Development and Performance Evaluation of a Screw-Blade Type Dehusking Machine for Dry Areca Nuts

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ABSTRACT

This study aims to develop and test the performance of a screw-blade-type dehusking machine for dry areca nuts. This machine was developed using a screw-blade as a rotator and a concave as a stator, which remove the husk from dried areca nuts. The experimental machine performance was evaluated based on the machine capacity and percentage of fully husked areca nuts. The machine was tested with dried areca nuts having average major diameters of 59.21±3.35 mm and seeds of 26.08±2.27 mm. The optimal rotational speed was found to be 1100 rpm, achieving a maximum capacity of 41.65±2.16 kg/h, with 80% of the nuts fully husked. Future work should focus on optimizing the machine for higher efficiency and broader applicability, exploring different materials and designs for the screw-blade, and integrating sensors for real-time adjustments to improve the dehusking efficiency and reduce the percentage of unhusked nuts. Additionally, a cost-benefit analysis is recommended to assess the economic viability of the machine for both small-scale farmers and large-scale operations.

Keywords-case study; appropriate technology; agricultural engineering; areca nuts; farm machinery; machine design

I. INTRODUCTION

Areca nut, also known as betel nut, is a significant agricultural product in many tropical and subtropical regions, particularly in South and Southeast Asia. Traditional dehusking methods are labor-intensive, time-consuming, and often result in low efficiency and inconsistent quality of the final product. As the demand for areca nuts continues to rise, there is an increasing need for more efficient and reliable mechanical solutions to replace manual dehusking methods [1-3]. Previous studies have focused on developing various types of dehusking machines. However, achieving optimal and satisfactory machine performance remains an area of ongoing research. Addressing these challenges requires innovative approaches and technological advancements to enhance machine efficiency, reliability, and the quality of the dehusked nuts.

The development of dehusking machines for areca nuts has evolved significantly, driven by the need to improve efficiency, productivity, and consistency in the post-harvest processing of areca nuts [4-7]. Traditionally, the dehusking process was performed manually, but early attempts at mechanization involved the use of simple, manually operated devices that offered limited improvements over traditional methods. Although these initial machines were innovative, they often faced challenges, such as frequent mechanical failures, difficulty in handling varying sizes and conditions of areca nuts, and suboptimal dehusking quality. Consequently, researchers and engineers continue to explore new designs and technologies to overcome these limitations.

Agricultural machinery advancements have led to the development of sophisticated and efficient dehusking machines for dry areca nuts. Modern machines incorporate advanced mechanical components and automation technologies to enhance their performance and reliability [8-12]. For instance, some of the latest designs utilize rotary mechanisms, adjustable blades, and automated feeding systems to ensure uniform pressure and motion during dehusking. These improvements have resulted in higher dehusking efficiency, reduced labor requirements, and improved nut quality. Additionally, the integration of sensors and control systems has enabled the real-time monitoring and adjustment of machine parameters, further optimizing the dehusking process [13-16]. However, further research is still essential to address the remaining challenges, such as energy consumption, machine durability, and adaptability to different varieties of areca nuts.

This study investigates the development and performance of a screw-blade-type dehusking machine for dry areca nuts. Unlike traditional machines, this new design incorporates a screw blade as a rotator and a concave as a stator to effectively remove the husk from dried areca nuts. The screw-blade mechanism promises to deliver a more consistent and efficient dehusking process by maintaining uniform pressure and motion throughout the operation. This innovation addresses some critical limitations of earlier models, such as uneven dehusking and mechanical bottlenecks that hinder continuous operation.

This research aims to develop, test and optimize the performance of a screw-blade type dehusking machine specifically designed for dry areca nuts, thereby providing a viable alternative and contributing to the advancement of agricultural mechanization. Moreover, the machine performance parameters were evaluated. Hence, this study contributes a novel mechanical solution and comprehensive performance dataset to the field, offering replicable insights for researchers and manufacturers.

II. MATERIALS AND METHODS

A. *Sample Collection and Machine Performance Tests*

The dry areca nut samples were divided into those used to measure the physical properties of the dry areca nuts and those used for machine testing. The physical properties of the nuts were considered when designing the distance between the screw blade (rotator) and the concave (stator). Subsequently, another sample was used to evaluate the performance of the designed machine. The dimensions of 30 dried areca fruits and seeds were measured. The performance of the dehusking machine was evaluated using dried areca nuts. For each test, 1.0 kg samples were prepared.

Machine testing was performed to determine the appropriate rotational speed of the screw-blade. This test was carried out at 1100, 1000, 900, and 700 rpm rotational speeds of the screw-blade shaft in triplicate. A digital laser RPM tachometer (Generic SE188) was used to measure and confirm the speed of the screw-blade shaft. Furthermore, the machine capacity was calculated as the ratio of the total weight of the areca nuts fed to the time required for husking from feeding to the last areca nut being husked in the machine. The dehusked and unhusked samples were then separated and weighed. The dehusked and unhusked areca nuts are reported as percentage ratios.

ANOVA through the Least Significant Difference (LSD) and Tukey Honest Significant Difference (HSD) post-test techniques with $p<0.05$ were performed to evaluate the machine capacity and the percentage of fully dehusked areca nuts and those that were not dehusked [4, 17, 18]. The ANOVA tests the null hypothesis that all rotational speeds produce equal results. The assumptions of this study were confirmed through the normality test (Shapiro-Wilk test, $p>0.1$), homogeneity of variance (Levene's test, $p=0.32$), and independence of observations (through random testing order).

B. *Mechanism of Dry Areca Nut Dehusking Machine*

The nut dehusking machine works by placing dried areca nuts through the hopper, and then they fall one by one towards the cylinder and the spinning screw-blade. The function of the screw blade is to dehusk the fiber of the dried areca nuts using the principle of continuous pulling on the fiber of the areca nut until it is completely dehusked. After that, the areca nut and areca fiber/shells fall into the concave. Separation of the areca nuts from the areca nut fiber occurs in the concave region. The areca nut falls through the holes in the concave and exits through the outlet below. Meanwhile, the areca nut fiber is removed through the outlet above.

An analysis of the dehusking force required to dehusk one dry areca nut was performed to estimate the power requirements of the dry areca nut feeding machine. Measurements were carried out on various types of dried areca nuts using a spring force gauge [19, 20], as shown in Figure 1. Thirty dry areca nuts were used to test the dehusking force through this method.

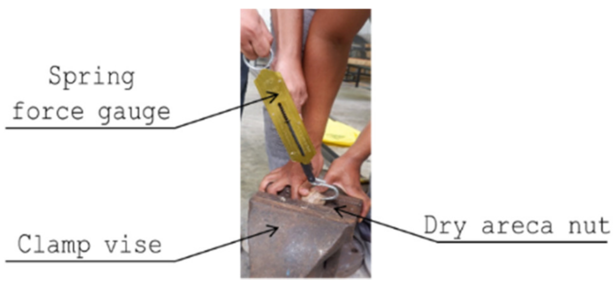

Fig. 1. Process for measuring the force requirements for dehusking dried areca nuts.

III. RESULTS AND DISCUSSION

A. Physical and Mechanical Properties of Dried Areca Nut

The physical properties of the dried areca fruits and nuts are depicted in Figure 2. Their dimensions are influenced by the various shapes and sizes of the areca nut fruits and nuts and the thickness of the dried areca nut husks [21]. Dried areca nuts with the largest dimensions do not necessarily have large nut dimensions and vice versa. Dimensional measurement data for the dried areca nuts and fruits were used to determine the main components of the machine to be designed, such as the screw-blade, the distance between the screw-blade and the holder, the hopper, the concave, and other components.

The results showed that the largest major diameters of dried areca fruits and nuts were 64.3 mm and 31 mm, respectively. Their minor diameters reached 37.5 mm and 28.3 mm, respectively. The smallest dimensions of the dried areca fruits and nuts for the major diameter were 51.8 mm and 22.8 mm, respectively. The smallest dimensions of dried areca fruits and nuts for the minor diameters were 28.7 mm and 18.9 mm, respectively. Their average major diameters were 59.21 mm and 26.08 mm, respectively, while their average minor diameters were 31.86 mm and 22.77 mm, respectively. These results are similar to those reported in [22], where the major and minor diameters of areca nuts were 53.40 and 31.95 mm, respectively.

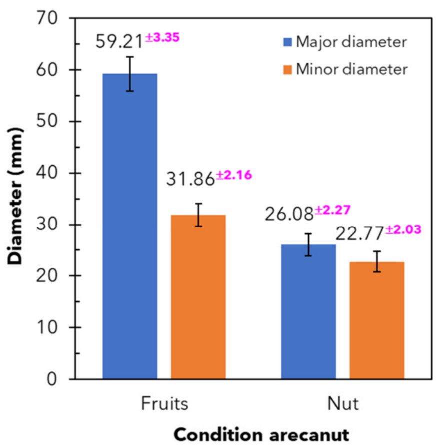

Fig. 2. Results of measuring the dimensions of dried areca fruits and nuts.

The dehusking force derived from 30 samples of dried areca nuts was found to be 129.0±20.40 N and the maximum force recorded was 160 N. The difference in dehusking force is influenced by the dimensions and shape of the areca nut and the thickness of the areca fiber [23].

B. Characteristics of the Screw-blade Type Dehusking Machine

The design of the screw-blade type dehusking machine is presented in Figure 3. The machine frame was designed using 5 × 3 cm UNP iron in a rectangular shape with a length of 70 cm, a height of 80 cm, a bottom width of 51 cm, a top width of 43 cm and a machine stand with a length of 25 cm and width of 56 cm. The machine frame was assembled using electric welding. The designed hopper was made from an iron plate with a thickness of 2 mm. The hopper was 31 cm long and 17 cm wide, and the hopper hole diameter was 6 cm. The concave design was made of an iron plate with a thickness of 2 mm. The size or dimensions of the concave were 50 cm in length and 33 cm in width, and there were 32 holes with a hole diameter of 32 mm. The diameter of the hole in the concave was taken from the largest dimensions of the areca nut, as obtained by measuring the dimensions of the dried areca nuts before the design process. The designed outer layer was made of an iron plate with a thickness of 2 mm. This output channel was divided into an output channel for nuts and an output channel for fibers/shells. The seed outlet channel was 60 cm long and 56 cm wide, whereas the coir discharge channel was 17 cm long and 14 cm wide.

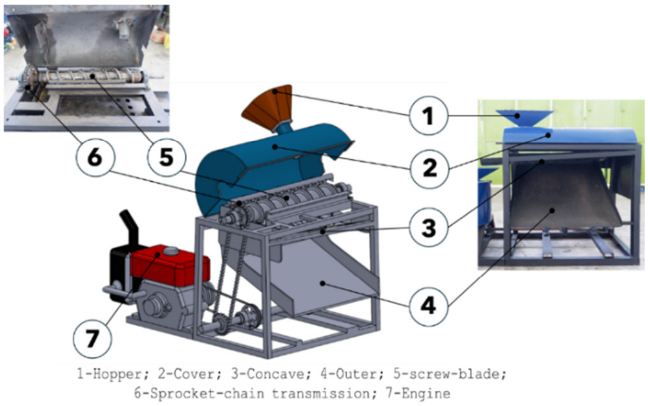

Fig. 3. Design of the screw-blade dehusking machine for dry areca nuts.

The engine used was a diesel motor with a maximum rotational speed of 2200 rpm. The diesel engine was 68.2 cm in length, 32.3 cm in width, 49.2 cm high, and weighed 67 kg. The transmission system consisted of a pulley belt and a sprocket chain. The utilized blade was screw-shaped; thus, it is referred to as a screw blade. The screw blade was made of an iron pipe with a diameter of 12 cm, length of 53 cm, and several threads of eight pieces with a stripper eye on each thread, and there was a retainer 47 cm in length. The shaft was made of an iron pipe with a diameter of 1 inch and a length of 83 cm. The shaft had a husking cylinder, and bearings were installed at both ends of the shaft. The bearings were connected to the frame using 14 mm bolts. The type of bearing used was FBJ P205.

Based on the force required to dehusk one areca nut, the power requirements for the dry areca nut dehusking machine were estimated (160 N) and used as the upper limit for the power requirements. The diameter of the screw blade was 120 mm, and the torque arm (r) was 60 mm. From this, a torque value of 9.6 N • m on the screw blade shaft was estimated. By applying the maximum rotational speed of the engine of 2200 rpm, the angular speed of the screw blade shaft (ω) was 230.27 rad/s. Thus, the minimum power requirement for this machine is 2210.56 W or 2.96 hp.

C. Machine Capacity of Dehusking Machine

Figure 4 shows the ANOVA analysis with a post-hoc Tukey HSD for the dehusking capacity of the dry areca nut machine at several rotational speeds. It can be seen that the capacity of the areca husking machine is directly proportional to the increase in machine rotation speed except for the rotation speed of 1000 rpm. At 700 rpm, the machine capacity was 22.25 kg/h and increases at speeds of 900 rpm and 1100 rpm with values of 26.99 kg/h and 41.65 kg/h, respectively. Therefore, the highest machine capacity was achieved at a rotational speed of 1100 rpm. This is related to the time or speed of the husking process, where a higher rotational speed results in a faster areca nut husking process, thereby increasing the machine capacity. According to Figure 4, the machine capacity increases significantly at 900 and 1100 rpm. However, at 700 and 1000 rpm, there was no significant change in the machine capacity. This is related to the amount of time spent husking several areca nuts, which is also similar.

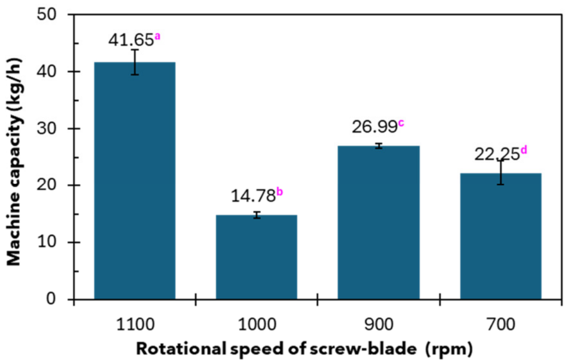

Fig. 4. Performance from the machine capacity evaluator.

According to [6], when testing the performance of areca nut dehusking machines, it is necessary to pay attention to the interaction between the machine components to achieve the best performance. The test results revealed that the dehusking knife distance and rotational speed had the maximum effect on the good performance of the areca nut dehusking machine. According to [24], the machine capacity increases with the rotation of the screw-blade cylinder. However, the effectiveness of the machine decreased as the proportion of broken nuts increased. This is in accordance with the present study's results, which show that the highest speed of 1100 rpm had the highest machine capacity value but also had the highest percentage of incompletely dehusked areca nuts. However, according to [25], the current market demand for buying and selling areca nuts includes whole areca nut seeds, split areca nut seeds and sliced areca nuts, which not only depend on whole round areca nuts, but also non-whole or split areca nuts.

D. Percentage of Husked Dry Areca Nut

The results of a husked areca nut using dehusking dry areca nut machines, followed by ANOVA, and a post-test by Tukey HSD at four levels of rotational speed are presented in Figure 5. Among the four screw-blade rotational speed variations, the highest percentage of whole husked areca nuts was 80% at a speed of 1100 rpm, followed by a speed of 900 rpm at 77%. This is because at a rotational speed of 900 rpm the husking screw-blade tends to rotate more stably with a sufficient level of tightness compared to speeds of 700 rpm and 100 rpm, where the screw-blade rotates more slowly, which results in many nuts still being stuck in the skin and areca nuts not being husked at all.

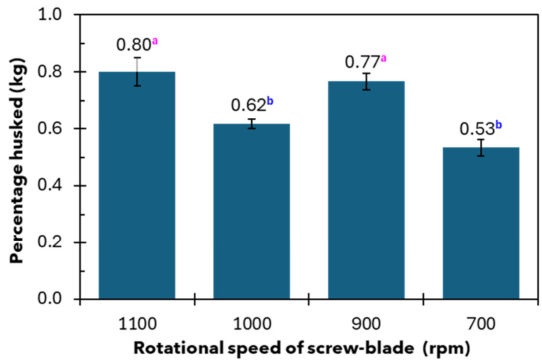

Fig. 5. Performance from percentage husked dry areca nut evaluator.

The lowest percentage of husked areca nuts was at a speed of 1000 rpm, and the percentage of husked areca nuts was not much different from that at 700 rpm, namely 53%. This is because more areca nuts are unhusked, so the husked percentage is low. According to [26], setting the rotational speed significantly influences the performance of the machine in carrying out the production process and production results. The speed at which the machine works more effectively must be determined through performance tests as a reference. In addition, the two main components that determine whether husking results are categorized as good are the rotational speed and number of husking cylinders, in addition to the dimensions and dryness level of the commodity.

E. Percentage of Unhusked Dry Areca Nut

Figure 6 illustrates the percentage of unhusked nuts produced by the proposed screw-blade machine across the tested rotational speeds, with the lowest unhusked yield (20%) achieved at 1100 rpm. The findings were analyzed using ANOVA and further examined using a Tukey HSD post-test at some rotational speeds on the shaft of the screw-blade as a rotator. The rotational speed that produced the highest percentage of unhusked areca nuts was 700 rpm, which was 47%. The difference is very important when compared with the speeds of 900 rpm and 1100 rpm, which are not significantly different with values of 23% and 20%, respectively. Based on the test results, the smallest unhusked areca nut was obtained at 1100 rpm rotational speed. This is because during the testing process, the husking screw blade rotates very fast and causes the engine to vibrate strongly, so that the husking machine also vibrates and exerts a pull accompanied by a hit on the areca nuts. According to [25], increasing the rotational speed affects the husking results and time efficiency. The higher the rotational speed is, the greater are the savings or speed of the husking process. However, this is inversely proportional to the husking yield percentage, where the higher the rotational speed of the machine is, the lower is the yield of the areca nut husked in the form of whole nuts.

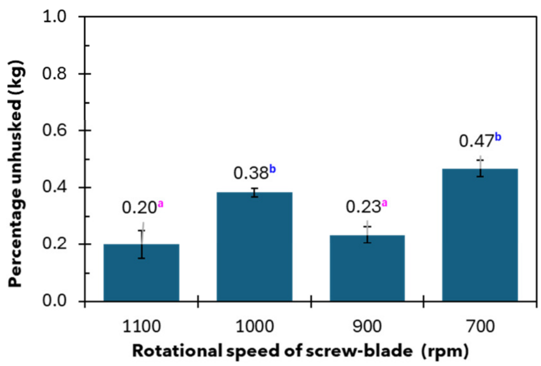

Fig. 6. Percentage of unhusked dry areca nuts at varying rotational speeds (700–1100 rpm) for the screw-blade dehusking machine.

IV. CONCLUSIONS

The development and testing of the performance of a screw-blade-type dehusking machine specifically for dry areca nuts were successfully carried out. The machine can work with dried areca fruits having average major and minor diameters of 59.21±3.35 mm and 31.86±2.16 mm, respectively and nuts with average major and minor diameters of 26.08±2.27 mm and 22.77±2.03 mm, respectively. Under these sample conditions, the results of this study suggest that the optimal rotational speed of the shaft of the screw blade as a rotator is 1100 rpm. The maximum capacity was 41.65±2.16 kg/h, with husked dry areca nuts at 80% and unhusked at about 20%.

Future work should focus on optimizing the screw-blade dehusking machine for higher efficiency and broader applicability. This could involve exploring different materials and designs of screw blades to enhance their durability and performance. Additionally, testing the machine with varying moisture contents and sizes of areca nuts from other regions could provide more comprehensive insights. Integrating sensors and automation for real-time adjustments to the rotational speed and blade position can improve the dehusking efficiency and reduce the percentage of unhusked nuts. Finally, conducting a cost-benefit analysis to assess the economic viability of machines for small-scale farmers and large-scale operations would be valuable for their commercial adoption.

REFERENCES

[1] C. S. Karthik, A. Pariari, K. C. Bhutia, and S. O. Bhutia, "Processing Methodologies for Few Plantation Crops in India (Arecanut, Betelvine, Cashew, Cocoa and Oil Palm)," in *Innovations in Food Technology: Current Perspectives and Future Goals*, P. Mishra, R. R. Mishra, and C. O. Adetunji, Eds. Singapore: Springer, 2020, pp. 29–39.

[2] H. Gaminian, B. Ahvazi, J. J. Vidmar, U. Ekuere, and S. Regan, "Revolutionizing Sustainable Nonwoven Fabrics: The Potential Use of Agricultural Waste and Natural Fibres for Nonwoven Fabric," *Biomass*, vol. 4, no. 2, pp. 363–401, Jun. 2024, https://doi.org/10.3390/biomass 4020018.

[3] S. Mandal and R. K. Sharma, "Application of Gasification Technology in Agriculture for Power Generation," in *Handbook of Energy Management in Agriculture*, A. Rakshit, A. Biswas, D. Sarkar, V. S. Meena, and R. Datta, Eds. Singapore: Springer Nature, 2023, pp. 261–282.

[4] B. Jarimopas, S. Niamhom, and A. Terdwongworakul, "Development and testing of a husking machine for dry betel nut (*Areca Catechu Linn.*)," *Biosystems Engineering*, vol. 102, no. 1, pp. 83–89, Jan. 2009, https://doi.org/10.1016/j.biosystemseng.2008.09.033.

[5] A. Sitorus, D. Nugraha, D. Rustamli, M. Muslimin, A. R. Hasan, and R. Bulan, "Design and Construction of a Cutting Machines for Fresh Betel Nut (Areca Catechu Linn)," in *2019 5th International Conference on Computing Engineering and Design (ICCED)*, Singapore, Apr. 2019, pp. 1–4, https://doi.org/10.1109/ICCED46541.2019.9161115.

[6] H. K. Madhusudhana, G. J. Satish, N. Vijayakumar, and P. Sachin, "Design and optimization of operating parameters for areca nut de-husker," *IOP Conference Series: Materials Science and Engineering*, vol. 872, no. 1, Jun. 2020, Art. no. 012011, https://doi.org/10.1088/1757-899X/872/1/012011.

[7] C. L. Oria and E. V. Palconit, "Performance Investigation of an Inflatable Solar Dryer with Steel-Can Solar Air Heater for Drying Coffee and Corn," *Engineering, Technology & Applied Science Research*, vol. 12, no. 3, pp. 8707–8711, Jun. 2022, https://doi.org/10.48084/etasr.4966.

[8] M. Javaid, A. Haleem, R. P. Singh, and R. Suman, "Substantial capabilities of robotics in enhancing industry 4.0 implementation," *Cognitive Robotics*, vol. 1, pp. 58–75, Jan. 2021, https://doi.org/10.1016/j.cogr.2021.06.001.

[9] J. Morgan, M. Halton, Y. Qiao, and J. G. Breslin, "Industry 4.0 smart reconfigurable manufacturing machines," *Journal of Manufacturing Systems*, vol. 59, pp. 481–506, Apr. 2021, https://doi.org/ 10.1016/j.jmsy.2021.03.001.

[10] M. Soori, B. Arezoo, and R. Dastres, "Machine learning and artificial intelligence in CNC machine tools, A review," *Sustainable Manufacturing and Service Economics*, vol. 2, Apr. 2023, Art. no. 100009, https://doi.org/10.1016/j.smse.2023.100009.

[11] I. S. Cebro and A. Sitorus, "Performance Evaluation Of A Hand Tractor To Climbing Sloping Land," *International Journal of Scientific & Technology Research*, vol. 8, no. 7, pp. 781–785, Jul. 2019.

[12] D. X. Dong, P. V. Minh, N. Q. Ninh, and D. X. Dinh, "Development of Renewable Energy Sources to Serve Agriculture in Vietnam: A Strategic Assessment using the SWOT Analysis," *Engineering, Technology & Applied Science Research*, vol. 13, no. 5, pp. 11721–11727, Oct. 2023, https://doi.org/10.48084/etasr.6211.

[13] S. Tepjit, P. Aungkulanon, and C. Ketviriyakit, "Defining the System Operation Modes and Key Parameters for the Conceptualization of CPS-Based Rice Milling Machine – Consideration of Quality Aspect," in *Advanced in Creative Technology- added Value Innovations in Engineering, Materials and Manufacturing*, Cham, 2024, pp. 393–409, https://doi.org/10.1007/978-3-031-59164-8_32.

[14] D. K. Bwambok *et al.*, "QCM Sensor Arrays, Electroanalytical Techniques and NIR Spectroscopy Coupled to Multivariate Analysis for Quality Assessment of Food Products, Raw Materials, Ingredients and Foodborne Pathogen Detection: Challenges and Breakthroughs," *Sensors*, vol. 20, no. 23, Jan. 2020, Art. no. 6982, https://doi.org/10.3390/s20236982.

[15] M. M. Strieder, F. S. Bragagnolo, R. S. Pizani, and M. A. Rostagno, "The impact of using an expansion gas with high-intensity ultrasound on the pressurized liquid extraction of bioactive compounds from an industrial coffee solid residue," *Innovative Food Science & Emerging Technologies*, vol. 92, Mar. 2024, Art. no. 103575, https://doi.org/10.1016/j.ifset.2024.103575.

[16] A. Sitorus, A. Fauzi, G. Ramadhan, R. Kuswandi, A. R. Hasan, and A. Karyadi, "Conceptual Design of Harvesters Knife for Chinese Spinach (Ipomoea Reptans Poir.): CAD Approach," in *2018 International Conference on Computing, Engineering, and Design (ICCED)*, Bangkok, Thailand, Sep. 2018, pp. 7–12, https://doi.org/10.1109/ICCED.2018.00012.

[17] S. Raseetha, S. P. Heenan, I. Oey, D. J. Burritt, and N. Hamid, "A new strategy to assess the quality of broccoli (*Brassica oleracea L. italica*) based on enzymatic changes and volatile mass ion profile using Proton Transfer Reaction Mass Spectrometry (PTR-MS)," *Innovative Food Science & Emerging Technologies*, vol. 12, no. 2, pp. 197–205, Apr. 2011, https://doi.org/10.1016/j.ifset.2010.12.005.

[18] A. Sarker, A. Deltsidis, and T. E. Grift, "Effect of Aloe Vera Gel-Carboxymethyl Cellulose Composite Coating on the Degradation

Kinetics of Cucumber," *Journal of Biosystems Engineering*, vol. 46, no. 2, pp. 112–128, Jun. 2021, https://doi.org/10.1007/s42853-021-00092-z.

[19] J. S. Jo, F. G. Okyere, J. M. Jo, and H. T. Kim, "A Study on Improving the Performance of the Planting Device of a Vegetable Transplanter," *Journal of Biosystems Engineering*, vol. 43, no. 3, pp. 202–210, Jan. 2018.

[20] A. R. Gorbushin and A. A. Bolshakova, "Unsteady axial force measurement by the strain gauge balance," *Measurement*, vol. 152, Feb. 2020, Art. no. 107381, https://doi.org/10.1016/j.measurement.2019.107381.

[21] P. S. Deshmukh *et al.*, "Effect of mechanical and chemical treatments of arecanut (*areca catechu* L.) fruit husk on husk and its fibre," *Waste Management*, vol. 95, pp. 458–465, Jul. 2019, https://doi.org/10.1016/j.wasman.2019.06.026.

[22] R. Bulan, Devianti, E. Septi Ayu, and A. Sitorus, "Effects of moisture content on some engineering properties of arecanut (areca catechu L.) fruit which are relevant to the design of processing equipment," *INMATEH Agricultural Engineering*, vol. 60, no. 1, pp. 61–70, Apr. 2020, https://doi.org/10.35633/inmateh-60-07.

[23] G. Sunny and T. P. Rajan, "An effect of retting process and extraction methods on physical and mechanical properties of areca nut fibers," *International Journal of Clothing Science and Technology*, vol. 36, no. 4, pp. 722–739, May 2024, https://doi.org/10.1108/IJCST-09-2023-0133.

[24] S. Widyotomo, "Evaluasi Kinerja Mesin Pengupas Kulit Buah Kopi Basah Tipe Silinder Horisontal," *Jurnal Enjiniring Pertanian*, vol. 8, pp. 27–38, Apr. 2010.

[25] I. Syahrizal and D. Perdana, "Uji kinerja mesin pengupas buah pinang kering menggunakan mekanisme pengupas tipe impact rotary poros horizontal," *Turbo : Jurnal Program Studi Teknik Mesin*, vol. 11, no. 1, pp. 37–46, Jun. 2022, https://doi.org/10.24127/trb.v11i1.1821.

[26] E. Budiyanto, L. D. Yuono, and A. Farindra, "Upaya Peningkatan Kualitas dan Kapasitas Produksi Mesin Pengupas Kulit Kopi Kering," *Turbo : Jurnal Program Studi Teknik Mesin*, vol. 8, no. 1, pp. 88–98, Jun. 2019, https://doi.org/10.24127/trb.v8i1.926.