VERMICOMPOSTING OF RABBIT MANURE FOR SUSTAINABLE ORGANIC WASTE MANAGMENT AND ENVIRONMENTAL QUALITY IMPROVEMENT

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ABSTRACT

This paper analyzes a model of sustainable organic waste management through the utilization of rabbit manure via vermicomposting. Rabbit manure, consisting of solid and liquid excreta combined with bedding materials (straw, sawdust), is not directly applied to agroecosystems but is biologically transformed using California red worms (*Eisenia fetida*). Given the high annual manure output (approximately 90 kg per animal), this approach represents an efficient valorization strategy. During vermicomposting, organic matter is decomposed and converted into stable humus with significantly increased macroelement content compared to conventional farmyard manure, including nitrogen, phosphorus, and potassium. The process is conducted under controlled conditions in wooden containers with continuous addition of fresh manure. The resulting vermicompost is applied in the production of fruit, vegetables, and ornamental plants without the use of synthetic fertilizers. The results indicate that this system enables nutrient cycling within the household, reduces waste generation, and improves soil fertility while simultaneously supporting the production of healthy feed for rabbits. The described approach represents a practical model of sustainable agricultural practice applicable in small-scale production systems.

Keywords: vermicomposting, *Eisenia fetida*, rabbit manure, organic waste management, soil fertility, environmental quality.

INTRODUCTION

The intensification of agricultural production has led to an increase in the amount of organic residues originating from livestock production systems, posing a challenge for sustainable resource management and environmental protection. Contemporary agricultural production concepts are increasingly based on the principles of the circular economy, in which organic by-products are regarded not as waste, but as valuable resources that can be reintroduced into the production cycle through appropriate treatment and management practices [1].

Inadequate management of animal-derived organic matter can result in nutrient losses, the generation of unpleasant odors, greenhouse gas emissions, and the potential contamination of soil and water resources. Consequently, modern agricultural production systems increasingly employ biological treatment processes that stabilize organic matter and convert it into products with greater agronomic value.

Vermicomposting is a biotechnological process that stabilizes organic matter through the activity of specialized epigeic earthworm species and the associated microbial community [2,12]. During this process, organic material is fragmented, decomposed, and transformed into stable humic compounds. Unlike conventional composting, vermicomposting relies on the active participation of epigeic earthworm species that inhabit organic matter-rich surface soil layers and play a key role in its transformation [2].

Eisenia fetida is one of the most widely used earthworm species in vermicomposting systems due to its high tolerance to a wide range of organic substrates, rapid reproduction, and efficiency in the transformation of organic matter [3,13,17]. In addition to its direct role in the decomposition process, the activity of this species also influences the development of microbial communities, which play a crucial role in the stabilization of organic matter.

Recent studies indicate that vermicomposting is a complex biological system in which interactions between earthworms and microorganisms determine the course of substrate transformation. Microbial communities associated with *Eisenia fetida* contribute to changes in the composition of organic matter and the formation of a more stable end product [4], [5], [14].

Rabbit manure is a specific organic material consisting of a mixture of feces and bedding used in rabbit production facilities. Owing to its organic matter content and nutrient composition, it represents a potentially valuable substrate for biological transformation. Recent studies have also demonstrated that rabbit manure represents a suitable substrate for vermicomposting because it undergoes rapid biological stabilization and produces a nutrient-rich organic fertilizer [12].

Molina *et al*. [6] demonstrated that rabbit manure can be successfully processed through vermicomposting using *Eisenia fetida*, resulting in the stabilization of organic matter and the production of a material with potential agricultural applications.

The application of vermicompost can improve the physical, chemical, and biological properties of soil, increase soil organic matter content, and enhance nutrient use efficiency in crop production [7,15].

In small-scale agricultural systems, particularly on family farms where livestock and crop production are closely integrated, vermicomposting represents a practical model of a closed-loop nutrient cycling system. In this way, organic matter generated from rabbit production can be transformed into a valuable input for crop production.

The aim of this study was to demonstrate the potential for sustainable management of rabbit manure through vermicomposting at the Dimitrijević family farm in the village of Barje Čiflik, near Pirot, Serbia, and to examine the significance of this process within the context of circular agriculture, environmental protection, and the efficient utilization of organic resources.

Legal Framework for Sustainable Organic Matter Management and Rabbit Welfare

Sustainable management of organic matter generated in agricultural production constitutes an integral part of the broader framework for environmental protection and the rational use of natural resources. In the Republic of Serbia, this area is regulated by legislation that establishes the

principles of environmental protection, waste management, soil conservation, and the responsible treatment of animals.

The Law on Environmental Protection of the Republic of Serbia (2004), [8], establishes the fundamental principles of environmental protection, including pollution prevention, the conservation of natural resources, and the implementation of practices that promote sustainable development. In this context, the utilization of rabbit manure through the vermicomposting process represents an example of transforming organic material into a product with beneficial applications rather than allowing it to become an environmental burden.

The Law on Waste Management of the Republic of Serbia (2025), [9], defines the principles of waste prevention, reuse, and material recovery whenever feasible. Although organic matter generated from agricultural production has a specific legal status compared with municipal waste, the principles of sustainable resource management and the prevention of adverse environmental impacts provide an important basis for the application of processes such as vermicomposting.

In addition to the sustainable management of organic matter, the sustainability of agricultural production systems also requires the provision of appropriate conditions for animal welfare. The Law on Animal Welfare of the Republic of Serbia (2009), [10], stipulates the obligation to ensure appropriate housing conditions, safeguard animal health, provide adequate nutrition and accommodation, and implement management practices that prevent unnecessary suffering.

In rabbit production, animal welfare is closely associated with housing hygiene, bedding quality, ventilation, moisture control, and the regular removal of organic waste. Proper manure management is an integral component of good agricultural practice, as it contributes to maintaining hygienic conditions and reducing potential risks to both animal health and the environment.

Accordingly, the vermicomposting of rabbit manure can be regarded as an integrated approach that links animal welfare, the sustainable management of organic resources, and environmental protection through a closed-loop nutrient cycle.

METHODOLOGY SECTION

Research Site and Characteristics of the Production System

The study was conducted at the Dimitrijević family farm in the village of Barje Čiflik near Pirot, Serbia, where rabbit production and the management of organic material generated during the rearing process are carried out. The farm's production system includes the New Zealand White rabbit and the English Spot rabbit breeds.

The subject of this research was a practical model for the utilization of rabbit manure as an organic substrate for the vermicomposting process, with the aim of assessing its potential transformation into a more stable organic material suitable for application in crop production.

The organic matter management system was based on the integration of livestock and crop production through a closed nutrient cycle:

rabbit production → manure generation → vermicomposting → production of organic fertilizer → crop production

This approach to organic resource management is consistent with the principles of circular agriculture, in which by-products from one production activity are utilized as resources in another. In this way, more efficient nutrient utilization is achieved, the need for removing organic material from the production system is reduced, and a more sustainable approach to farm management is promoted.

Generation and Collection of Rabbit Manure

The organic material used in the vermicomposting process originated from rabbit production at the Dimitrijević family farm, which had 11 animal housing cages during the observation period.

The housing facilities and cages were cleaned once or twice a week, ensuring the maintenance of appropriate hygienic conditions and reducing the accumulation of moisture and harmful gases, particularly ammonia, which at elevated concentrations can negatively affect rabbit health and welfare.

During cleaning, special attention was given to corners and hard-to-reach areas within the facility where organic material could accumulate. Disinfection of the housing facility was carried out periodically, in accordance with the requirements of the production system.

The rabbit manure used in the vermicomposting process consisted of a mixture of solid and liquid excreta combined with bedding material composed of straw and sawdust.

The material was collected after cage cleaning, whereby the housing system with wooden slatted flooring enabled more efficient collection of organic material and its subsequent transfer for further processing.

Figures 1 and 2 document the generation of organic waste, which represents the initial substrate for the biological transformation process. They illustrate the rabbit housing system and the facility hygiene maintenance procedures that precede the collection and further processing of organic matter.



Figure 1. Female rabbit before cage cleaning (source: Lj. Dimitrijević, 2025)



Figure 2. Female rabbit after cleaning the wooden slatted floor cage (source: Lj. Dimitrijević, 2025)

Vermicomposting Process

Rabbit manure supplemented with bedding material was used as the initial substrate for the vermicomposting process. Californian red worms of the species *Eisenia fetida* were introduced into the prepared organic material. Continuous feeding of fresh organic material during vermicomposting was performed in accordance with recommendations for maintaining stable earthworm activity under small-scale production conditions [17]. This species is frequently used in vermicomposting systems due to its high efficiency in the transformation of various organic substrates [2].

The vermicomposting process was carried out at the Dimitrijević family farm using wooden boxes measuring 1 × 2 m, which were suitable for the storage and processing of the generated manure.

Figure 3 shows four wooden boxes containing the initial organic substrate, which served as the basis for the transformation process.

During the process, conditions favorable for earthworm and microbial activity were maintained, primarily appropriate substrate moisture and temperature. Maintaining suitable environmental conditions represents one of the key factors determining the success of vermicomposting, as the activity of *Eisenia fetida* depends on the characteristics of the environment in which the process takes place.

Fresh rabbit manure was added gradually in smaller quantities, as recommended for continuous vermicomposting systems [17], enabling the continuous progression of the process and the gradual transformation of organic matter.

During vermicomposting, interactions between earthworms and microorganisms occur, resulting in the physical fragmentation, decomposition, and transformation of organic material into a more stable organic product enriched with humic compounds.



Figure 3. Wooden boxes containing rabbit manure *(source: Lj. Dimitrijević, 2025)*

It is important to note that laboratory analyses of the physical, chemical, and microbiological properties of the obtained vermicompost were not conducted within the scope of this study. Therefore, the evaluation of the significance of the process is based on direct observation of the production system and comparison with the findings of previous scientific studies.

Application of the Obtained Vermicompost

The obtained vermicompost was used in crop production at the Dimitrijević family farm as an organic fertilizer intended to improve soil quality and support plant nutrition.

The application of vermicompost enables the return of nutrients originating from rabbit production back into the soil system. In this way, a closed cycle of organic matter is achieved:

rabbit production → generation of organic material → vermicomposting → production of organic fertilizer → crop production

The use of vermicompost contributes to increasing soil organic matter content, improving soil structure, and creating more favorable conditions for plant development, which is consistent with previous research findings on the role of vermicompost in sustainable agriculture [7].

The application of the obtained product within the same farm represents the final stage of a closed production cycle, in which organic material generated from livestock production is reintroduced into crop production.



Figure 4. Greenhouse at the Dimitrijević family farm where vermicompost produced from rabbit manure is applied (source: Lj. Dimitrijević, 2025)

Data Analysis and Approach to Results Interpretation

The results of this study are based on a descriptive analysis of the practically implemented model of organic material management at the Dimitrijević family farm and a comparison with available findings from previous scientific studies in the field of vermicomposting.

The following data sources were used within this study:

- direct observation of the production system;
- documentation of the process through photographs
- data on rabbit housing methods and organic material management;
- description of the vermicomposting procedure at the farm;
- comparison with the results of previous scientific studies.

Literature data were used to interpret the significance of the vermicomposting process, the characteristics of *Eisenia fetida*, the role of microbial communities, the properties of vermicompost, and its application in sustainable agriculture.

The obtained results represent a description of the practical implementation of a sustainable organic material management model under the conditions of a small family farm rather than an experimental laboratory study involving quantitative measurements.

RESULTS AND DISCUSSION

Practical Application of Rabbit Manure Vermicomposting at the Dimitrijević Family Farm

Based on the presented production model at the Dimitrijević family farm in the village of Barje Čiflik near Pirot, the possibility of practical valorization of rabbit manure through the vermicomposting process was confirmed. Organic material generated as a by-product of rabbit production was not considered waste requiring disposal, but rather a resource that can be reintroduced into the production cycle through appropriate treatment.

In the observed system, rabbit manure, consisting of excreta and bedding material (straw and sawdust), was used as the initial substrate for the development of the vermicomposting process with the application of *Eisenia fetida*. During the process, biological transformation of organic matter occurs [12], resulting in the formation of a more stable organic material intended for use in crop production.

The presented model demonstrates the possibility of establishing a closed nutrient cycle within a small family farm:

rabbit production → manure generation → vermicomposting using *Eisenia fetida* → organic fertilizer → crop production

In this way, livestock and crop production are integrated, whereby nutrients originating from the livestock production system are returned to the soil system. This approach is consistent with the principles of circular agriculture, in which organic by-products are utilized as resources, thereby reducing the need for their disposal and increasing the efficiency of available material utilization.

The photographs presented in this study (Figures 1–4) document the course of the process, from the generation of manure in rabbit housing facilities, through its collection and processing in wooden boxes, to the application of the obtained vermicompost in the farm's greenhouse.

The model implemented at the Dimitrijević family farm represents an example of a small integrated production system (Figure 5), in which organic matter is transformed and returned to the production cycle. Such systems are particularly important for small agricultural holdings because they enable the rational use of locally available resources through the application of simple biotechnological processes.

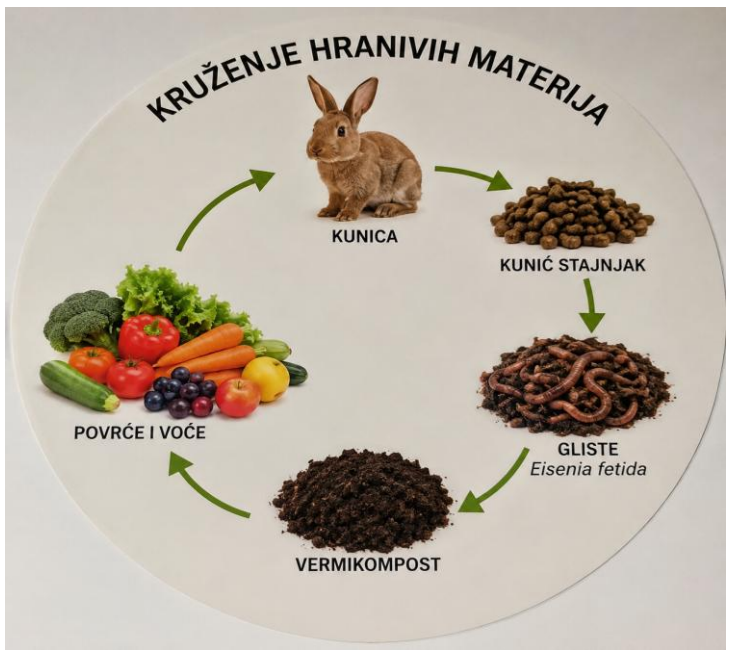


Figure 5. Nutrient Cycling
(Legend: Nutrient Cycling - Female Rabbit; Rabbit Manure; Earthworms; Vermicompost; Fruit and Vegetables)

Transformation of Organic Waste and the Role of *Eisenia fetida*

The vermicomposting process represents a complex biological system in which the combined activity of earthworms and microorganisms leads to the physical fragmentation, decomposition, and stabilization of organic matter.

The species *Eisenia fetida* is one of the most commonly used species in vermicomposting systems due to its ability to adapt to various organic substrates, high reproductive capacity, and efficiency in organic matter transformation [2], [3].

The activity of this species is not limited to the direct consumption of organic material but also involves changes in the microbial community of the substrate. Earthworms and

microorganisms participate in interconnected processes, whereby earthworms fragment the material and create more favorable conditions for the development of microorganisms responsible for the further decomposition of organic compounds. Species-specific interactions between *Eisenia fetida* and microbial communities have been shown to accelerate the decomposition of organic matter and influence the succession of microbial populations during vermicomposting [14].

Recent studies confirm the importance of microbial changes during vermicomposting. Srivastava *et al*. [5] demonstrated that vermicomposting involves the succession of bacterial communities, i.e., changes in the composition and function of microbial populations associated with organic matter transformation. Furthermore, Budroni *et al*. [4] highlighted the importance of microbiota associated with vermicomposting systems in the stabilization processes of organic material.

Under the conditions of the Dimitrijević family farm, the application of *Eisenia fetida* represents a biological treatment approach through which organic material generated from rabbit production is converted into a more stable product suitable for use in crop production.

Specific Characteristics of Using Rabbit Manure as a Substrate

Rabbit manure represents a valuable organic by-product of livestock production due to its content of organic matter and plant nutrients. Its composition, which includes excreta and bedding materials, enables its utilization as a potentially suitable substrate for biological transformation processes.

Direct application of fresh organic materials to soil may be limited by their instability and possible adverse effects if they are not appropriately treated. Vermicomposting enables the controlled transformation of organic matter and the formation of a more stable product with more favorable properties for application in crop production.

Molina *et al*. [6] demonstrated that rabbit manure can be successfully used in the vermicomposting process with the application of *Eisenia fetida*, resulting in the stabilization of organic matter and the formation of a product with greater potential for agricultural use.

During the process, easily available organic compounds are decomposed, while more complex organic structures are transformed into more stable humic compounds. Vermicomposting also increases the concentration and availability of essential plant nutrients, particularly nitrogen, phosphorus and potassium, compared with untreated livestock manure [12]. The formation of humus plays an important role in improving soil properties, as it can contribute to:

- Increased soil water retention capacity;
- Improved binding of nutrients;
- Enhancement of soil structure;
- Creation of more favorable conditions for the development of plant root systems.

In this way, vermicomposting of rabbit manure represents a process through which an organic by-product is transformed into a product with greater agronomic value.

Significance of Vermicompost for Soil and Crop Production

The vermicompost obtained at the Dimitrijević family farm is used in greenhouse crop production as an organic fertilizer. Its application represents the final stage of a closed production cycle, in which material originating from rabbit production is returned to the soil system.

According to Lazcano and Domínguez [7], the application of vermicompost can positively influence the physical, chemical, and biological properties of soil by increasing organic matter content and stimulating soil biological activity.

Atiyeh *et al*. [11] reported that vermicomposts can contribute to improving conditions for plant growth, with the effect depending on vermicompost characteristics, plant species, and the method of application.

Within small-scale production systems, the use of vermicompost is particularly significant because it enables the utilization of materials generated on the farm itself and reduces dependence on external production inputs.

Contribution to Circular Agriculture and Environmental Protection

The model implemented at the Dimitrijević family farm represents a practical example of circular agriculture, as it enables the reintegration of organic matter into the production process.

Unlike a linear system:

production → organic waste → disposal

a circular system is established:

rabbit production → manure → vermicompost → crop production → return of nutrients to the agroecosystem

Bernal *et al*. [1] emphasize the importance of proper management of animal-derived organic materials in order to reduce nutrient losses and enhance the sustainability of agricultural systems.

In accordance with the principles established by the Law on Environmental Protection of the Republic of Serbia (2004), [8], and the Law on Waste Management of the Republic of Serbia (2025), [9], organic materials generated within production processes should be considered from the perspective of their potential for reuse and valorization whenever this is technically and environmentally justified.

In this regard, vermicomposting of rabbit manure represents a process that contributes to more responsible management of organic materials by enabling their transformation into a useful product rather than their inappropriate disposal.

Such a system is particularly important for small family farms, where the integration of livestock and crop production can lead to more efficient resource utilization and a reduction in the amount of material leaving the production system. Comprehensive reviews indicate that vermicomposting represents one of the most efficient biological approaches for converting different types of agricultural organic waste into high-quality organic fertilizers while supporting circular agriculture principles [16].

Environmental Aspects of Rabbit Manure Vermicomposting and Its Contribution to Environmental Protection

The management of organic materials originating from livestock production represents an important aspect of environmental protection, particularly in small-scale production systems where the proper storage, treatment, and utilization of manure directly influence production area hygiene and the conservation of natural resources.

Inadequate manure management can result in nutrient losses, the generation of unpleasant odors, and potential impacts on soil and water resources. Therefore, processes that stabilize organic matter and enable its reuse within production systems represent an important component of sustainable resource management.

Vermicomposting of rabbit manure represents an environmentally acceptable method for organic material transformation, as it enables the conversion of unstable organic matter into a more stable organic product. In this way, nutrients remain within the production system and can be reused through crop production.

The application of the obtained vermicompost on the same farm contributes to closing the material cycle and is consistent with the principles of the circular economy. This approach can contribute to reducing the need for mineral fertilizer application, increasing soil organic matter content, and preserving its physical, chemical, and biological properties.

From the perspective of the legislative framework of the Republic of Serbia, this approach to organic material management is associated with the principles of pollution prevention, rational use

of natural resources, and responsible waste management, as defined by the Law on Environmental Protection (2004), [8], and the Law on Waste Management (2025), [9].

At the same time, manure management is also connected with rabbit welfare, as maintaining hygienic conditions in housing facilities, regular removal of organic material, and control of factors such as moisture and the concentration of harmful gases represent important elements of good production practice. In accordance with the Law on Animal Welfare of the Republic of Serbia (2009), [10], ensuring appropriate housing conditions represents a fundamental prerequisite for maintaining animal health and welfare.

The example of the Dimitrijević family farm demonstrates that vermicomposting is not merely a technique for producing organic fertilizer, but rather an integrated approach that connects environmental protection, responsible management of organic resources, rabbit welfare, and sustainable crop production.

CONCLUSION

Vermicomposting of rabbit manure represents a sustainable biotechnological process through which an organic by-product of livestock production is transformed into a more stable organic material suitable for reuse within the agricultural system. The example of the Dimitrijević family farm confirms the possibility of establishing a closed nutrient cycle, thereby integrating livestock and crop production in accordance with the principles of circular agriculture.

The particular value of the presented model lies in its simplicity and adaptability to the conditions of small-scale farms, where significant contributions to resource conservation and soil quality improvement can be achieved with minimal technical requirements. Thus, vermicomposting is demonstrated as a process that simultaneously connects animal welfare, rational management of organic materials, and environmental protection.

A limitation of this study is the fact that laboratory analyses of the physical, chemical, and microbiological properties of the obtained vermicompost were not conducted. Future studies should include detailed analyses of nutrient content, the carbon-to-nitrogen ratio (C:N), microbial activity, vermicompost maturity, and comparisons with recently developed continuous-flow vermicomposting systems [17].

DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

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