

Utilization of Tofu By-Products as Cattle Feed within an Integrated Agribusiness Framework

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Abstract. *Tofu waste is an agro-industrial by-product with significant potential as an alternative feed for cattle due to its relatively good nutritional content and abundant availability. This study aims to analyze the utilization of tofu waste as cattle feed from an integrated agribusiness perspective, covering upstream to downstream aspects. The research method employs a literature review and a qualitative descriptive approach by examining various scientific sources related to animal feed, the tofu agro-industry, and agribusiness systems. The results indicate that the utilization of tofu waste not only reduces feed costs but also supports the efficiency of livestock enterprises, minimizes environmental waste, and creates business linkages among agribusiness subsectors. Therefore, the utilization of tofu waste as cattle feed represents a strategic alternative for supporting the development of sustainable integrated agribusiness.*

Keywords: *Tofu Waste; Cattle Feed; Integrated Agribusiness; Agro-Industrial Waste*

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INTRODUCTION

Cattle rearing is a strategic element in the livelihoods of rural regions, the stimulus of local economic performance, and the assurance of supplying animal protein to the broader societies (Devendra, 2001). In many areas, cattle production is not only a commercial activity, but an economic survival mechanism as part of a household and a productive resource. However, the sustainability and performance of cattle farming, especially in the small and medium scale farms, still face structural issues that have remained intact.

The most prominent of these issues is the question of feed availability, cost, and control that becomes the strongest indicator of efficiency of production and business (Devendra, 2001; Atzori et al., 2021). The largest share of the total production expense in the cattle production systems is always the feed expenditure which is often greater than the total expenditure of all other components of operation. The structure of this cost makes livestock business extremely susceptible to changes in the price of feed and availability of supply, and at the same time limits the ability of farmers to improve output or grow their activities (Dong, 2021; Davis et al., 2021).

Feed costs are too high of the problem of livestock production that it can be turned into a technical issue connected with ration balancing or feeding behavior. Instead, it is indicative of a more fundamental structural inadequacy in the organization of livestock production, in this instance, the overdependence on commercial and externally acquired feed inputs. Isbah (2022) highlights that the high percentage of feed expenses in the livestock businesses significantly reduces the profit margins of the farmers and increases their exposure to market fluctuations.

Once the cost of feed increases or the supply gets volatile, farmers are often forced to reduce the quality of feed, reduce their herd size or face declining economic returns (Benoit & Mottet, 2023; Trommsdorff et al., 2023). This situation shows that the feed problem is not only a scope of nutritional adequacy but also a systemic economic limit that influences the overall robustness and sustainability of livestock manufacturing systems.

This reliance on commercial feeds also suggests a further dislocation between livestock production and bases of resources locally available (Mason-D'Croz et al., 2022). In most countryside regions, agricultural and agro-industrial produce results in a variety of organic by-products that are underutilised as farmers of livestock continue to depend on relatively expensive industrial rations (Mutwedu et al., 2022; Munubi & Lamtane, 2021; Beriso, 2022).

This situation reveals a lack of efficiency in the use of resources and points to the disintegrated scope of agribusiness systems which have different subsectors working separately instead of working together in an integrated, mutually reinforcing fashion. At the systems level, this kind of fragmentation undermines the economic connection of the local economies, increases the cost of production and reduces the capacity of farming communities to adapt to economical and environmental challenges.

A bright example is the underutilization of agro-industrial by-products, such as tofu dregs, which are produced in large amounts during the tofu processing industry (Karim et al., 2025). With the increase in consumption of tofu or more specifically, as a low-cost source of plant protein, there is also an increase in the daily production of tofu dregs by small and medium-sized tofu companies (Afoan & Kiha, 2022). Even after being considered a waste, tofu dregs have high nutritional value that can be used in the livestock feeding system.

Suparno and Muhlasin (2016) show that tofu dregs have significant potential as a beef cattle feed resource due to the high level of proteins and fiber that meets the digestive needs of ruminants. This fact proves that tofu dregs are not just some by product, but it could be a useful factor of production provided management and use (Eleutério et al., 2023; Montibus et al., 2021).

Biologically and nutritionally, cattle are ruminants; that is, they have a special digestive system which makes it easy to use fibrous feeds as a result of fermentation by microbes in the rumen (Choudhury et al., 2015). This physical characteristic makes cattle very susceptible to the exploitation of different agricultural and agro-industrial by-products, such as tofu dregs. Fu dregs used in the cattle feeds in appropriate forms, fresh or processed tofu can be used to meet nutritional needs and at the same time decrease the reliance on commercial feeds.

However, the realization of this obvious technical potential in introducing tofu dregs in cattle feed is still miles away and is often done loosely and on an informal basis. Simultaneously, the fact that tofu dregs are produced in large volumes and become waste is a notable environmental problem to local populations. As pointed out by Buditama and Oktariyanda (2021), when unchecked, tofu wastes may cause environmental pollution, such as bad smells and other nuisance that reduce the quality of life of the locals living around the areas.

This case demonstrates a twofold issue that defines most agribusiness systems: on the one hand, there is a high feed price and lack of ready access to cheap feed sources; on the other hand, agro-industrial participants have to deal with the problem of waste management that has environmental and social expenses. These issues within one local production environment suggest a basic inefficiency in the management and allocation of agribusiness subsector resources.

This is not just the consequence of technical flaws or the lack of information about the nutritional worth of tofu dregs. Instead, it is indicative of a more general structural problem associated with the absence of integration between the agro-industry and the livestock production systems. In most cases, tofu manufacturers and cattle breeders are independent economic players with a lack of integration; however, their interactions are material with each other.

As such, good by-products are not used efficiently as livestock producers incur high production costs. This situation shows that the issue of tofu dreg consumption could not be considered in a technical or nutritional context only, but one had to be viewed in a broader scope in which the structure and unification of the agribusiness system is taken into account. The literature concerning the use of tofu dregs as livestock feed has placed a significant emphasis on nutritional values, production processes of tofu dregs, and the direct economic gain at the farm level.

To illustrate a case in point, Suparno and Muhlasin (2016) focus on the technical promise of tofu dregs as a feed source of the beef cattle, which is linked to its nutritional profile and economical viability. Although these studies are necessary to determine the technical feasibility of tofu dregs, they are more likely to put the matter in the context of feed replacement, but not in a larger system of production and resource management. Therefore, the broader effects of the use of tofu dregs to agribusiness integration, inter-sectoral connection, and system efficiency are under-researched.

This restriction is especially crucial since feed systems are not independent systems of livestock production but rather they are a part of a complex network of production, processing, and distribution. Feed sourcing decisions do not only determine farm-level cost arrangements but also tendencies in economic relationship between various agribusiness participants. In situations where livestock feeding is mainly done by sourcing it externally, a large percentage of the economic value produced by livestock production moves out of the local economy.

On the other hand, with feed resources sourced locally based on locally produced by-products, including tofu dregs, there is the opportunity to build stronger local economic connections and establish more cohesive and robust production systems. The idea of integrated agribusiness is, in this case, especially applicable. Systems of agribusiness can be described as being functionally connected to the subsectors where the product of one activity is the input of another and vice versa which leads to increased efficiency of the system and less wastage of resources.

Najihah et al. (2023) attach considerable importance to the issues of efficiency and economic performance in the livestock enterprises, stating the role cost structures and resource management practices play in the income of the farmers and the sustainability of their business. In this regard, the application of tofu dregs as cattle feed may be regarded not only as a technical approach towards minimizing feed costs but as an actual process of enhancing the consolidation between agro-industrial and livestock subsectors.

Introduction of tofu dregs into the livestock feeding systems will change the material as a perceived waste product that needs to be discarded into a productive resource that improves the production of livestock. At the same time, livestock farming is not only coexistent with industrial feed consumption, but actively engaged in controlling and use of industrial agro-industrial by-products, which creates a two-way impact. The producers of tofu can receive less waste-management overhead and other environmental difficulties, whereas cattle farmers will be able to attain reduced feeds and higher production output.

More importantly, this integration promotes the development of more coherent and interconnected system of agribusiness where resources flow with greater efficiency and economic value has been retained within the local production context. However, in most real-life situations, this integration is poor, informal, and underdeveloped. The use of tofu dregs as animal feed is often based on personal connections or on a temporary supply, or on an occasional solution, not on the regular and institutionally based collaboration of subsectors.

This has resulted in the fact that the prospective advantages of integration are not efficiently achieved, and the practice was at risk of interruptions and instability in supply and demand. This situation shows a huge disparity between the perceived potential of tofu dregs as a feed resource and its real role within a system of agribusiness integrated. Moreover, the fact that

the cost of feed remains high and is a constant problem, as Isbah (2022) discusses, and that the issue of tofu waste and its lack of environmental friendliness persists, as Buditama and Oktariyanda (2021) point out, means that the current practices have not managed to resolve the existing issues in a sustainable and widespread way.

Although the limited usage of tofu dregs may be beneficial to individual farmers, there are still large structural issues of the fragmentation of resources and inefficiency of the system. This state of affairs highlights the need to employ analytical methodologies that go beyond farm-level technical factors and channel the organizations and integration of the agribusiness system per se. It goes without saying that on this background the use of tofu dregs as cattle food should not be viewed as a technical feeding approach but rather as one element in a larger process of enhancing the efficiency, sustainability and resiliency of agribusiness systems.

The agribusiness approach can be used to analyze this problem based on inter-sector/resource flows, system-level results, and not necessarily in terms of nutritional composition or short-term cost savings. The given view is especially relevant in the situations when small and medium-sized farmers are forced to face ongoing economic limitations and when the management of agro-industrial waste is a still unresolved environmental problem.

Thus, this paper intends to examine the use of tofu dregs as cattle feed in the integrated agribusiness approach with a focus on how it decreases feed prices, better resource-use efficiency, and enhances the agro-industrial-livestock sub-sector connections. The proposed study aims to offer a more in-depth insight into the role of tofu dreg use as a part of the more extensive agribusiness system by assuming a qualitative descriptive approach, which would involve the literature review and contextual analysis. In contrast to the change in the technical focus of the current research, the research aims at repositioning and reinterpreting the findings of the current research in a system-level approach with an emphasis on integration, coordination, and sustainability.

Using this methodology, the study envisions the improvement of conceptual consistency in terms of the transformation of agro-industrial by-products into strategic livestock production and rural economic development inputs. In the long term, these conceptual understandings could help to establish more efficient, environmentally friendly, and economically stable agribusiness models where waste is no longer defined as a kind of problem to be controlled, but as a valuable resource that is a part and parcel of the production process of agriculture.

METHODS

Training Location and Time

This training was conducted in Sugiwaras Village, Wonomulyo District. The selection of the training location was carried out purposively, based on the consideration that the area has active cattle farming activities and close proximity to tofu agro-industrial enterprises, which ensures the availability of tofu dregs as a raw material with potential to be utilized as livestock feed. These conditions were considered relevant to the objectives of the training, which examined the utilization of tofu dregs as cattle feed within an integrated agribusiness perspective. The training was conducted on 19 December 2025.

Data Collection Techniques

Data were collected using several techniques, as follows: a) Observation was conducted directly at the study site to obtain an actual overview of the conditions of cattle farming operations, the utilization of *Eco Ampas Feed* as livestock feed, and its linkage with tofu agro-industrial activities in Sugiwaras Village, Wonomulyo District. Through observation, the researcher was able to understand the field conditions in a factual and contextual manner; b) Interviews were conducted with cattle farmers, tofu business operators, and other relevant stakeholders considered to possess information pertinent to the study. This interview technique aimed to obtain in-depth data and information regarding the process of utilizing *Eco Ampas Feed*

tofu dregs, economic considerations, constraints encountered, and the benefits perceived by business actors within the integrated agribusiness system; c) Documentation was used to complement data obtained from observations and interviews, including notes, photographs, production data, and other supporting documents related to cattle farming and tofu agro-industry activities. Documentary data served as supporting and reinforcing evidence in the research analysis, thereby enhancing the accuracy and scientific accountability of the study findings.

Community Service Method

The implementation stages of the Community Service Program (PKM) began with survey and socialization activities in Sugiwaras Village.

Survey and Socialization

The survey activities were carried out by students of Universitas Muhammadiyah Parepare through interviews with cattle farmers regarding the utilization of *Eco Ampas Feed* as an alternative livestock feed. The socialization activities were conducted interactively through discussions and question-and-answer sessions, enabling community members and farmers to share their experiences as well as the constraints encountered in livestock management. Through these activities, it is expected that the community will be able to apply the sustainable utilization of *Eco Ampas Feed* tofu dregs as livestock feed, which in turn can improve the efficiency of cattle farming operations and enhance community welfare. (Nisa et al., 2025)

After obtaining preliminary information, data validation was conducted through direct visits to farmers to confirm the availability of tofu dregs and their actual use in livestock feeding practices. In addition, follow-up interviews were conducted to collect initial data on the processing of *Eco Ampas Feed* tofu dregs, including sources of raw materials, processing methods, feeding frequency, and its application as livestock feed within the husbandry systems implemented by the community or farmers.

Socialization and Training

Prior to the implementation of the socialization and training activities, an interview stage was conducted with cattle farmers. This stage employed a questionnaire consisting of questions designed to assess the extent of farmers' knowledge and skills regarding the utilization of *Eco Ampas Feed* tofu dregs as livestock feed. The socialization activities on the utilization of *Eco Ampas Feed* tofu dregs as livestock feed were delivered to local farmers. These activities aimed to enhance farmers' knowledge and understanding of the potential of tofu dregs as an alternative livestock feed with adequate nutritional value and economic benefits. (Rismawati et al., 2024)



Figure 1. Socialization on the Utilization of *Eco Ampas Feed* Tofu Dregs for Cattle Farmers

During the implementation, lecturers and students of Universitas Muhammadiyah Parepare (UMPAR) presented materials related to the nutritional content of *Eco Ampas Feed* tofu dregs, their role in reducing feed costs, and their contribution to minimizing waste generated by the tofu processing industry. The socialization sessions were conducted interactively through discussions and question-and-answer sessions, allowing farmers to share their experiences and the constraints encountered in livestock management. Through these activities, it is expected that farmers will be able to sustainably apply the utilization of *Eco Ampas Feed* tofu dregs as livestock feed, which in turn can improve the efficiency of livestock farming operations.

RESULTS AND DISCUSSION

Based on the conceptual framework that was drawn, this section elaborates and critically evaluates the empirical evidence, especially the use of tofu by-products as cattle feed as part of an integrated agribusiness paradigm. This analysis is not just technical and operational account of the tofu by-product utilisation, but also a challenge to its economic impacts, its ability to strengthen connections between agro-industrial and livestock subsectors, and how it contributes to resource-use efficiency and environmental responsibility. Plugging the findings into a systems-based agribusiness model, this discussion will attempt to show that the utilization of tofu by-products goes beyond a simplistic feed-substitution strategy, and is, in fact, part of a much more comprehensive integrative process that develops more effective, sustainable, and resilient livestock production systems.

The Potential of Tofu By-Products as Cattle Feed

Tofu by-products contain relatively good nutritional components, particularly protein and crude fiber, which make them a promising option as supplementary or mixed feed in cattle rations. Protein is an essential nutrient that plays a crucial role in supporting livestock growth, facilitating body tissue formation, and enhancing overall cattle productivity. Adequate protein intake is necessary to maintain physiological functions, support muscle development, and improve feed utilization efficiency. Therefore, the inclusion of tofu by-products in cattle diets can contribute positively to meeting the nutritional requirements needed for optimal growth and production performance (Anggraini et al., 2019)

In addition to protein, the crude fiber content of tofu by-products is highly compatible with the biological characteristics of cattle as ruminant animals. Cattle possess a complex digestive system that relies on the activity of microorganisms in the rumen to break down fibrous feed materials. The presence of sufficient crude fiber supports rumen fermentation processes, promotes microbial activity, and helps maintain digestive health. As a result, tofu by-products can be efficiently utilized by cattle and serve as a suitable feed component, particularly when incorporated into a balanced ration that meets the nutritional needs of ruminant livestock (Wisaptiningsih et al., 2019).

In addition to their nutritional value, tofu by-products exhibit fairly good digestibility when they are properly managed and processed. Appropriate handling practices are essential to preserve nutrient availability and ensure that the feed can be efficiently utilized by cattle. When incorporated correctly into cattle rations, tofu by-products can support nutrient absorption and contribute to stable animal performance. Proper management also helps reduce spoilage and prevents the loss of valuable nutrients, thereby enhancing the overall effectiveness of tofu by-products as a feed resource.

The utilization of tofu by-products can be implemented in various forms, including fresh, dried, or fermented feed, depending on farmers' conditions, resources, and management capacity. Fresh tofu by-products are commonly used due to their immediate availability, while drying and fermentation are applied to extend shelf life and improve practicality. Fermentation, in particular, can enhance feed quality by improving digestibility and reducing undesirable odors. These relatively simple processing methods aim to maintain nutritional quality, facilitate storage and handling, and improve feeding management for livestock, making tofu by-products a more reliable and sustainable feed option for cattle farmers.

The use of tofu by-products as cattle feed provides direct benefits by reducing farmers' dependence on commercial feeds. By utilizing locally available feed resources, farmers can significantly reduce feed costs, which constitute the largest component of livestock production expenses. This cost efficiency is particularly important for small- and medium-scale farmers who face limitations in business capital

Therefore, the utilization of tofu by-products as cattle feed not only provides technical nutritional benefits but also offers significant economic advantages for livestock enterprises. By

reducing dependence on commercial feed, farmers can lower production costs, particularly feed expenses, which represent the largest component of livestock farming costs. This improved cost efficiency contributes to better financial performance and increases the competitiveness of livestock enterprises, especially for small- and medium-scale farmers.

Furthermore, the potential of tofu by-products positions them as a strategic alternative feed resource in improving overall production efficiency and strengthening farmer self-reliance. The use of locally available feed inputs reduces vulnerability to price fluctuations in commercial feed markets and encourages more resilient farming systems. In the long term, this approach supports the development of sustainable livestock production systems that balance economic viability, resource efficiency, and environmental responsibility.



Figure 2. Eco Ampas Feed Tofu Dregs as Livestock Feed

Utilization of Tofu By-Products in Integrated Agribusiness Systems

In an integrated agribusiness system, tofu by-products serve as an important link between the tofu agro-industry subsector and the cattle farming subsector. Waste generated from the tofu production process is no longer viewed as a valueless residue, but rather as a valuable resource that can be utilized as livestock feed. This transformation enhances the efficiency of resource use and promotes a more integrated production system in which outputs from one subsector become inputs for another. Through this utilization, functional linkages among agribusiness subsectors are strengthened, allowing production activities from upstream to downstream to operate in a more efficient and sustainable manner. The integration reduces waste accumulation, improves coordination between agro-industry and livestock enterprises, and supports the implementation of circular economy principles (Isbah, 2022). As a result, the agribusiness system becomes more resilient, environmentally responsible, and economically viable in the long term.

Through the utilization of tofu by-products, functional linkages among agribusiness subsectors are significantly strengthened, enabling production activities from upstream to downstream to operate in a more efficient and sustainable manner. This integration allows resources to be used more effectively, as waste from agro-industrial processes can be directly redirected into livestock production. Consequently, the overall efficiency of the agribusiness system is improved through better coordination and resource optimization. (Sutrisno et al., 2025) Moreover, this integrated approach reduces waste accumulation, enhances collaboration between agro-industry and livestock enterprises, and supports the implementation of circular economy principles. By minimizing environmental burdens and promoting the reuse of by-products, the agribusiness system becomes more resilient and environmentally responsible. In the long term, such integration also contributes to economic viability by creating stable linkages among subsectors and supporting sustainable agricultural development.

Beyond direct utilization, integration within an integrated agribusiness framework creates opportunities for the development of new business activities based on the processing of

tofu by-products. These by-products are no longer limited to simple feed inputs but can be transformed into value-added products that support the livestock sector. Such integration encourages innovation in feed processing and strengthens the linkage between agro-industry and livestock enterprises. Tofu by-products can be further processed through methods such as fermentation, drying, or blending with other feed ingredients to enhance nutritional quality and extend shelf life. These processing activities not only improve the practicality and quality of livestock feed but also have the potential to generate additional economic value. Furthermore, the development of tofu by-product processing enterprises can create new employment opportunities at the local level, contributing to rural economic growth and the sustainability of integrated agribusiness systems.

Thus, the utilization of tofu by-products within integrated agribusiness systems not only enhances the efficiency of livestock enterprises but also promotes local economic development and environmentally friendly waste management practices. By transforming agro-industrial waste into valuable inputs for livestock production, this approach supports more efficient resource use and reduces environmental pressures associated with waste disposal. Furthermore, integration among agribusiness subsectors represents a key strategy for achieving a productive, competitive, and sustainable agribusiness system. Strong linkages between agro-industry and livestock enterprises improve system resilience, encourage innovation, and enhance overall economic performance. In the long term, such integration contributes to sustainable development by balancing economic growth with environmental responsibility and social benefits.

Economic and Environmental Benefits

Economically, the utilization of tofu by-products as cattle feed can significantly improve production cost efficiency, particularly in feed expenses, which have traditionally represented the largest cost component in livestock farming. By incorporating tofu by-products as alternative feed or as part of cattle rations, farmers are able to reduce their reliance on relatively expensive commercial feeds. This strategy allows farmers to optimize production inputs while maintaining adequate nutritional standards for livestock. As a result, the reduction in feed costs directly contributes to improved operational efficiency and increased profit margins for farmers. Lower production expenses enhance the financial sustainability of livestock enterprises and provide greater economic stability, especially for small- and medium-scale farmers. Over time, improved cost efficiency can support business expansion, better herd management, and increased competitiveness within the livestock sector.

In addition to lowering production costs, the utilization of tofu by-products also has the potential to increase farmers' income in the long term. Improved feed cost efficiency enables farmers to manage their financial resources more effectively, allowing for better planning and investment in their livestock enterprises. As feed expenses are reduced, farmers gain greater flexibility in allocating capital to other productive activities. This improved allocation of resources allows farmers to enhance herd management practices, improve livestock quality, or expand the scale of their operations. With livestock productivity being maintained or even increased as a result of better management and nutrition, farmers' income can grow in a more stable and sustainable manner. Ultimately, this approach contributes to the long-term economic resilience of livestock farming systems.

From an environmental perspective, the use of tofu by-products as livestock feed contributes significantly to reducing the volume of agro-industrial waste that might otherwise cause environmental pollution. When tofu by-products are not properly managed, they can generate unpleasant odors and pose risks to the surrounding environment, including soil and water contamination. Therefore, effective waste management is essential to minimize these negative impacts (Sinaga & Rais, 2024; Mashudi et al., 2023; Oluwagbayide et al., 2024; Galbi et al., 2021; Harefa, 2023; Wikarta et al., 2025). By redirecting tofu by-products into livestock feed, potential environmental problems can be substantially reduced. This practice transforms waste into a valuable resource, supports cleaner production processes, and decreases the

environmental burden associated with waste disposal. As a result, the utilization of tofu by-products contributes to more environmentally friendly livestock production and supports sustainable agricultural systems (Manik et al., 2021; Colimoro et al., 2023; Karim et al., 2025; Shah et al., 2025; Dai et al., 2023; Nurwidiana & Ela, 2025).

Furthermore, the utilization of tofu by-products supports the implementation of sustainable agriculture and livestock production concepts. By converting agro-industrial waste into useful feed resources, this approach promotes more efficient use of inputs and reduces the amount of waste generated within agribusiness systems. Such practices align with sustainability principles by optimizing resource utilization and minimizing environmental impacts. Therefore, the utilization of tofu by-products not only provides economic benefits for farmers but also plays an important role in maintaining environmental balance. By reducing waste and encouraging resource recycling, this practice contributes to the long-term sustainability of agricultural systems as a whole. In the broader context, it supports environmentally responsible production while ensuring that agricultural and livestock activities remain productive and resilient over time.

CONCLUSION

The utilization of *Eco Ampas Feed* tofu dregs as cattle feed represents an alternative strategy to improve the efficiency of livestock farming operations, particularly through the reduction of feed costs. From an integrated agribusiness perspective, the use of *Eco Ampas Feed* tofu dregs is able to link the agro-industrial and livestock subsectors, thereby generating economic benefits for farmers while simultaneously reducing the environmental pollution associated with agro-industrial waste.

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