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Energy Consumption Analysis on Ginger Extract Powder Mixer Machine

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ABSTRACT

Ginger extract powder is a popular product in the beverage and health industry, requiring careful processing to produce high-quality results. This study aims to determine the efficiency of the stirring blade design on the ginger extract powder stirring machine. The intensive stirring process can lead to faster wear of the blades, making the selection of suitable materials crucial. The research was conducted through direct observation at UKM Bekti Pertiwi. The data collection process was structured to capture both quantitative data: 1) Energy consumption: energy used by the machine was measured in kilowatt-hours (kWh) using a standardized electricity meter, and 2) Cycle time: the time for a full cycle was recorded, from material input to the completion of the stirring process. A controlled sample of 2 kg of ginger essence was used in each test to standardize conditions and ensure consistent results. The sample size was chosen based on typical batch sizes processed by SMEs, aiming to represent common production volumes. The ginger essence sample was prepared with a standardized consistency and viscosity to reduce variability and ensure repeatability across tests. The stirring blade samples were manufactured from stainless steel with a Teflon coating, selected due to its corrosion resistance and durability in acidic environments. Blade dimensions were set to 504 mm in diameter and 3 mm in thickness, based on initial design research suggesting these dimensions as optimal for the desired mixing efficiency and wear resistance. Each test was conducted under the same operational settings, including motor speed and cycle duration, to maintain uniformity in testing conditions. Results indicate that a combination of stainless steel and Teflon in the stirring blades provides optimal performance, with energy consumption reaching 0.1072 kWh for 2 kg of ginger extract. The electricity cost for one production cycle is IDR 144.93. These findings can be used for future production planning, as well as to improve operational efficiency and the quality of ginger extract products.

Keywords: Energy, Consumption, Extract, Ginger, Mixer, Machine

INTRODUCTION

Ginger extract is a popular processed product in the beverage and health industry [1]. Ginger extract, a concentrated extract derived from the root of Zingiber officinale, has gained significant traction in the beverage and health industry due to its potent flavor and well-documented health benefits [2][3]. Traditionally used in both culinary and medicinal applications, ginger is valued for its anti-inflammatory, antioxidant, and digestive properties. It contains bioactive compounds like gingerol and shogaol, which have been shown to aid in reducing nausea, alleviating muscle pain, and enhancing immune function [4].

The global demand for natural health products has been on the rise, with consumers increasingly seeking alternatives to artificial flavorings and synthetic ingredients. This shift has opened a promising market for ginger-based products, including ginger teas, wellness shots, juices, and herbal remedies. As a result, the production of high-quality ginger essence is now critical for companies striving to meet this demand. A well-processed ginger essence provides a concentrated, stable, and potent form of ginger that can be readily incorporated into both beverages and supplements without losing its therapeutic qualities [5][6][7][8].

For small and medium-sized enterprises (SMEs), optimizing ginger extract production can enhance both product quality and profitability. However, ginger extract is particularly challenging to process due to its high viscosity and particulate content, which can lead to sedimentation and uneven mixing. Efficient stirring and mixing are thus essential to maintain the consistency and potency of the final product, which directly impacts flavor, shelf stability, and consumer satisfaction.

Ginger extract requires careful processing to produce a high-quality product [9]. One of the crucial stages in this process is stirring, which aims to mix the ginger essence evenly and avoid sedimentation of undissolved ginger particles.

The efficiency of a ginger essence mixer depends on several factors such as machine energy consumption, machine dimensions, and cycle time analysis [10]. In this context, improving the design and materials of stirring equipment for ginger extract processing is not only important for operational efficiency but also essential for producing a product that meets industry standards for quality [11][12]. By achieving uniform mixing and reducing material wear, companies can lower maintenance costs, enhance product quality, and deliver a consistent product to the health-conscious consumer market [13].

The stirring blade is an important component in the stirring machine that serves to mix and homogenize the ginger essence [14]. Choosing the right material for the stirring blade greatly affects the performance, efficiency, and durability of the equipment [15]. Ginger essence is characterized by high viscosity and contains small particles, which requires the stirring blade to have good mechanical strength and corrosion resistance. The material should also minimize friction and wear, ensuring consistent mixing without compromising the quality of the ginger essence [16].

Problems often encountered in the material selection of stirring blades include resistance to the acidic chemicals of ginger essence, wear resistance, and the ability to provide effective stirring [17]. Unsuitable materials can cause damage to the stirring blades and reduce the efficiency of the production process, as well as affect the quality of the ginger essence produced. In addition, ergonomic design is an issue. Blade wear and ergonomic design are two major problems often encountered in the development of ginger essence mixer blades. Mixer blade materials are often made of materials that are not durable or suitable for the characteristics of ginger essence [18]. Some of the most used materials are wood and stainless steel.

The intensive stirring process causes the blades to wear faster than they were designed to [19]. Intensive friction between the blade material and the pan can also affect the wear rate and hinder the speed of the stirring process. In addition, blade design also affects the effectiveness of the stirring process. Blade designs with optimal angles and thicknesses can reduce wear and increase machine productivity [20].

To address these challenges, research and innovation in stirrer blade materials is critical. Proper material selection will not only increase the service life of the agitator blades, but also contribute to reduced maintenance costs, improved energy efficiency, and consistent quality of the final product [21][22]. Therefore, it is important to explore different types of materials and stirring blade designs that can meet the specific needs in ginger essence processing.

Engine energy consumption refers to the amount of energy used by the engine in the process of its operation [23]. Engine energy consumption is expressed in kilowatt-hours (kWh). Engine energy consumption can be calculated with the following steps: 1) determine engine power; 2) measure operating time; 3) and calculate energy consumption. Engine power is usually listed in the engine's technical specifications and is expressed in kilowatts (kW).

The stirring speed of a ginger essence mixer refers to how fast the stirring blade rotates while mixing the ginger essence. The stirring blade is an important component in the mixer machine that serves to mix and homogenize the ginger essence. The selection of the right material for the stirring blade greatly affects the mixing effectiveness, product consistency, process time, and quality [24]. Ginger essence is characterized by high viscosity and contains small particles, which requires the stirring blade to have good mechanical strength and corrosion resistance.

Cycle time is the duration required to complete one complete round of the stirring process [25]. Starting from inputting materials to getting the result and removing the finished product. The cycle time analysis of the ginger essence stirring machine refers to the assessment of the time required to complete one full cycle of the stirring process. It is an important measure in understanding machine efficiency and productivity [26]. Here are some key aspects of cycle time analysis: 1) preparation time is the time required to prepare the raw materials before starting to stir, including loading the ginger essence into the machine; 2) stirring time is the duration of stirring or mixing the ginger essence in the machine; and 3) discharge time is the time required to discharge the ginger essence after the stirring process is complete [15][27].

The purpose of the study was to determine the efficiency of the stirring blade design on the performance of the ginger essence stirring machine. When the operational efficiency is known, the results of this study can be used for further production planning.

RESEARCH METHOD

The use of direct observation in this study was strategic due to several key advantages [28]. Direct observation allows for real-time monitoring of machine operations and interactions between components (e.g., stirring blades and ginger essence), which is critical in understanding wear patterns, material behavior, and energy use. Unlike automated data logging or indirect observational methods, direct observation enables the researcher to note nuanced interactions, such as subtle vibrations or sounds indicating blade wear, which can provide early warnings of mechanical issues.

Additionally, direct observation is more adaptable, allowing adjustments to data collection as unexpected conditions arise (e.g., variations in viscosity of ginger essence). This method offers a comprehensive perspective on operational efficiency and cycle time, capturing qualitative insights alongside quantitative measurements. Given the exploratory nature of this study, direct observation was chosen to maximize the quality and depth of data, setting a strong foundation for future controlled studies or automated monitoring implementations.

The design research process involved iterative analysis and testing to optimize the ginger essence stirring blade. Using Autodesk Inventor, the blade's dimensions, geometry, and material composition were carefully modeled and refined. The primary objectives in the design phase were to achieve homogeneous mixing, reduce wear, and maintain energy efficiency.

A user-centered design approach was employed, considering the needs of small and medium-sized enterprises (SMEs) that process ginger essence. Key considerations included the blade's ease of maintenance, cost-effectiveness, and longevity. By integrating these factors, the design phase focused on balancing performance with durability in real-world production settings.

Performance testing of the ginger essence mixer machine was carried out on July 28, 2024, at UKM Bekti Pertiwi. The data collection process was structured to capture both quantitative data. Quantitative data: 1) Energy consumption: Energy used by the machine was measured in kilowatt-hours (kWh) using a standardized electricity meter, and 2) Cycle time: The time for a full cycle was recorded, from material input to the completion of the stirring process.

The research method used to determine the operational effectiveness of the ginger essence mixer machine is observation. This research step consists of 1) the type of observation used is direct observation; 2) the observation instrument used is a recording form; and 3) data analysis.

A controlled sample of 2 kg of ginger essence was used in each test to standardize conditions and ensure consistent results. The sample size was chosen based on typical batch sizes processed by SMEs, aiming to represent common production volumes. The ginger essence sample was prepared with a standardized consistency and viscosity to reduce variability and ensure repeatability across tests.

The stirring blade samples were manufactured from stainless steel with a Teflon coating, selected due to its corrosion resistance and durability in acidic environments. Blade dimensions were set to 504 mm in diameter and 3 mm in thickness, based on initial design research suggesting these dimensions as optimal for the desired mixing efficiency and wear resistance. Each test was conducted under the same operational settings, including motor speed and cycle duration, to maintain uniformity in testing conditions.

The data analysis step starts from grouping the data that has been obtained in the field such as engine power consumption data and operating time. Next, an assessment of the data that has been collected is carried out.

Machine operating time is a record of how long the machine operates. The unit used to measure operating time is the hour. Cycle time is a record of the time from putting ginger essence into the stirring machine until it is finished, and the ginger essence is emptied from the machine. The way to calculate cycle time is by using the formula:

$$cycle\ time = outlet\ time - inlet\ time$$

Where:

Inlet time: Record the time the ginger essence is fed into the machine.

Out time: record the time when the stirring is completed, and the finished product is removed from the machine.

The formula used to calculate energy consumption is as follows:

$$energy\ consumption = power\ x\ operating\ timee$$

Where:

Energy consumption (kWh)

Engine power (kW)

Engine operating time (hour)

RESULT AND DISCUSSION

The analysis of needs and specifications is seen from the aspects of stirring objectives, material characteristics, and dimensions. The purpose of stirring ginger essence is to achieve homogeneous crystallization of ginger essence and minimize sediment or scale on the pan. The selection of suitable materials becomes the next important point. The selection of Teflon material is done with the consideration that Teflon material is one of the food grade materials so that it can be applied to food processing machines. In addition, Teflon material is flexible enough to reduce sediment or crust on the pan. The dimensions of the stirring blade are an important point.

The design process is carried out using Autodesk Inventor software. The 3-dimensional cross section can be seen from Figure 1.

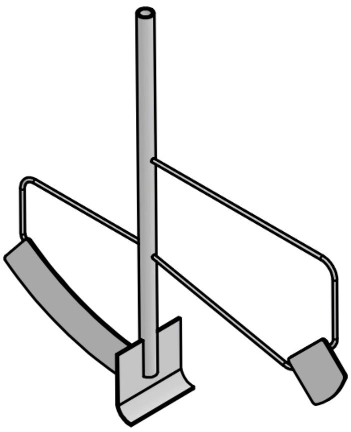

Figure 1. 3D stirring blade design result

The material used as the main frame of the stirring blade is stainless steel. The stirring blade uses a combination of 3 mm stainless steel blades and Teflon. This combination is done to improve the quality of the ginger essence mixture and operating time so that an effective energy consumption value is obtained [29][30][31]. The diameter of the stirring blade of the machine shown in Figure 1 is 504 mm.

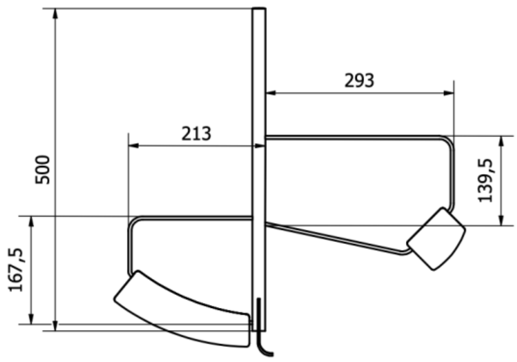

Figure 2. Stirring blade dimension

Testing the performance of the ginger essence stirring machine was carried out by cooking 2 kg of ginger essence. It is known that the motor power used in the ginger essence stirring machine is 160 watts. The recording time from the time the ginger essence is put into the pan (Fig. 3) until it comes out of the machine (fig. 4) is 50 minutes. While the time needed to cook ginger essence is 45 minutes.

Figure 3. Initial condition

Figure 4. Final condition

Engine energy consumption can be determined by performing the following calculations:

energy consumption = Power x Operating

energy consumption = 0,160 kw x 0,67 hour

energy consumption = 0,1072 kwh

The amount of electrical energy used by the ginger essence mixer in one production of 2 kg of ginger essence required 0.1072 kWh. Energy consumption data can be used to calculate operational costs. The cost of electricity bill for Bekti Pertiwi SMEs, which are included in the R1 Household Power 900 VA customer group, is IDR 1,352 per kWh. This means that in one production of 2 kg of ginger essence, the electricity cost required is as much as:

$$energy\ cost = energy\ consumption\ x\ household\ power$$

$$energy\ cost = 0{,}1072\ kWh\ \ x\ IDR\ 1.352/kWh$$

$$energy\ cost = IDR\ 144{,}93$$

The amount of electricity costs required by UKM Bekti Pertiwi in one production is IDR 144.93.

The findings of this study provide valuable insights into optimizing ginger essence processing by refining the design and material selection of stirring blades. The use of stainless steel and Teflon materials for the blade demonstrated several performance benefits, including reduced wear and increased energy efficiency, which are essential for consistent, high-quality production.

The energy consumption rate of 0.1072 kWh per production cycle translates to a low operating cost of IDR 144.93 per cycle, making this stirring machine economically viable for small and medium enterprises (SMEs) like UKM Bekti Pertiwi. For comparison, traditional stirring methods or machines using less efficient designs typically have higher power demands due to increased friction and suboptimal mixing, which can lead to both higher energy costs and more frequent maintenance. This study's results suggest that optimized blade materials and design can lower operational costs and energy use, providing an environmentally sustainable solution that aligns with the global push toward greener industrial practices.

Material Performance: The combination of stainless steel and Teflon proved effective in addressing wear and corrosion, critical factors given ginger essence's acidic properties. Stainless steel offers the mechanical strength needed to handle the high viscosity and particulate content of ginger essence, while Teflon provides a smooth, food-grade surface that reduces friction and prevents sediment buildup. This material synergy not only minimizes the risk of contamination and degradation but also extends the blade's operational lifespan. As a result, this material selection significantly contributes to product consistency and machine durability, reducing the downtime and cost associated with frequent blade replacements.

Further studies could explore additional materials or coatings that might improve blade durability even more, particularly in higher-volume production settings. Composite materials, for instance, might offer increased resistance to wear while maintaining food safety standards.

The analysis of cycle time—encompassing preparation, mixing, and discharge stages—highlights opportunities to further streamline production. While the machine operates efficiently for a 2 kg batch, scaling up production would require adjustments in both machine capacity and blade design. Optimizing the blade geometry, such as adjusting angle and thickness, could enhance mixing efficiency, reduce cycle time, and potentially allow for larger batch processing without compromising quality.

By reducing cycle time, SMEs could increase production throughput, meeting higher demand without substantial energy cost increases. Additionally, future designs could integrate automated cycle tracking or IoT-based monitoring to further optimize cycle times, minimize energy consumption, and alert operators to any wear or performance issues in real-time [32].

This study demonstrates a scalable, cost-effective solution that could be adapted across various food and beverage production processes that involve viscous mixtures, such as sauces, herbal extracts, and other concentrated beverages. By focusing on energy-efficient design and durable materials, similar equipment could be tailored to industries aiming to minimize waste and energy consumption, enhancing the environmental sustainability of production practices. Furthermore, using such optimized machines aligns with industry standards, such as those set by ISO 50001, promoting energy management and sustainability.

While this study provides a solid foundation, further research could explore: 1) Scaling Efficiency for Larger Batches: Testing the blade design and energy efficiency at various production volumes would provide insights for larger-scale producers, 2) Alternative Blade Designs: Investigating blade shapes and angles tailored to different viscosities or particulate compositions could offer even better mixing efficiency and product quality, and 3) Wear and Durability Testing Under Varied Conditions: Extending the testing period and using various environmental conditions would yield more data on long-term durability, which is critical for industrial adoption.

By addressing these factors, this study contributes significantly to the growing body of knowledge focused on cost-efficient, durable, and environmentally sustainable equipment solutions for the food and beverage industry. Implementing these design improvements in production environments supports SMEs in achieving higher operational efficiency, reducing costs, and ultimately delivering consistent, high-quality products to meet consumer demand.

CONSLUSION

This study successfully demonstrates that the optimized design and material selection of stirring blades—using a combination of stainless steel and Teflon—significantly enhances the efficiency and durability of ginger extract stirring machines. By effectively reducing wear and providing superior mixing consistency, this design contributes to a lower operational cost, with each 2 kg production cycle consuming only 0.1072 kWh of energy at an approximate cost of IDR 144.93. These findings highlight the potential for small and medium enterprises (SMEs) to improve production efficiency while maintaining product quality and reducing operational expenses.

The enhanced durability of the stainless steel and Teflon blade combination proves essential in addressing the challenges of high viscosity and particulate content in ginger essence. This design choice minimizes blade replacement frequency, reduces downtime, and extends machine life, making it a practical choice for SMEs focused on cost-effective, high-quality production. Additionally, the energy efficiency achieved in this study aligns with broader industry goals to reduce environmental impact, showcasing a model of sustainable equipment design.

Looking forward, further research on scaling production and testing alternative materials could provide even greater insights into optimizing similar processing machines for other food and beverage applications. Overall, this study's approach to material selection, energy efficiency, and cost optimization offers a valuable framework for SMEs seeking to enhance their production capabilities in a competitive market.

REFERENCES

[1] R. Dewi Puspita Sari, W. Trijayanthi Utama, and R. Indriyani, 'PEMBUATAN PRODUK MINUMAN HERBAL KELUARGA DARI JAHE DI DESA DWI WARGA TUNGGAL JAYA KABUPAEN TULANG BAWANG', *Jurnal Pengabdian Kepada Masyarakat BUGUH*, vol. 2, no. 2, p. 2022, 2022.

[2] H. Huda *et al.*, 'Exploring the ancient roots and modern global brews of tea and herbal beverages: A comprehensive review of origins, types, health benefits, market dynamics, and future trends', *Food Sci Nutr*, 2024.

[3] M. Zebeaman, M. G. Tadesse, R. K. Bachheti, A. Bachheti, R. Gebeyhu, and K. K. Chaubey, '2 Medicinal and Commercial Application of Zingiber officinale', in *Medicinal Roots and*

Tubers for Pharmaceutical and Commercial Applications, CRC Press, 2023, pp. 16–26.

[4] T. Prabhu, S. Shenbagavalli, R. Rubika, M. I. Manivannan, A. Baskaran, and J. Rajangam, 'Unlocking the full potential of functional beverages in medicinal and aromatic plants', *Ann Phytomed*, vol. 13, no. 1, pp. 337–346, 2024.

[5] I. R Kubra and L. Jaganmohanrao, 'An overview on inventions related to ginger processing and products for food and pharmaceutical applications', *Recent Pat Food Nutr Agric*, vol. 4, no. 1, pp. 31–49, 2012.

[6] J. Wang *et al.*, 'Different origins and processing methods affect the intrinsic quality of ginger: a novel approach to evaluating ginger quality', *Front Chem*, vol. 11, p. 1296712, 2023.

[7] T. Laelago Ersedo *et al.*, 'Food flavor enhancement, preservation, and bio-functionality of ginger (Zingiber officinale): a review', *Int J Food Prop*, vol. 26, no. 1, pp. 928–951, 2023.

[8] B. B. Bag, 'Ginger processing in India (Zingiber officinale): A review', *Int J Curr Microbiol App Sci*, vol. 7, no. 4, pp. 1639–1651, 2018.

[9] J. Zagórska, L. Czernicka-Boś, W. Kukula-Koch, R. Szalak, and W. Koch, 'Impact of Thermal Processing on the Composition of Secondary Metabolites of Ginger Rhizome—A Review', *Foods*, vol. 11, no. 21, p. 3484, 2022.

[10] Dessy Agustina Sari, S. Sukanta, N. W. Saputro, M. Hasyim, and M. I. Fardiansyah, 'Transformasi sistem pengadukan dalam produksi serbuk jahe merah', *Jurnal Inovasi Hasil Pengabdian Masyarakat (JIPEMAS)*, vol. 6, no. 2, pp. 430–439, Aug. 2023, doi: 10.33474/jipemas.v6i2.19130.

[11] F. Chemat *et al.*, 'Green extraction of natural products. Origins, current status, and future challenges', *TrAC Trends in Analytical Chemistry*, vol. 118, pp. 248–263, 2019.

[12] N. Lebovka, E. Vorobiev, and F. Chemat, *Enhancing extraction processes in the food industry*. Crc Press Boca Raton, 2012.

[13] H. A. Santoso, N. Islahudin, and D. K. Wijaya, 'Design and manufacturing optimization of herbal drink crystallization machine using reverse engineering method', *OPSI*, vol. 16, no. 2, pp. 225–240, 2023.

[14] Y. S. Pramesti, I. Setyowidodo, Fatkur Rhohman, and Ah. Sulhan Fauzi, 'Analisis gaya dan daya pada alat pengaduk mesin kristalisasi jahe dengan kapasitas 5 kg/jam', *Jurnal Mesin Nusantara*, vol. 6, no. 1, Jul. 2023, doi: 10.29407/jmn.v6i1.19929.

[15] J. Bridgwater, 'Mixing of powders and granular materials by mechanical means—A perspective', *Particuology*, vol. 10, no. 4, pp. 397–427, 2012.

[16] S. Arva, N. Alam, and E. Priyantono, 'PENGARUH VOLUME PENGENCERAN EKSTRAK JAHE MURNI TERHADAP SIFAT FISIKOKIMIA DAN ORGANOLEPTIK MINUMAN JAHE INSTAN Effect of Pure Ginger Extract Dilution Volume on Physicochemical and Organoleptic Properties of Instant Ginger Drinks', *J. Agrotekbis*, vol. 12, no. 3, pp. 644–652, 2024, doi: 10.22487/agrotekbis.v12i3.2143.

[17] M. Yusuf, F. Yudhanto, and D. P. Purbajati, 'Desain, Manufaktur dan Uji Kinerja Mesin Pengolah Serbuk Jahe Merah', *Quantum Teknika : Jurnal Teknik Mesin Terapan*, vol. 2, no. 2, pp. 87–92, Apr. 2021, doi: 10.18196/jqt.v2i2.11573.

[18] C. Anam, N. Widyamurti, D. Praseptiangga, A. Yulviatun, and D. A. Himawanto, 'Aplikasi Mesin Pemasak Minuman Rempah Jahe (Zingiber officinale) Dengan Pengaduk Otomatis di UKM Polanmadu', *PRIMA: Journal of Community Empowering and Services*, vol. 5, no. 2, p. 199, Dec. 2021, doi: 10.20961/prima.v5i2.44202.

[19] F. Maghfurah and D. Desria Chandra, 'PERANCANGAN MESIN PENGADUK BAHAN DASAR ROTI KAPASITAS 43 KG', *Jurnal SAINTEK*, vol. 6, no. 1, 2019.

[20] P. Fernando, A. Risal, M. Mukhnizar, A. Afdal, and V. Selviyanty, 'Perencanaan Mesin Pembuat Serbuk Jahe', *Jurnal Teknik Industri Terintegrasi*, vol. 6, no. 3, pp. 828–836, Jul. 2023, doi: 10.31004/jutin.v6i3.17208.

[21] M. Mahendradatta and M. Asfar, 'Characteristics of simplicia ginger (Zingiber officinale) and lemongrass (Cymbopogon citratus) powder by different drying method', in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2021, p. 022052.

[22] P. Mishra and D. K. Bhatt, 'A Study on development of fortified pasta with ginger powder', *J Environ Sci Toxicol Food Technol*, vol. 10, no. 8, pp. 14–18, 2016.

[23] V. Ledianti, A. Yusuf, and A. Widyasanti, 'Rancang Bangun Mesin Pengaduk Adonan Kerupuk Bawang (Studi Kasus di Usaha Kecil dan Menengah Sakinah, Cimahi)', *Jurnal Keteknikan Pertanian Tropis dan Biosistem*, vol. 9, no. 1, pp. 26–33, Apr. 2021, doi: 10.21776/ub.jkptb.2021.009.01.04.

[24] Kriswanto, W. aryadi, D. Subarkah Hadikawuryan, I. Wahyu Pamungkas, O. Yusuf Briantoro, and F. Hasyim, 'Penerapan Mesin Pengaduk Adonan Kue pada Usaha Bakpia di Kelurahan Pakintelan', *Jurnal Penerapan Teknologi dan Pembelajaran*, vol. 17, no. 2, pp. 35–40, 2019, doi: 10.15294/rekayasa.v17i2.21727.

[25] A. Carlsson-Kanyama and K. Boström-Carlsson, 'Energy use for cooking and other stages in the life cycle of food', *A*

study of wheat, spaghetti, pasta, barley, rice, potatoes, couscous and mashed potatoes. Stockholms Universitet/Systemekologiochfoi. FMS report, vol. 160, 2001.

[26] R. Osae, G. Essilfie, R. N. Alolga, E. Bonah, H. Ma, and C. Zhou, 'Drying of ginger slices—Evaluation of quality attributes, energy consumption, and kinetics study', *J Food Process Eng*, vol. 43, no. 2, p. e13348, 2020.

[27] B. B. Bag, 'Ginger processing in India (Zingiber officinale): A review', *Int J Curr Microbiol App Sci*, vol. 7, no. 4, pp. 1639–1651, 2018.

[28] S. A. Rolfe, 'Direct observation', in *Doing early childhood research*, Routledge, 2020, pp. 224–239.

[29] G. Tranchida, 'Corrosion resistance of different stainless steel grades in food and beverage industry', 2020.

[30] A. K. Dewangan, A. D. Patel, and A. G. Bhadania, 'Stainless steel for dairy and food industry: a review', *J. Mater. Sci. Eng*, vol. 4, no. 5, pp. 1–4, 2015.

[31] S. S. Shindalkar, S. S. Humbe, G. M. Joshi, and C. R. Kumar, 'Engineering properties of Teflon derived blends and composites: a review', *Polymer-Plastics Technology and Materials*, vol. 61, no. 18, pp. 1973–1987, 2022.

[32] S. Asri *et al.*, 'Arduino-Based Automatic Weighing Machine Design', in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2024, p. 012028.