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VARIATIONS OF GADUNG TUBER EXTRACT (*Discorea hispida*) AND BORIC ACID IN GEL FORM AS COCKROACH BAIT (*Blatella germanica*)

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ABSTRACT

Variations of Gadung Tuber Extract (Discorea hispida) and Boric Acid in Gel Form as Cockroach Bait (Blatella germanica). Cockroaches are disease vectors that pose health and aesthetic problems. Traditional control methods use insecticides, which are becoming ineffective and environmentally harmful due to residue. An alternative method involves gel bait with plant-based insecticides, such as grading tubers, which are toxic to insects. This research aims to determine the optimal combination of grading tuber extract and boric acid in gel bait by calculating LC50 and LT50. Conducted at the Yogyakarta Health Polytechnic Vector and Animal Control Laboratory in February-March 2023, the study used a proper experimental design with a post-test-only control group. Five treatments were tested with five repetitions each, using 125 female cockroaches (Blatella germanica) selected via purposive sampling. Mortality data were analyzed using One Way Anova, LSD tests (p-value < 0.05), and probit regression. Results showed significant differences in mortality rates among treatments (p-value = 0.000). Variation C had the highest mortality rate, while variation B was the most effective, with an LC50 of 7.227 g. LT50 values were 99.237 hours for 5 g, 93.797 hours for 10 g, and 73.463 hours for 15 g. This study concludes that gel bait with grading tuber extract and boric acid is a promising alternative for cockroach control.

INTRODUCTION

Vector-borne and zoonotic diseases are diseases transmitted through disease-carrying insects and disease-carrying animals [1]. The cockroach is one of the insects that serves as a disease vector. Apart from being a vector, the German cockroach (Blattella germanica) also disrupts human life in terms of aesthetics and sanitation indicatorsCockroaches consume food and faeces, then regurgitate some of the food they have consumed [2]. Cockroaches act as mechanical vectors for several pathogenic microorganisms, such as Escherichia coli, Streptococcus, Salmonella sp., Shigela sp., Campylobacter sp., Pseudomonas aeruginosa, Mycobacterium leprae, and Klebsiella pneumoniae, thus playing a role in the spread of diseases such as dysentery, diarrhea, cholera, hepatitis A virus, and polio, as well as an intermediate host for several species of worms [3].

The Regulation of the Minister of Health of the Republic of Indonesia Number 50 of 2017 concerning Environmental Health Quality Standards and Health Requirements for Vectors and Disease-Carrying Animals states that the permitted quality standard is <2 animals. If ≥2

individuals are found, follow-up efforts must be made. The tourism industry, especially the hotel industry, specifically requires that hotel facilities and other public areas within the hotel environment be free from vectors and disease-carrying animals, one of which is cockroaches [4].

Cockroach control is used to avoid the negative impacts mentioned above. Control can be achieved through improved sanitation, trapping, and insecticide application [5]. Pest control companies frequently carry out cockroach control in residential and industrial environments, such as hotels, restaurants, and offices. German cockroach control is often carried out using chemical insecticides such as organophosphates, pyrethroids, and carbamates, but these types of insecticides are ineffective or experience resistance. [6]. Control is also carried out by the pest control company; PT This company also observed a decrease in the killing power of the two insecticides used against cockroaches at its clients' business locations.

The spraying method is effective, but it cannot be used in all locations, such as storage locations for cutlery and food ingredients. The spraying insecticide application method will cause a lot of residual effects and pollute the environment [7]. Control using the poison bait method can reduce the presence of insecticide residues in the environment. To target cockroaches, poison bait is usually presented in gel form.

To avoid the negative impacts of using chemical insecticides to control cockroaches in the form of resistance and environmental pollution, alternative solutions that are not persistent are needed. A plant-derived insecticide (botanical insecticide) is one insecticide that does not cause resistance or environmental pollution is an insecticide derived from plants (botanical insecticide). Gadung tuber (Discorea hispida) is one of Indonesia's plants that can act as an insecticide. Gadung tubers contain dioscorin alkaloids, cyanide acid, and cyanogenic glycosides. Research shows that gadung tubers contain dioscorin, a type of alkaloid that is a water-soluble poison that can cause vomiting of blood, difficulty breathing, and death. [8].

Boric acid is an insecticide that is often used as a stomach poison in the digestive tract because it is abrasive against insect exoskeletons. [9]. According to research, adding 5 grams of sucrose to 5 grams of boric acid as a ready-to-use bait causes 90% mortality in cockroaches (Periplaneta icana) [10]. The advantage of using boric acid as an insecticide is that it has low toxicity to humans, and fewer insects are resistant. The use of boric acid in gel bait is intended to increase gadung tuber extract's toxic power, provide quick death to cockroaches, and function as a preservative.

Gel bait formulation using the cockroach's favourite type of feed with the addition of gadung tuber extract and boric acid is an interesting experiment because it combines the cockroach's favourite feed, which functions as a cockroach food attractant, with poison from gadung tuber extract and boric acid to kill cockroaches when they eat the bait. We used this experiment as an alternative approach to control cockroaches, ensuring it is appropriate, effective, does not pollute the environment, leaves no residue, and suppresses the possibility of resistance. We then conducted a research stage to determine the LC50 and LT50 values of gadung tuber extract, which we added to a variety of gel baits. The goal of this study is to find out what happens to cockroaches (Blatella germanica) when different amounts of gadung tuber extract and boric acid are added to phagostimulant feed as gel bait. The study will look at the highest mortality value, LC50 value, and LT50 value.

MATERIALS AND RESEARCH METHODS

The research was conducted from February to March 2023 at the Vector and Nuisance Animal Control Laboratory and the Microbiology Laboratory of the Health Polytechnic of the Ministry of Health, Yogyakarta, using a true experiment and post-test design with only one control gThe study involved three treatment groups: variation A, which included 5 grammes of gadung tuber extract and 5 grammes of boric acid, variation B, which included 10 grammes

of gadung tuber extract and 5 grammes of boric acid, and variation C, which included 15 grammes of gadung tuber extract and 5 grammes of boric acid. The study also included two control groups: a negative control, which included gel bait without the addition of gadung tuber extract and boric acid, and a positive control group, which included gel bait available under the H brand and containing the active ingredient. The research object was adult female German cockroaches (Blatella germanica) aged 2–3 months, characterised by complete genitalia and the same size, which came from several hotels in Yogyakarta and Central Java. Each treatment required 5 adult cockroaches with 5 repetitions, so the number of cockroach samples was 125. The following materials and tools are included: gadung tubers, gadung tuber extract, granulated sugar, rice flour, boric acid, water, chloroform, test jar, fine mesh cloth, spoon, pan, stove, injection, analytical balance, pestle and mortar, measuring cup, knife, cutting board, blender, insulation, and thermohygrometer. The data were tested for normality using the Shapiro Wilk statistical test, followed by the one-way Anova test, followed by the LSD test with a level of significance of 0.05.

RESEARCH RESULTS AND DISCUSSION

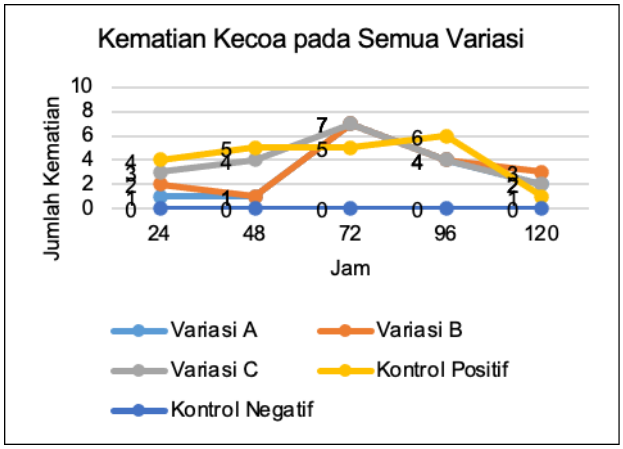
The research activity began with making gel bait using rice flour slurry with phagostimulant sugar solution and adding gadung tuber extract and boric acid. Gel bait is given to test insects (cockroaches) and is followed by observing cockroach activity, recording cockroach deaths, and calculating the percentage of cockroach death (mortality) at observation hours 24, 48, 72, 92, and 120 Hours After Application (JSA) [(11)]. In addition, physical environmental parameters, including temperature and humidity, were measured in the test room. The observation table then contains data on the deaths of test insects and the results of measurements of physical environmental parameters.

Data on cockroach death after gel bait treatment with variation A, variation B, variation C, positive control, and negative control can be seen in Table 1.

Table 1. Number of Cockroach Deaths in Each Treatment with 5 Repetitions

Observations After Treatment (O'clock)	Number of Deaths for Each Treatment				
	X1 Variation A	X2 Variation B	X3 Variation C	X4 Positive Control	X5 Negative Control
24	1	2	3	4	0
48	1	1	4	5	0
72	7	7	7	5	0
96	4	4	4	6	0
120	2	3	2	1	0
Amount	15	17	20	21	0
Average	3	3,4	4	4.2	0
% Mortality	60	68	80	84	0

After being given gel bait variations A, B, and C, the lowest number of test insect deaths resulted in gel bait variation A, namely 15 individuals, an average of 3 deaths, and a mortality percentage of 60%. The highest mortality was produced in variation C gel bait, with a number of test insect deaths of 20, an average of 4 deaths, and a mortality percentage of 80%.



Picture1. Cockroach Mortality Graph in All Variations

According to Figure 1, the test insects in each treatment, given gel bait variations A, B, and C, began to die at 24 JSA. The highest death rate was at 72 JSA, namely 7 individuals, and mortality decreased at 120 JSA. The positive control group began to experience death in 24 JSA, namely 4 animals. The highest mortality rate was in 96 JSA, namely 6 animals, and mortality decreased in 120 JSA to 1 animal. The negative control group had no deaths, ranging from 24 JSA to 120 JSA. This demonstrates that all bait treatment variations resulted in different increases and decreases in test animal mortality.

The normality test results on the mortality data for gel bait variations A, B, and C, as well as the positive control, obtained a p-value > 0.05, indicating that the data in the four groups had a normal distribution. Based on the normality test, it was continued with One Way Anova, whose results are presented in Table 2.

Table1. One Way Anova Test Results

Treatment	Average Mortality	elementary school	Sig
X1	3	0.707	
X2	3,4	1,140	
X3	4	0.707	,000
X4	4.2	0.837	
X5	0	0	

The results of the one-way Anova test in Table 2 show a p-value of 0.000 (p-value <0.05), so it rejects Ho, meaning that statistically there are differences in the number of cockroach mortality rates in various additions of gadung tuber extract and boric acid in phagostimulant feed as gel bait. The test results showed that adding various gadung tuber extracts and boric acid as gel bait to phagostimulant feed had an effect on the mortality of German cockroaches (Blatella germanica). To determine the differences between each variation, the test was continued with the LSD test, the results of which are presented in Table 3.

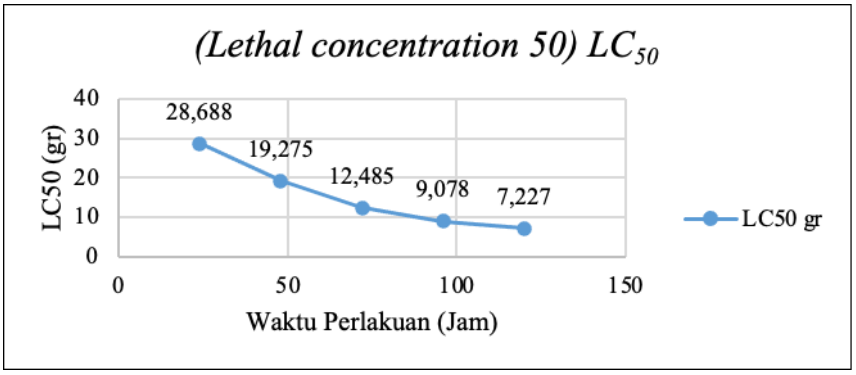
Table2. LSD (Least Significant Difference) Test Results

Treatment	Treatment	Sig.	Information
Variation A	Variation B	,424	No Difference
	Variation C	,034	There's a difference
	Positive control	,024	There's a difference
	Negative control	,000	There's a difference
Variation B	Variation A	,424	No Difference
	Variation C	,235	No Difference
	Positive control	,118	No Difference
	Negative control	,000	There's a difference
Variation C	Variation A	,034	There's a difference
	Variation B	,235	No Difference
	Positive control	,687	No Difference
	Negative control	,000	There's a difference
Positive control	Variation A	,024	There's a difference
	Variation B	,118	No Difference
	Variation C	,687	No Difference
	Negative control	,000	There's a difference
Negative control	Variation A	,000	There's a difference
	Variation B	,000	There's a difference
	Variation C	,000	There's a difference
	Positive control	,000	There's a difference

**. The mean difference is significant at the 0.05 level.*

According to Table 3, significant differences only occurred in variations A and C. Between treatment variations A, B, and C and the positive control, significant differences only occurred in variation A and the positive control between treatment variations A, B, and C. The treatments A, B, and C, as well as the negative control treatment, all exhibited significant differences.

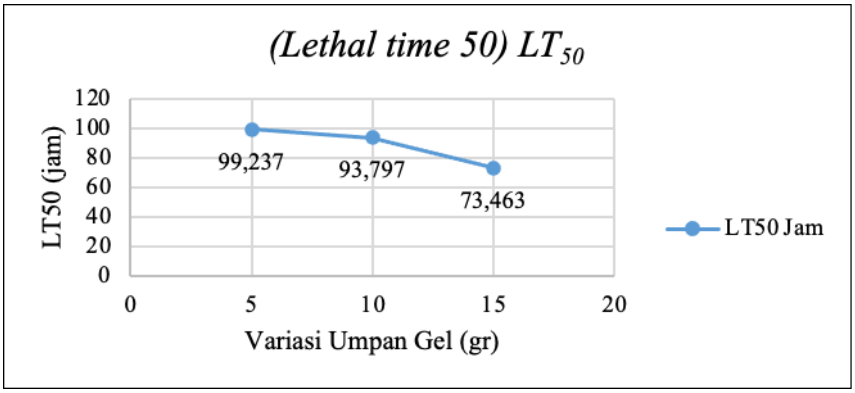
Next, we analysed the gel bait, which included variations of gadung tuber extract and boric acid, using a probit regression test to determine the LC50 and LT50 values.



Picture2. LC50 Gadung Tuber Extract Against Test Insect (Blatella Germanica)

After being given gel feed treatment for 24, 48, 72, 96, and 120 JSA, the LC50 value obtained at 120 JSA was 7.227 gr, with a mortality rate of 50% in the test animals. This LC50 value is

above variation A, namely the addition of 5 grammes of gadung tuber extract, and below variation B, namely the addition of 10 grammes of gadung tuber extract.



Picture3. LT50 Gadung Tuber Extract Against Test Insect (Blatella Germanica)

A gel bait treatment with 5, 10, and 15 grammes of gadung tuber extract was used. The LT50 value for the 5 grammes of gadung tuber extract variation was 99.237 hours, and the LT50 value for the 15 grammes of gadung tuber extract variation was 73.463 hours. The results above show that varying extract weights influence the death time of test animals (cockroaches).

It is highly recommended to control cockroaches using the baiting method, because controlling the insects using the spraying method will have a panic effect on cockroaches. Apart from that, cockroaches have a very thick layer of wax on their integument, making it difficult for insecticides to penetrate. As a result, quite a lot of insecticide is needed, and this results in high insecticide residues in the environment.

Blatella gemanica prefers sweet and carbohydrate-rich foods. To meet their energy needs, male and female cockroaches require sugar and carbohydrates. Female German cockroaches prefer foods with a high sugar content because they require a lot of energy and nutrients for the production of their ootek [12]. In this research, we use rice flour porridge with added sugar as a phagostimulant with a soft texture, aiming to make the bait preferred by cockroaches because it meets their energy needs and adapts to their mouth shape. We then add gadung tuber extract and boric acid to the preferred bait in gel form in the hopes that cockroaches will find it easier to consume the poisonous bait.

German cockroaches' food choices are influenced by odor attraction and palatability, assisted by fine hairs on the antennae and cerci sensory organs. According to Morales-Ramos et al. (2020) [13], at the start of their search for food, insects are attracted to the attractive smell of food, but after the food is consumed and does not meet their nutritional needs, the insect will stop the eating process and look for another food source that meets its nutritional needs. Therefore, gel bait needs to contain the nutrients that cockroaches require, while also attracting them to eat it.

Using poisonous bait in gel form to control cockroaches will be safer for the environment and humans because it does not leave residue that can pollute the environment, and the poisoned bait will only hit the target animal via the oral route. Cockroaches will consume a lethal dose of these feeds alone; therefore, gel baits are considered less likely to cause high levels of resistance than other direct-application insecticides. [14]. The gel bait works by entering through the oral route and continuing into the test insect's digestive system. The effect that occurs after the bait is swallowed is that the cockroach experiences poisoning and even death. This bait does not have a deterrent effect, so the test insects are not rejected, and cockroaches can return to the baiting area repeatedly.

Of the three gel bait variations (A, B, and C), gel bait variation C had the highest number of deaths. The number of deaths reached 20 individuals, with a mortality rate of 80%. The gel

bait variation A had the lowest mortality rate, with a total of 15 deaths and a mortality percentage of 60%. The results of this research also prove that the higher the concentration of the extract used, the higher the active ingredient content, so the higher the killing power against the test insects. [15].

Different kinds of gadung tuber extract and boric acid in the form of gel bait are said to work if they can kill more than 50% of the test insects and the concentration of the active ingredient extract is higher than the LC50 value (7.227 gr). Gadung tuber extract and boric acid in the form of gel bait that meets these two requirements is gel bait variation B. It killed 68% of the test insects, which is 50% more, and it had 10 grammes of extract, which is 7.227 grammes more. This result is in accordance with the statement by Putri Dwi, Khaerah, and Akbar (2022) [16], which states that a concentration, extract, or compound is said to be effective if the mortality percentage shows >50%.

The LC50 (lethal concentration 50) results for gadung tuber extract variations with observation times of 24 JSA, 48 JSA, 72 JSA, 96 JSA, and 120 JSA were 28,688 gr, 19,275 gr, 12,485 gr, 9,078 gr, and 7,227 gr, respectively. The LC50 value at 120 JSA of 7.227 gr confirms that gel bait variation B, which adds 10 grammes of gadung tuber extract and 5 grammes of boric acid, is the most effective. This is because the LC50 value is at 5 gr and 10 gr LC50.

The relationship between the length of observation time and the LC50 (picture) shows that the higher the variety of gadung tuber extract added, the faster the time required to kill the test insects. This is due to the high content of dioscorin, an alkaloid, and HCN.

The LT50 (lethal time 50) results showed that the 5 gr gadung tuber extract variation could kill 50% of cockroaches for 99.237 hours, the 10 gr gadung tuber extract variation for 93.797 hours, and the 15 gr gadung tuber extract variation for an extended period of 73,463 hours.

The relationship between variations in gadung tuber extract and LT50 (picture) shows that the time of death of the test animals was influenced by variations in gadung tuber extract added to the gel feed. The higher the variation in extract addition, the faster the time required to kill German cockroaches.

Physically, variation A gel bait is light brown; variation B is darker brown, like the gel bait in the negative control group; variation C is dark brown; and in the negative control group, it is white. The difference in gel bait colour is caused by the addition of variations in gadung tuber extract to the gel bait. The more gel bait you add, the darker the gel bait will be. Gel bait, which has been added to gadung tuber extract, has a sweet, nutty smell. In this study, changing the gel bait color did not affect the cockroaches' preference for each bait. This is as stated by Lauprasert (2006) (17): when looking for food, cockroaches do not differentiate bait based on colour. This is because cockroaches have compound eyes, namely false eyes that can only differentiate between dark and light olors. German cockroaches' feeding activity towards bait is strongly influenced by smell attraction and palatability attraction [18].

Variations A, B, and C of gel bait, along with the negative control, exhibit a soft and mushy texture similar to that of gel paste. This texture is the result of using rice flour slurry as the main ingredient in making gel bait. This is in accordance with research conducted by Maula et al. (2020) [19], which states that food texture also greatly influences German cockroaches' interest in food, where German cockroaches tend to prefer food with more water content and food with a soft texture.

Each variation of gel bait received the same treatment, which involved placing it in a uniform test jar for each variation. All treatment jars were placed in the same room. Next, temperature and humidity measurements were taken in the room using a thermohygrometer. The results of measuring the average temperature in the research room for 5 days were 28.6 oC, and the average room humidity was 72.4%. The measurement data falls within the optimal temperature range of 24-33 oC for cockroaches, as per Ogg's research from 2006 [20]. Room humidity is in the range of 58–80%. These results are in accordance with research conducted by Diyana (2021), which states that German cockroaches are often found in surrounding environments such as kitchens with a humidity of 58–80%. The temperature and humidity of this laboratory support cockroach activity in searching for food while also improving the

bait's performance. This is in line with the research results of Appel and Tanley (2000) [22], which revealed that feed performance was better at temperatures greater than 15 oC.

Environmental factors in the laboratory, which serves as a test site for German cockroaches, influence changes in the texture of the gel bait. After 5 days of observation, the gel bait's condition changed to become denser than its texture on the first day. This occurred because the testing laboratory had a temperature of 28.6 oC and was equipped with a fan that was continuously on during the research.

The poisons added to the gel bait in this study were gadung tuber extract and boric acid. Gadung tubers are a type of plant that can kill insects and contain solid alkaloid poisons called dioscorin, diosgenin, and dioscin that can make people or animals have seizures if they eat them. According to Sohor (2001), gadung tubers contain the alkaloid dioscorine, which is an alkaline substance that contains one or more nitrogen atoms and is often a toxin, which can cause drunkenness and seizures. Gadung tuber extract has killing power, is toxic, and cannot be tolerated by German cockroaches.

The gel bait's poison enters the body orally, travels through the digestive organs, and is absorbed by the walls of the digestive tract. Next, the poison will be taken to a deadly target location, such as the central nervous system, so that the German cockroach will experience poisoning and die the following day. Gel bait poisoning symptoms are characterized by a change in the cockroach's behavior to become more active, then weaken by turning upside down and convulsing, as well as changes in feces.

In this study, researchers did not examine the content of gadung tuber extract, so they do not know clearly what toxic compounds there are and how many toxic compounds are in gadung tuber extract. The poisoning symptoms in cockroaches are thought to be due to the dioscorin and HCN content in gadung tuber extract. According to research by Wihartati, Santosa, and Kartika (2021) [24], the dioscorin and HCN content can mess up metabolism and make it harder to digest food by decreasing the activity of protease and amylase enzymes, which help the digestive system work better when food goes into the digestive tract. If enzyme secretion is disrupted, the food digestion process and metabolism of German cockroaches will be disrupted, causing the cockroach to lack energy, become weak, and, over time, die.

Dioscorin is also toxic to nerves (neurotoxic) and has convulsant properties, which can cause paralysis of the central nervous system (CNS) in test insects. The mechanism of poisoning through paralysis is similar to picrotoxins (toxins from plants that work to affect the CNS) [25]. According to research results by Muhidin, Muchtar, and Hasnelly (2020) [26], Gadung tubers contain the compounds dioskorin, diosgenin, and dioscin. This compound is toxic to humans because it can irritate the nerves, causing dizziness and vomiting for those who consume the tubers. This compound is also toxic to animals, so when the compound enters the animal's body, the animal will quickly die.

Boric acid's mechanism of action is to enter the insect's stomach and damage the insect's digestion, thereby inhibiting cockroach growth. Damage to cockroach digestion causes severe dehydration, weakens the cockroach, and eventually kills. Boric acid in this gel bait serves not only as a poison but also as a preservative for the gel bait itself. This is proven by the comparison of the physical condition of the gel bait after storage between the treated gel bait and the negative control gel bait. The negative control bait underwent a physical change, becoming waterier, and contained fungi that were absent from the treatment bait. These results align with the findings of Fitriani, Istikowati, and Lusyiana (2018) [27], which highlight the widespread use of boric acid or sodium carbonate in soap and detergent production, insect repellent, medicine, and preservation.

Based on descriptive and statistical analysis, it was found that the addition of gadung tuber extract and boric acid in phagostimulant feed as gel bait had an effect on cockroach (Blatella germanica) mortality. The highest mortality percentage was in variation C with the addition of 15 grammes of gadung tuber extract and 5 grammes of boric acid, namely 80%. The difference in the mortality percentage of German cockroaches (Blatella germanica) in this

study was influenced by variations in gadung tuber extract added to the gel bait. The gel bait variation B is the most effective for German cockroach (Blatella germanica) mortality.

CONCLUSIONS AND RECOMMENDATIONS

The addition of variations in gadung tuber extract and boric acid as gel bait has an effect on cockroach (Blatella germanica) mortality. Variation A gel bait causes 60% of cockroach mortality. Variation B gel bait caused 68% of cockroach mortality. Variation C gel bait causes 80% of cockroach mortality. The LC50 (lethal concentration 50) value of the gel feed at the observation time of 120 JSA was 7.227 gr. The gel bait's LT50 (lethal time 50) value for the 5 gr gadung tuber extract variation is 99.237 hours, 10 gr is 93.797 hours, and 15 is 73.463 hours. Variation B is the most effective gel bait with variations of gadung tuber extract and boric acid. The pest control industry and the public can apply gel bait variation B to control the German cockroach vector (Blatella germanica). Researchers can then test the gel bait on a community scale and determine the content of gadung tuber extract. The researcher would like to express their gratitude to everyone involved. Hendrika Puspita Sari and Rizki Heriyansa, employees of PT

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