Journal of Bio-Science
https://doi.org/10.3329/jbs.v33i2.87446
pISSN: 1023-8654 | eISSN: 2408-8595
Volume 33 | Issue 02 2025

RESEARCH ARTICLE

Check for updates

Bioactivities of the Peacock Flower *Caesapinia pulcherrima* (L.) Sw. Against Mosquitoes and Three Stored Product Pests

Sharmin Sultana[1], Pritam Chandra Roy[1], Asia Khatun[2,3] and Md. Nurul Islam[1]*

OPEN ACCESS

[1]Department of Zoology, University of Rajshahi, Bangladesh.
[2]Graduate School of Agriculture, Ehime University, Japan.
[3]Graduate School of Agriculture, Kagawa University, Japan.

***Correspondence:**
Email: nurulislam@ru.ac.bd

How to Cite the Article:
Sultana, S., Roy, P. C., Khatun, A. and Islam, M. N. (2025). Bioactivities of the Peacock Flower *Caesapinia pulcherrima* (L.) Sw. against Mosquitoes and three Stored Product Pests. Journal of Bio-Science 33(2): 77-86.

Peer Review Process:
The Journal abides by a double-blind peer review process such that the journal does not disclose the identity of the reviewer(s) to the author(s) and does not disclose the identity of the author(s) to the reviewer(s).

Abstract

Petroleum ether, chloroform ($CHCl_3$) and methanol (CH_3OH) extracts of the flowers and leaves of *Caesalpinia pulcherrima* (L.) were evaluated for their larvicidal activity against *Culex quinquefasciatus* Say and their repellent activity against three stored grain pests: *Tribolium castaneum* (Hbst.), *Sitophilus oryzae* (L.) and *Callosobruchus chinensis* (L.). The LC_{50} values of the petroleum ether and $CHCl_3$ extracts of the flowers were 119.80, 37.34, 25.06, 17.12, and 10.36 ppm and 101.04, 76.67, 66.67, 58.24, and 51.82 ppm, respectively, after 24, 30, 36, 42, and 48 h of exposure. The $CHCl_3$ leaf extract showed LC_{50} values of 361.21, 321.10, 245.41, 207.09, and 203.19 ppm after 24, 30, 36, 42, and 48 h of exposure, respectively. Depending on the intensity of larvicidal activity on the mosquito, the extracts can be classified in descending order as follows: petroleum ether (flower) >$CHCl_3$ (flower) >$CHCl_3$ (leaf). Extracts of flowers with petroleum ether demonstrated a highly significant repellent effect against adult *T. castaneum* ($p<0.01$), extracts of leaves with $CHCl_3$ and CH_3OH showed a moderately significant repulsion against adult *T. castaneum* ($p<0.05$), and extracts of leaves with petroleum ether also showed a moderately significant repulsion against adult *S. oryzae* ($p<0.05$).

Keywords: *Caesalpinia pulcherrima*, *Culex quinquefasciatus, Tribolium castaneum, Sitophilus oryzae, Callosobruchus chinensis,* Larvicidal activity, Repellent activity.

Received: 23 August 2025 | **Revised**: 26 October 2025 | **Accepted**: 09 December 2025 | **Published**: 31 December 2025

Introduction

Medicinal plants are attracting increasing interest due to their minimal side effects, allowing them to manage or cure a wide range of ailments and thus playing an important role in the discovery of new drugs. *Caesalpinia pulcherrima* (L.) Sw. is one such plant, widely used in traditional medicine to treat various diseases, which has led researchers to discover the different phytochemical compounds it produces (Bhagya 2024). It is also known as peacock flower, is an ornamental and medicinal plant found along roadsides. Different parts of this plant have been studied for their toxicological properties. The essential oil from its root has been shown to have insecticidal properties against the stored-food pests *Tribolium castaneum* and *Callosobruchus analis*, with mortality rates of 20% and 40%, respectively (Erharuyi et al. 2017). The ethanolic and acetone extracts of its leaves possess ovicidal activity (Krishnaveni et al. 2023). Both ethanolic and aqueous extracts exhibit antibacterial effects against various bacterial strains (Gbenga et al. 2024). This plant has a long history of use in various medicinal contexts, making it one of the most common medicinal plants and playing a key role in the treatment of fever, microbial infections, cancer, and in several other traditional medicine systems (Deepika et al. 2020).

Leaf extracts of this plant are used for wound healing, likely due to the presence of phenolic compounds and their antioxidant, antimicrobial, analgesic, anti-inflammatory, and astringent properties (Pusztahelyi et al. 2015). The plant produces secondary metabolites as a chemical defense mechanism against microbial destruction and oxidative stress, notably through the formation of triplet chlorophyll radicals, single hydroxyl radicals and oxygen radicals (Gechev et al. 2006, Rao et al. 2007). A detailed and thorough review of this plant was published by Krupanidhi et al. (2024) reporting all its potential anti-arthritic, anti-asthmatic, analgesic, antibacterial, anticonvulsant, antidiarrheal, antidiabetic, antifertility, antifungal, anthelmintic, anti-inflammatory, antimalarial, antimetastatic by molecular docking, antinociceptive, antioxidant, antituberculosis, antitussive, antiulcer, antiviral, anxiolytic, arginase inhibitor, cytotoxic, immunosuppressive, immunomodulatory, larvicidal, leishmanicidal, hepatoprotective, purgative and insecticidal activity.

A similar publication by Sangeetha et al. (2024) confirms the findings of Krupanidhi et al. (2024), which mention the numerous therapeutic properties of this plant. Numerous phytoactive compounds, including glycosides, rotenoids, benzoic acid, tannins and hydrocyanic acid, isoflavones, flavanones, chalcones, flavanols, flavones, and sterols, have been identified in *C. pulcherrima*, and even the authors described this plant as "marvelous" in the title of their publication. These properties are reportedly used to treat cholera, ulcers, fever, tumors, asthma, miscarriages, promote menstruation, act as a purgative (or laxative), boost energy, relieve chest pain, treat bronchitis, and treat malarial fevers. Furthermore, the plant is said to possess antimicrobial, analgesic, anti-inflammatory, antioxidant, anthelmintic, antiulcer, cytotoxic, antiviral, anticancer, antidiabetic, immunosuppressive, and vasorelaxant properties. Thus, information on the chemistry and biological potential of *C. pulcherrima* is abundant, particularly concerning the biological activities of extracts from its roots, leaves, wood, and even flowers on various test organisms. However, this study aimed to better define its activity against stored-food pests, using the leaves and flowers as test material. It was therefore conducted to evaluate the larvicidal activity of *C. pulcherrima* extracts against the mosquito *C. quinquefasciatus* and their repellent activity against three stored-food pests: *T. castaneum* (Hbst.), *S. oryzae* (L.), and *C. chinensis* (L.).

The southern house mosquito *C. quinquefasciatus* is a well-known vector for human lymphatic filariasis, caused by the parasitic nematodes like *Wuchereria bancrofti*, *Brugia malayi* and *Brugia timori,* which are transmitted from person to person by the mosquito (Bockarie et al. 2009, Chhabi et al. 2017). The red flour beetle *T. castaneum* (Hbst.) is recognized globally as a pest of stored products, particularly cereals, and is widely used as a model organism in food safety research (Ridley et al. 2011, Grünwald et al. 2013). The rice weevil *S. oryzae* (L.) mainly infests stored rice, reducing its nutritional value and converting it into unusable protein residues (Benhalima et al. 2004, Akhtar et al. 2015, Zakladnoy 2018. The pulse beetle *C. chinensis* (L.) is a pest which is generally associated with legume processing industries and inflicts significant damage to stored legumes (Ahmed et al. 2018, Seni et al. 2025).

Materials and Methods

Collection of plant and preparation of extracts

Fresh leaves and flowers of *C. pulcherrima* were collected in September 2024 in Chowddopai, Rajshahi. The plant's phylogenetic position was verified by a taxonomist from the Department of Botany at Rajshahi University. The plants were chopped, shade-dried, and then ground into a fine powder using an electric grinder. The resulting powder was weighed and placed in an Erlenmeyer flask. The solvent was added in two stages, at a rate of 60 g × 180 mL, and the mixture was stirred for 48 hours. After filtration through Whatman filter paper (made in China), the petroleum ether extract was collected in a round-bottom flask. The same procedure was repeated with chloroform ($CHCl_3$) and methanol (CH_3OH) (Mohammad et al. 2025) (Fig. 1&2). After evaporation, the extracts were transferred into glass vials, labeled and kept refrigerated at 4°C until use .

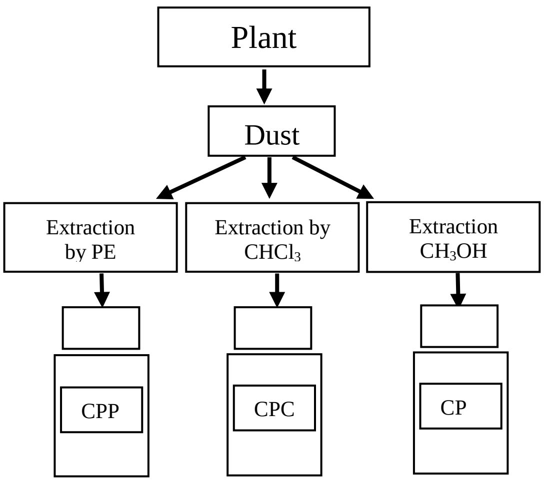

Fig. 1: Collection of *C. pulcherrima* extracts using organic solvents.

Fig. 2: Extracts in bottles with labels.

Collection of the test insects and their culture

Egg masses of *C. quinquefasciatus* were collected from campus gutters and reared at the Crop Protection and Toxicology Laboratory of the Zoology Department at Rajshahi University. These egg masses were placed in 500 ml beakers containing filtered pond water. After 24 h, the eggs hatched, and the larvae were collected and used for experiments. Adult beetles of *T. castaneum*, *S. oryzae*, and *C. chinensis* were collected in the same laboratory. Stocks and subcultures were maintained throughout the experimental period to ensure a continuous supply of insects for testing (Chhabi et al. 2017).

Larvicidal activity tests

Extracts of *C. pulcherrima* flowers in petroleum ether (concentrations of 50, 30, and 10 ppm) and extracts of flowers in chloroform (concentrations of 80, 70, 60, and 50 ppm) were used for the larvicidal activity test against *C. quinquefasciatus (Fig*. Extracts of *C. pulcherrima* leaves in chloroform (concentrations of 300, 250, and 200 ppm) were also tested. Each test tube contained ten newly hatched larvae at the indicated concentrations. Mortality was observed after 6, 12, 18, 24, and 30 h of exposure (Fig. 3).

Fig. 3: Bioassay with plant extracts on *C. quinquefasciatus* larvae.

Repellent activity tests

The repellent activity test was adapted from the method of McDonald et al. (1970) with some modifications. Filter paper half-discs (Whatman No. 40, 9 cm in diameter) were used. Each half-disc was cut in half, and one of the halves was treated with specific doses of petroleum ether/$CHCl_3$/CH_3OH extracts: 0.1571, 0.0785, 0.0392, 0.0196, and 0.0098 mg cm^{-2}. Each treated half-disc was then taped lengthwise to a control half-disc, and the assembly was placed at the bottom of Petri dishes intended to hold *T. castaneum*. For the repellent activity test on *C. chinensis* and *S. oryzae*, similar Petri dishes were divided into three zones by placing two narrow sticks on the ground using adhesive tape, and the two parts on each side were filled with treated and untreated food, in the central part where ten beetles of the same age were released and the doses were the same as those mentioned above. Their orientation was modified to prevent external directional cues from affecting the distribution of the tested insects. Ten adult insects were placed in the center of each circle of filter paper. The same procedure was applied to all extracts. The concentration of the extracts in each solvent was tested five times. Insects deposited on each untreated portion of the Petri dishes were counted after 1 h, and then data were collected hourly five times. Using the formula of Talukder and Howse (1993, 1995), the count means were converted to percentage repulsion (PR) = (Nc – 5) × 20, where Nc represents the hourly mean number of insects observed on the untreated halves of the Petri dishes (Fig. 4).

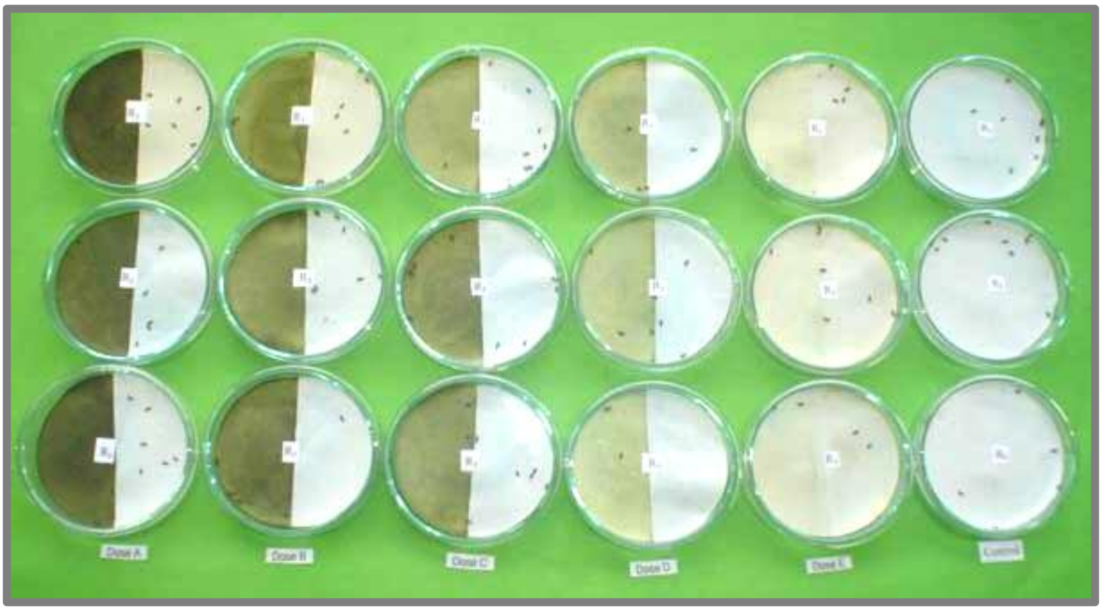

Fig. 4: Experiment on the repellent activity test with an extract of *C. pulcherrima* against *T. castaneum* adults according to McDonald et al. (1970).

Statistical analyses

Larval mortality (%) was corrected using Abbott's formula (Abbott 1925). The data were then subjected to probit analysis according to Finney (1947) and Busvine (1971). Data relating to the percentage of repulsion were subjected to analysis of variance (ANOVA) to compare means at significance levels of 5% and 1% (Chhabi et al. 2017).

Results

Larvicidal effects on mosquito

Petroleum ether, $CHCl_3$, and CH_3OH extracts of *C. pulcherrima* flowers and leaves were evaluated for their larvicidal activity against *C. quinquefasciatus*. Both the petroleum ether and $CHCl_3$ flower extracts, as well as the $CHCl_3$ leaf extract, showed larvicidal activity against the tested larvae. The $CHCl_3$ leaf extract exhibited LC_{50} values of 361.21, 321.10, 245.41, 207.09, and 203.19 ppm after 24, 30, 36, 42, and 48 h of exposure, respectively. The petroleum ether flower extract showed LC50 values of 119.80, 37.34, 25.06, 17.12, and 10.36 ppm at the same exposure intervals. Meanwhile, the CHCl3 flower extract showed LC50 values of 101.04, 76.67, 66.67, 58.24, and 51.82 ppm after 24, 30, 36, 42, and 48 hours of exposure, respectively (Fig. 5).

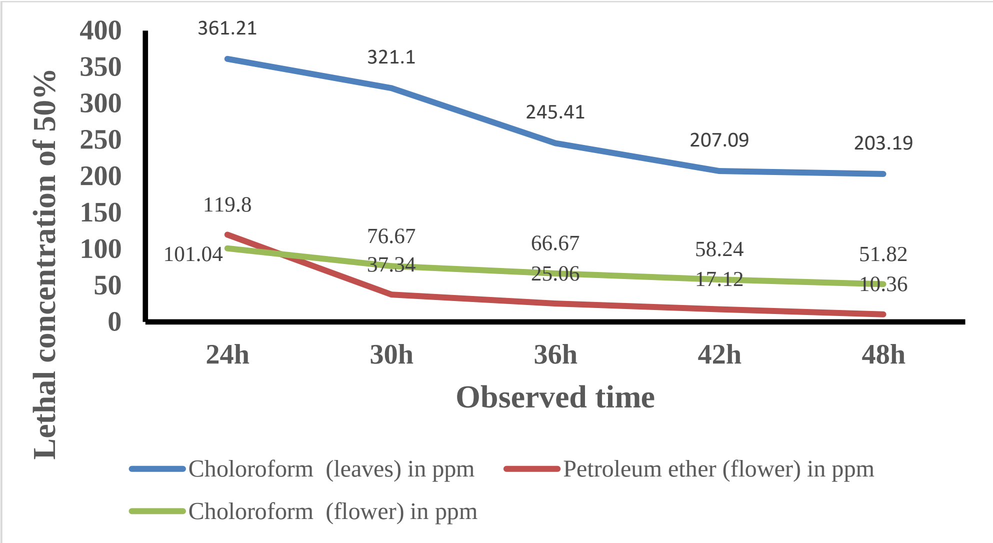

Fig. 5: Larvicidal activity of *C. pulcherrima* against *Culex quinquefasciatus*.

Repellent activities against stored pests

Only the petroleum ether flower extract demonstrated a significant repellent effect against adult *T. castaneum* ($p<0.01$). The other extracts showed no repellent activity against *T. castaneum*, *S. oryzae*, or *C. chinensis*. Among the leaf extracts, the $CHCl_3$ and CH_3OH extracts showed moderately significant repellent activity against adult *T. castaneum* ($p<0.05$), and the petroleum ether leaf extract also showed moderate repellent activity against adult *S. oryzae* ($p<0.05$) (Table 1).

Table 1: Summary of the repellent activities of *C. pulcherrima* leaf and flower extracts against three stored-food pests.

Plant parts	Test agents	Solvent of extraction	Sources of variation			F-ratio with level of significance		P- values	
			Bd	Bti	Error	Bd	Bti	Bd	Bti
Leave	*T. castaneum*	Pet. ether	4	4	16	4.98	1.52	0.008	0.242
		$CHCl_3$	4	4	16	13.44*	1.05	5.5E-05	0.413
		CH_3OH	4	4	16	12.31*	1.56	9.2E-05	0.233
	S. oryzae	Pet. ether	4	4	16	17.68*	1.96	1.0E-05	0.151
		$CHCl_3$	4	4	16	3.12	2.74	0.045	0.066
		CH_3OH	4	4	16	3.43	0.47	0.033	0.755
	C. chinensis	Pet. ether	4	4	16	2.20	1.62	0.115	0.217
		CH_3OH	4	4	16	4.79	10.38	0.011	0.0002
Flower	*T. castaneum*	Pet. ether	4	4	16	25.30**	2.83	9.5E-07	0.060
		$CHCl_3$	4	4	16	2.12	3.60	0.125	0.028
		CH_3OH	4	4	16	1.23	2.96	0.337	0.052
	S. oryzae	Pet. ether	4	4	16	5.61	3.24	0.005	0.041
		$CHCl_3$	4	4	16	1.55	4.28	0.235	0.015
		CH_3OH	4	4	16	4.08	0.38	0.018	0.821
	C. chinensis	Pet. ether	4	4	16	2.72	0.11	0.067	0.978
		$CHCl_3$	4	4	16	4.96	2.81	0.009	0.061
		CH_3OH	4	4	16	4.19	0.38	0.016	0.821

Discussion

Laboratory experiments were conducted to evaluate the larvicidal and repellent activity of petroleum ether, $CHCl_3$, and CH_3OH extracts of *C. pulcherrima* flowers and leaves against mosquitoes and three stored-food pests. These experiments yielded satisfactory results. The $CHCl_3$ leaf extract exhibited LC_{50} values ranging from 361.21 to 203.19 ppm after 24 to 48 h of exposure, respectively. The petroleum ether flower extract exhibited LC_{50} values ranging from 119.80 to 10.36 ppm after 24 to 48 h of exposure, respectively. Meanwhile, the $CHCl_3$ flower extract showed CL_{50} values ranging from 101.04 to 51.82 ppm after 24 to 48 h of exposure, respectively.

Previous studies on the biological potential of *Caesalpinia* spp. have corroborated the findings of this research. Krishnaveni et al. (2023) demonstrated the ovicidal activity of ethanolic and acetone extracts of *C. pulcherrima*, and their results showed that these extracts significantly reduced the hatching rate of mosquito eggs. These results are consistent with those of Cai et al. (2004) and Badami et al. (2003), who demonstrated that extracts prepared from ethyl acetate, methanol, and water all exhibited strong antioxidant activity, reducing harmful free radicals, both *in vitro* and in living organisms. Administered at certain doses (50 and 100 mg/kg body weight) to living models, these extracts not only neutralized free radicals, but also improved levels of important protective enzymes such as superoxide dismutase (SOD) and catalase. These enzymes help our cells manage oxidative stress, that is, damage caused by free radicals (Badami et al. 2003, Cai et al. 2004). Further experiments conducted by these same authors showed that *C. pulcherrima* extract possesses anti-inflammatory activity. Kim et al. (2004) highlighted that extracts, including chloroform, methanolic, and aqueous solutions, were able to lower the minimum concentration required to inhibit the growth of microorganisms. You et al. (2005) described how an important active compound in this plant, braziline, reduced blood glucose levels in diabetic animals.

Krupanidhi et al. (2024) demonstrated the full range of pharmacological properties of *C. pulcherrima*, including antiarthritic, antiasthmatic, analgesic, antibacterial, anticonvulsant, antidiarrheal, antidiabetic, antifertility, antifungal, anthelmintic, anti-inflammatory, antimalarial, antimetastatic, antinociceptive, antioxidant, antitubercular, antitussive, antiulcer, antiviral, anxiolytic, arginase inhibitor, cytotoxic, immunosuppressive, immunomodulatory, larvicidal, leishmanicidal, hepatoprotective, purgative, and insecticidal effects. The oil extracted from the roots of this plant induced a mortality rate of 20% in *Tribolium castaneum* and 40% in *Callosbruchus analis*. Sangeetha et al. (2024) confirmed the properties mentioned above, specifying that different parts (leaves, flowers, bark, seeds) of this beautiful, colorful ornamental plant with distinctive foliage are used in traditional medicine to treat ailments such as intestinal worms, coughs, and as a purgative or abortifacient. It contains compounds with potential anti-inflammatory, antimicrobial, antihypertensive, antiulcer, and anticancer properties, among others. Uadia et al. (2023) conducted a phytochemical study, an analysis of the immediate composition, acute toxicity, anti-inflammatory and antinociceptive activities of extracts from *Caesalpinia pulcherrima* flowers which could be considered as further confirmation of the potential of peacock flower. This study focused on the larvicidal and repellent activity of the tested plant, corroborating previous findings (Govindarajan et al. 2011). These results suggest that crude extracts of *C. pulcherrima* could be a promising source for mosquito control. Furthermore, repellent activity tests were conducted on stored products, confirming the plant's repellent effect and suggesting another potential application for protecting stored goods.

Conclusion

The results of this study on the repellent activity tests and larvicidal potential of *C. pulcherrima* have highlighted the need to continue research on its potential future applications in the mosquito, storage pests and vector control sectors in order to make biodegradable and environmentally friendly repellents and agents for the treatment of drainage and stagnant water available on the market.

Acknowledgements

SS sincerely thanks to the Ministry of National Science and Technology (NST), Bangladesh for providing her the NST Fellowship to support this research project. The authors are grateful to the Chairman, Department of Zoology, University of Rajshahi for providing laboratory facilities.

Conflict of interest: The authors declare no conflicts of interest.

Author's contribution: SS, PCR and AK collected samples and data, conducted experiments, writing the draft, analysis was done statistically. NI designed the conceptualization and supervised the study, writing review and editing the manuscript. All authors have read and approved the final manuscript.

Funding source: No funding.

Data availability: The data used the current study are available from the corresponding author upon reasonable request.

References

Abbott WS (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18(2): 265-267.

Ahmad S, Haque A and Mahmud H (2018). Effect of pulse beetle, *Callosobruchus chinensis* (L.) on oviposition and damage in some important genotypes of pulse crops in Bangladesh. Biomedical Journal of Scientific and Technical Research 2(2): 2544-2548. doi: 10.26717/BJSTR.2018.02.000739.

Akhtar M, Raza ABM, Iram N, Chaudhry MI and Azeem W (2015). Effect of infestation of *Sitophilus oryzae* L. (Coleoptera: Curculionidae) on protein quality of rice under storage conditions. International Journal of Agriculture and Applied Science 7(1): 43-45.

Badami S, Moorkoth S, Rai SR, Kannan E and Bhojraj S (2003). Antioxidant activity of *Caesalpinia sappan* Heartwood. Biological and Pharmaceutical Bulletin 26(11): 1534-1537.

Benhalima H, Chaudhry MQ, Mills KA and Price NR (2004). Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. Journal of Stored Products Research 40(3): 241-249.

Bhagya N (2024). A critical review on the phytochemistry, pharmacology and toxicology of *Caesalpinia pulcherrima* (L.) Sw. South African Journal of Botany 174: 796-819.

Bockarie MJ, Pedersen EM, White GB and Michael E (2009). Role of vector control in the global program to eliminate lymphatic filariasis. Annual Review of Entomology 54: 469-487.

Busvine JR (1971). A critical review of the techniques for testing insecticides. 2nd Ed., Slough: Commonwealth Agricultural Bureaux, pp. 345.

Cai Y, Luo Q, Sun M and Corke H (2004). Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sciences 74(17): 2157-2184.

Chhabi SB, Sarkar D, Zaman S, Islam S, Rahman Z and Islam N (2017). Insecticidal, insect repellent, cytotoxic and larvicidal activities of *Cnesmone javanica* Blume extracts. University Journal of Zoology Rajshahi University 36: 26-31.

Deepika S, Selvaraj CI and Roopan SM (2020). Screening bioactivities of *Caesalpinia pulcherrima* L. Swartz and cytotoxicity of extract synthesized silver nanoparticles on HCT116 cell line. Materials Science and Engineering. C, Materials for Biological Application 106:110279. doi: 10.1016/j.msec.2019.110279.

Erharuyi O, Imieje VO, Oseghale IO, Ubhenin AE, Falodun AB and Choudhary AI (2017). Identification of compounds and insecticidal activity of the root of pride of barbados (*Caesalpinia pulcherrima* L.). Journal of Applied Sciences and Environmental Management 21(2): 281.

Finney DJ (1947). Probit analysis: A statistical treatment of the sigmoid response curve. Cambridge: Cambridge University Press, p. 256.

Gechev TS, Frank VB, Stone JM, Denev I and Laloi C (2006). Reactive oxygen species as signals that modulate plant stress responses and programmed cell death. BioEssays 28(11): 1091-1101.

Gbenga A, Giwa OE, Ogundowole O and Eyinola OM (2024). Evaluation of the nutritional and antibacterial activities of aqueous and ethanolic extract from peacock flower (*Caesalpinia pulcherrima* L.) for traditional medicine. Journal of Pharmacognosy and Phytochemistry 13(4): 90-96.

Govindarajan M, Mathivanan T, Elumalai K, Krishnappa K and Anandan A (2011). Ovicidal and repellent activities of botanical extracts against *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles stephensi* (Diptera: Culicidae). Asian Pacific Journal of Tropical Biomedicine 1(1): 43-48. doi: 10.1016/S2221-1691(11)60066-X.

Grünwald S, Adam IV, Gurmai AM, Bauer L, Boll M and Wenzel U (2013). The red flour beetle *Tribolium castaneum* as a model to monitor food safety and functionality. Advances in Biochemical Engineering/Biotechnology 135: 111-122.

Kim KJ, Yu HH, Jeong SI, Cha JD Kim SM and You YO (2004). Inhibitory effects of *Caesalpinia sappan* on growth and invasion of methicillin-resistant *Staphylococcus aureus*. Journal of Ethnopharmacology 91(1): 81-87.

Krishnaveni G, Tamilarasi A, Mohanraj RS and Saranya M (2023). Impact of *Caesalpinia pulcherrima* (L.) Sw. (Fabaceae) ethanol and acetone leaf extracts on the *Aedes aegypti* (Diptera: Culicidae) eggs. International Journal of Zoological Investigations 9(1): 247-256.

Krupanidhi AM, Dabadi P, Kavya K and Chandana M (2024). A comprehensive review on bioactive properties of plant *Caesalpinia pulcherrima* (L.). International Journal of Research on Pharmacology and Pharmacotherapeutics 13(3): 332-341.

Mohammad N, Pone RA, Islam M, Shefa M, Eva KA, Nisa S and Islam N (2025). Bioactive potential of *Euphorbia tirucalli* L. extracts: Antioxidant, cytotoxicity and antimicrobial activities. Journal of Entomology and Zoology Studies 13(3): 253-259. https://doi.org/10.22271/j.ento.2025.v13.i3c.9521.

McDonald LL, Guy RH and Speirs RD (1970). Preliminary evaluation of new candidate materials as toxicants, repellents, and attractants against stored-product insects. Agricultural Research Service, United States Department of Agriculture, p. 882.

Pusztahelyi T, Holb IJ and Pocsi I (2015). Secondary metabolites in fungus-plant interactions. Frontiers in Plant Science 6: 573. doi: 10.3389/fpls.2015.00573.

Rao YK, Geethangili M, Fang SH and Tzeng YM (2007). Antioxidant and cytotoxic activities of naturally occurring phenolic and related compounds: A comparative study. Food and Chemical Toxicology 45(9): 1770-1776.

Ridley AW, Hereward JP, Daglish GJ, Raghu S, Collins PJ and Walter GH (2011). The spatiotemporal dynamics of *Tribolium castaneum* (Herbst): adult flight and gene flow. Molecular Ecology 20(8): 1635-1646.

Sangeetha S, Saravanakumar A, Parthiban P, Kavinkumar C, Loganathan M, Harshitha ST, Pooja S, Raj Mohan S and Heera G (2024). An overview of the marvelous plant: *Caesalpinia pulcherrima*. International Journal of Research in Pharmacology and Pharmacotherapeutics 13(4): 714-728.

Seni A, Pal R, Mohapatra S and Bansude S (2025). Evaluation of essential and vegetable oils against pulse beetle, *Callosobruchus chinensis* (Coleoptera: Chrysomelidae) infesting horse Gram, *Macrotyloma uniflorum* Lam. (Verdc.). Vegetos, doi: 10.1007/s42535-025-01212-2.

Talukder FA and Howse PE (1993). Deterrent and insecticidal effects of extracts of Pithraj, *Aphanamixis polystachya* (Meliaceae), against *Tribolium castaneum* in storage. Journal of Chemical Ecology 19(11): 2463–2471.

Talukder FA and Howse PE (1995). Evaluation of *Aphanamixis polystachya* as a source of repellents, antifeedants, toxicants and protectants in storage against *Tribolium castaneum* (Herbst). Journal of Stored Products Research 31(1): 55-61.

Uadia JO, Nnamdi EK, Chigozie N Ndubisi VI, Ogbeide OK (2023). Phytochemical investigation, proximate composition, acute toxicity, anti-inflammatory and antinociceptive activities of extracts of *Caesalpinia Pulcherrima* Linn flower. Waliongo Journal of Chemistry 6(2): 194-207. doi: 10.21580/wjc.v6i2.18175

You EJ, Khil LY, Kwak WJ, Won HS, Chae SH, Lee BH and Moon CK (2005). Effects of brazilin on the production of fructose-2,6-bisphosphate in rat hepatocytes. Journal of Ethnopharmacology 102(1): 53-57.

Zakladnoy GA (2018). Effect of grain infestation with the rice weevil *Sitophilus oryzae* L. (Coleoptera, Dryophthoridae) on the quality of grain and grain products. Entomological Review 98(6):659-662. doi: 10.1134/S0013873818060015.