



NATURE'S ARSENAL: HARNESSING ANNONACEOUS ACETOGENINS FOR ECO-FRIENDLY PEST CONTROL

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Introduction

The search for safe and sustainable alternatives to chemical pesticides has led researchers to rediscover the potential of natural plant compounds. Among these, acetogenins, derived mainly from the Annona family (such as custard apple and soursop), have gained significant attention. These bioactive molecules offer strong pesticidal effects while being biodegradable and eco-friendly, making them promising candidates for future crop protection.

What are Acetogenins?

Annonaceous acetogenins, naturally occurring compounds found in plants of the

Annonaceae family, exhibit potent insecticidal properties and are being explored as natural insecticides.

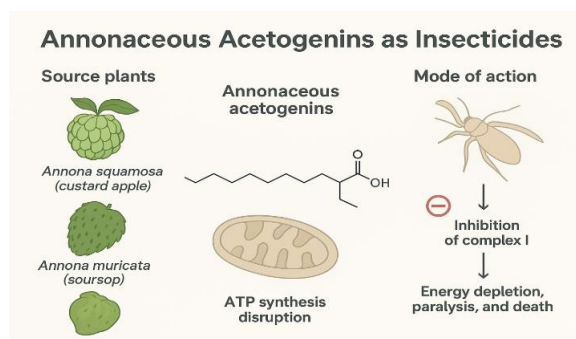
These compounds, particularly those with tetrahydrofuran (THF) rings, have demonstrated toxicity to a wide range of insect pests, including mosquito larvae, spider mites, aphids, and various beetle species.

Studies have shown that acetogenins can be toxic at low concentrations and affect insects at different developmental stages. Famous examples include bullatacin, squamocin and rolliniastatin, all known for their potent biological activity.

Table 1: Sources of Annonaceous Acetogenins in *Annona* Species

Annona species	Common name	Plant part(s) rich in acetogenins	Remarks / Uses
<i>Annona squamosa</i>	Custard apple	Seeds, leaves, bark	Insecticidal, medicinal
<i>Annona muricata</i>	Soursop/ Graviola	Leaves, seeds, fruit pulp, bark	Widely studied for anticancer activity
<i>Annona cherimola</i>	Cherimoya	Seeds, leaves, stem bark	Bioactive extracts used in pest control
<i>Annona reticulata</i>	Bullock's heart	Seeds, bark, leaves	Insecticidal & medicinal potential

<i>Annona glabra</i>	Pond apple	Leaves, stem bark, seeds	Reported for antimicrobial and pesticidal activity
<i>Annona montana</i>	Mountain soursop	Leaves, seeds, bark	Wild species with diverse acetogenins
<i>Annona senegalensis</i>	African custard apple	Roots, bark, leaves	Traditional medicine, bio-pesticide potential
<i>Annona diversifolia</i>	Ilama	Seeds, leaves, bark	Antimicrobial and insecticidal reports



How they work

Mitochondrial Inhibition

Acetogenins disrupt the mitochondrial electron transport chain (the process cells use to generate energy), specifically at complex I (the first protein complex in this sequence), hindering energy production in insect cells.

Apoptosis Induction

This disruption can lead to apoptosis (programmed cell death) in insect cells.

Feeding Deterrence

Some acetogenins also act as feeding deterrents, reducing insect feeding on treated plants.

Developmental Effects

They can also cause delays in insect development and mortality, particularly in larval and pupal stages.

Spectrum of pesticidal activity

Purified acetogenins and extracts rich in these compounds are effective against various pests, showing larvicidal, growth-inhibitory, ovicidal, and antifeedant properties

- Lepidoptera - *Spodoptera litura*, *S. littoralis*, *S. frugiperda*—seed/leaf extracts of *A. squamosa* cause high larval mortality and growth inhibition; semi-field trials with natural and analogue ACGs suppress *S. frugiperda*.
- Coleoptera - *Tribolium castaneum* - strong insecticidal activity is exhibited by seed extracts.
- Acarids and others - As complex-I inhibitors, ACGs are mechanistically comparable to METI acaricides; reports note activity across mites and other orders depending on extract and dose. A recent comparative analysis concluded ACGs are toxic at low concentrations relative to commercial standards, underscoring promise as botanicals.

Benefits

Natural and Biodegradable

Acetogenins are naturally derived and are expected to biodegrade, making them a potentially more environmentally friendly

option compared to some synthetic insecticides.

Alternative to Synthetic Insecticides

They offer a promising alternative for insect control, especially considering the increasing concern about synthetic pesticide resistance.

Broad-Spectrum Activity

Acetogenins have shown activity against a wide range of insect pests, suggesting their potential for broad-spectrum pest control.

Potential for Integrated Pest Management

Their ability to act as both toxins and feeding deterrents could be valuable in integrated pest management strategies.

Formulation & application prospects

- Plant sources: Seeds and leaves of *Annona squamosa*, *A. muricata*, *A. cherimola*, *Asimina triloba*, among others, are rich ACG reservoirs.
- Extracts vs. isolates: Crude or semi-purified seed/leaf extracts are effective in lab and semi-field bioassays; microencapsulation and emulsifiable concentrates are being explored to stabilize labile constituents.
- Use cases: As standalone botanicals, tank mixes to broaden spectrum, or components in Integrated Pest Management (IPM) with rotation to reduce resistance pressure

Environmental fate and safety considerations

- Non-target risks: Being potent complex-I inhibitors, ACGs can be broadly bioactive. Ensuring safety

requires careful attention to exposure routes, the dose, and formulation.

- Resistance management: Rotate with different IRAC groups; avoid repeated applications that select for complex-I resistance mechanisms already known with METIs.

Further Research

- Further research is needed to fully understand the mechanisms of action and potential ecological impact of acetogenins.
- Investigating the effectiveness of acetogenins against a wider range of insect pests and developing methods for their efficient application are important areas of future study.
- Exploring the potential of acetogenins in combination with other pest control strategies could enhance their efficacy

Conclusion

Acetogenins exemplify the potential of plant-derived compounds as green pesticides. By harnessing these natural molecules, agriculture can move closer to reducing dependency on synthetic chemicals, ensuring both crop protection and environmental sustainability. With continued research, acetogenins could soon play a vital role in shaping the future of eco-friendly pest management.

Reference

1. Chang FR, Wu YC. Novel cytotoxic annonaceous acetogenins from *Annona muricata*. *Journal of Natural Products*. 2001;64(7):925–931.
2. Liaw CC, Chang FR. Annonaceous acetogenins: Recent progress. *Journal*

- of Natural Products. 2004;67(12):2075–2082.
3. McLaughlin JL. Paw paw and cancer: Annonaceous acetogenins from discovery to commercial products. *Journal of Natural Products*. 2008;71(7):1311–1321.
 4. Murugan K, et al. Insecticidal activity and midgut histology changes in *Spodoptera litura* in response to *Annona squamosa* seed extract. *Journal of Applied and Natural Science*. 2023;15:4371.
 5. Rupprecht JK, Hui YH, McLaughlin JL. Annonaceous acetogenins: A review. *Journal of Natural Products*. 1990;53(2):237–278.
 6. Tripathi AK, Prajapati V, Kumar S. Insecticidal activity of *Annona squamosa* seed extracts against *Tribolium castaneum*. *Journal of Stored Products Research*. 1999;35(1):35–44.