

Insecticidal Efficacy of Onion and Garlic Peel Extracts for Sweet Potato Preservation

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Abstract

*This study examined the insecticidal activity of onion and garlic peel extracts as a control method for sweet potato beetles, *Cylas formicarius*, infesting sweet potatoes after harvest. The primary objective of this study was to extract bioactive compounds from onion and garlic peels using a column chromatographic technique. The extracts were bioassayed against five *C. formicarius* adults in various concentrations: 0.01 g/0.25 kg, 0.02 g/0.25 kg, and 0.04 g/0.25 kg. Methanolic extract of onion peel being the most effective was subjected to isolation using column chromatography packed with silica gel of 60-120 mesh, employing a gradient elution technique. The elution started from 100% hexane and gradually incorporated 10% ethyl acetate until a 10% methanol in ethyl acetate solution. TLC was used to monitor similar fractions collected, and the combined fractions were then subjected to Prep-TLC until a pure compound, known as OM-15, was obtained. The results revealed that onion peel methanolic extract (OMH) caused 93.3% mortality 96 h postexposure. In contrast, garlic peel methanolic extract (GMH) caused 73.3% mortality, but hexane garlic peel extract caused 80% mortality 96 h postexposure, and the pure compound showed mortality of 60% on *Cylas formicarius* 96 h postexposure. It can be concluded that the methanolic extract of onion peels was more effective than the ethyl acetate and hexane extracts, and is not statistically different from the standard insecticide (cypermethrin) at $P < 0.05$ significant level. The extracts are eco-friendly and potent against *Cylas formicarius*, providing a scientific rationale for incorporating their development into biopesticides.*

Keywords:

Effective extract, Insecticidal potential, Methanolic extract, Pest

Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam.) is a tuberous root crop that is widely cultivated in tropical, subtropical, and warm-temperate regions of the world (Ray & Ravi, 2005). It is a major source of food, income, nutrition, and one of the world's seven leading food crops owing to its adaptability, nutritional value, and role in ensuring food security (Woolfe, 1992; Ray & Ravi, 2005). Sweet potatoes are a staple and complementary crop in the majority of developing nations, and their production residues are further utilised for animal feed and industrial processing (Jha et al., 2015). Despite its agronomic and nutritional value, the sweet potato weevil (*Cylas formicarius*, Fabricius) remains the most destructive insect pest of stored and field-stored tubers. This insect causes serious yield and postharvest losses of 15% to 65% globally and 32% to 60% in India during a two-month storage period (Ray & Ravi, 2005; Raju, 2021). The insect's feeding and oviposition activities not only physically injure the tubers but also induce biochemical modifications that make them unsuitable for use due to the accumulation of toxic terpenoids (Ames et al., 2010). To check such pest damage, farmers have traditionally relied on chemical pesticides. Although these chemicals offer short-term efficacy, they have introduced long-term environmental and health problems.

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Pesticide poisoning has become a public health problem worldwide, with more than 200,000 yearly fatalities, most in developing countries where control, education, and precautions are inadequate (Gunnell et al., 2007; Boedeker et al., 2020). Although the consumption of chemical pesticides in Africa accounts for only 2% of the world's consumption (Ray & Ravi, 2005), their overuse and improper use have led to high rates of human poisoning and environmental contamination, considering their weight. In addition, toxic residues from synthetic pesticides have been implicated in chronic diseases like cancer, endocrine disruption, reproductive toxicity, and neurodevelopmental disorders (Mostafalou & Abdollahi, 2013; Kim et al., 2017). The environmental effects include the emergence of pesticide-resistant pest populations, loss of biological diversity, and the killing off of beneficial microorganisms in the soil (Sánchez-Bayo & Wyckhuys, 2019). These growing concerns have prompted the world to switch towards environmentally friendly and sustainable methods of pest management based on biopesticides derived from natural plant sources (Pavela & Benelli, 2016; Isman, 2017). Plant-derived insecticides are biodegradable, less toxic to non-target organisms, and have multiple modes of action, which reduces the possibility of resistance (Salgado et al., 2011). The potential botanical sources being investigated include onion (*Allium cepa* L.) and garlic (*Allium sativum* L.), whose peels are routinely discarded as agricultural waste, yet contain bioactive compounds with intense pesticidal activity (European Commission, 2018; Soedarto & Tembalang, 2021). Existing studies have demonstrated that onion and garlic peels differ in their content of flavonoids (especially quercetin), organosulfur compounds, and phenolics, which exhibit pronounced antioxidant, antimicrobial, and insecticidal properties (Benítez et al., 2011; Benítez et al., 2017). The European Commission (2018) has even authorised the use of onion oil as a natural insecticide for managing carrot fly infestations in umbelliferous crops, indicating how such natural compounds can be practically applied for pest management. Onion peels, for example, have acetogenin-like molecules that repress insect digestive enzymes, feed suppression, and even cause mortality (Soedarto & Tembalang, 2021), while garlic extracts, on the contrary, are famous for their broad-spectrum insecticidal activity against insects due to allicin, diallyl disulfide, and diallyltrisulfide, which disrupt insect nervous systems and respiratory metabolism (Tripathi et al., 2009; Chaudhary et al., 2017). Based on their bioactivity,

availability, and low environmental footprint, the valorisation of onion and garlic peels as biopesticide products represents a green approach to pest control and waste management. Utilisation of these agricultural wastes can simultaneously address the twin issues of pesticide toxicity and agro-waste buildup. This aligns with the United Nations' global sustainable development goals (FAO, 2021). Hence, the current study examined the insecticidal activity of onion and garlic peel extracts for controlling *Cylas formicarius* as a sustainable and environmentally friendly alternative for sweet potato postharvest management. The approach can help enhance food safety, minimise postharvest losses, increase storage life, and promote sustainable pest control in the framework of circular bioeconomy and eco-innovation in agriculture.

Materials and Methods

Collection and preparation of crude extracts

Fresh red onion and garlic peels weighing 1.0 kg and 0.75 kg, respectively, were purchased from Bodija market, Ibadan. The peels were washed gently in water, then drained and shade-dried at ambient temperature (27 ± 2 °C) and low humidity for four weeks, until a constant weight was achieved. The samples were ground separately using a mechanical blender.

Following the extraction protocols stipulated by Ncube et al. (2008) and Sukhdev et al. (2008), with slight modifications, approximately 1.0 kg (1000 g) of red onion peel powder was dissolved in 5.3 L of n-hexane and allowed to extract for 72 h with occasional shaking. The setup was then filtered using Whatman No. 4 filter paper to obtain the filtrate, which was subsequently concentrated to dryness using a rotary evaporator. The crude hexane extracts of onion peels obtained weighed 4.46 g, corresponding to a percentage yield of 0.446%. The n-hexane marc was shade-dried and reweighed. Approximately 0.85 kg (850 g) of hexane marc was dissolved in 4.53 L of ethyl acetate and left for 72 hours for further extraction. Approximately 16.337 g of crude ethyl acetate onion peel extract was obtained, yielding a percentage of 1.92%. The same procedure was performed with 0.82 kg (820 g of ethyl acetate marc) in 4 L of methanol and allowed to extract for 72 h. Approximately 15.59 g of methanolic extract from onion peels was obtained, yielding a percentage of 1.90%.

Similarly, a 0.75 kg (750 g) powder sample of garlic peel was macerated sequentially in 5.3 L hexane in glass-stoppered flasks for 72 h. Following the previous

procedures, a total of approximately 3.10 g crude hexane extract of garlic peels was obtained with a percentage yield of 0.41%; while 1.90 g crude ethyl acetate extract of garlic peels was obtained with a percentage yield of 0.25 %, and the methanolic crude extract of garlic peel gave 10.51 g with a percentage yield of 1.46%. The crude extracts were stored on the laboratory bench in opaque amber bottles before use.

Qualitative phytochemical screening

Qualitative phytochemical screening of the n-hexane, ethyl acetate, and methanolic extracts of garlic and onion peels was conducted to identify the secondary metabolites present in the extracts using standard procedures, as described by Samatha (2012) and Marjoka et al. (2016). Alkaloids, saponins, flavonoids, terpenoids, cardiac glycosides, tannins, and phenols were all individually screened in the extracts.

Alkaloids test

In a test tube, 3.0 mL of each garlic and onion extract was mixed with 1.0 mL of 1% aqueous HCl in another test tube. The blend was then heated for 20 minutes. Afterwards, the mixture was filtered and cooled. Two drops of Wagner's reagent were added to a 1.0 mL aliquot of the filtrate. Alkaloids were indicated by the formation of a brown precipitate, as reported by Adeniyi et al. (2010).

Saponin test

Approximately 5.0 mL of distilled water and 0.1 g of crude onion and garlic peels extracts were thoroughly mixed in a separate test tube. The frothing mixture was well stirred once again after a few drops of olive oil were added to each tube. Based on the procedure of Ladan et al. (2014), the inability to create long-lasting foam within 10 minutes indicated the absence of saponins.

Flavonoid test

Approximately 2.0 mL of extract was mixed with two drops of sodium hydroxide solution; the extract initially turned deep yellow. The flavonoids' indication, as described by Awoyinka (2007) with minor adjustments, was the slow disappearance of this colour upon the addition of a few drops of diluted HCl.

Terpenoids test

About 1.0 mL of chloroform and a few drops of concentrated sulfuric acid were added to 2.0 mL of each extract. Following Falana et al. (2016) with a modification, the presence of terpenoids was indicated

by the appearance of an immediate reddish-brown precipitate.

Cardiac glycoside test

About 2.0 mL of chloroform was mixed with 1.0 mL of crude onion and garlic peels extracts in another test tube, and the mixture was shaken thoroughly. The mixture was allowed to settle before the solution was added gradually using concentrated sulfuric acid (H_2SO_4). With minimal modifications by Abba et al. (2009), reddish-brown precipitate at the interface indicated the presence of an aglycone component of cardiac glycoside.

Tannin test

Approximately 5.0 mL of distilled water was mixed with 0.2 g of onion and garlic peels extract and then filtered. Approximately 0.1% ferric chloride reagent was added to the filtrate. According to Usman et al. (2009), tannins were indicated by the appearance of blue-black or green precipitate.

Phenol test

A new ferric chloride solution was combined with approximately 1.0 mL of an aqueous solution. Samatha et al. (2012) state that the formed coloured complex, which produced dark-coloured solutions, was an indicator of the presence of phenols.

Isolation and purification techniques

About 2.0 g of crude onion methanol extract was adsorbed onto silica gel for isolation of bioactive compounds, and the resulting slurry was allowed to dry. A 100 cm × 5 cm glass column was packed with 30 g of silica gel (60-120 mesh, Qingdao Marine Chemistry Co., Ltd.) in n-hexane. The gel was allowed to settle. Following that, the dry methanolic extract slurry was loaded into a packed column. Gradient elution, starting with 100% n-hexane, was implemented by first increasing the concentration of ethyl acetate in hexane by 10%, then adding pure ethyl acetate, and finally adding methanol to ethyl acetate to achieve a 10% methanol concentration in ethyl acetate. Approximately 21 column fractions were gathered in 25 mL beakers. Thin Layer Chromatography (TLC) was used to monitor the fractions as they evaporated. A distinctive retention factor (R_f) spot of 0.51 was observed when similar fractions with matching R_f values were combined, washed with acetone, and then subjected to TLC using n-hexane:methanol (6:4, v/v) as the solvent system. After drying in air for 30 minutes, the resulting chromatogram was observed

under a UV lamp at short wavelengths of 254 nm and long wavelengths of 366 nm, respectively.

Screening for insecticidal activity against *Cylas formicarius* F.

About 250 g (0.25 kg) of sweet potato sample was placed in one litre (1 L) perforated plastic containers for the evaluation of their insecticidal activity. Aliquots of onion and garlic extracts at concentrations of 0.01g/0.25kg, 0.02 g/0.25 kg, and 0.04g/0.25kg were admixed with the sweet potato samples. The samples were placed in the perforated plastic boxes lightly and uniformly sprayed with the reconstituted crude extracts. The boxes were left open for 40 minutes for the solvent to evaporate. Five unsexed four-day-old *C. formicarius* beetles, which were obtained from the culturing of *C. formicarius* for 28 days on sweet potatoes were then added to each box and covered with muslin cloths. Three replicates of each treatment were set up. Five (5) unsexed adult insects and 0.25 kg of sweet potatoes were also used for a control experiment, which had no crude extracts. Three replicates of every treatment were made. The mortality of the insects was noted and counted at 24-h intervals for four days (96 h). Weevils that were immobile and did not respond to pin probing were counted as dead. Abbott's formula of 1925 was used to correct mortality after the 96-h post-treatment interval, as described by Asawalam et al. (2006).

$$\frac{\text{Mortality of treated insects}}{\text{Mortality of control insects}} \times 100 = \text{Corrected mortality} \quad \dots \text{Eqn. 1}$$

Results and Discussion

Phytochemical analysis

Table 1 presents the qualitative phytochemical screening, which revealed the presence of various important secondary metabolites in hexane, ethyl acetate, and methanolic extracts of red onion and garlic

peels. Alkaloids, saponins, flavonoids, terpenoids, cardiac glycosides, tannins, and phenols were detected in the hexane and methanolic extracts of red onion peels, while saponins and cardiac glycosides were absent in the ethyl acetate extracts of red onion peel. On the contrary, saponins, flavonoids, cardiac glycosides, tannins, and phenols were absent in the garlic skin's hexane extract, while the ethyl acetate extract contained all the phytochemicals screened except the cardiac glycosides. However, the phytochemicals screened were in the methanolic extract of the garlic peels (Table 1). Garlic hexane extracts contain extremely small or no phenols since hexane is a nonpolar solvent that primarily extracts nonpolar substances like organosulfur compounds and terpenoids, while phenolic compounds are polar. Phenolic compounds are found to be extracted more efficiently by polar solvents such as ethanol or ethyl acetate, and in higher concentration in aqueous extracts.

Additionally, hexane garlic extract does not contain tannins, as tannins are more soluble in polar solvents, such as ethanol and water. Tannins are polar molecules, and hexane is a nonpolar solvent; thus, it will not dissolve tannins effectively. Instead, hexane extracts are strongly nonpolar in composition, with nonpolar constituents such as terpenoids. Hexane extracts of garlic do not contain cardiac glycosides, as these compounds are typically absent in hexane extracts but are often found in other extractions, such as methanolic extracts. Phytochemical screenings of garlic have revealed the presence of alkaloids in hexane extracts, as well as terpenoids. The ethyl acetate extract of garlic peels contains no cardiac glycosides. It contains flavonoids, saponins, and tannins. It does not contain saponins, but the ethyl acetate extract of onion peels typically does not contain them because they are less polar compounds, such as flavonoids and alkaloids, while saponins are more polar and are found in methanolic extracts.

Table 1: Methanolic extract phytochemical analysis of onion and garlic peels

Phytochemicals	OHX	GHX	OEA	GEA	OMH	GMH
Alkaloid	+	+	+	+	+	+
Saponin	+	-	-	+	+	+
Flavonoid	+	-	+	+	++	+
Terpenoids	+	+	+	+	+	+
Cardiac Glycosides	+	-	-	-	+	+
Tannin	+	-	+	+	+	+
Phenol	+	-	+	+	+	+

Where: + = present, ++ = highly present, - = absent

OHx=Onion Hexane Extract, GHx= Garlic Hexane Extract, OEA= Onion Ethyl acetate Extract, GEA= Garlic Ethyl Acetate Extract, OMH= Onion Methanolic Extract, GMH= Garlic Methanolic Extract

Insecticidal activity: Effect of onion peel extracts on *Cylas formicarius* mortality

From Table 2, it can be observed that the methanolic onion extract (OMH) at a concentration of 0.04 g/0.25 kg was consistently the most potent, reaching 93.3% mortality at 96 h, similar to the synthetic standard in the 96 h post exposure period. The ethyl acetate and hexane fractions showed intermediate activity. These results indicate a strong time- and dose-dependent effect, suggesting that polar constituents are primarily responsible for the insecticidal activity.

Insecticidal activity: Effect of garlic peel extracts on *Cylas formicarius* mortality

Table 3 shows that the methanolic garlic extract (GMH) at the concentration of 0.04g/0.25 kg showed the highest early response among garlic fractions (66.67% at 24 h) and maintained high mortality through 96 h (73.3%). At 96 h, methanolic and some hexane fractions reached mortalities greater than 70% but remained below the synthetic standard, cypermethrin, which demonstrated statistically significant differences among low-response ethyl acetate garlic extract at 0.02 g/0.25 kg, and untreated, and high-response treatments (GMH) at concentrations of 0.04 g/0.25 kg and GHx at a concentration of 0.02 g/ 0.25 kg.

Insecticidal activity: Effect of pure isolate (OM-15) on *Cylas formicarius* mortality

The pure compound (OM-15) exhibited a clear dose-dependent response; 10 mg/0.25 kg produced significantly higher mortality than 5 mg/0.25 kg at all-

time points ($P \leq 0.05$). Neither concentration matched cypermethrin's efficacy at 96 h. Adult sweet potato weevils (*Cylas formicarius*) were maintained under laboratory ambient conditions (27 ± 2 °C and 76.5% RH) to evaluate the insecticidal potential of onion and garlic peels extracts, pure isolate (OM-15) of onion peel extract, and synthetic insecticide (cypermethrin). In each treatment, mortality increased considerably ($P < 0.05$) with concentration and exposure duration (24–96 h). Onion (OMH) and garlic (GMH) methanolic extracts were significantly better than the majority of the solvent controls and lower-concentration treatments, indicating that polar bioactive phytochemicals, such as flavonoids, phenolics, and organosulfur derivatives, were predominantly adequately extracted. Statistical classifications indicated botanical treatments equivalent to the standard in subsequent exposure times and those significantly lower.

The rich diversity of phytochemicals in onion and garlic peels (Table 1) is the principal cause of having an insecticidal effect. These phytochemicals, including phenolics, terpenoids, and alkaloids, are previously known to disrupt various physiological processes in pest insects (Isman, 2006). These can individually inflict damage on the lining of the gut, inhibit primary enzymes, or disrupt the nervous system, ultimately leading to death. This affirming outcome aligns with previous studies conducted by Isman (2006), which demonstrated that neem extracts rich in azadirachtin suppress insect feeding and reproduction, thereby enhancing mortality.

Table 2: Effect of Mortality on *Cylas formicarius* caused by Onion peel Extracts

Treatment	24 h	48 h	72 h	96 h
OHx 0.01	20.00 ^h	20.00 ^f	33.30 ^g	53.30 ^b
OHx 0.02	26.70 ^g	26.70 ^e	26.70 ^h	66.70 ^d
OHx 0.04	13.30 ⁱ	26.70 ^e	40.00 ^f	66.67 ^e
OEA 0.01	33.30 ^f	40.00 ^d	53.30 ^d	53.33 ^g
OEA 0.02	33.30 ^f	40.00 ^d	53.30 ^d	53.33 ^g
OEA 0.04	40.00 ^e	40.00 ^d	53.30 ^d	53.30 ^h
OMH 0.01	40.00 ^e	60.00 ^c	40.00 ^f	66.70 ^d
OMH 0.02	46.70 ^d	60.00 ^c	46.67 ^e	66.70 ^d
OMH 0.04	66.60 ^b	73.30 ^b	80.00 ^b	93.30 ^b
ConHx	60.00 ^c	60.00 ^c	60.00 ^c	60.00 ^f
ConEA	40.00 ^e	40.00 ^d	40.00 ^f	80.00 ^c
ConMH	20.00 ^h	20.00 ^f	20.00 ⁱ	20.00 ⁱ
Untreated	0.00 ^j	0.00 ^g	0.00 ^j	20.00 ⁱ
Standard	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a

The values are expressed as Mean \pm SEM at ($P \leq 0.05$). Where OHx= Onion Hexane Extract, OEA= Onion Ethyl Acetate, OMH= Onion Methanolic Extract. Grouping letters (same letter within a column = not significantly different at $P < 0.05$)

Table 3: Effect of Mortality on *Cylas formicarius* caused by Garlic peel Extracts

Treatment	24 h	48 h	72 h	96 h
GHx 0.01	40.00 ^g	53.30 ^e	40.00 ⁱ	60.00 ^d
GHx 0.02	46.00 ^f	53.30 ^e	66.67 ^d	80.00 ^b
GHx 0.04	40.00 ^g	53.30 ^e	53.33 ^f	46.67 ^f
GEA 0.01	53.30 ^d	20.00 ^g	40.00 ⁱ	46.67 ^f
GEA 0.02	6.67 ^j	33.30 ^f	33.30 ^j	60.00 ^d
GEA 0.04	33.30 ^h	53.33 ^d	46.67 ^h	40.00 ^g
GMH 0.01	40.00 ^g	53.30 ^e	53.30 ^g	53.30 ^e
GMH 0.02	46.67 ^e	53.30 ^e	46.67 ^h	60.00 ^d
GMH 0.04	66.67 ^b	53.30 ^e	73.30 ^c	73.30 ^c
ConHx	20.00 ⁱ	60.00 ^c	60.00 ^e	20.00 ^h
ConEA	20.00 ⁱ	80.00 ^b	80.00 ^b	20.00 ^h
ConMH	60.00 ^c	60.00 ^c	80.00 ^b	100.00 ^a
Control	0.00 ^k	0.00 ^h	0.00 ^k	20.00 ^h
Standard	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a

The values are expressed as Mean \pm SEM at ($P \leq 0.05$). Where GHx= Garlic Hexane Extract, GEA= Garlic Ethyl Acetate, GMH= Onion Methanolic Extract, Grouping letters (same letter within a column = not significantly different at $P < 0.05$):

Table 4: Effect of pure isolate OM-15 from onion peel on *Cylas formicarius*

Treatment	24 h	48 h	72 h	96 h
OM-15 (5 mg/0.25 kg)	13.33 ^c	26.00 ^c	40.00 ^c	53.33 ^c
OM-15 (10 mg/0.25 kg)	20.00 ^b	33.33 ^b	46.67 ^b	60.00 ^b
Control	0.00 ^d	0.00 ^d	0.00 ^d	0.00 ^d
Cypermethrin	100.00 ^a	100.00 ^a	100.00 ^a	100.00 ^a

The values are expressed as Mean \pm SEM at ($P \leq 0.05$).

Just as the essential oils of *Ocimum basilicum* and other related species contain insect pest toxic and repellent effects. The mortality of *C. formicarius* was achieved by extracts of onion and garlic peels. Among the garlic extracts, the methanolic extract (GMH 0.04 g/0.25 kg) caused the highest initial response (66.67% at 24 h) and maintained high mortality to 96 h (73.3%). In parallel, the methanolic and hexane extracts achieved mortalities of over 70%, while the synthetic standard (cypermethrin) achieved 100%. Statistically significant differences ($P < 0.05$) were observed between the high-response treatments (GMH 0.04, GHx 0.02) and the low-response treatments, such as garlic ethyl acetate extract (GEA 0.02) and the untreated control. Similarly, the methanolic onion extract (OMH, 0.04 g/0.25 kg) was the most effective of all, achieving 93.3% mortality at 96 h, comparable to the synthetic standard. The ethyl acetate and hexane fractions were intermediate in activity. Mortality rates for OMH increased steadily from 66.67% at 24 h to 93.3% at 96 h, which validated significant time- and dose-dependent toxicity and pointed towards polar constituents as the primary insecticidal compounds.

These findings are consistent with previous data on plants' bioactive compounds, which show similar properties. Mathu (2015) reported that eugenol extracted from *Ocimum suave* is an effective repellent of *Sitophilus zeamais*. The insecticidal activity reported in this study also shares similarities with highly documented botanical insecticides, such as nicotine from *Nicotiana tabacum*, which acts as both a contact and stomach poison (Mathu, 2015). Due to their effectiveness, biodegradability, environmental safety, and accessibility, botanical pesticides are gaining widespread usage as alternatives to chemical pesticides. At comparable exposures, onion peel extracts were more toxic than garlic extracts. For instance, at 48 h, the methanolic onion extract showed a mortality of 73.33%, while the garlic extract reached 53.3% at the same concentration (0.04 g/0.25kg). At 72 h, the mortalities were 80% (onion) and 73.3% (garlic), and at 96 h, the methanolic extracts from onion and garlic showed 93.3% and 73.3% mortality, respectively. All the extracts applied were significantly more effective ($P < 0.05$) than the untreated control, which recorded minimal mortality (<20%). The pure

OM-15 isolate exhibited a slower but cumulative action: mortality increased from 13.33% after 24 h (5 mg/0.25 kg) to 60% after 96 h (10 mg/0.25 kg).

The dose- and time-dependent pattern is characteristic of cumulative toxicity resulting from prolonged exposure. Comparable results were reported by Okwute (2006), who purified new *daphnane orthoester* compounds with reported insecticidal activity from *Excoecaria agallocha*. The difference in mortality rates between the pure OM-15 isolate and the crude methanolic extract of onion peels, as well as the standard insecticide (cypermethrin), may be due to compound synergy, concentration, and chemical diversity. For example, the crude extract contains a mixture of bioactive compounds from onion peels, which may act synergistically to enhance insecticidal potency. In contrast, the pure isolate, although active, lacks these synergistic partners, resulting in lower efficacy (60% mortality) 96 h postexposure. The standard insecticide is chemically optimised for maximum mortality, often targeting multiple physiological pathways in pests, hence, the 100% mortality. It can also be speculated that natural extracts may have narrower action spectra or slower modes of action.

Additionally, the crude methanolic extract of onion peels contained higher concentrations of active compounds or compounds that improve absorption and reduce toxicity, whereas the pure OM-15 isolate might be less bioavailable or metabolised more quickly by the *Cylas formicarius*. It can also be speculated that the crude methanolic extract of onion peels contains secondary metabolites that enhance toxicity or inhibit pest detoxification enzymes. Isolating a single compound can reduce this complexity and overall effectiveness. Overall, both methanolic extracts of onion and garlic peels exhibited high insecticidal activity on *C. formicarius*, with a few performances even comparable to cypermethrin. Their reproducibility, as well as their biodegradable and renewable nature, render them good candidates for use in future integrated management schemes for sweet potato weevils.

Conclusion and Recommendation

The present study demonstrated that extracts from the peels of red onion (*Allium cepa*) and garlic (*Allium sativum*) exhibit significant insecticidal activity against the sweet potato weevil (*Cylas formicarius*). Mortality increased significantly with both concentration and duration of contact, confirming a dose- and time-dependent positive effect. Among the

solvent extracts, the methanolic extracts of onion and garlic peels (OMH and GMH) were most effective, with mortalities of 93.3% and 73.3% respectively, at 96 h postexposure, comparable to the synthetic insecticide cypermethrin. The results highlight that polar bioactive compounds, such as flavonoids, phenolics, and organosulfur compounds play crucial roles in insecticidal activity through the interference with enzymatic activity, induction of oxidative stress, and neurotoxicity toward the target pest. The mortality obtained with the pure OM-15 isolate again substantiates the involvement of specific phytochemical components in the observed bioactivity. Due to their effectiveness, biodegradability, environmental friendliness, and easy availability as agro-wastes, onion and garlic peel extracts are excellent, eco-friendly alternatives to traditional synthetic insecticides. Incorporation into integrated pest management (IPM) programmes may reduce postharvest losses of sweet potato and promote sustainable pest control. Future research should be directed towards optimising formulation, field testing efficacy, and defining the very synergy each phytochemical achieves to enhance insecticidal performance.

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