NATURE'S PEST PATROL- A JOURNEY INTO ORGANIC CONTROL OF COCKROACH

Juvariaazmath[1] Heera Raheen[2] Shumaila Khaleel[3] Nabila Sundus[4] Syeda Amtul Hafeza Jamal[5]
[1]Assistant Professor,St.Ann's College for Women,Hyderabad,Telangana.
[2,3,4,5]Students, St.Ann's College for Women,Hyderabad,Telangana.

ABSTRACT: *Cockroaches are common household pests that pose health risks and sanitation concerns. Contemporary methods of cockroach control often involve the use of chemical insecticides, which may raise environmental and health concerns. As a result, there has been growing interest inexploring organic methods for cockroach control that are effective, environmentally friendly, and sustainable.*

This research provides an overview of organic methods for cockroach control, drawing upon a synthesis of scientific literature and field studies. The review begins by discussing the biology and behaviour of cockroaches, highlighting key factors that contribute to their infestation and persistencein indoor environments.

This research highlights the potential of organic methods for cockroach control as viable alternatives to conventional chemical insecticides. By integrating scientific evidence with practical insights, it provides valuable guidance for pest management professionals, policymakers, and homeowners seeking environmentally friendly and sustainable solutions for cockroach infestation. Further research and innovation in organic pest control methods are warranted to address emerging challenges and optimise their efficacy in diverse settings.

KEY WORDS: Contemporary methods,Cockroaches, Chrysanthemum, infestation, pest managemenr

ABBREVIATIONS:
Chrysanthemum Flower Ash:
CFALemon Juice: LJ
Ginger Extract:
GEClove
Powder: CP

INTRODUCTION

In India, popular pest control products include well-known brands, which offer a variety of household insecticides such as aerosol sprays, mosquito coils, and electric vaporizers targeting mosquitoes, flies, and other flying insects. Some widely used brands provide insecticide sprays and mosquito coils effective against common household pests like mosquitoes and cockroaches. These brands specialise in mosquito repellent products, including electric vaporizers, mats, and coils designed to protect against disease-carrying mosquitoes like those responsible for dengue and malaria, some formulated as a gel, specifically targets cockroaches, while some brands offers diverse pest control solutions, including sprays, coils, and mats effective against both flying and crawling insects.

These brands are prevalent choices for households in India, addressing various pest control needs, and it's important for users to adhere to the product instructions for safe and efficient application. The use of pest control chemicals, if not handled with care, can pose potential health risks to humans. Inhaling fumes or aerosols from certain pesticides may lead to respiratory issues, causing coughing or wheezing. Direct contact with these chemicals can result in skin irritation or allergic reactions, particularly for those with sensitive skin, while contact with the eyes may cause redness or more severe problems. Accidental ingestion poses serious health risks, emphasising the importance of safe storage away from food and out of reach of children. Prolonged exposure to pesticides may be associated with chronic health concerns, including neurological and reproductive issues.

Even though there's so many problems being caused to humans, cockroaches have become immune to it. The phenomenon of cockroaches developing resistance to certain pesticides is known as insecticide resistance. Over time, repeated exposure to the same type of pesticide can lead to a natural selection process favouring the survival of cockroaches with genetic traits that make them less susceptible to the pesticide. These resistant individuals then reproduce, passing on their resistance to future generations.

Cockroach Species Found In India:

1) *Blattella germanica* (German cockroach)

- Adult 10-15mm, lifecycle more than 100 days, major pests in restaurants, hotels and apartments mainly in dark and secluded areas like behind the refrigerator or under cupboards.
- Organic methods of killing: peppermint oil, cedarwood oil, Cypress oil, crushed bay leaves and coffee grounds, powdered sugar+boric acid.



Fig. 1 *Blattella germanica*

2) *Periplaneta americana* (American Cockroach)

- Adult 35-40mm, largest pest cockroach, shining red chocolate brown in colour, life cycle 100 days to 3 years. Prefers a warm and humid environment such as drains and sewers, borewells.
- Organic methods of killing: Boric acid, hot water, baking soda+LJ, crushed Garlic cloves.



Fig. 2 *Periplaneta americana*

3) *Supella longipalpa* (Brown banded cockroach)

- Adult 10-14mm, smallest pest cockroach, yellow brown stripes across abdomen, life cycle 90 to 115 days, warm and humid environments
- Organic methods of killing: Baking soda+sugar, boric acid, Vinegar, petroleum jelly.



Fig. 3 *Supella longipalpa*

4) *Blatta orientalis* (Oriental cockroach)

- Adult 25-32 mm, dark brown species, live up to 170 days. They rather run than fly and can tolerate lower temps than other cockroaches
- Organic methods of killing: baking soda+water because they need water to live. These are some methods used to get rid of cockroaches in old days



Fig. 4 *Blatta orientalis*

Factors contributing to insecticide resistance in cockroaches include:

1. Overreliance on a Single Chemical: Continuous use of a specific type of pesticide can accelerate the development of resistance within cockroach populations.
2. Incomplete Elimination: If a pesticide application fails to eliminate the entire cockroach population, surviving individuals may carry resistance genes, contributing to a more resilient population.
3. Adaptability: Cockroaches have shown a remarkable ability to adapt to changing environments, including exposure to pesticides, through genetic variations that confer resistance.

Around 4000 different species but only about 40 are considered pests among which only 4 are found in the Southern part of India.
Repellant sprays often used to treat symptoms i.e. temporarily stop them from entering but not the cure, to eliminate their breeding ground.

Location of cockroach infestation:
Bathrooms, kitchens, laundry rooms, basements, drains

Contemporary ways of killing cockroaches:

The traditional ways use borax or bleach as it can be very effective. Using Phosphorus paste as bait was effective against american cockroaches and then they were stomped and they would smoke up. In the mediaeval era, people used crushed and dried chrysanthemum flower petals to make insecticidal dust, and simple ash can also be used. It causes drying out of the pheromone pads on their feet and may cause death. Garlic oil and black pepper were also used.

MATERIALS USED

This project focuses on the development of organic formulations for cockroach control, utilising a combination of natural ingredients, including Chrysanthemum flower extract, phosphorus, Vinegar, LJ, GE, Atta (wheat flour) and Maida (all-purpose flour). The aim is to explore the synergistic effects of these ingredients in targeting and controlling cockroach populations while minimising environmental impact and ensuring safety for human health.

Each ingredient was carefully selected based on its known pesticidal properties, availability, and compatibility with other components of the formulation. CFA and phosphorus serve as the primary active ingredients, providing natural insecticidal action against cockroaches. Vinegar and LJ contribute acidity, acting as deterrents and disinfectants, while GE adds additional repellent properties.

The inclusion of Atta (wheat flour) and Maida (all-purpose flour) serves as carriers for the active ingredients, enhancing adhesion and dispersion of the formulation. Moreover, these ingredients offer supplementary benefits such as attracting cockroaches and facilitating ingestion of the active compounds.

The project methodology involved systematic experimentation to optimise the formulation composition and concentration of each ingredient. Various formulations were tested for efficacy, safety, and practicality, with emphasis on minimising environmental impact and ensuring ease of application in domestic settings.

By harnessing the combined effects of CFA, phosphorus, Vinegar, LJ, GE, Atta (wheat flour) and Maida (all-purpose flour), the project aims to offer a sustainable and environmentally friendly alternative to conventional chemical insecticides.

1. Chrysanthemum flower:

Chrysanthemum flower is an organic method for cockroach control. Two batches of Chrysanthemum flowers were prepared using different drying methods, namely sun drying and oven drying, followed by crushing into ashes. The effectiveness of these preparations was evaluated in controlling cockroach infestations.

Preparation of CFA:
Two batches of Chrysanthemum flowers were harvested and dried using two different methods: sun drying and oven drying. The sun-dried batch was exposed to direct sunlight for one to two days until fully dried. The oven-dried batch was dried at a controlled temperature of 800° Celsius for 30 minutes.

Once dried, both batches were manually crushed into ash. The ash obtained from both batches of Chrysanthemum flowers served as the primary ingredient in the organic cockroach control formulation.

The utilisation of CFA represents a natural and environmentally friendly approach to pest control, with potential implications for sustainable pest management practices.



Fig. 5 Chrysanthemum flower



Fig. 6 Chrysanthemum flower ash

2. Phosphorus powder:

Phosphorus was used as a supplementary ingredient, in conjunction with CFA. Phosphorus, obtained in a significantly smaller quantity relative to the CFA (800 grams), was selected for its availability and potential synergistic effects in pest control applications.

A judicious amount of phosphorus was incorporated into the organic formulation, keeping in consideration its potency and compatibility with the CFA. The ash quantity utilised was meticulously determined through preliminary experimentation and optimization to ensure optimal efficacy without compromising safety or environmental sustainability.

3. Vinegar:

Vinegar is a natural ingredient in organic cockroach control formulations. Vinegar, known for its acidic properties and antimicrobial effects, is evaluated for its ability to repel, deter, and eliminate cockroach infestations while maintaining environmental sustainability and human safety.

Each batch of the palettes consisted of 5 ml of Vinegar, with a total of six batches prepared for experimentation. The efficacy of Vinegar in controlling cockroach populations was assessed as part of this project. Each formulation is meticulously designed and tested to optimise Vinegar concentration, compatibility with other ingredients, and effectiveness against cockroach populations.

4. Lemon Juice:

LJ is a supplementary ingredient in organic cockroach control formulations. With a minimal dosage of 1 ml, LJ's acidic properties are hypothesised to enhance the repellent and insecticidal effects of the formulation when combined with other natural ingredients such as, GE, Atta (wheat flour).

The methodology involves the systematic integration of LJ into experimental cockroach control formulations, followed by comprehensive testing to assess its impact on formulation efficacy.

5. Ginger Extract:

GE is utilised in a minimal dosage of 1 ml, as a novel ingredient in organic cockroach control formulations. GE, renowned for its bioactive compounds and repellent properties, is hypothesised to contribute to the formulation's insecticidal effectiveness when combined with other natural ingredients, like LJ, atta.

Methodology involves the systematic incorporation of GE into select cockroach control formulations, followed by rigorous testing to evaluate its impact on formulation performance. Each formulation is meticulously prepared and evaluated for its ability to repel, deter, and eradicate cockroach populations under controlled laboratory conditions.

Experimental trials are conducted to assess cockroach response to GE-based formulations, employing standardised protocols and statistical analyses to quantify repellency and mortality rates. Comparative studies are also conducted to elucidate potential synergistic interactions between GE and other active ingredients, aiming to optimise formulation efficacy.

6. Atta (Wheat flour)

Atta (wheat flour) is a key component in organic cockroach control formulations. Utilising a total quantity of 500 grams across two experiments, atta's adhesive and baiting properties are evaluated for their potential to enhance the effectiveness of formulations in attracting and eliminating cockroach populations.

The experimental design encompasses two distinct approaches to incorporating Atta into cockroach control formulations. In the first experiment, Atta serves as a carrier for active ingredients such as LJ, and GE. The formulation is prepared to optimise adhesion and dispersion, aiming to increase cockroach exposure and ingestion of the active compounds.

In the second experiment, Atta is utilised as a baiting agent in combination with CFA, phosphorus and Vinegar. The formulation is strategically deployed in areas of high cockroach activity, exploiting atta's attractiveness to cockroaches to lure them into contact with the insecticidal components.

Cockroach response to the formulations is monitored and evaluated through systematic observation and focusing on factors such as attraction and mortality rates.

7. Laung (Clove Powder)

CP is a natural insecticidal agent in organic cockroach control formulation. With a quantity of 100 grams allocated for a single experiment, CP's potential as an active ingredient in pest management is explored, aiming to provide an environmentally friendly and sustainable alternative to conventional chemical insecticides.

The experimental methodology involves the integration of CP into a formulation alongside other natural ingredients, such as Vinegar, and all-purpose flour. The formulation is carefully prepared to optimise the dispersion and concentration of CP, ensuring maximum efficacy against cockroach infestations.

8. Maida (All purpose flour)

Maida (all-purpose flour) is a versatile ingredient in organic cockroach control formulations across three distinct experiments. With a total quantity of 700 grams allocated, Maida's adhesive properties and potential as a carrier for active ingredients are investigated to optimise formulation efficacy in repelling and eliminating cockroach infestations.

In the first experiment, Maida serves as a primary component in a formulation combined with CFA, phosphorus and Vinegar. The formulation is prepared to ensure even dispersion and optimal adhesion to surfaces frequented by cockroaches, facilitating exposure and ingestion of the active compounds.

In the second experiment, Maida is integrated into a baiting formulation alongside CP and Vinegar. Deployed strategically in areas of high cockroach activity, the formulation capitalises on Maida's attractiveness to lure cockroaches into contact with the insecticidal components, resulting in enhanced efficacy in pest control.

The third experiment explores Maida's potential as a standalone agent for cockroach control. Utilising Maida in combination with CFA, Phosphorus and Vinegar, the formulation is evaluated for its ability to deter cockroach infestations and disrupt their reproductive cycles, offering a sustainable alternative to conventional chemical insecticides.

Each experiment is conducted under controlled laboratory conditions, with standardised protocols for formulation preparation, application, and monitoring of cockroach response. Data analysis includes quantitative assessment of cockroach mortality rates, repellency, and residual efficacy to determine the effectiveness of Maida-based formulations.

The findings of this study contribute to the understanding of LJ's role in organic pest management and its potential applications in sustainable cockroach control strategies. By harnessing the natural properties of LJ and integrating it into organic cockroach control formulations, this research aims to offer environmentally friendly alternatives to conventional chemical insecticides.

METHODOLOGY

FORMULATION 1

MATERIALS

LJ, GE, Atta (flour), Gloves, Mask.

PREPARATION OF PELLETS

- Ingredients:
  - LJ, GE, atta(flour)
- Mixing procedure:
  - We took Atta in the petri dish. We added LJ and GE and mixed it and made a dough then divided it into small balls/palettes.



Fig. 7

FORMULATION 2

MATERIALS

Chrysanthemum, Phosphorus, Vinegar, Atta (flour), Gloves, Mask.

PREPARATION OF PELLET

- Ingredients:
  - CFA, Phosphorus, Vinegar, Atta(flour)
- Mixing procedure:
  - We mixed the dry ingredients first i,e., Atta CFA and Phosphorus powder, then we added Vinegar, and mixed it and made a dough and divided it into small balls/palettes.



Fig. 8

FORMULATION 3

MATERIALS

Chrysanthemum, Phosphorus, Vinegar, Maida (All purpose flour), Gloves, Mask.

PREPARATION OF PELLETS

- Ingredients:
  - CFA, Phosphorus, Vinegar, Maida(all purpose flour)
- Mixing procedure:
  - We mixed the dry ingredients first i,e., CFA and Phosphorus powder, Maida then we added Vinegar, and mixed them and made a dough and divided it into small balls/palettes.



Fig. 9

FORMULATION 4

MATERIALS

CP, Maida (All purpose flour), Vinegar, Gloves, Mask.

PREPARATION OF PELLETS

- Ingredients:
  - CP, Maida (All purpose flour), Vinegar.
- Mixing procedure:
  - We mixed the dry ingredients first i.e., Maida and CP, then we added Vinegar and mixed it and made a dough and divided it into small balls/ pellets .



Fig. 10

FORMULATION 5

MATERIALS

CFA, Vinegar, Gloves, Mask.

PREPARATION OF pellets

- Ingredients:
  - CFA and Vinegar.
- Mixing procedure:
  - Vinegar was added to the CFA and was mixed well and made into small balls/ pellets



Fig. 11

FORMULATION 6

MATERIALS

CFA, Maida (All purpose flour) and Vinegar, Gloves, Mask.

PREPARATION OF pellets

- Ingredients:
  - CFA, Maida (All purpose flour) and Vinegar.
- Mixing procedure:
  - We mixed the dry ingredients first i.e., Maida, and CFA then we added Vinegar and made a dough then divided it into small balls/pellets .

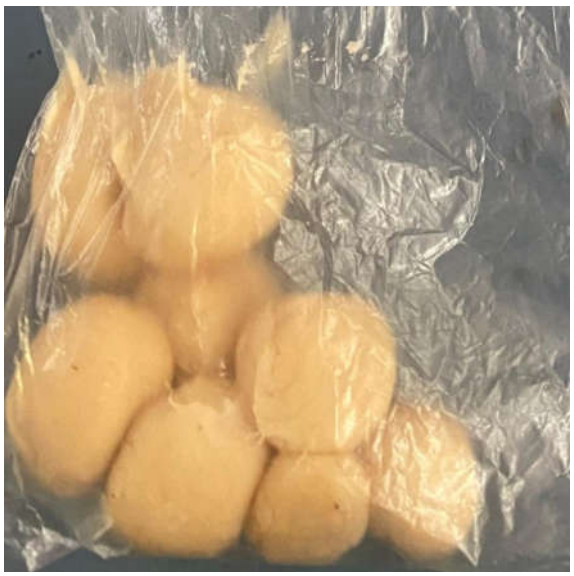


Fig. 12

EXPERIMENTAL DESIGN

Location:
The experiment was conducted in a residential setting, specifically targeting a house with a notable cockroach infestation. The choice of location was based on the observed high cockroach activity within the premises.

Population:
Rather than predefining a specific number of cockroaches, the experiment aimed to address the existing population within the selected residence. The approach involved strategically placing the pellets in areas where heightened cockroach presence had been observed.

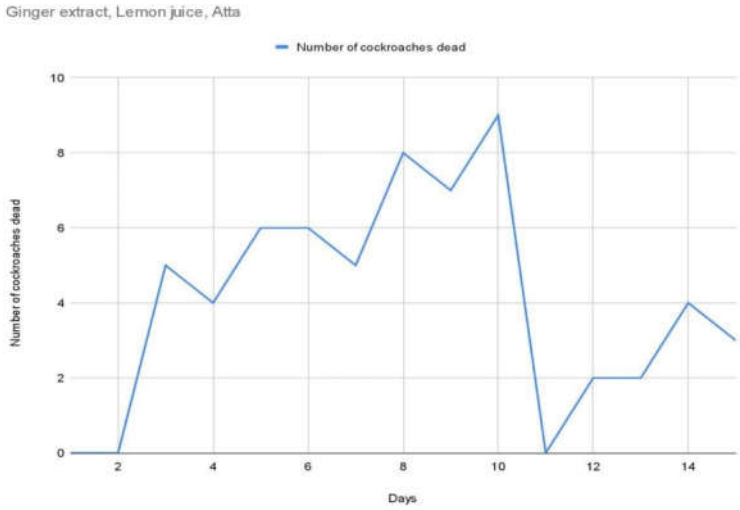
Application of pellets:
The poison was administered in accordance with the identified areas of increased cockroach activity within the house. Dosage was determined based on the extent of the observed infestation, ensuring an appropriate and proportional application.

OBSERVATION

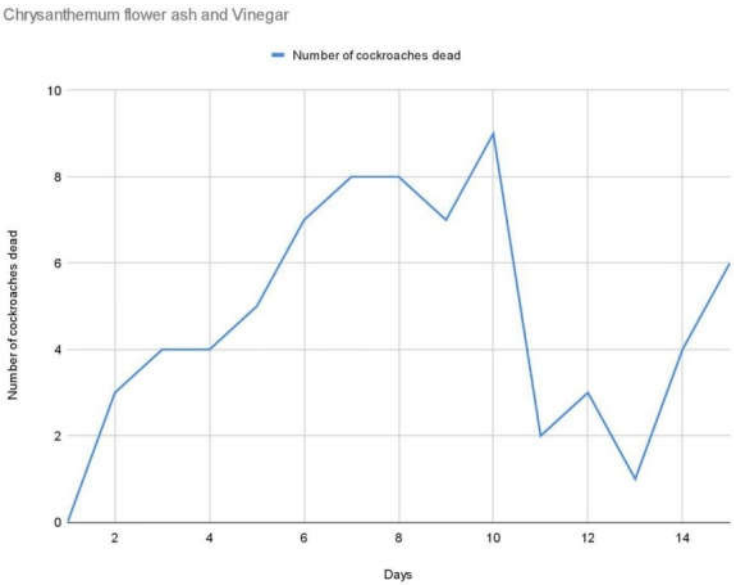
Days	LJ, GE, Atta	CFA, Vinegar	CFA, Maida, Vinegar	CP, Vinegar, Maida	Vinegar, CFA, Atta, Phosphorous	CFA, Maida, Phosphorous, Vinegar
1	0	0	0	0	0	0
2	0	3	1	0	0	0
3	5	4	1	0	1	2
4	4	4	0	1	0	1
5	6	5	1	1	0	2
6	6	7	0	2	1	1
7	5	8	0	0	2	0
8	8	8	2	0	0	0
9	7	7	0	0	0	0
10	9	9	0	0	0	1
11	0	2	-	-	-	-
12	2	3	-	-	-	-
13	2	1	-	-	-	-
14	4	4	-	-	-	-
15	3	6	-	-	-	-

Table 1 - Observation

FORMULATIONS WITH DESIRED RESULT

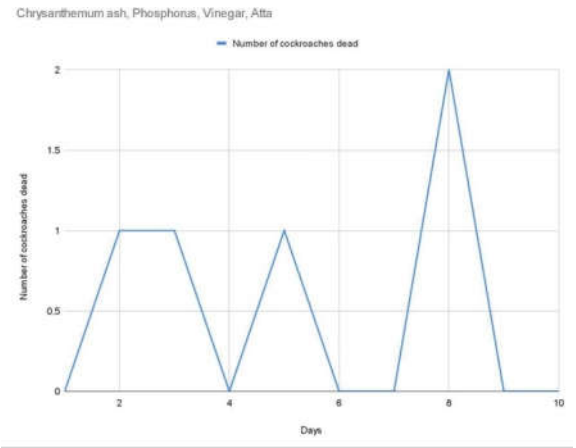


Graph 1

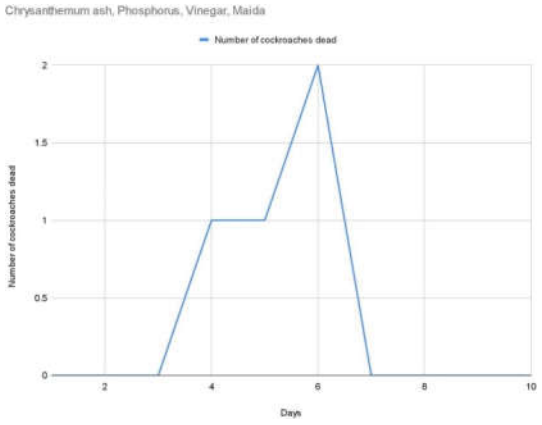


Graph 2

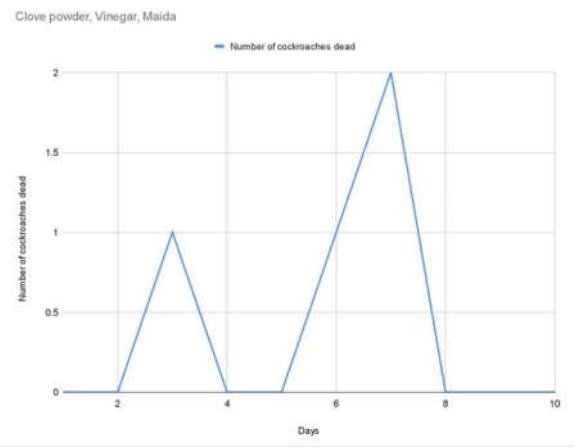
OTHER FOUR FORMULATIONS



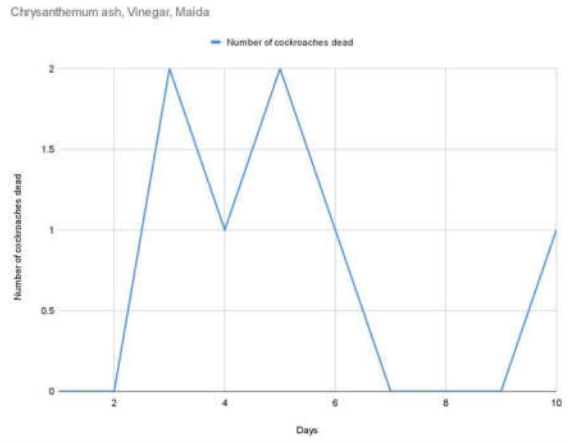
Graph 3



Graph 4



Graph 5



Graph 6



a. CFA and Vinegar



b. CFA and Vinegar



c. LJ, GE, Atta (wheat flour)



d. LJ, GE, Atta (wheat flour)



e. CFA, Maida and Vinegar



f. CP, Maida, Vinegar

(a-f Cockroaches affected by the pellets)

RESULT

The aim of our project was to explore contemporary methods of cockroach control at the household level. Through rigorous experimentation, we evaluated the efficacy of six formulations in mitigating cockroach infestations, aiming to identify effective and environmentally friendly solutions for pest management.

Despite the pellets only being moderately useful, they did serve as attractive substrates for egg-laying. Cockroaches were observed laying eggs on the surfaces of the pellets, indicating that the pellets provided a conducive environment for reproduction. However, upon closer examination, it was noted that the laid eggs did not rupture or produce offspring as expected.

This observation suggests that while the pellets may have provided a suitable surface for egg-laying, they possessed properties that interfered with the normal development of cockroach eggs or larvae. This limited impact on cockroach reproduction indicates a partial efficacy of the pellet formulations, as they disrupted the reproductive cycle of the insects to some extent.

Upon comprehensive analysis of the experimental data, it was observed that two out of the six formulations yielded exceptional results, surpassing initial expectations. The LJ, GE, and Atta formulation, along with the CFA and Vinegar formulation, demonstrated remarkable effectiveness in controlling cockroach populations. These formulations exhibited significant cockroach mortality rates and effectively deterred further infestations, showcasing their potential as viable options for organic cockroach control.

Throughout the experimentation process, a total of 152 cockroaches were recorded as either deceased or affected by the formulations in a time period of 70 days. While this represents a significant impact on cockroach populations, it also underscores the persistent challenge of effectively managing pest infestations in domestic settings. The results of our project highlight the importance of continued research and innovation in developing sustainable and efficacious methods of cockroach control, emphasising the need for holistic approaches that prioritise both effectiveness and environmental sustainability.

FORMULATIONS WITH DESIRED RESULTS

GE, LJ and Atta (Wheat Flour):

Contrary to expectations, the GE and flour pellets with LJ addition did not demonstrate significant repellent effects on cockroaches. While the pellets emitted a pungent smell characteristic of Ginger and Lemon, there was no observable reduction in cockroach activity compared to the control group. Cockroaches appeared indifferent to the presence of the pellets, exhibiting similar behaviour and activity levels as in areas with no treatment.

CFA and Vinegar:

The pellets made from CFA and Vinegar demonstrated high effectiveness in repelling cockroaches initially. Cockroaches exhibited aversion to the pellets, likely due to the combined effects of the insecticidal properties of CFA and the acidic odour of Vinegar. However, over time, the effectiveness of the pellets diminished as the odour of Vinegar dissipated.

Observations revealed that the repellent effect lasted for a certain period, typically a few days to a week, depending on environmental conditions such as humidity and ventilation. Once the Vinegar lost its characteristic smell, the pellets became ineffective, and cockroach activity resumed in the treated areas. Subsequent observations indicated that cockroaches showed no aversion to the pellets once the Vinegar odour dissipated, suggesting that the repellent effect was primarily odour-dependent.

The effectiveness of the CFA and Vinegar pellets as a short-term cockroach repellent can be attributed to the combined action of pyrethrins in the CFA and the acidic odour of Vinegar. Pyrethrins are known to have insecticidal properties and can repel insects upon contact or inhalation. Additionally, the acidic odour of Vinegar may act as a deterrent for cockroaches, disrupting their olfactory receptors and navigation cues.

However, the short duration of effectiveness observed in this experiment highlights a limitation of using Vinegar as a repellent component. Vinegar is volatile and prone to rapid evaporation, leading to the loss of its odour over time. As a result, the repellent effect of the pellets is transient and requires frequent replenishment to maintain efficacy, which may not be practical for long-term cockroach control strategies.

OTHER FOUR FORMULATIONS

1. CFA, Phosphorus, Vinegar, Atta
2. CFA, Phosphorus, Vinegar, Maida
3. Cloves, Maida, Vinegar
4. CFA, Maida, Vinegar

Although the four formulations showcased unique combinations of natural ingredients, their effectiveness in controlling cockroach populations provided valuable insights and opportunities for learning. Each formulation contributed to our exploration of sustainable and environmentally friendly approaches to pest control, highlighting the diversity and potential of organic methods in tackling infestations. Our experimentation with these formulations sparked creativity and innovation within our team, encouraging us to think outside the box and explore unconventional solutions to the challenge of cockroach management.

Furthermore, the process of refining and optimising these formulations prompted us to critically evaluate our methodologies and experiment with adjustments. By identifying areas for enhancement, we iteratively improved our experimental techniques and sought to optimise the performance of subsequent formulations. This iterative process of learning and adaptation underscored the importance of resilience and perseverance in scientific inquiry, ultimately contributing to our growth and development as researchers and problem-solvers.

DISCUSSION

The observed partial efficacy of the pellet formulations may be attributed to several factors. It is possible that the ingredients used in the formulations possessed properties that inhibited egg development or larvae survival, thereby limiting the reproductive success of the cockroaches. Additionally, the physical structure of the pellets may have hindered egg viability or provided an inhospitable environment for larvae development.

Furthermore, the presence of ingredients such as chrysanthemum ash, phosphorus, vinegar, all-purpose flour, and cloves may have deterred cockroaches from actively colonizing the treated areas, contributing to a reduction in overall cockroach population despite the limited impact on reproduction.

CONCLUSION

Our project on cockroach control has been an eye-opening experience. While we had high hopes for all six formulations, it became clear that only two really did the trick. The Lemon Juice, Ginger Extract, and Atta mix, along with the Chrysanthemum Flower Ash and Vinegar combination, proved to be real winners, significantly reducing cockroach numbers in our tests.

On the flip side, the other four formulations didn't quite live up to our expectations. Despite our best efforts, they just didn't seem to have the same impact on the cockroach population. It's disappointing, but it's also a valuable lesson. Sometimes, even with the best intentions, things don't always go as planned.

Throughout the project, we saw a total of 152 cockroaches getting affected by the formulations in a time period of 70 days. While this number is significant, it also shows that we still have a lot of work to do in finding the most effective and sustainable ways to control pests in our homes.

In the end, this project taught us the importance of perseverance and adaptability. We may not have found the perfect solution yet, but we've gained valuable insights that will guide us in future experiments. By continuing to explore new ideas and techniques, we believe we can eventually find a method that works wonders for cockroach control while keeping our homes safe and eco-friendly.

REFERENCES

1. My Pest Pros. (n.d.). *Cockroaches*. Retrieved July 1, 2024, from https://www.mypestpros.com/cockroaches/
2. Rentokil PCI. (n.d.). *Global expertise in pest control*. Retrieved July 1, 2024, from https://www.rentokil.com/
3. PCTonline. (n.d.). *Traditional ways of killing cockroaches*. Retrieved July 1, 2024, from https://www.pctonline.com/
4. Quora. (2003). *How did our ancestors control pests?* Retrieved July 1, 2024, from https://www.quora.com/How-did-our-ancestors-control-pests
5. Asian Journal of Advanced Multidisciplinary Researches. (2022, May). *Organic methods of cockroach control*. Retrieved July 1, 2024, from Journal website or database if available.
6. Malik, A., Mahmood, K., Nadeem, M. S., & Malik, K. (2023, December 4). *Plant based pest repellents which highlights the use of essential oils*. *Journal of Pure and Applied Agriculture*. Retrieved July 1, 2024, from Journal website or database if available.
7. Nasirian, H. (2017). *Infestation of cockroaches in the human dwelling environments: A systematic review and meta-analysis*. *PubMed*. Retrieved July 1, 2024, from https://pubmed.ncbi.nlm.nih.gov/
8. Gondhalekar, A. D., & Romero, A. (2021). *A review of alternative management tactics employed for the control of various cockroach species*. Retrieved July 1, 2024, from Journal website or database if available.

9. Wannigama, D. L., Dwivedhi, R., & Zahraei-Ramazani, A. (2014). *Prevalence and antibiotic resistance of gram-negative pathogenic bacteria species isolated from Periplaneta americana and Blattella germanica in Varanasi, India*. *Journal of Arthropod-Borne Diseases*. Retrieved July 1, 2024, from Journal website or database if available.
10. Gallardo, R. D., Ramos, R. A., & Digang, L. (2009). *Effects of different organic insecticides on the mortality of cockroaches*. Retrieved July 1, 2024, from Journal website or database if available.