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DESIGN OF A PEANUT SHELLING MACHINE USING A 250-WATT ELECTRIC MOTOR TO IMPROVE COMMUNITY ECONOMIC DEVELOPMENT

Ebbit Dermawan Purba [1], Immanuelta Sitepu [2], Darwan Ediyanto Saragih [3]

[1,2,3]Faculty of Engineering, Universitas Simalungun, Pematangsiantar, Indonesia
Corresponding Author: ebitpurba8@gmail.com

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ABSTRACT

Manual peanut postharvest processing remains a challenge to improving productivity and efficiency in farmers' economic activities. This study aims to design a peanut shelling machine powered by a 250-watt electric motor and examine its potential as an appropriate technology to support community economic development in Nagori Marjandi Pisang, Panombeian Panei District, Indonesia. The study employs an engineering design approach involving static structural simulations using SolidWorks 2018, focusing on structural stress, displacement, and safety factors. The simulation results indicate that the machine frame, constructed from ASTM A36 steel, achieves a safety factor of 8.5, suggesting adequate structural capacity under the simulated loading conditions. From a development economics perspective, the proposed machine has the potential to accelerate postharvest processing, improve labor efficiency, and support agricultural productivity among rural farming communities. However, these economic benefits remain prospective because production costs and farmers' income have not been directly measured. The study provides a technical foundation for developing appropriate agricultural technology innovations aimed at supporting rural economic development.

Keywords: *Appropriate Technology; Agricultural Productivity; Rural Economy; Technological Innovation; Peanut Shelling Machine.*

1. INTRODUCTION

The agricultural sector plays a strategic role in supporting rural economic development by providing employment opportunities, meeting food needs, and promoting business activities based on local resources (Girsang et al., 2025; Suhendar et al., 2024). One agricultural commodity with considerable development potential is peanuts (Arachis hypogaea L.), which are widely used as

food and as raw materials for various processed products (Saragih et al., 2025; Suhendar et al., 2025). Despite their economic value, the development of this commodity depends not only on successful cultivation practices but also on the effectiveness of postharvest processing (Y. H. J. Saragih et al., 2024). Processing activities that continue to rely on manual labor may require considerable time and human resources, thereby limiting farmers' ability to optimize production output. The Food and Agriculture Organization (FAO) explains that agricultural mechanization and automation can contribute to increased productivity and labor efficiency, although their effectiveness is strongly influenced by economic conditions, technological capacity, and the characteristics of the communities adopting these technologies.

The development of appropriate technology represents one approach to overcoming productivity constraints in small-scale agricultural enterprises. The adoption of technologies that correspond to the needs and capabilities of local communities has the potential to improve production efficiency, reduce the burden of manual labor, and enhance the management of economic resources. Paudel et al. (2023) demonstrated that scale-appropriate agricultural mechanization in Nepal was associated with increased productivity, farm profitability, and household food security among the farmers examined. However, the benefits of technological adoption are not necessarily distributed equally, as they depend on farm size, labor availability, and access to production resources. Therefore, agricultural technological innovations should be developed by considering the compatibility between machine characteristics, community needs, and potential economic benefits.

In peanut processing, shelling constitutes a critical postharvest operation that requires precision and labor input. Manual shelling can be relatively time-consuming, particularly when harvest volumes increase. Furthermore, inappropriate shelling mechanisms may damage peanut kernels, potentially reducing the quality of processed products. Yanto & Sukma (2021) developed a peanut shelling machine as a mechanization alternative to address the productivity limitations associated with manual shelling. Similarly, Endriatno (2025) emphasized the importance of developing efficient shelling mechanisms through the application of transmission systems in peanut shell separation machines. These studies indicate that technological innovations in postharvest processing play an important role in improving the technical efficiency of agricultural product processing.

Challenges associated with manual peanut processing have also been identified among farming communities in Nagori Marjandi Pisang, Panombeian Panei District. Based on the problems identified in this study, peanut shelling activities are still partially conducted using manual equipment, resulting in suboptimal processing outcomes. The main challenges include labor and time requirements and the possibility of kernel damage caused by unsuitable shelling mechanisms.

These conditions highlight the need for alternative technologies capable of supporting more effective postharvest processing activities. A peanut shelling machine powered by a 250-watt electric motor is considered a potential technological innovation to support farmers' production activities. Nevertheless, the potential benefits of such a machine in terms of cost efficiency and increased community income must be distinguished from its technical feasibility.

From a development economics perspective, the mechanization of agricultural processing can be understood as an effort to improve productivity by transforming the utilization of production factors, particularly labor, time, energy, and equipment. Improvements in technical efficiency may generate economic benefits when technological adoption reduces processing costs per unit of output, minimizes postharvest losses, or increases marketable production capacity. However, machine utilization also entails investment requirements, electricity expenses, maintenance costs, and operational skills. Tufa et al. (2024) demonstrated that smallholder farmers' ability and willingness to access agricultural mechanization services are influenced by household characteristics, asset ownership, farm size, and market access. These findings indicate that successful agricultural technology adoption cannot be determined solely by machine performance but must also consider economic feasibility and the capacity of communities to utilize technology sustainably.

Several previous studies have examined the development of peanut shelling machines from the perspectives of engineering design and mechanical performance improvement. However, the integration of machine structural feasibility with its potential contribution to rural economic activities requires further investigation. The research gap addressed in this study concerns the need to connect the design of a 250-watt electric peanut shelling machine with postharvest processing productivity and the potential efficiency of farmers' economic activities. This study does not assume that increased income is an automatic consequence of machine development. Instead, it positions technical feasibility as an initial foundation for evaluating the potential application of technology in community-based agricultural enterprises.

Based on these considerations, this study aims to design and evaluate the structural feasibility of a peanut shelling machine powered by a 250-watt electric motor and to examine its potential contribution to postharvest processing efficiency and community economic development in Nagori Marjandi Pisang, Panombeian Panei District. The technical evaluation is conducted through structural strength simulations, while the economic implications are discussed based on the conceptual relationships among mechanization, production factor utilization, and agricultural productivity. This study is expected to provide an initial contribution to the development of appropriate agricultural technologies that accommodate the production needs of rural communities and serve as a

foundation for further research investigating the effects of machine utilization on production costs, productivity, and farmers' income.

2. RESEARCH METHOD

This study employed an engineering design method incorporating a static simulation approach to evaluate the structural feasibility of a peanut shelling machine powered by a 250-watt electric motor. The machine was designed to provide an alternative appropriate technology capable of supporting peanut postharvest processing activities, particularly among farming communities in Nagori Marjandi Pisang, Panombeian Panei District. Within the context of community economic development, this technological design represents an initial step toward improving the efficiency and productivity of agricultural product processing.

The research process began by identifying problems associated with manual peanut shelling, particularly those related to labor requirements, processing time, and potential kernel damage during the shelling process. Based on these identified problems, a peanut shelling machine powered by a 250-watt electric motor was designed, taking into consideration operational requirements and the structural strength of the machine frame. The machine was designed with overall dimensions of 800 × 600 × 1,400 mm and frame dimensions of 800 × 600 × 900 mm. The frame was constructed using ASTM A36 steel L-profiles measuring 50 × 50 mm with a thickness of 4 mm.

Structural feasibility testing was conducted through static simulations using SolidWorks 2018 software. The simulations aimed to assess the machine frame's ability to withstand applied loads based on the material properties and the designed structural configuration. Two loading conditions were considered: the first involved a 40 kg load representing the cover, shaft, and bearing components, while the second involved a 20 kg load representing the electric motor. The parameters analyzed included equivalent stress (Von Mises stress), structural deformation (displacement), and the factor of safety. These three parameters were used to evaluate the frame's capacity to support the machine components under the simulated loading conditions.

Data analysis was performed using a descriptive quantitative approach based on the simulation outputs. The analysis involved identifying maximum and minimum stress values, the magnitude of structural displacement, and the safety factor of the proposed design (Umar et al., 2024). The resulting stress values were compared with the material strength properties to assess the structural safety of the machine frame. In addition, stress calculations were performed for several sections of the frame based on the relationship between the applied force and the material's cross-sectional area. The results were used to assess the technical feasibility of the machine design as a foundation for developing peanut processing technology.

Furthermore, the relevance of the machine design to community economic development was examined conceptually by considering the relationships among processing technology adoption, labor efficiency, processing time, and potential improvements in agricultural productivity. This analysis was not intended to

measure economic impacts directly but rather to explain the potential application of the machine as an appropriate technology for supporting production activities in rural communities. Accordingly, the scope of this study was limited to evaluating technical feasibility through structural simulations and discussing potential economic implications, without directly measuring changes in production costs, farmers' income, or their socioeconomic well-being.

3. RESULT AND ANALYSIS

Design of a Peanut Shelling Machine as an Appropriate Technological Innovation

The development of agricultural processing technologies represents an important effort to improve productivity and efficiency in rural economic activities (Abiri et al., 2023; Bocean, 2024). In this study, the design of a peanut shelling machine powered by a 250-watt electric motor was motivated by challenges associated with postharvest processing, which continues to rely heavily on manual equipment. These challenges are particularly relevant to agricultural activities in Nagori Marjandi Pisang, Panombeian Panei District, where labor requirements, shelling time, and the quality of processed peanut kernels remain important considerations.

The peanut shelling machine was designed as an alternative technology to facilitate the separation of peanut shells from kernels. The driving mechanism utilizes a 250-watt electric motor, while the supporting frame is constructed from ASTM A36 steel L-profiles. This structural configuration was selected to develop a machine capable of supporting its components under the analyzed loading conditions. The main specifications of the machine are presented in Table 1.

Table 1. Design Specifications of the Peanut Shelling Machine

No	Component	Dimensions
1	Peanut shelling machine	800 × 600 × 1,400 mm
2	Machine frame	800 × 600 × 900 mm
3	250-watt electric motor	200 × 200 × 250 mm

Source: Research design data.

As presented in Table 1, the machine has overall dimensions of 800 × 600 × 1,400 mm, with a supporting frame measuring 800 × 600 × 900 mm. This configuration provides the basis for developing the machine structure and positioning its driving components. The frame was designed using 50 × 50 mm steel L-profiles with a thickness of 4 mm. The selection of this material is an important consideration in determining the structural capacity to withstand applied loads during operation.

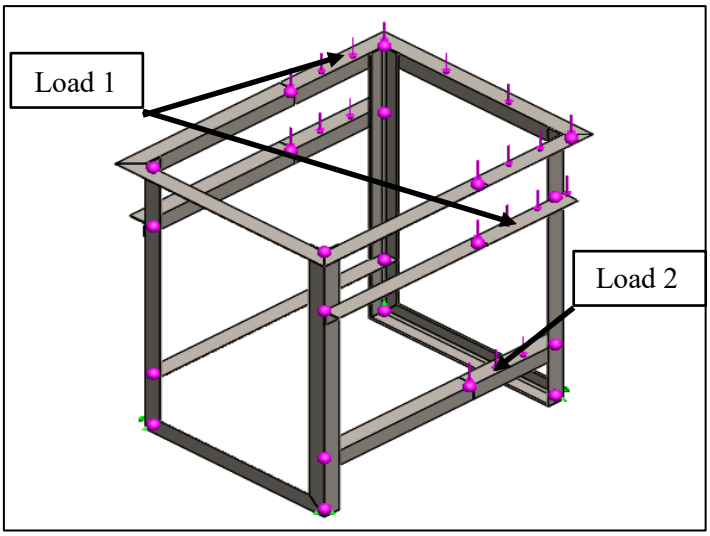


Figure 1. Structural Frame Design of the Peanut Shelling Machine

Figure 1 illustrates the structural frame designed to support the main components of the peanut shelling machine. From the perspective of appropriate technology development, this design represents an initial step toward providing alternative equipment that can be adapted to the agricultural processing needs of rural communities. Nevertheless, the suitability of technology for farmers cannot be determined solely by machine specifications. Other considerations, including ease of operation, investment costs, energy requirements, maintenance, and community access to technology, must also be taken into account (Ahmed et al., 2024). Hamilton et al. (2022) explains that agricultural mechanization has the potential to increase productivity and labor efficiency, although its benefits are influenced by socioeconomic conditions and access to technology. Therefore, the machine design presented in this study should be understood as a technical foundation for supporting agricultural technological development rather than direct evidence of increased community income.

Structural Feasibility Simulation Results of the Peanut Shelling Machine

The structural feasibility of agricultural processing machinery is an essential aspect of technological development because it determines the equipment's ability to support its components during operation. In this study, structural evaluation was conducted through static simulations using SolidWorks 2018 software. The parameters analyzed included equivalent stress (Von Mises stress), structural deformation (displacement), and the factor of safety.

The simulations considered two loading conditions. The first involved a 40 kg load representing the cover, shaft, and bearing components, while the second involved a 20 kg load representing the electric motor. These loading conditions were applied to identify the structural response of the machine frame based on the designed configuration.

Structural Simulation Results Under the First Loading Condition

The first structural simulation was conducted by applying a load of 40 kg. The simulation results revealed variations in stress distribution across several sections of the machine frame. Based on the simulation output, the maximum Von Mises stress reached 2.935×10^7 N/m^2, while the minimum stress was recorded at 2.802×10^6 N/m^2.

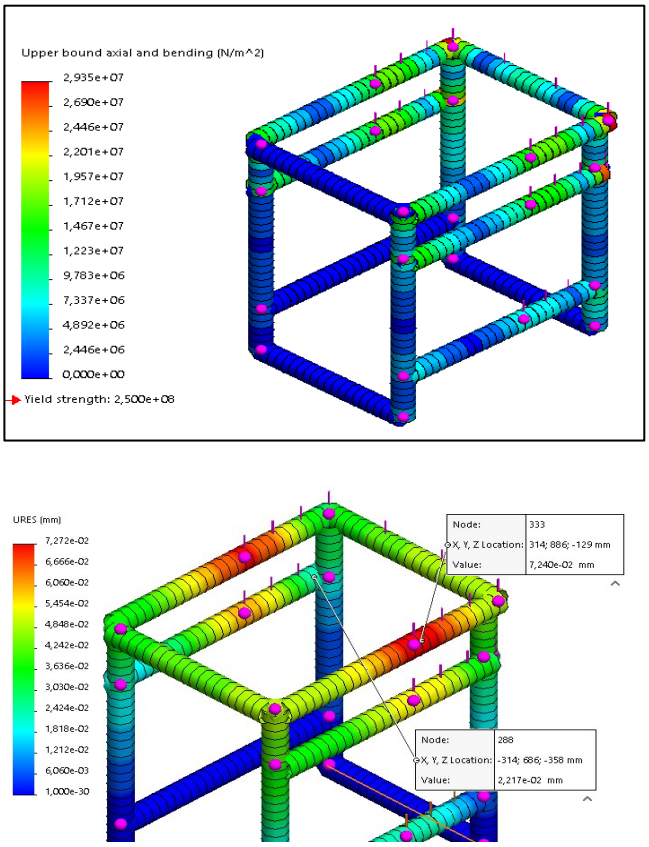


Figure 2. Von Mises Stress Distribution in the Machine Frame Under a 40 kg Loa

Figure 2 illustrates the stress distribution within the frame structure under the first loading condition. The maximum stress value was recorded at 29.35 MPa, which was lower than the material yield strength of 250 MPa specified in the simulation model. This result indicates that the resulting stress remained within the material's strength limits under the assumptions of the static simulation (Fazlali et al., 2024). In addition to structural stress, the analysis examined frame deformation resulting from the applied load. The simulation results indicated a maximum displacement of 7.240×10^{-2} mm and a minimum displacement of 2.217×10^{-2} mm.

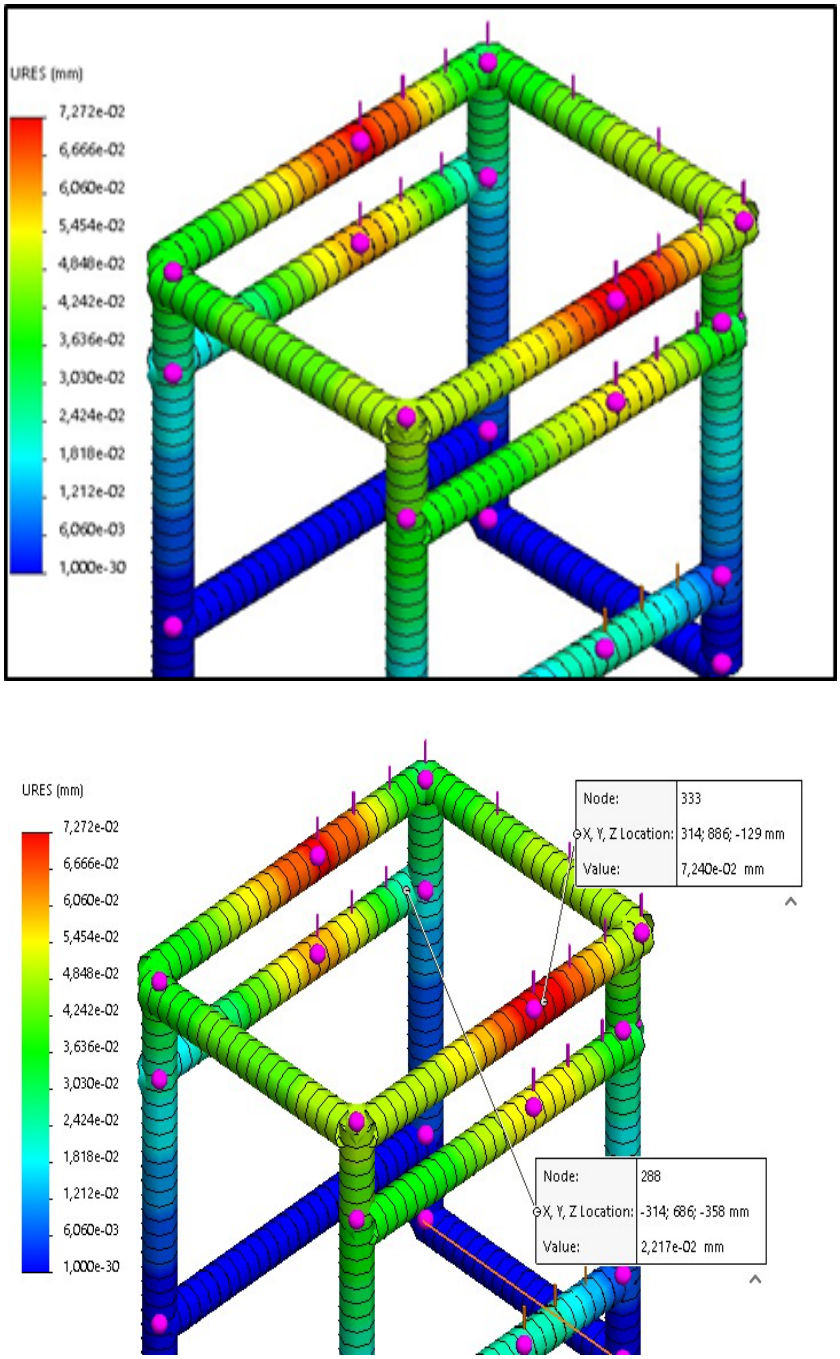


Figure 3. Displacement Simulation Results of the Machine Frame Under a 40 kg Load

Figure 3 presents the magnitude of structural displacement resulting from the applied load. The maximum displacement of 0.07240 mm indicates relatively minor deformation under the simulated configuration. However, a comprehensive assessment of deformation feasibility requires comparison with the design tolerance limits and the machine's actual operating conditions. Furthermore, the factor of safety was evaluated to determine the relationship between the material's load-bearing capacity and the stress generated under the applied loading conditions.

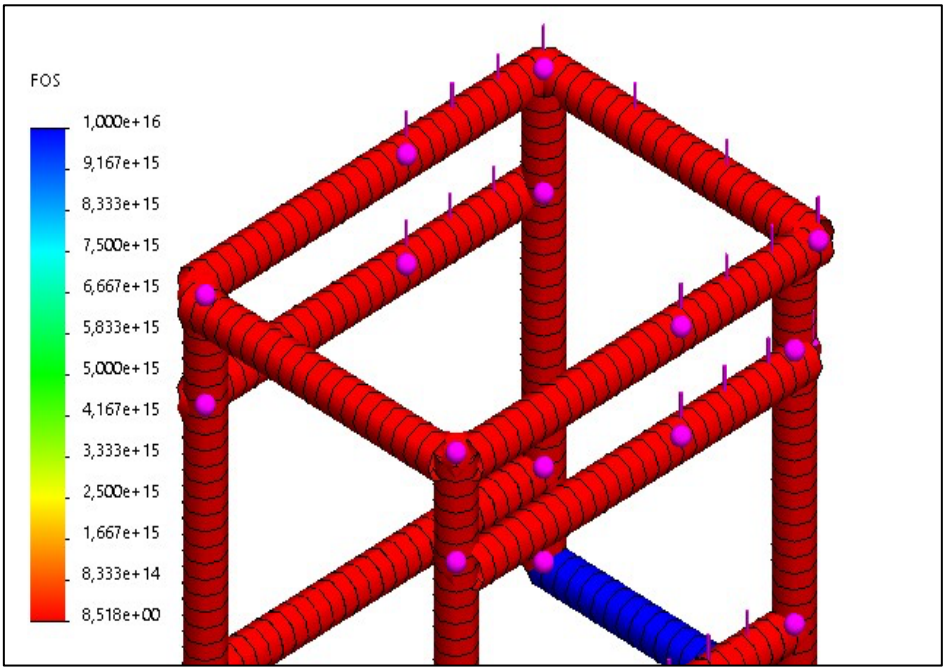


Figure 4. Factor of Safety Simulation Results of the Machine Frame Under a 40 kg Load

The simulation results indicated a minimum factor of safety of 8.5. This value exceeds one, suggesting that the structure possesses a safety margin under the modeled static loading conditions. Based on these results, the proposed frame demonstrates preliminary structural feasibility for supporting the machine components within the simulated conditions. Nevertheless, these findings do not eliminate the need for physical testing, particularly to evaluate vibration, dynamic loading, and long-term machine operation.

Structural Simulation Results Under the Second Loading Condition

The second simulation was performed by applying a 20 kg load representing the electric motor mounted on the machine frame. The results indicated a maximum Von Mises stress of 7.080×10^6 N/m^2 and a minimum stress of 1.994×10^6 N/m^2. The corresponding stress distribution is illustrated in Figure 5.

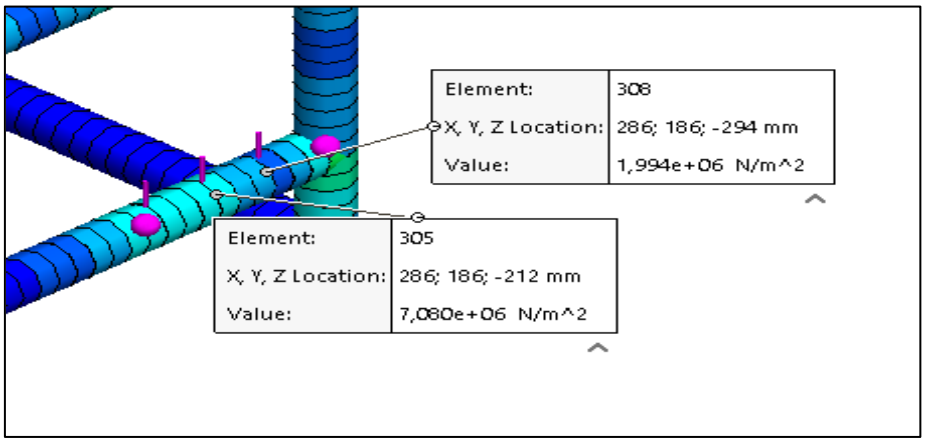


Figure 5. Von Mises Stress Distribution in the Machine Frame Under a 20 kg Load

As shown in Figure 5, the maximum stress of 7.08 MPa remained below the material yield strength of 250 MPa used in the simulation. This finding indicates that the stress generated in the frame under the second loading condition remained below the material strength limit within the model. The maximum stress under the second loading condition was also lower than that recorded under the first loading condition. However, this difference should be interpreted by considering the loading configuration, force direction, and load application points within the simulation. The subsequent evaluation examined structural deformation using the displacement parameter.

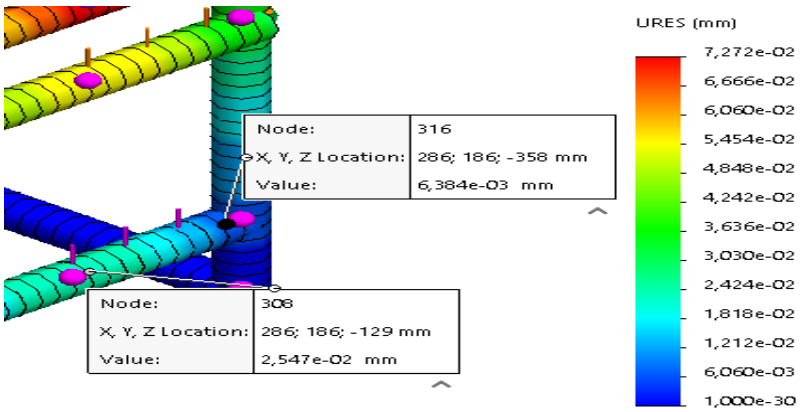


Figure 6. Displacement Simulation Results of the Machine Frame Under a 20 kg Load

The original research manuscript reported two displacement values under the second loading condition: 6.384×10^{-3} mm and 2.547×10^{-2} mm. However, the smaller value was identified as the maximum displacement, while the larger value was reported as the minimum. Therefore, the classification of these values requires further verification against the original SolidWorks simulation output before conclusions can be drawn regarding the magnitude of structural deformation. The results of the factor of safety evaluation are presented in Figure 7.

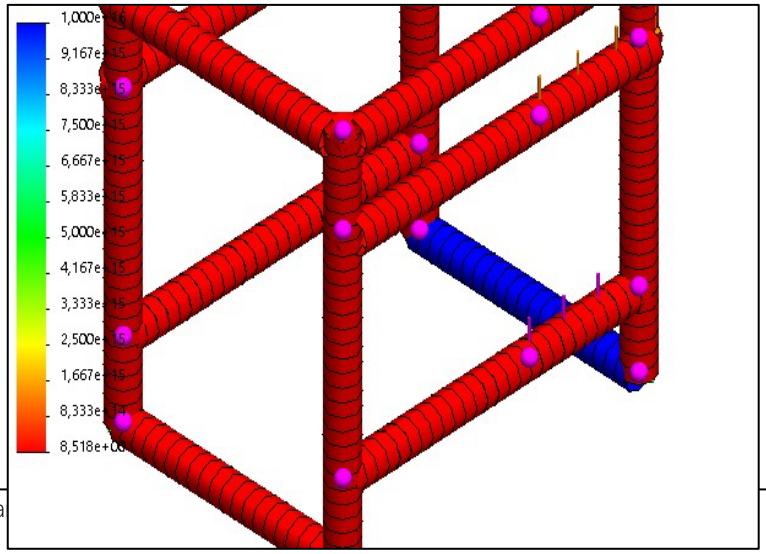


Figure 7. Factor of Safety Simulation Results of the Machine Frame Under a 20 kg Load

The research manuscript reported a minimum factor of safety of 8.5 under the second loading condition. However, this value requires further examination based on the relationship between the recorded maximum stress and the material yield strength used in the simulation model. Such verification is necessary to ensure consistency in interpreting the structural feasibility of the machine frame. A summary of the simulation results under both loading conditions is presented in Table 2.

Table 2. Summary of Static Simulation Results for the Peanut Shelling Machine Frame

Parameter	40 kg Load	20 kg Load
Maximum Von Mises stress (N/m^2)	2.935×10^7	7.080×10^6
Minimum Von Mises stress (N/m^2)	2.802×10^6	1.994×10^6
Maximum displacement (mm), as originally reported	0.07240	0.006384*
Minimum displacement (mm), as originally reported	0.02217	0.02547*
Minimum factor of safety, as originally reported	8.5	8.5*
Material yield strength (N/m^2)	2.500×10^8	2.500×10^8

Overall, the simulation results provide an initial understanding of the structural response of the machine frame under the two loading conditions. The maximum stress values recorded in both simulations remained below the material yield strength specified in the model. These findings support the preliminary feasibility of the proposed design in terms of static stress performance; however, they do not establish the overall operational performance of the machine.

From the perspective of appropriate technology development, structural feasibility assessment has economic relevance because structural reliability is one of the prerequisites for utilizing machinery in production activities. A structure capable of performing according to its design requirements may contribute to processing continuity and reduce the risk of technical disruptions. Nevertheless, this relationship remains conceptual because the present study did not measure maintenance costs, failure frequency, or the machine's economic service life.

Analytical Stress Calculations for the Machine Frame Structure

In addition to the SolidWorks simulations, analytical stress calculations were performed on three sections of the machine frame, designated as Sections A, B, and C. These calculations were based on the relationship between the applied force and the area used in the analytical model.

Mathematically, stress was calculated using the following equation:

$$\sigma = F/A$$

Where:

σ = Stress (N/m^2)

F = Applied force (N)

A = Area used in the calculation (m^2)

For Section A, a force of 400 N was applied over an area of 0.04 m^2, resulting in a calculated stress of 10,000 N/m^2. For Section B, a force of 400 N acted over an area of 0.03 m^2, producing a stress value of 13,333 N/m^2. Meanwhile, for Section C, a force of 200 N was applied over an area of 0.04 m^2, resulting in a stress value of 5,000 N/m^2.

Table 3. Analytical Stress Calculation Results for the Machine Frame Structure

Frame section	Applied force (N)	Area (m^2)	Stress (N/m^2)
Section A	400	0,04	10,000
Section B	400	0,03	13,333
Section C	200	0,04	5,000

As presented in Table 3, the highest analytically calculated stress occurred in Section B, reaching 13,333 N/m^2, while the lowest stress was recorded in Section C at 5,000 N/m^2. These differences were associated with variations in the applied forces and the areas used in the respective calculations. The results indicate that stress distribution is influenced by loading configurations and the geometric characteristics of the structure.

These analytical calculations provide additional information regarding the frame's structural response based on a simplified stress model. However, the calculated values cannot be directly compared with the maximum stress obtained from finite element simulations without ensuring consistency in assumptions, cross-sectional area definitions, boundary conditions, and load distributions. Therefore, both approaches serve as supporting information for evaluating the proposed design, while structural safety assessments should be based on a consistently verified simulation model.

Implications of Machine Design for Production Efficiency and Community Economic Development

The application of appropriate technology in agricultural activities is relevant to community economic development because it can potentially influence production factor utilization, processing capacity, and business cost management (Pilarski et al., 2025; Suhendar et al., 2023). In the context of peanut processing, the design of a shelling machine powered by a 250-watt electric motor can be considered an effort to introduce an alternative mechanization system for postharvest activities that have traditionally relied heavily on manual labor.

From a productivity perspective, machine utilization has the potential to increase the quantity of products processed per unit of time, provided that the machine's operating capacity exceeds that of manual shelling. Increased processing capacity may also enable farmers to handle harvested products more efficiently and prepare their agricultural output for marketing activities. However, these potential benefits must be demonstrated through empirical testing of shelling capacity, the percentage of intact kernels, energy consumption, and actual processing time.

The findings of Paudel et al. (2023) indicate that scale-appropriate agricultural mechanization can support improvements in productivity and farm profitability among smallholder farmers in Nepal. These findings demonstrate a relationship between agricultural technology adoption and the economic performance of farming households. Nevertheless, the results cannot be directly generalized to the peanut shelling machine developed in this study because of differences in technological characteristics, agricultural commodities, production conditions, and user characteristics.

In terms of cost efficiency, the peanut shelling machine has the potential to reduce direct labor requirements during the shelling process. If processing time decreases while production capacity increases, labor costs per unit of output may decline. However, these potential savings must be compared with the costs of purchasing or manufacturing the machine, electricity consumption, component replacement, and maintenance. Therefore, economic efficiency cannot be determined solely on the basis of the machine's 250-watt electric motor or its structural safety simulation results.

The development of the peanut shelling machine may also support community economic activities by improving access to agricultural processing technologies. For smallholder farmers, technology utilization may be implemented individually or collectively through farmer groups, provided that it is compatible with users' economic capabilities. Tufa et al. (2024) demonstrated that demand for agricultural mechanization services is influenced by household characteristics, farm size, asset ownership, and market access. These findings highlight the importance of considering the ability of rural communities to adopt and utilize agricultural technologies sustainably (Becerra-Encinales et al., 2024; Bhujel & Joshi, 2024).

In the context of Nagori Marjandi Pisang, the proposed peanut shelling machine represents an alternative technology that may support postharvest processing activities. However, the present study did not conduct an economic evaluation involving machine users and therefore cannot establish the magnitude of cost savings, changes in farmers' income, or improvements in socioeconomic well-being. Accordingly, the economic contribution of the proposed machine remains potential rather than empirically demonstrated, based on the technological

characteristics of the design and the conceptual relationship between mechanization and agricultural productivity.

To clarify the relationship between machine design and community economic development, several relevant indicators for future evaluation are presented in Table 4.

Table 4. Indicators of the Potential Economic Benefits of Peanut Shelling Machine Utilization

Economic dimension	Measurement indicator	Status in the present study
Processing productivity	Shelling capacity (kg/hour)	Not measured
Time efficiency	Shelling time per kilogram	Not measured
Labor efficiency	Labor hours per unit of output	Not measured
Cost efficiency	Shelling cost per kilogram	Not measured
Product quality	Percentage of intact and damaged kernels	Not measured
Economic feasibility	Machine investment and operating costs	Not measured
Community income	Changes in farm profitability	Not measured

Table 4 demonstrates that evaluating the economic benefits of machine utilization requires indicators that differ from those employed in technical simulations. Measurements of productivity, cost efficiency, and changes in income are essential when research aims to establish the contribution of technology to community economic development. Consequently, the machine design developed in this study provides an initial foundation for agricultural processing technology innovation but cannot yet be used to conclude that community economic conditions have empirically improved.

Opportunities and Challenges in the Application of Appropriate Technology in Rural Communities

The development of a peanut shelling machine presents opportunities to support the mechanization of postharvest processing in small-scale agricultural enterprises. The utilization of a 250-watt electric motor is one of the design characteristics that must be considered in relation to energy requirements and the infrastructure available to potential users. However, a relatively low motor power rating does not automatically demonstrate that the machine's operating costs are more economical than manual shelling or alternative technologies.

From a local economic development perspective, appropriate technology can be promoted by strengthening production capabilities and improving farmers' access to agricultural processing equipment (Yogi et al., 2025). Nevertheless, technology adoption in rural communities also requires consideration of electricity availability, investment costs, operational skills, access to repair services, and the ability of community members to manage machine utilization.

FAO (2022) emphasizes that the benefits of agricultural automation must be supported by adequate institutional conditions, infrastructure, and access to technology to prevent widening inequalities among user groups. Therefore, the

development of the peanut shelling machine should consider not only technical feasibility but also the compatibility of the proposed technology with farmers' needs and economic capabilities.

The primary limitation of this study is the absence of operational and socioeconomic measurements that could directly demonstrate the benefits of machine utilization. The available research data primarily concern machine design and structural strength simulations. Consequently, actual shelling capacity, energy consumption, kernel quality, and the effects of machine utilization on farmers' income could not be empirically evaluated.

Based on these findings, the contribution of this study lies in providing a preliminary peanut shelling machine design evaluated through structural simulations and identifying the economic aspects that should be considered when developing agricultural technologies for rural communities. Further experimental testing and economic feasibility analysis are necessary to assess the benefits of the proposed technology through measurable changes in productivity, production costs, and farmers' income.

4. CONCLUSION

This study developed and evaluated the preliminary structural feasibility of a peanut shelling machine powered by a 250-watt electric motor as an appropriate technological innovation intended to support postharvest agricultural processing in Nagori Marjandi Pisang, Panombeian Panei District. The machine was designed using ASTM A36 steel L-profiles, with structural performance assessed through static simulations using SolidWorks 2018. The simulation results showed maximum Von Mises stress values of 29.35 MPa and 7.08 MPa under loading conditions of 40 kg and 20 kg, respectively, both remaining below the material yield strength of 250 MPa. The reported minimum factor of safety of 8.5 indicates a preliminary structural safety margin under the simulated conditions, although several simulation outputs require further verification. From a socioeconomic perspective, the proposed machine offers potential benefits for improving postharvest processing efficiency, reducing manual labor requirements, and supporting agricultural productivity among rural farming communities. However, these benefits have not been empirically established because actual processing capacity, operating costs, labor efficiency, and changes in farmers' income were not measured. Therefore, the contribution of this study lies in establishing an initial technical foundation for developing appropriate agricultural technology while identifying its potential relevance to rural economic development. Future research should integrate operational testing, economic feasibility analysis, and field-based assessments involving farmers to determine the actual contribution of

machine utilization to production efficiency, agricultural profitability, and community economic well-being.

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