirtus,* and *H. annuus* aerial parts in weevil control during cowpea storage. The effectiveness of ethanol in extracting insecticidally active constituents from plants, using mortality and LT_{50} indices, was reported for ethanol extracts of *Kigelia africana* stem bark (Obembe *et al*., 2020) and five other Nigerian plant extracts (Edwin & Jacob, 2017) after 96 h of exposure to weevils. In the present study, LT50 was used to compare the insecticidal potency of *H. annuus* and *C. hirtus*, with *H. annuus* found to be twice as effective as *C. hirtus* in weevil control.

Additionally, LC_{50} has been used as a valuable quantitative tool to evaluate the effectiveness of ethanol extracts of certain plants (Edwin & Jacob, 2017; Ehimemen & Salisu, 2020) after 48-96 h of exposure. These workers found the ethanol extract to be the most effective among the solvent extracts tested, with LC_{50} values of 2.27 mg/L (*Tephrosia vogelii*) (Ehimemen & Salisu, 2020) and 36.3 mg/ml (*Cordia millenii*) (Edwin & Jacob, 2017) recorded for the most potent plant extracts. In another investigation similar to the present study, aqueous extracts of five plants were shown to elicit varying degrees of effectiveness against *Callosobruchus maculatus* over a 336 h exposure period (Akbar *et al*., 2022a), and *Nicotiana tabacum* and *Melia azedarach* were observed to have the lowest LC_{50} values. The effectiveness of HXN and ACT (based on the LC50 values) in extracting potent insecticidal components from plants, according to this present study, corroborates the findings of Fotso *et al* (2019), Ehimemen & Salisu (2020), and Olayemi *et al*. (2022) on other plants. Considering both LC_{50} and LT_{50} parameters, *H. annuus* ACT extract and *C. hirtus* HXN extract have demonstrated remarkable toxicity against *Callosobruchus maculatus.* Consequently, these two plants can be recommended for commercial use in preserving stored cowpeas. In earlier investigations, the effectiveness of HXN and ACT extracts of *C. hirtus* (Gbolade *et al.,* 2024d) and *M. longifolium* (Gbolade *et al*., 2024a) in reducing oviposition and emergence of *Callosobruchus maculatus* during cowpea storage, as well as the reduction in seed damage parameters at higher concentrations tested, was reported. Therefore, this current study is an addendum to the effectiveness of *H. annuus, M. longifolium,* and *C. hirtus* in the preservation of stored cowpea from weevil damage.

The concentration- and time-dependent increases in weevil mortality when treated with *H. annuus* ACT*, C. hirtus* HXN, and *M. longifolium* HXN extracts according to this study align with the reports of Fotso *et al*. (2019), Ehimemen & Salisu (2020), Akbar *et al* (2022a and 2022b), and Olayemi *et al* (2022). The exposure period to obtain near complete weevil mortality in stored cowpeas when fumigated with *H. annuus* HXN and *C. hirtus* ACT extracts in this study was 168 h, which is in agreement with that of Fotso *et al* (2019) for *Hemizygia welwitschii*. These authors observed mortalities exceeding 90% with the most active HXN extract of Hemizygia welwitschii across different concentrations and exposure times. However, a longer exposure time of 240 h was required to achieve reasonable mortality with *M. longifolium* HXN extract. Therefore, it is reasonable to also accept HXN as an efficient extracting solvent of active insecticidal plant constituents. Plant-derived insecticides are effective conventional insecticides. Results obtained in this study suggest great potential for the extracts of *M. longifolium* leaf, *C. hirtus* aerial parts, and *H. annuus* aerial parts in weevil control during cowpea storage. This underscores the effectiveness of organic solvents in extracting potent insecticidal compounds from plants.

Conclusion

This investigation has revealed that all three tested plant extracts exhibited high insecticidal activity against *Callosobruchus maculatus*, thereby protecting stored cowpeas against weevil attack. The two outstanding tested agents were *H. annuus* acetone extract and *C. hirtus* hexane extract**.** However, *H. annuus* was more effective than *C. hirtus.* Concentrations of 200 mg/ml each of *H. annuus* ACT extract and *C. hirtus* HXN extract for 168 h are recommended for adequate preservation of stored cowpea seeds from weevil infestation. Using 66.66 mg/ml of HXN extract of *M. longifolium*, a longer exposure period of 240 h is recommended.

Conflict of interest

The authors declare no conflict of interest in this work.

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