

# Decision Support System (DSS) for Rodenticide Selection using the TOPSIS Method

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**Abstract:** Selecting an appropriate rodenticide is a critical decision in pest control operations, as each product differs in effectiveness, application cost, safety level, environmental impact, and resistance potential. In practice, rodenticide selection is often based on technician experience or habitual product use, which may result in subjective and less optimal decisions. This study aims to develop a decision support system for rodenticide selection using the TOPSIS method within a multi-criteria decision-making (MCDM) framework. The evaluation is conducted based on six criteria: effectiveness, application cost, safety derived from LD50 values, secondary poisoning risk, resistance potential, and application convenience. To improve the robustness of the decision-making model, this study incorporates an adaptive TOPSIS approach through scenario-based weighting and compares the results with the Simple Additive Weighting (SAW) method. The findings show that alternatives with a balanced performance in terms of safety and operational cost consistently achieve higher rankings, with Warfarin Bait and Zinc Phosphide appearing as top-performing options across different evaluation scenarios. In addition, the proposed model is implemented in a web-based system using a prototype development approach, enabling automated calculations and transparent ranking results. This study provides a structured and practical decision support model that integrates technical, economic, and environmental considerations to support more objective decision-making in pest control management.

**Keywords:** Decision Support System, Multi-Criteria Decision Making, Pest Control, Rodenticide Selection, TOPSIS

## INTRODUCTION

Rodents are among the most common urban pests and are known to cause significant economic, environmental, and public health problems. Their presence in residential and commercial environments may lead to structural damage, food contamination, and the transmission of various zoonotic diseases. Previous studies indicate that rodent populations in urban ecosystems exhibit high adaptability and reproductive capacity, making them difficult to control without appropriate management strategies (Jurišić et al., 2022). Consequently, effective rodent control has become an essential component in maintaining environmental hygiene and food safety.

One of the most widely used approaches in pest management is the application of rodenticides. However, selecting an appropriate rodenticide is not a straightforward task, as each product differs in terms of effectiveness, toxicity level, environmental impact, resistance potential, and operational cost. In practice, rodenticide selection is often based on technician experience or habitual product usage rather than systematic evaluation. Such subjective decision-making may lead to suboptimal outcomes, including ineffective pest control, increased resistance among rodent populations, and higher environmental risks. Therefore, a structured decision-making approach is required to evaluate rodenticide alternatives objectively based on multiple relevant criteria.

Decision Support Systems (DSS) combined with Multi-Criteria Decision Making (MCDM) techniques have been widely applied to support complex decision-making processes in various domains, including environmental management, agriculture, healthcare, and resource allocation (Ali et al., 2023; Kizielewicz et al., 2025; Sahoo & Goswami, 2023; Sharma et al., 2023). These approaches enable decision makers to evaluate multiple alternatives simultaneously by considering several criteria, resulting in more rational and transparent decisions.

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Among various MCDM methods, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is one of the most commonly used approaches. This method ranks alternatives based on their relative distance from the positive ideal solution and the negative ideal solution, allowing decision makers to identify the most preferable option among competing alternatives (Behzadian et al., 2012; Márquez-Barja et al., 2011).

Despite its extensive application, studies specifically addressing rodenticide selection in urban pest control contexts remain limited. Most existing research focuses on pesticide selection in agricultural environments, whereas urban pest control involves different operational considerations. In addition, previous studies rarely integrate toxicological safety indicators such as LD50 values, environmental risk factors such as secondary poisoning, and resistance potential within a unified evaluation framework. These aspects are crucial in modern pest management, where effectiveness must be balanced with safety and sustainability considerations.

To address this gap, this study proposes a decision support system that integrates technical, economic, and environmental criteria within a multi-criteria evaluation framework. The proposed model applies the TOPSIS method using safety indicators derived from LD50 values, operational cost considerations, secondary poisoning risk, resistance potential, and application practicality. A logarithmic transformation is applied to LD50 values to improve data stability prior to normalization.

In addition, this study introduces an adaptive TOPSIS approach through scenario-based weighting to examine the consistency of ranking results under different decision priorities, such as cost, safety, and effectiveness. To further validate the robustness of the proposed model, a comparative analysis using the Simple Additive Weighting (SAW) method is also conducted. Furthermore, the proposed model is implemented in a web-based decision support system developed using a prototype approach, enabling practical application in pest control operations.

Based on the identified research gap, this study aims to develop a web-based decision support system for rodenticide selection that provides more objective, transparent, and adaptable decision-making results for pest control practitioners.

## LITERATURE REVIEW

A Decision Support System (DSS) is an information system designed to support complex decision-making processes, particularly when various criteria which are often conflicting must be considered simultaneously. DSS have been widely applied in various domains, including supplier evaluation, healthcare prioritization, and environmental management (Balicka, 2023; Elkady et al., 2024). Many (MCDM) methodologies have been developed to facilitate a systematic evaluation of various options in the context of multi-criteria decision analysis. The (TOPSIS) is one of the most commonly used approaches. This method is recognized for its computational simplicity and its capability to rank alternatives according to their relative closeness to a positive ideal solution and their distance from a negative ideal solution (T.-Y. Chen, 2023; Shyur & Shih, 2024).

In recent years, the TOPSIS method has been implemented across various sectors. In manufacturing, it has been used for equipment selection and production performance evaluation (Taherdoost & Madanchian, 2024). In the healthcare sector, TOPSIS has been applied to prioritize treatment options and allocate medical resources (Rana et al., 2023). Similarly, in environmental management, the method has been utilized for ecological risk assessment and sustainability-oriented decision making (Huang et al., 2022; Mishra et al., 2025). These studies demonstrate that TOPSIS is capable of handling multiple conflicting criteria and producing objective rankings among competing alternatives.

Within the agricultural sector and chemical product evaluation, MCDM methods including TOPSIS have also been applied to assess pesticide alternatives, irrigation strategies, and crop selection (Abdolalizadeh et al., 2025; Chowdhury & Bharadwaj, 2022). For instance, (Lombardi & Todella, 2023) applied TOPSIS to evaluate several pesticide formulations based on environmental and economic criteria. Similarly, Yao et al., (2023) utilized the TOPSIS method to rank herbicide products by considering toxicity levels, cost, and crop safety. These findings indicate that MCDM techniques are well suited for evaluating chemical products that involve multiple performance indicators.

Despite the wide application of TOPSIS in product evaluation, research specifically focusing on rodenticide selection for operational pest control services remains limited. Most previous studies have concentrated on pesticide management in agricultural contexts or environmental risk assessments rather than the practical selection of rodenticide products used in urban pest management services (Ili Sama et al., 2025; Steingrimsdóttir et al., 2018; Sukanto et al., 2023) This situation highlights a research gap that requires further investigation through the development of a systematic decision-support model.

In chemical product evaluation, safety aspects are commonly assessed using toxicity indicators such as LD50 values, which represent the acute toxicity level of a substance toward test organisms (Z. Chen et al., 2020; Gunawan & Utama, 2024). However, the wide variation in LD50 values can potentially create distortion in multi-criteria analysis. Therefore, several studies recommend applying data transformation techniques, such as logarithmic transformation, to stabilize the distribution of values before the normalization stage in MCDM

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calculations (Lombardi & Todella, 2023). This approach helps improve the stability and reliability of the evaluation results.

Furthermore, sensitivity analysis is frequently applied in decision support system development to evaluate the robustness of a model against changes in criteria weights (Abdolalizadeh et al., 2025; Chowdhury & Bharadwaj, 2022). Sensitivity testing is important to ensure that changes in decision priorities, such as increased emphasis on cost or safety, do not lead to extreme shifts in alternative rankings.

In addition to conventional TOPSIS applications, several studies have explored model enhancement techniques such as sensitivity analysis and comparative evaluation using alternative MCDM methods. These approaches are important to assess the robustness and consistency of decision-making models under different weighting scenarios. However, the integration of scenario-based adaptive weighting and method comparison within a unified framework for rodenticide selection remains limited.

Based on the literature reviewed, it can be concluded that although TOPSIS has been widely implemented in various fields, studies integrating toxicological safety indicators based on LD50 values, operational cost considerations, secondary poisoning risk, and resistance potential within a unified evaluation framework for rodenticide selection remain limited. Furthermore, limited attention has been given to evaluating model robustness through adaptive weighting scenarios and comparative methods. Therefore, this study addresses this gap by developing a TOPSIS-based decision support system enhanced with adaptive weighting and comparative analysis to support more reliable decision-making in pest control operations.

## METHOD

### Research Workflow

This study follows a structured sequence of stages, starting from problem identification and ending with the implementation of a decision support system. The overall process is designed to ensure that the proposed model reflects practical needs in selecting rodenticide products for pest control operations. The first stage involves identifying issues in current selection practices, which are often based on personal experience or habitual product use. Such practices may result in inconsistent and less effective decisions. To address this issue, a more systematic and criteria-based evaluation approach is required. Next, a literature review is conducted to determine appropriate decision-making methods and relevant evaluation criteria. Based on this stage, a set of rodenticide alternatives and criteria is established. The dataset used in this study consists of 30 rodenticide alternatives, combining real product data and simulated data to provide broader analytical representation. These data are then organized into a decision matrix that reflects the performance of each alternative against the selected criteria.

The decision matrix is processed using the TOPSIS method to generate preference values and ranking results. To further examine the consistency of the model, an adaptive weighting approach is applied through several decision scenarios, reflecting different priority perspectives such as cost, safety, and effectiveness. In addition, the SAW method is employed as a comparison technique to validate the ranking outcomes. Finally, the model is implemented into a web-based decision support system developed using the prototype approach. This system allows users to manage data, adjust criteria weights, and obtain ranking results automatically.

### Decision-Making Method

This research applies the (TOPSIS) as the primary decision-making method. TOPSIS is a MCDM technique that determines the best alternative based on its relative distance from an ideal solution (Madanchian & Taherdoost, 2023). The basic concept behind TOPSIS is that the best option is the one that is as close as possible to the positive ideal solution. This approach can produce a fair evaluation of various options by considering cost and benefit factors simultaneously. TOPSIS has been widely used in various decision support system applications due to its ability to handle multiple evaluation criteria and provide a transparent ranking mechanism.

### Alternatives and Evaluation Criteria

The alternatives analyzed in this study consist of 30 rodenticide products, including real products commonly used in pest control operations and simulated alternatives to broaden analytical coverage. These alternatives represent different active ingredients, mechanisms of action, and formulation types. The selection was based on product availability, accessibility of Material Safety Data Sheet (MSDS) information, and representation of various rodenticide categories such as first-generation anticoagulants, second-generation anticoagulants, and acute toxicants.

Six evaluation criteria were used in this study: effectiveness, application cost, safety, secondary poisoning risk, resistance potential, and application convenience. Effectiveness reflects the ability of a rodenticide to control rodent populations based on its mechanism of action. Application cost represents the estimated expense required for a single treatment in a typical operational setting. Safety is evaluated using LD50 values obtained from MSDS data, which are transformed using a logarithmic scale to improve data stability. Secondary poisoning risk and

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resistance potential are assessed based on toxicological characteristics and supporting literature, while application convenience is determined by formulation type, such as block, pellet, paste, or powder.

The dataset used in this study combines real and simulated data. Real data were obtained from MSDS documentation and product specifications of rodenticides commonly used in pest control operations. However, not all evaluation criteria are consistently available in quantitative form across different products, particularly for attributes such as resistance potential and secondary poisoning risk.

To address this limitation, simulated alternatives were incorporated to ensure that all criteria could be represented consistently and to extend the diversity of the dataset. This approach allows the model to be evaluated under a broader range of conditions while maintaining its relevance to practical applications. The use of simulated data in this study is intended to support the robustness of the analysis rather than to replace real-world observations.

**TOPSIS Calculation Procedure**

The TOPSIS method is applied to evaluate and rank alternatives based on multiple criteria. The process begins by constructing a decision matrix that represents the performance of each alternative with respect to the defined criteria. To ensure comparability across different measurement scales, the matrix is normalized using vector normalization:

$$r_{ij} = \frac{x_{ij}}{\sum x_{ij}^2} \tag{1}$$

The normalized values are then multiplied by their respective criterion weights to obtain the weighted normalized matrix:

$$y_{ij} = w_j x r_{ij} \tag{2}$$

Based on this matrix, the positive ideal solution and negative ideal solution are determined. The separation distance of each alternative from these ideal solutions is calculated using:

$$D_i^+ = \sqrt{\sum (y_{ij} - y_j^+)^2} \tag{3}$$

$$D_i^- = \sqrt{\sum (y_{ij} - y_j^-)^2} \tag{4}$$

Finally, the preference value for each alternative is computed as:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{5}$$

Higher preference values indicate that an alternative is closer to the positive ideal solution and therefore more preferable. The overall TOPSIS calculation process implemented in this study is illustrated in Figure 1.

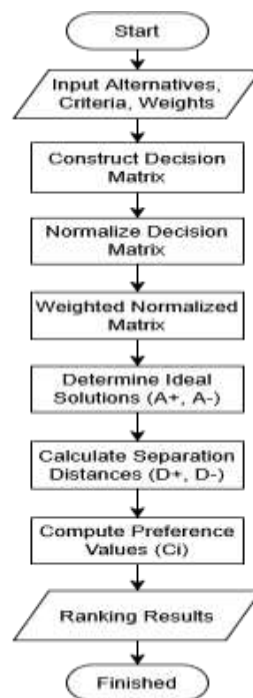


Fig 1. TOPSIS Calculation Process

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The procedure begins with defining the alternatives, evaluation criteria, and their corresponding weights. A decision matrix is then constructed and normalized to ensure comparability across different criteria scales. The normalized matrix is weighted to produce the weighted normalized matrix, followed by the identification of positive and negative ideal solutions. Next, the separation distances of each alternative are calculated, and preference values are obtained to determine the final ranking results.

**Algorithm Representation**

To provide a clearer description of the computational process, the TOPSIS method used in this study is summarized in the following pseudocode:

Algorithm TOPSIS

Input: Alternatives (A), Criteria (C), Weights (W), Decision Matrix (X)

Output: Preference values (Ci) and ranking results

1. Construct the decision matrix X
2. Normalize the decision matrix to obtain R
3. Calculate the weighted normalized matrix Y
4. Determine the positive ideal solution (A<sup>+</sup>) and negative ideal solution (A<sup>-</sup>)
5. Compute the distance of each alternative to A<sup>+</sup> and A<sup>-</sup>
6. Calculate the preference value (Ci) for each alternative
7. Rank alternatives based on Ci values

**Adaptive TOPSIS Approach**

This study extends the standard TOPSIS method by incorporating a scenario-based adaptive weighting strategy. Instead of applying a single fixed weighting scheme, three different scenarios are defined to represent distinct decision priorities, namely cost-oriented, safety-oriented, and effectiveness-oriented conditions.

In each scenario, one criterion is assigned a higher weight to reflect its priority, while the remaining criteria are proportionally adjusted to ensure that the total weight remains equal to one. The same dataset and decision matrix are maintained across all scenarios to preserve consistency in the evaluation process.

The TOPSIS method is then applied separately for each scenario to obtain preference values and ranking results. The resulting rankings are compared to examine how variations in weighting influence the relative position of each alternative. This approach provides a more comprehensive evaluation by capturing the sensitivity of ranking outcomes under different decision priorities. The weighting configurations used in each scenario are presented in Table 1.

Table 1.  
 Weighting Scenarios for Adaptive TOPSIS

Code	Criteria	Cost-Oriented	Safety-Oriented	Effectiveness-Oriented
C1	Effectiveness	0.20	0.15	0.40
C2	Application Cost	0.35	0.10	0.15
C3	Safety	0.15	0.40	0.20
C4	Secondary Poisoning Risk	0.10	0.20	0.10
C5	Resistance Potential	0.10	0.10	0.10
C6	Application Convenience	0.10	0.05	0.05

**Comparative Method using SAW**

To validate the consistency of the ranking results, the Simple Additive Weighting (SAW) method was used as a comparative approach. SAW is a multi-criteria decision-making technique that determines the overall score of each alternative by aggregating normalized criterion values based on their respective weights.

In this study, the same dataset and weighting scheme applied in the TOPSIS method were used to ensure a consistent basis for comparison. The normalization process distinguishes between benefit and cost criteria. Benefit criteria are normalized by comparing each value to the maximum value, while cost criteria are normalized using the inverse proportion.

The preference value of each alternative is calculated using the following equation:

$$V_i = \sum_{j=1}^n (w_j \cdot r_{ij}) \tag{6}$$

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where  $V_i$  represents the final score of alternative  $i$ ,  $w_j$  is the weight of criterion  $j$ , and  $r_{ij}$  is the normalized value. Alternatives are then ranked based on their preference values, where higher values indicate better performance.

### System Development Using the Prototype Model

The decision support system in this study was developed using a prototype-based approach. This method facilitates iterative interaction between developers and users, allowing the system to be gradually refined according to operational needs.

The development process started with the identification of user requirements based on pest control workflows. An initial system design was then formulated, including the database structure, TOPSIS computation module, and user interface components. A web-based prototype was subsequently implemented and evaluated to assess its functionality and usability.

Based on the feedback obtained, the system underwent several refinement cycles until it met the expected requirements. The final system enables users to manage rodenticide alternatives, define evaluation criteria and weights, and automatically generate ranking results using the TOPSIS method.

The overall system architecture is illustrated in Figure 2.

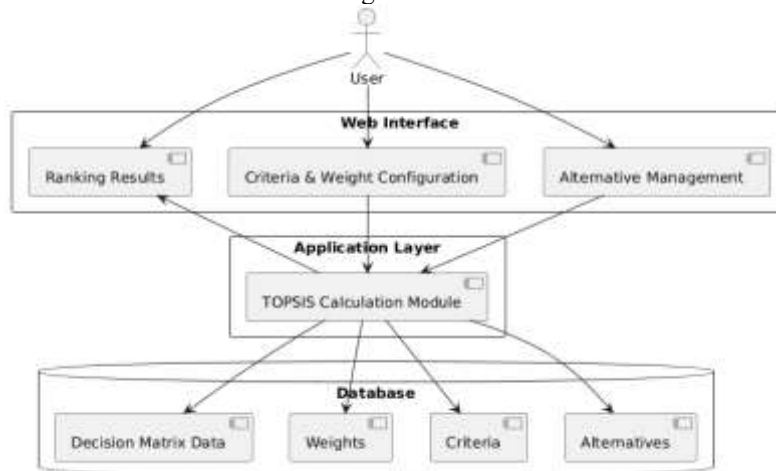


Fig 2. Architecture of the Proposed Decision Support System

### Expert Validation

To enhance the reliability of the proposed decision model, an expert validation process was conducted involving practitioners in the field of pest control. The experts evaluated the relevance of the selected criteria and the consistency of the ranking results with real-world practices.

## RESULTS

### Criteria and Dataset Definition

This study evaluates 30 rodenticide alternatives using six criteria: effectiveness (C1), application cost (C2), safety based on LD50 (C3), secondary poisoning risk (C4), resistance potential (C5), and application convenience (C6). The classification of each criterion as benefit or cost is presented in Table 1.

Table 1. Defined Criteria and Their Respective Weights

Code	Criteria	Description	Weight	Type
C1	Effectiveness	Based on rodenticide mechanism (Gen 2, Acute toxin, Gen 1)	0.30	Benefit
C2	Application Cost	Estimated cost for treatment in a ±100 m <sup>2</sup> residential area	0.15	Cost
C3	Safety	Logarithmic transformation of LD50 values	0.25	Benefit
C4	Secondary Poisoning Risk	Toxicological classification of rodenticide	0.15	Cost
C5	Resistance Potential	Likelihood of rodent resistance development	0.10	Cost
C6	Application Convenience	Product formulation type	0.05	Benefit

The dataset consists of real products obtained from MSDS documentation and several simulated alternatives to enhance analytical coverage. Each alternative is represented by numerical values for all criteria, forming a

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decision matrix used in the TOPSIS and SAW calculations. A summarized representation of the dataset is provided in Table 2.

Table 2. Resulting Decision Matrix

Alt	Product	C1	C2	C3	C4	C5	C6
A1	Klerat Block	3	60000	-0,569	3	1	3
A2	Maki Block	3	44000	0,051	2	1,5	3
A3	Rodilon Block	3	64000	-0,252	3	1	3
A4	Storm Block	3	70000	-0,602	3	1	3
A5	Racumin Paste	1	36000	1,217	1	2	2
A6	Warfarin Bait	1	24000	2,509	1	3	2
A7	Zinc Phosphide	2	30000	1,602	0,5	0,5	2
A8	Maki Pellet	3	42000	0,051	2	1,5	2
A9	Klerat Pellet	3	58000	-0,569	3	1	2
A10	Racumin Powder	1	20000	1,217	1	2	1
...	...	...	...	...	...	..	...
A30	Pellet Formulation with Balanced Performance Characteristics	3	60000	0,04	2	1,5	2

### TOPSIS Results

The TOPSIS method was applied to the decision matrix to obtain preference values and ranking results for all alternatives. The calculation process includes normalization, weighting, determination of ideal solutions, and distance measurement, as described in the Methods section.

The results indicate that Warfarin Bait (A6) achieved the highest preference value, followed by Zinc Phosphide Bait (A7) and Racumin Paste (A5). These alternatives consistently show higher performance compared to others in the dataset.

The complete ranking results based on the TOPSIS method are presented in Table 3. For clarity and space limitations, only the top-ranked and lowest-ranked alternatives are displayed, while the full ranking list is used in the analysis.

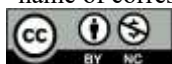
Table 3. TOPSIS Ranking Results

Alt	Product	Preference Value ( $C_i$ )	Rank
A6	Warfarin Bait	0.769	1
A7	Zinc Phosphide Bait	0.580	2
A5	Racumin Paste	0.457	3
A10	Racumin Powder	0.450	4
A29	Block Formulation with High Efficacy Level	0.248	5
A25	Block Formulation with High Toxicological Impact	0.243	6
A4	Storm Block	0.241	7
A14	FirstStrike Bait	0.240	8
A12	Final Blox	0.238	9
A3	Rodilon Block	0.237	10
...	...	...	...
A28	Bait Formulation with Minimal Secondary Poisoning Risk	0.102	29
A27	Paste Formulation with Enhanced Safety Profile	0.100	30

### Adaptive TOPSIS Results

To enhance the robustness of the decision model, a scenario-based adaptive weighting approach was applied. Three weighting scenarios were defined to represent different decision priorities, namely cost-oriented, safety-oriented, and effectiveness-oriented conditions.

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Each scenario assigns a higher weight to a specific criterion while maintaining the total weight equal to one. The same dataset and decision matrix were used across all scenarios to ensure consistency in comparison.

The TOPSIS method was then executed separately for each scenario. The results indicate that Warfarin Bait (A6) consistently ranks first across all scenarios, followed by Zinc Phosphide Bait (A7) and Racumin Paste (A5). The top-ranked alternatives remain stable, while minor variations are observed in lower-ranked alternatives.

The comparison of ranking results across scenarios is presented in Table 4.

Table 4. Ranking Comparison Across Adaptive TOPSIS Scenarios

Rank	Alt	Product	Cost	Safety	Effectiveness
1	A6	Warfarin Bait	1	1	1
2	A7	Zinc Phosphide Bait	2	2	2
3	A5	Racumin Paste	3	3	3
4	A10	Racumin Powder	4	4	4
5	A29	Block Formulation with High Efficacy Level	5	5	5
...	...	...	...	...	...
30	A27	Paste Formulation with Enhanced Safety Profile	30	29	30

### Comparative Results using SAW

To validate the consistency of the decision-making results, the Simple Additive Weighting (SAW) method was applied as a comparative approach. The same dataset and weighting scheme described in the Methods section were used to ensure a fair comparison.

A comparison between TOPSIS and SAW ranking results is presented in Table 5.

Table 5. Comparison of TOPSIS and SAW Ranking Results

Alt	Product	TOPSIS Rank	SAW Rank
A6	Warfarin Bait	1	3
A7	Zinc Phosphide Bait	2	1
A5	Racumin Paste	3	26
A10	Racumin Powder	4	15
A29	Block Formulation with High Efficacy Level	5	24
...	...	...	...
A27	Paste Formulation with Enhanced Safety Profile	30	28

### Statistical Comparison of Ranking Results

To further examine the consistency between the TOPSIS and SAW methods, a statistical comparison was conducted using Spearman's rank correlation coefficient. This analysis was performed based on the ranking results of all alternatives obtained from both methods.

The calculation produced a Spearman correlation coefficient of -0.0901, indicating a low level of agreement between the two ranking results. This suggests that TOPSIS and SAW generate different ranking patterns when applied to the same dataset.

This difference can be attributed to the distinct underlying principles of each method. TOPSIS evaluates alternatives based on their relative distance to positive and negative ideal solutions, whereas SAW applies a direct additive aggregation of weighted criteria. As a result, each method emphasizes different aspects of the evaluation criteria, which may lead to variations in the final ranking.

Rather than indicating inconsistency, this finding highlights that different multi-criteria decision-making methods may produce different decision perspectives. Therefore, the selection of an appropriate method should be aligned with the decision context and the priorities of the decision maker.

### Expert Validation Results

To ensure the reliability of the developed decision model, an expert validation process was carried out involving pest control practitioners with experience in the use and selection of rodenticides.

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The experts assessed the relevance of the criteria used in this study, including effectiveness, cost, safety, secondary poisoning risk, resistance potential, and application convenience. In addition, they reviewed the structure of the decision model and the consistency of the ranking results generated by the system.

The validation results indicate that the selected criteria are relevant to operational needs in real-world pest control practices. The ranking results are also considered consistent with practical considerations, particularly in balancing effectiveness, safety, and operational cost.

These findings suggest that the proposed model can be effectively used as a decision support tool in pest control operations.

### System Implementation

The developed system provides an interactive platform for managing rodenticide selection using the TOPSIS method. Users can input alternative data, define evaluation criteria, and adjust weighting parameters according to operational needs.

The system automatically processes the input data and generates ranking results based on TOPSIS calculations. This functionality enables users to obtain structured and transparent decision recommendations.

The implementation demonstrates that the proposed model can be effectively applied in practical pest control operations.

### DISCUSSIONS

The results of the TOPSIS analysis indicate that several alternatives consistently occupy top ranking positions, particularly Warfarin Bait (A6), Zinc Phosphide Bait (A7), and Racumin Paste (A5). These alternatives demonstrate relatively balanced performance across multiple evaluation criteria, allowing them to remain close to the ideal solution.

The implementation of adaptive weighting scenarios provides further insight into the stability of the decision model. Across cost-oriented, safety-oriented, and effectiveness-oriented scenarios, the top-ranked alternatives remain unchanged. This consistency suggests that the proposed model is robust against moderate variations in decision priorities. However, slight differences are observed in lower-ranked alternatives, indicating that less competitive options are more sensitive to changes in weighting.

The comparison with the SAW method reveals noticeable differences in ranking positions. While TOPSIS evaluates alternatives based on their relative distance from ideal solutions, SAW aggregates weighted scores in a linear manner. As a result, alternatives with imbalanced performance across criteria may receive significantly different rankings. For example, Racumin Paste (A5), which ranks highly in TOPSIS, shows a lower position in SAW due to its weaker performance in certain criteria. This is also reflected in the low level of agreement between the two methods, indicating that different MCDM approaches may lead to different decision perspectives in practical applications.

In addition, the results reveal a clear trade-off between effectiveness, cost, and safety. Alternatives with high effectiveness often exhibit higher toxicity or cost, while safer alternatives tend to have lower effectiveness. This trade-off explains why some alternatives change their ranking positions under different weighting scenarios, particularly when one criterion becomes dominant.

These findings highlight the importance of method selection in multi-criteria decision-making. TOPSIS tends to provide more stable results when a balance among criteria is required, whereas SAW is more sensitive to dominant criteria values. Therefore, the choice of method should be aligned with the decision context and priority structure.

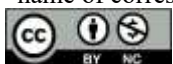
From a practical perspective, the developed system enables decision-makers in pest control operations to evaluate rodenticide alternatives in a structured manner. By incorporating multiple criteria, including effectiveness, cost, and safety, the system supports more transparent and consistent decision-making compared to experience-based selection.

Overall, the integration of adaptive weighting and comparative analysis strengthens the reliability of the proposed decision support system and provides a more comprehensive understanding of rodenticide selection under different operational conditions. These findings also demonstrate the practical value of combining multiple evaluation approaches in supporting more informed decision-making.

### CONCLUSION

This study presents a decision support system for rodenticide selection using the TOPSIS method, incorporating multiple evaluation criteria, including effectiveness, cost, safety, secondary poisoning risk, resistance potential, and application convenience. The results demonstrate that Warfarin Bait (A6) consistently achieves the highest ranking, followed by Zinc Phosphide Bait (A7) and Racumin Paste (A5), indicating their suitability as recommended alternatives under the evaluated conditions.

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To enhance the robustness of the decision model, this study introduces an adaptive TOPSIS approach through scenario-based weighting. The findings show that the top-ranked alternatives remain stable across different decision priorities, confirming the consistency of the model. In addition, the comparison with the SAW method reveals variations in ranking results, further supported by the statistical analysis using Spearman's rank correlation, which indicates differences in ranking patterns between methods. This highlights the importance of method selection in influencing decision outcomes.

The developed web-based system successfully integrates the decision model into a practical application, enabling users to perform structured and transparent evaluations. This contributes to reducing subjectivity in rodenticide selection and supports more consistent decision-making in pest control operations.

Overall, the integration of adaptive weighting, comparative analysis, and validation approaches strengthens the reliability of the proposed decision support system and enhances its practical applicability.

Future research may consider expanding the dataset with more diverse products, integrating additional environmental impact indicators, and exploring hybrid decision-making methods to further improve the accuracy and applicability of the model.

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